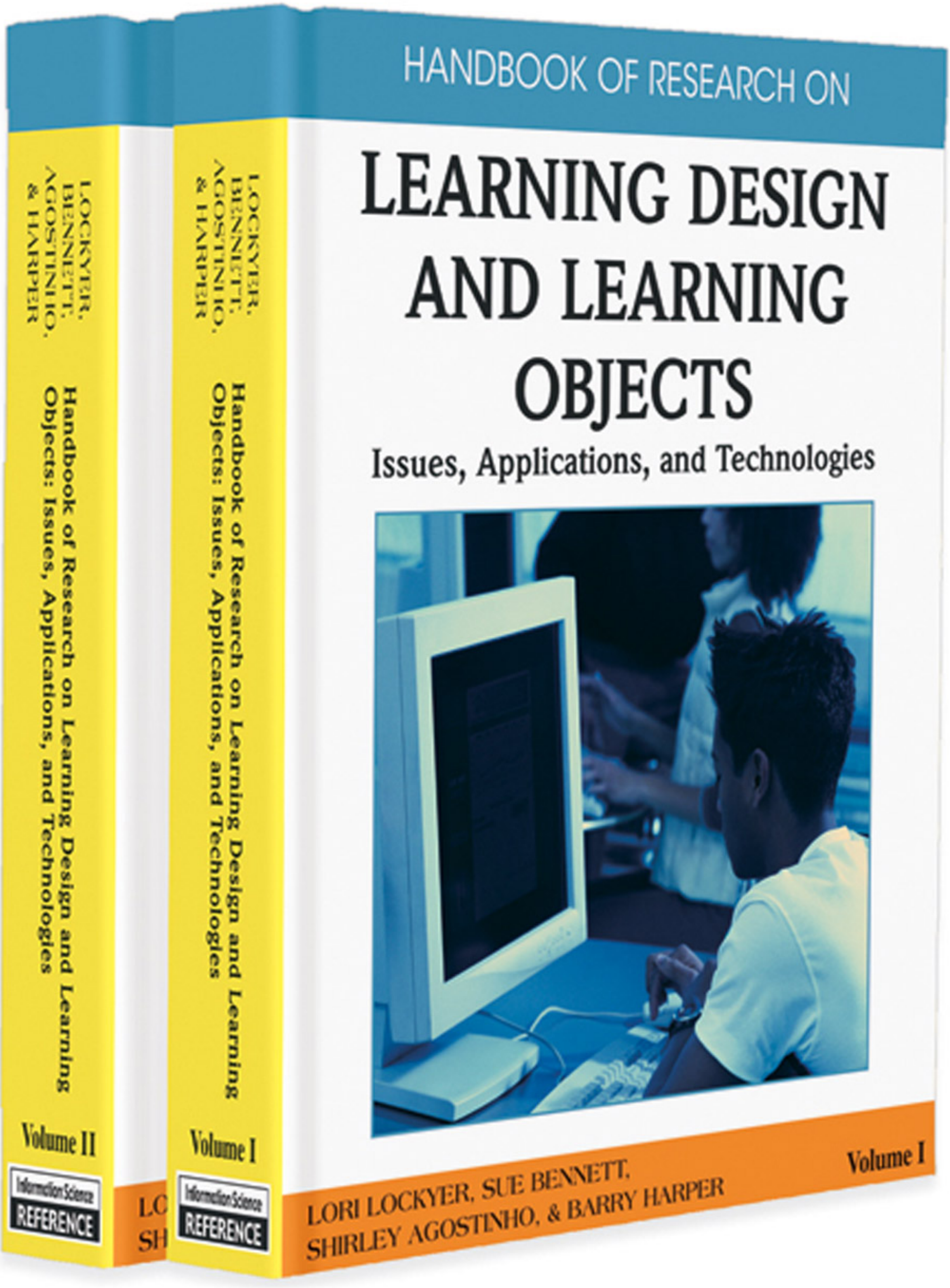
HANDBOOK OF RESEARCH ON
LEARNING DESIGN AND LEARNING OBJECTS
Issues, Applications, and Technologies
Volume I
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SHIRLEY AGOSTINHO, & BARRY HARPER
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the purpose and the metaphor for design, coupled with consideration of the audience for practice models, suggesting that while generic models are useful for technical developers they may not be an effective way of sharing teaching practice. The possibility that a rich domain map coupled with community building activities and richly contextualised exemplars might be more effective is briefly discussed. The complex interactions of characteristics of a design representation underpin the necessity for different representations to fulfil different user needs.

IMS Learning Design (IMSLD) is an open standard that can be used to specify a wide range of pedagogical strategies in computer-interpretable models. Such models then can be played in any LD compatible execution environment to support teachers and students to conduct online teaching-learning. This chapter introduces the basic knowledge required to effectively use LD. First of all, we present fundamental principles behind LD. Then, we introduce main concepts and their relations in LD and discuss some technical issues about how to make a learning design executable in a computer-based environment. Finally, how to model learning designs using LD is explained through demonstrating the whole procedure to model a use case in Extensible Markup Language (XML). We expect that the readers of this chapter can apply LD to create simple learning designs and understand learning designs with sophisticated features.

The IMS LD specification is internally complex and has been used in a number of different ways. As a result, users who have a basic understanding of the role of the specification in interoperability may nevertheless find it difficult to get an overview of the potential of the specification, or to assess what has been achieved through its use. This chapter seeks to make the task simpler by articulating the modes of use of the specification, and analysing the work carried out in each. The IMS LD specification is briefly introduced. Four aspects of the IMS Learning Design specification are identified and described: modelling language, interoperability specification, modelling and methodology, and infrastructure. The different opportunities provided by each mode of use are explored and the achievements of work so far carried out are assessed. A number of valuable contributions are identified, but the practical and widespread use of the specification to exchange learning activities has not so far been achieved. The changing technological and organisational environment in which IMS LD operates is discussed, and its implications explored. Conclusions are offered which summarise achievements with IMS LD to date, with comments on prospects for the future.

A design pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander et al., 1977). In the field of e-learning, design patterns are frequently advocated as a powerful way of providing structured, teacher-friendly, textual representations of learning designs, or of expressing the design rationale underlying learning objects. The purpose of this chapter is to look at e-learning design patterns from a critical perspective. We provide a historical, multidisciplinary excursus of the notion of design patterns. We propose a taxonomy of e-learning design patterns, providing examples in the various categories. Finally, we discuss both the benefits of design patterns for e-learning professionals (particularly, novice ones) and their drawbacks, and investigate how such pros and cons may affect the role of patterns for learning designs.

Design patterns have received considerable attention for their potential as a means of capturing and sharing design knowledge. This chapter provides a review of design pattern research and usage within education and other disciplines, summarizes the reported benefits of the approach, and examines design patterns in relation to other approaches to supporting design. Building upon this work, it argues that design patterns can capture learning design knowledge from theories and best practices to support novices in effective e-learning design. This chapter describes the authors' work on the development of designs patterns for e-learning. It concludes with a discussion of future research for educational uses of design patterns.

This chapter provides an overview of recent research and development (R&D) activity in the area of educational design patterns and pattern languages. It provides a context for evaluating this line of R&D by sketching an account of the practice of educational design, highlighting some of its difficulties and the ways in which design patterns and other aids to design might play a role. It foregrounds a tension between optimising design performance and supporting the evolution of design expertise. The chapter provides examples of recent research by the authors on design patterns for networked learning, as well as pointers to complementary research by others. Connections are made with R&D work on Learning Design and other approaches to supporting design activity.

The chapter provides a theoretical framework for understanding learning activities: centering on two key aspects: (1) the capture and representation of activities and (2) mechanisms for scaffolding the design process, which is introduced here as a formal methodology for learning design. The chapter begins by describing how information can be abstracted from learning activities via a range of different forms of representation (models, iconic diagrams, textual case studies, etc.), which are defined here as "mediating artefacts." It discusses how different mediating artefacts can be used to inform the process of designing a new learning activity. It augments and provides an illustration of the theoretical arguments developed in the chapter by summarizing some of the findings from relevant research on learning design and uses the DialogPlus toolkit as a case study and an example of a mediating artefact that can be used to support the design of a learning activity. The toolkit includes examples of learning activities (i.e., representations of activities as outline in 1) as well as guidelines and support (i.e., mechanisms for scaffolding the design process as outlined in 2). The chapter argues that this approach to learning design, which centres on the concept of mediating artefacts, and their role in the design process, can be used as a descriptive framework for describing the dynamics, processes, and different aspects involved in learning design.

This chapter uses Activity Theory to construct a framework for the design and deployment of pedagogic planning tools. It starts by noting the impact of digital technology on teachers' practice, particularly the role of planning in the creation of effective technology-mediated learning. It espouses the reconceptualization of planning as design for learning and identifies a key role for the emergent genre of pedagogic planning tools in stimulating practitioners' engagement in this reconceptualized practice. Drawing on Activity Theory, the chapter then characterizes the principal elements and relationships in design for learning. From the insights gained, it analyzes research data from two projects to pinpoint the enabling factors and tensions in current practice that might be conducive to (or, conversely, impede) the effective design and deployment of pedagogic planning tools. It then synthesizes these into a framework in which software developers and policy-makers can explore their own contexts for implementing such tools.

This chapter describes the development of a taxonomy of learning designs based on a survey of 52 innovative ICT-using projects that formed the basis of a grounded approach to classifying high quality learning designs. The concept of learning designs has the potential to support academics in the process of offering high quality ICT supported learning settings in the higher education sector. The taxonomy is

IMS Learning Design (IMS LD) is a specification for describing a range of pedagogic approaches. It allows the linking of pedagogical structure, content and services, whilst keeping the three separate, thus providing the potential for re-use as well as forming the basis for interoperability between learning activities and services. As such, this specification promises unprecedented opportunities to build effective tutor support and presence into e-learning systems. The tools that implement the specification have primarily been used for research purposes and have not been targeted at teaching practitioners or learners working in teaching and learning situations. There is a perception amongst practitioners and tool developers that the specification and tools are too technical or difficult for practitioner use. This chapter examines practitioner use of current tools for creating IMS LD and the use of IMS LD units of learning (UoLs) with learners through projects being undertaken at Liverpool Hope University (LHU). It presents some of the experiences and findings gained from these projects. The chapter also examines current technologies and tools for creating and running IMS LD UoLs, and finally discusses the potential and future for IMS LD.

Decision-making processes in relation to complex natural resource require recognition and accommodation of diverse and competing perspectives in a decision context that is frequently ill defined and fraught with value judgements. Online environments can be used to develop students' skills and understanding of these issues. The focus of this chapter is the learning design of an online roleplay-simulation (Mekong e-Sim) which was created to develop learning experiences about these types of issues across multiple institutions with students from the disciplines of engineering and the humanities. The key stages of interaction within the e-Sim are described and linked to student tasks, resources and supports. The evolution and adaptation of the learning design used in the Mekong e-Sim has been described. Eight key challenges in the design and implementation of online roleplay-simulations have been identified. In this chapter we have tried to address a gap in the online role-based collaborative learning literature about the design of these activities, linkages between pedagogy and information and communication technology and how to exploit these linkages for effective learning.

Digital animations are complex to create and are usually made by experts for novices to download from Web sites or copy from DVDs and CDs to use as learning objects. A new teaching approach, "Slowmation" (abbreviated from "Slow Motion Animation"), simplifies the complex process of making animations so that learners can create their own comprehensive animations of science concepts. This chapter presents the learning design that underpins this new teaching approach to facilitate the responsibility for creating animations to be shifted from experts to learners. The learning design has four phases which guides instructors and learners in creating animations of science concepts: (1) planning; (2) analysis; (3)

This chapter introduces an approach to writing content for online learning over networked media. It argues that few resources currently utilise the fluid and multi-voiced capacity of the Internet's networked nodal structure to provide multiple pathways through content, opportunities for independent research and reflection or collaboration with peers in knowledge building. "Learning objects" are one way to conceptualise content ideas and learning activities within this flexible environment. To effectively use this resource requires something quite different to traditional sequential writing. A more appropriate approach is to use nonlinear software that can map the nodes of the knowledge domain and make visible the internal relationships, connections and paths of meaning. The purpose of this chapter is to provide the reader with a guide to developing a better understanding of how meaning is managed visually, and proposes tools and strategies for a new structure of writing for networked media.

Due to the increasingly diverse student population in multicultural nations such as Australia, the U.S., Canada, and the UK, educators are faced with the challenge of how to best meet the needs of students with limited English proficiency without "watering-down" the curriculum. The use of educational digital resources is one way of enhancing non-English Speaking Background (NESB) students' academic skills and understandings, but without explicit English as a Second Language (ESL) support integrated into these resources the benefits for NESB students are limited. This chapter documents a study of the content and format of a number of Learning Objects designed by The Le@arning Federation in an attempt to explore how specific learning objects can be modified to address the language needs of NESB students and unlock the value of their content. Design guidelines for ESL adaptation of digital learning content are provided based on current research and second language acquisition (SLA) principles.

The main idea behind learning objects is that they are to exist as digital resources separated from the learning task in which it is used. This allows a learning object to be reused with different learning tasks. However, not all learning objects operate in similar ways, neither are all learning tasks the same, and this exposes the problem that current recommendations from literature fail to link learning objects and their reuse in varied learning tasks. In this chapter, we explore definitions of learning objects and learning tasks. We also suggest that appropriate matches would lead to more effective pedagogical applications that can be used as set of recommendations for designers of learning objects and teachers who plan learning tasks and select learning objects for student learning activities. In addition, we discuss applications of learning objects delivered by emerging technologies which may change how digital resources are accessed and used by students in and out of classrooms.

The question addressed in this chapter is: What is the evidence for the effects of online programs of learning objects (henceforth LOs) on motivation and learning? Much of the research available on ICTS generally yields short-term or ambiguous findings, with recommendations that centre on the need for more attention to theorizing and documenting: • how ICTs can be located within sequences of curricular learning; • the kinds of learning that new ICTs offer (factual, conceptual, application, and transfer); and • the ways in which existing pedagogies and uses of ICTs both adapt to and transform one another. This chapter aims to advance discussion of these issues by summarizing ongoing evaluations of a large-scale national program of online LOs across key curriculum areas, drawing on survey and interview data and a field experiment in which the effects of exposure to LOs on learning outcomes in Mathematics are documented.

This chapter provides a model to analyse the effectiveness and efficiency of Learning Objects being used in primary and secondary schools by considering their place within that educational environment, paying particular attention to the manner in which they, like any resource, can aid or occlude productive interactions between teachers and students. It draws from a study of Australian and New Zealand schools that piloted the first release of Learning Objects from the Le@rning Federation. The chapter considers the place of Learning Objects within the overall systemic school environment, and in this environment, examines the individual classroom as the combination of tensions between the teacher's needs, the students' needs, and the potential available within the existing infrastructure. Within this framework, the chapter discusses the ways in which these three components interact during teacher selection of Learning Objects, students' accession of Learning Objects in the classroom, and the use of the Learning Objects by students. It concludes by suggesting how students' construction of knowledge can be enhanced through merging the capabilities of the resource with the needs of students and teachers.

Learning object review instrument (LORI) is an evaluation framework designed to support collaborative critique of multimedia learning resources. In this chapter, the interactions among reviewers using LORI are framed as a form of collaborative argumentation. Research on collaborative evaluation of learning resources has found that reviewers' quality ratings tend to converge as a result of their interactions. Also, novice instructional designers have reported that collaborative evaluation is valuable preparation for undertaking resource design projects. The authors reason that collaborative evaluation is effective as a professional development method to the degree that it sustains argumentation about the application of evidence-based design principles.

This chapter first argues that current approaches for sharing and retrieving learning objects or any other kinds of information are not efficient or scalable, essentially because almost all of these approaches are based on the manual or automatic indexation or merge of independently created formal or informal resources. It then shows that tightly interconnected collaboratively updated formal or semiformal large knowledge bases (semantic networks) can, should, and probably will, be used as a shared medium for the tasks of researching, publishing, teaching, learning, evaluating, or collaborating, and thus ease or complement traditional methods such as face-to-face teaching and document publishing. To test and support these claims the authors have implemented their ideas into a knowledge server named WebKB-2 and begun representing their research domain and several courses at their universities. The same underlying techniques could be applied to a semantic/learning grid or peer-to-peer network.

As the notion of learning objects has grown in popularity, so too has interest in how they should be stored to promote access and reusability. A key challenge to all repository projects is to understand the various motivations and needs to those wishing to contribute to and access the collection. To date there has been considerable attention given to technical issues of repositories, with much less consideration of how to attend to the needs of those who will use them. This chapter presents a needs analysis framework that was developed to guide the design of a new repository currently being created for the Australian higher education sector, The Carrick Exchange. The project to develop the framework is described, outlining the findings from analysis of literature and existing repositories, with input from a survey of potential users. The purpose of the framework was to distil key issues that should be considered in the design of the repository and we offer it here as an analytical tool that could be applied by others.

Health professional education is changing to meet the demands of a limited workforce and a focus on community-based clinical training. The change requires a focus on technology-supported learning in order to reach students and teachers who are separated by significant distances. The use of patient cases as reusable learning objects has received considerable attention in the sector and many support the use of such resources, but in order to do so the cases must be meaningfully integrated into the learning experience. This chapter reports the results of an analytical study that has developed eight generic case based learning designs categorised into three broad approaches supported by research evidence from the literature. These learning designs document common patterns in case based learning that could be adapted by teachers and designers to the specific requirements of different contexts. In closing, the authors consider how learning designs might be used as a vehicle for effectively integrating patient cases.

The shift in the way we visualise the nature of mathematics and mathematics learning has presented educational technologists with new challenges in the design of rich and powerful learning environments. Against this background, the design and use of learning objects in supporting meaningful mathematical learning assumes increased significance. I argue that learning objects need to be sufficiently pliable such that both teachers and learners could engage in knowledge construction that provides further avenues for growth and sophistication of mathematical schemas. In this chapter, the author aims to show the limitations of current views about mathematical learning objects and the need to reconceptualise these in terms of generic meta-schemas. A metaschematic framework would provide the mathematics community with powerful pedagogical tools to support and assess mathematics learning. Two examples of these meta-schemas for geometry are described.

This chapter provides an in depth discussion of the issues involved in integrating learning design and learning objects into generic Web sites. It has a dual focus and consists of two parts: the first part outlines and critiques the notion of the Net Generation and its implications for learning design, while the second part is based on a case study of a generic academic learning support Web site and allows for the testing of some of the theoretical assumptions about the Net Generation. Informed by empirical research, this chapter concludes by offering suggestions on ways to exploit convergent possibilities of integrating learning design and learning objects in a Web environment, while paying careful attention to divergent capabilities of students targeted in such an environment.

E-learning standards are a contentious topic amongst educators, designers and researchers engaged in the development of learning objects and learning designs. There is disagreement regarding the relative benefits and limitations of standards, while the relevance of standards to some education and training contexts has been questioned. It may be difficult for designers and educators to be sure that they need to implement standards, let alone to choose the most appropriate one from the plethora available. This chapter aims to provide individuals involved in the design and development of learning objects and learning designs with a wide-ranging critical overview of e-learning standards. It first traces the evolution of standards, and then examines their application in the present day. Finally, the chapter considers some of the limitations and criticisms of current standards, and suggests some possible directions for future development.

In developing modern instructional software, learning designs are used to formalize descriptions of roles, activities, constraints, and several other instructional design aspects and learning objects are used to implement those learning designs in instructional software. Central in both constructs is the use of design languages to support structuring a design task and conceiving solutions. Due to a lack of standardized design languages that are shared between designers, producers, and other stakeholders, the application of learning designs and learning objects is often unsatisfactory for three reasons: (a) different instructional and technical structures are often not meaningfully organized; (b) different levels of detail are mixed together; and (c) different expressions are used in a non-standardized manner. A decision model is introduced-the 3D-model-that supports better selection and application of design languages. Two studies show that the 3D-model contributes to a better information transition between instructional designers and software producers.

This chapter summarizes the work on instructional engineering and educational modeling accomplished since 1992 at the LICEF Research Center of Télé-université by the researchers of the CICE Research Chair. Recent results on learning design modeling and learning objects reusability processes are thoroughly presented using examples drawn from many projects conducted in the last 3 years. These are discussed to uncover the importance of a principled approach for the modeling of learning design and the reuse of learning objects in technology enhanced learning environments. Finally, delivery and dissemination issues are discussed and a summary of on-going and future directions for research is presented.

Foreword

It is a delight to see a high quality book integrating these two important topics. The work described here in learning design and in learning objects reflects a common goal: to leverage the expertise of our exemplary teachers beyond their own classes and institutions so that we can enhance learning outcomes and student success in a range of educational contexts. I am delighted to have the opportunity to set this volume in the context of larger issues in education and in other sectors of professional practice.

Let me first identify my personal stake in these matters. As a university administrator, I have been responsible for encouraging and supporting the adoption—or better, the adaptation—of innovations in learning and advances in technology to support teaching. I know first hand the time pressures experienced by our teachers and the need for new ways to foster communities of teaching practice which overcome the isolation of our classrooms. As a researcher in knowledge mobilization within corporate and public sector organizations, I have seen the benefits of systematic programs to share exemplary practices, and collaboratively develop and test advances in knowledge. How ironic it was to observe that so many of these knowledge mobilization efforts involved our faculty as catalysts and researchers, yet we lagged behind in taking advantage of these methods ourselves. Most importantly for me, as a teacher in higher education for over 30 years, I know how much I have yet to learn and also how much I have to share. (My apologies to my colleagues in other sectors of education and learning for focusing on the sector I know best. I have no doubt you will be able to translate my musings into your context to see how this book impacts your own work.)

In framing the focal issues explored in this book, I find it useful to contrast our context in higher education with that of other professional communities, especially in the high tech companies that have been partners in much of my research. They commonly distinguish amongst learning *for work*, learning *at work*, and learning *from work*. Learning *for work* takes place away from the job, and is the natural setting to establish a conceptual framework for understanding and advancing workplace knowledge. For teachers in higher education, there has traditionally been only superficial training in the conceptual underpinnings about how people learn and the implications for how we teach.

Most of us in higher education learned to teach *at work*, sometimes by mentoring from or interactions with colleagues, often by trial-and-error with our patient students. I contrast this with other contemporary knowledge workers, generating high value with their professional expertise, who benefit from significant investments in learning *at work* by just-in-time delivery of knowledge to their workplace at the point of need. More recently, online communities of practice have been instituted within corporate and public sector organizations to mobilize the best talent for the benefit of all community members. Again, higher education has often studied and validated these advances in knowledge mobilization, but failed to instantiate them ourselves.

Finally, learning *from work* involves reflective practice: a disciplined approach to asking what worked, what did not, why we got these results, and what we can learn from our experience to improve our future actions. This is common practice at the conclusion of projects in the high tech companies with whom I have worked, and it seems natural to regard teaching a module (or "course" in North America) as similar to a project in providing a natural unit of reflection. I think most teachers in higher education would like to do more of this, but like me will have found that these good intentions fall prey to other time pressures at the end of a term.

Of course, the domain of teaching in higher education is different from that of other professions, and we must develop our own methods for learning in these diverse ways, for mobilizing expertise and collaborative knowledge-building. That is why this book, and the growing body of knowledge and practice on which it reports, is so important at this time. We are at last starting to see the emergence of distinctive methods for higher education to systematically advance teaching and learning by mobilizing the wisdom of our exemplary practitioners and the knowledge uncovered by scholarly researchers.

Learning objects provide concrete illustrations of exemplary teaching practice which can be exchanged, re-used, evaluated and adapted—learning *at work*. New infrastructures are now being developed for learning objects to provide reflective spaces in which collaborative learning *from work* can take place. We are moving from thinking about repositories supported by communities to communities supported by repositories. Recent studies are exploring how we can link learning objects to research digests and other tools providing new pathways to learning *for work* in practical and focused ways.

The situation is similar for innovations reported here which are advancing learning design representations as a pathway for knowledge mobilization and collaborative knowledge-building. While some of the early work in the learning design field was focused on the possibility of automating the design or delivery of online instruction, the focus now is much more on the community knowledge aspects and social infrastructure for which learning design can become a catalyst.

Of course, pathways to advance learning resources and to mobilize teaching expertise will only be effective in the context of a larger motivating vision for enabling change in educational practice. Such a vision will be a shared image of the future education we want and are working toward, an affirmation of educational purpose that resonates with our sense of identity and values, a calling for educators that energizes a commitment of our gifts, our resources, and our time.

You will not find such a comprehensive educational vision articulated in this book—that is not its purpose, and the editors have done a fine job of keeping the authors focused on a few common themes explored in depth. But I am confident that you will feel the energy and commitment that underlies the work reported by these innovators, and that you will sense how these new pathways will support your own vision of educational opportunities and success for all our learners.

Professor Tom Carey
University of Waterloo, Canada

Preface

Designing high quality, technology-supported learning experiences is a significant challenge for educators. While there is a wide range of expert advice available, translating theories and good practice principles into learning settings can be a daunting task. The concepts of "learning designs" and "learning objects," on their own and through their integration, have emerged as potential strategies to help educators address this challenge.

Although educators have always shared ideas and resources, the formalisation of these activities using learning designs and learning objects is new. The idea of describing and presenting teaching and learning environments in a systematic way, and then potentially reusing them is now the focus of a broad international research agenda.

The editors of this handbook, through a call to experts, have assembled a collection of work from key research centres and influential individuals worldwide to showcase the latest research emerging to supporting high quality teaching and learning.

The handbook has been divided into three sections. Section I addresses the evolving concept of learning design, Section II presents current research on learning objects, and Section III examines the integration of learning designs and learning objects.

SECTION I LEARNING DESIGN

Learning design is a relatively new field in which research has predominantly occurred only in the last decade. Its "language of discourse" is evolving, with various conceptualisations being developed. The following 18 chapters present an international perspective on the latest research in learning design.

Explanation of Chapters and their Order

The first two chapters set the scene by introducing the concept of learning design and explaining the key issues that dominate the current discourse. In *Learning Design Representations to Document, Model, and Share Teaching Practice,* Agostinho presents a synthesis of the learning design literature by firstly exploring the definition of the term "learning design" and then explaining six learning design representations. The chapter compares and contrasts these learning design representations and proposes a pathway for future research. Falconer and Littlejohn, in *Representing Models of Practice,* further the discussion by examining ways in which learning designs can be used to share and also change teaching practice. The chapter discusses the findings from a UK research project that explored how practice models (generic learning designs) can be represented and used by teachers to improve their practice. Falconer and Littejohn conclude that while practice models may be useful to represent teaching practice, contextualised learning designs coupled with community building activities may be more effective in changing teaching practice.

The next three chapters provide a detailed analysis of two learning design representations—IMS LD and patterns. In *Using the IMS LD Standard to Describe Learning Designs*, Koper and Maio present a comprehensive explanation of IMS LD, perhaps one of the most detailed discussions written to date. The chapter summarises the research conducted in developing the IMS LD specification to explain the underlying principles of IMS LD, its main concepts, what it can offer, and how it can be used. Griffiths and Liber, in *Opportunities, Achievements, and Prospects for Use of IMS LD*, extend this discussion by presenting an analysis of the current uses of IMS LD, and explaining the opportunities and achievements generated for four derived modes of use. Griffiths and Liber explain the research work conducted for each mode of use and conclude by proposing a research direction for the future. In *A Critical Perspective on Design Patterns for E-Learning*, Garzotto and Retalis provide an extensive examination of patterns and how they could be used in field of e-learning. The chapter presents an historical discussion about the origins of patterns, an explanation of how they have been used in multiple disciplines, and a summary of the research and development projects conducted about patterns in e-learning. Garzotto and Retalis conclude that a systematic classification system is needed and present a taxonomy of e-learning design patterns. The chapter discusses the potential benefits and limitations of patterns and proposes a future research pathway.

The following set of six chapters focuses on the concept of learning design as a support tool to facilitate reuse and examines its potential to change and improve teaching practice. The first two chapters focus on how design patterns can be used as a support tool in the educational design process. The next two chapters explore learning design more broadly by explaining research work conducted towards the development of pedagogic planning tools. The final two chapters in this set take a different tack by discussing how learning designs can be categorised and how categorisation could facilitate reuse and help teachers to reflect on their teaching practice.

In *Design Patterns to Support E-Learning Design*, Frizell and Hübscher report on their research in developing design patterns to support novices in effective e-learning design. The chapter reviews the research on design patterns in education and other disciplines, and proposes a future research direction that focuses on three areas: the standardisation of the design pattern representation, the integration of design patterns with other research efforts in learning designs, and the development of software tools to facilitate the creation and use of design patterns.

In *Patterns and Pattern Languages in Educational Design*, Goodyear and Yang explain their work on the development and evaluation of educational design patterns and pattern languages for networked learning. Their research is considered within the wider context of educational design as the authors discuss the ramifications of adopting a patterns-based approach in supporting educational design. In *The Role of Mediating Artefacts in Learning Design*, Conole explains how learning activities can be described and documented using different forms of representations and how these “mediating artefacts” can inform the process of designing a new learning activity. Conole reports on the research and development of a tool that utilises mediating artefacts to support the learning design process. Masterman, in *Activity Theory and the Design of Pedagogic Planning Tools*, explores the potential for the use of pedagogic planning tools more broadly by proposing a framework for analysing the planning process, that is, “design for learning,” to inform how pedagogic planning tools can be effectively deployed to support the learning design process.

Harper and Oliver, in *Developing a Taxonomy for Learning Designs*, present a categorisation framework for learning designs developed from a project that surveyed over fifty learning designs implemented in higher education that utilise information and communication technologies. The framework is proposed as a mechanism to help academics access high quality learning designs to encourage reuse. In *Using Expert Reviews to Enhance Learning Designs*, McNaught, Lam, and Cheng report on how an evaluation study used the framework presented by Harper and Oliver to provide expert reviews on e-learning strategies at The Chinese University of Hong Kong. The findings of the evaluation are reported and the authors conclude that the evaluation instrument serves as a reflection tool that can help teachers better understand the teaching and learning potential of their implemented learning designs.

The next two chapters report on the application of learning designs in educational contexts. *Investigating Prospective Teachers as Learning Design Authors*, by Kearney, Prescott, and Young reports on a research project that explored how learning designs could be used to help prospective school teachers develop online learning tasks. The preservice teachers adapted generic learning designs to inform the development of their own contextualised learning designs. The study acknowledges that the use of generic learning designs and a learning design authoring tool can serve as effective support tools to help teachers design effective learning activities. In *Using IMS Learning Design in Educational Situations*, Hazlewood, Oddie, and Barrett-Baxendale explain how IMS LD has been used in a number of projects at Liverpool Hope University. The chapter reports the experiences of teaching practitioners in using IMS LD and is one of the few research studies that report learners' perceptions when experiencing IMS LD units of learning (UoL).

The next three chapters focus on the development of specific learning designs and their representation as generic learning designs. McLaughlan and Kirkpatrick, in *Online Role-Based Learning Designs for Teaching Complex Decision-Making,* explain how an online role-play learning design has been created to develop students' decision-making skills. The chapter explains the rationale for the learning design, describes in detail what the learning design entails in terms of tasks, content resources, and teacher supports, and reports on how it has been used. In *Facilitating Learner-Generated Animations with Slowmation,* Hoban describes the development of a learning design that incorporates slow motion animation to facilitate a deep understanding of science concepts. The rationale for this teaching approach is explained and the learning design is described in a similar way to that presented by McLaughlan and Kirkpatrick. That is, the "slowmation" learning design is described in terms of the tasks students perform, the content resources provided and how students are supported in the learning environment. Examples of how this learning design has been used are provided and a visual representation illustrates the generic learning design. In *Representation of Coordination Mechanisms in IMS Learning Design to Support Group-Based Learning*, Miao, Burgos, Griffiths, and Koper explain how IMS LD can be used to implement group based learning strategies. The chapter details a particular group-based learning strategy and illustrates how it can be represented generically in IMS LD.

The next chapter explores implementation issues when using IMS LD. Strobel, Lowerison, Abrami, Bethel, and Cote, in *Modelling Learning Units by Capturing Context with IMS-LD*, report on a research project that explored the process of representing and modelling learning activities in IMS LD. Five generic learning activities were modelled in IMS LD using the IMS LD editor MOT Plus.™ The chapter discusses the design decisions made when translating these learning activities into IMS LD and concludes by proposing a four-layer model to ensure the quality of the modelling process.

The final chapter in this section presents a potential strategy for fostering future collaboration to establish an international learning design community. Burgos, Hummel, Tattersall, Brouns, and Koper, in *Design Guidelines for Collaboration and Participation with Examples from the LN4LD (Learning Network for Learning Design),* present the lessons learned from the collaboration model implemented in an online community formed to investigate the potential of IMS LD.

SECTION II LEARNING OBJECTS

This section of the handbook brings together diverse perspectives on the design of learning objects and the outcomes of their use. Understanding of learning object design has progressed through our increasing and collective experiences with the process. The following 13 chapters report on the latest research in learning object design and implementation.

Explanation of Chapters and their Order

In *The Design of Learning Objects for Pedagogical Impact*, Boyle draws together the range of experiences of *The Centre for Excellence in Teaching and Learning in Reusable Learning Objects* to put forward a set of design principles, and considers the reusability of the learning objects and the designs, or pedagogical patterns, underpinning the learning objects.

In *Visual Meaning Management for Networked Learning*, Turner begins with the premise that university teachers experienced in developing print-based learning materials may not necessarily be able to easily make the conceptual shift needed when designing learning objects for a networked multimedia environment. Based on an analysis of the debate about visual meaning making, this chapter presents strategies and tools for learning object development.

Gitsaki considers design issues for learning objects in terms of students from non-English speaking backgrounds in *Modification of Learning Objects for NESB Students*. This chapter presents a linguistic analysis of learning objects designed for the K-12 environment. The analysis provides a basis on which recommendations are presented for modifications to cater for NESB learners.

Churchill and Hedberg, in *Learning Objects, Learning Tasks and Handhelds*, argue for the importance of the learning task when considering the design and use of learning objects. They provide suggestions for use of different types of learning objects. Also, given the growing interest in m-learning, they review the research and implications for learning objects and learning tasks for delivery through handheld devices.

A number of chapters focus on the evaluation of large scale learning object projects around the world such as *The Le@rning Federation* (TLF) K-12 curriculum content initiative in Australia and New Zealand and the *CELEBRATE* project in Europe.

The two chapters that report on evaluations in the Australian context both utilised a range of sources to understand both the actual use of and perspectives about learning objects by teachers and students. Freebody, Muspratt and McRae, in T*echnology, Curriculum, and Pedagogy in the Evaluation of an Online Content Program in Australia*, shed light on how learning objects are being used in various discipline areas, particularly in mathematics. This chapter contributes to the debate about the extent to which the 'learning' should be in the learning object. Lake, Lowe, Phillips, Cummings, and Schibeci, in *Effective use of Learning Objects in Class Environments*, analyse their evaluation findings through use of an educational environment model. The outcomes of the evaluation considered within this framework provide key evidence-based principles for design and implementation of learning objects.

In *A European Evaluation of the Promises of LOs*, McCormick, Jaakkola, and Nurmi present the outcomes of an evaluation of the *CELEBRATE* project in terms of production, distribution, and reusability. This chapter provides critical insights to the way learning objects are used, particularly with respect to different teaching approaches, and helps to address the question of what supports teachers and students may need to make best use of learning objects. In *Instructional Effectiveness of Learning Objects*, Jaakkola and Nurmi draw on the *CELEBRATE* project to present findings of an empirical study that compared the learning outcomes achieved through the use of drill-and-practice and simulation-type learning objects to more traditional teaching methods. The authors' use their findings to argue that learning object based teaching should not be seen as a rival to more traditional approaches, but should instead be viewed as complementary.

Two chapters in this section examine approaches to evaluation with learning objects. In *Evaluating Large-Scale European LO Production, Distribution, and Use*, McCormick identifies the possibilities and limitations of evaluation identified through experience within the *CELEBRATE* project. Nesbit and Leacock, in *Collaborative Argumentation in Learning Resource Evaluation*, describe a collaborative approach to the evaluation of learning objects whereby multiple reviewers individually evaluate a learning object according to a common set of criteria, and then collectively negotiate to arrive at a final review. The authors propose a range of applications for this process to assist design and selection of learning objects.

Beyond design, use, and reusability is the issue of accessibility. The final three chapters in this section focus on accessibility and learning object repositories. In *For the Ultimate Accessibility and Re-Usability*, Martin and Eboueya challenge the current approaches to sharing and retrieving both learning objects and information objects in terms of limitations of scalability. The idea of a global, collaboratively updated system is suggested in order to overcome the identified problems. Bennett, Parrish, Lefoe, O'Reilly, Keppell, and Philip, in *A Needs Analysis Framework for the Design of Digital Repositories in Higher Education*, detail the considerations that underpin the design of a repository that is intended to house an archive of educational resources in addition to supporting a community of participants through networking facilities. Additionally, they detail their analysis framework and offer it as a tool for others engaged in repository design projects. In *Costs and Sustainability of Learning Object Repositories*, Bramble and Pachman analyse the range of funding models used by currently available repositories and suggest possible ways forward. In doing so they contribute an economic perspective often missing from the body of learning object literature that emphasises the technical and pedagogical.

SECTION III INTEGRATION

This section presents current research investigating the integration of learning objects and learning designs. Much of the work reported illustrates the use and impact of learning objects in support of learning designs implemented in educational settings.

Explanation of Chapters and their Order

This section opens with two chapters that present case studies of the integration of learning objects and learning designs. These chapters demonstrate how these concepts can be used in concert to examine and analyse key aspects of the teaching and learning process. *A Learning Design to Teach Scientific Inquiry* (Elliott, Sweeney, and Irving) describes a learning design informed by problem-based and inquiry learning developed for medical education into which learning objects are integrated for customisation on a particular topic. The authors explore the prospect of learning object reusability by comparing the cost of reusing an existing learning object and the estimated cost of preparing it from scratch. In *Adapting Problem Based Learning to an Online Learning Environment*, Lobry de Bruyn describes the integration of learning objects into a problem based learning design created to cater for the needs of on- and off-campus learners. The author explores two variations of the learning design, each presented as a case study conducted over a 3-year period, and compares the patterns of communication undertaken by students.

Learning Objects and Generative Learning for Higher Order Thinking (Chuen, Aris and Abu) offer a different perspective in describing the design and evaluation of a Web-based learning environment that allows learners to select and organise learning objects from a library of resources. Based on the principles of generative learning, this design allows learners to choose the learning objects they consider relevant for a task and then to structure, and restructure, the items as they wish.

The next two chapters describe initiatives in which learning objects and learning designs (in the form of lesson plans or templates) have been collected into repositories for particular groups of educators. Both highlight the challenges in creating a repository that meets the needs of users, and ponder means of supporting effective integration of learning objects into effective learning experiences. In his chapter, *Applying Learning Object Libraries in K12 Settings*, Foti examines a series of projects begun more than 20 years ago that have collected and organised thousands of resources into databases for school education. Foti describes the process of categorisation and the dilemmas raised by this process. He goes on to consider the role of the teacher as organiser and designer and the challenges of integrating learning objects into meaningful learning experiences. Curda and Kelly, in *Guidelines for Developing Learning Object Repositories*, describe the development of a learning object repository to meet the needs of faculty in a university department. In the repository the designers have included templates that capture particular learning designs that can be combined with learning objects, an illustration of one approach to supporting teaching staff.

Next follow four chapters that offer more general discussion of learning objects and learning designs, and their integration. In *Reusability of Online Role Play as a Learning Objects or Learning Designs*, Wills and McDougall pose questions about the nature of learning objects and learning designs, and the extent to which either are reusable. The authors discuss how role-plays can be reused as learning objects, drawing on examples tracked over a period of more than 10 years. The discussion highlights some of the difficulty in clarifying the differences between learning objects and learning designs. Lockyer, Kosta, and Bennett, in *An Analysis of Learning Designs that Integrate Patient Cases in Health Professions Education*, present the outcomes of an analysis of case based learning in health professions education, identifying three broad approaches and eight generic learning designs into which variations can be categorised. Each learning design illustrates the integration of patient cases as learning objects. The authors argue that generic learning designs could function as a design support for educators enabling them to effectively integrate learning objects and plan their teaching. In *Reconceptualisation of Learning Objects as Metaschemas*, Chinnappan argues that the current view of learning objects in mathematical education is limited and offers an alternative conceptualisation that introduces the idea of "embedded learning objects" which would serve as overarching schema to organise multiple learning objects. This proposal is consistent with the notion of using a learning design that describes the overall pattern of a learning activity as a means to structure the integration of learning objects. In *Designing Learning Objects for Generic Web Sites*, Huijser considers what the notion of the "Net generation" might mean for the pedagogical foundations of learning design, and further explores the issue through a case study of an academic learning support site for students. The results are used to examine some of the assumptions made about learners and the implications of those for learning objects and their integration into learning designs.

The final three chapters consider standards and specifications for learning objects and learning designs and the roles these might play in supporting design and development. In *Standards for Learning Objects and Learning Designs*, Munro and Kenny trace the history of learning object and learning design standards and specifications, and examine how they have been applied in particular cases. The authors then provide a critique of current standards, offering advice on the selection of standards for a particular application and suggestions for further development. *Design Languages for Learning Designs* *and Learning Objects* (Boot, Botturi, Gibbons and Stubbs) describes a decision model intended to support the selection and application of design languages for formalising learning designs and labelling learning objects. The aim of the model is to improve communication between instructional designers and other stakeholders in the design and development process by enabling designs to be documented using a formalised description. Two validation studies are used in support of the authors' arguments for standardisation. *Principled Construction and Reuse of Learning Designs* (Paquette, Mariño, Lundgren-Cayrol, and Léonard) draws on 15 years of instructional engineering work to frame an argument for a principled approach to learning design modelling and learning object reusability. The authors outline the guiding design principles that underpin the approach, explain the role of learning design standards, and describe how learning objects can be integrated to create "reusability-centred designs." This chapter highlights the need to support complexity in the design process, while also achieving interoperability through the use of standards.

THE FUTURE

Worldwide interest in supporting learning has excited the re-examination of the design of learning settings. This renewed interest has been the catalyst for the learning object and learning design research movement. This handbook could be considered as one step in the building of a collaborative research agenda around learning design. We hope this handbook will serve as a catalyst to spark the motivation for further studies and the formation of an international alliance so that the learning design field can continue to move forward.

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Section I
Learning Design

"Learning design" is the term coined to a movement for more consistent approaches in describing and documenting teaching practice to facilitate communication and sharing, but also importantly to facilitate the improvement of teaching practice. Ironically, there is currently no standard definition for learning design. Because it is a relatively new field of endeavour, the concept is evolving and thus there is no consensus of what constitutes a learning design, nor standard or consistent ways of representing learning designs. There are, however, different perspectives about learning design and several emerging learning design representations. Learning design can be considered as both a process of designing learning experiences and a product, that is, the artefact of the design process. A substantial investment in research and development has been undertaken to explore these perspectives with notable initiatives including the development of the IMS Learning Design specification and the commitment by the UK Joint Information Systems Committee (JISC) in their Design for Learning funded program. This section of the Handbook presents the latest research that explores how learning designs can be represented and how learning design as both a process and product can be used to support teaching practitioners. Whilst this latest research demonstrates promising progress, researchers conclude that more empirical studies are needed to validate the potential of learning design and call for more international collaboration to further the field.

Chapter I
Learning Design Representations to Document, Model, and Share Teaching Practice

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ABSTRACT

The term "learning design" is gaining momentum in the e-learning literature as a concept for supporting academics to model and share teaching practice. Its definition and composition is evolving, and as such, there is currently no standard mode of representation for learning designs in education. Instead, there are several emerging learning design representations with different perspectives about their purpose. This chapter explores these issues and presents a summary of the current discourse about learning designs. The aim of this chapter is to address a gap in the literature by comparing and contrasting six learning design representations. The chapter discusses the research conducted to date about learning design representations and concludes by proposing a pathway for further research.

INTRODUCTION

In the higher education sector today, more so than ever before, academics are presented with many choices in how they can design and deliver their courses. As the use of information and communication technology (ICT) in teaching becomes mainstream, academics are faced with the challenge of making decisions on how best to integrate such technology within their teaching practice. In an environment where there is an increasing number of Internet tools available (e.g., blogs and wikis) and online educational resources to choose from (e.g., learning objects), this is a difficult task. Coupled with the constant focus in the sector on improving the quality of teaching and learning (e.g., Transcript, 2004) decisions on how to effectively integrate ICT to design pedagogically sound learning experiences can be quite overwhelming.

To add a further layer of complexity, the concept of a "university course" has broadened from a conventional model of synchronous teaching and learning activities (e.g., lectures and tutorials) to "unexplored dimensions" that include Internet based activities and the overall use of digital media to present, interact, and communicate in both synchronous and asynchronous modes (Botturi, 2006). Botturi has argued that the design of such courses to effectively integrate technologies is too complex for one person and requires the expertise of a teaching team. Unfortunately, unlike externally funded educational multimedia development projects where a team (composed of subject matter experts, instructional designers, programmers, and graphics artists led by a project manager) works together to craft a multimedia educational solution, the university teaching context is more individually focused where teachers are mostly required to fend for themselves in the design of their courses.

Thus, teachers need guidance and advice provided in an efficient and effective form to support them to create innovative pedagogy. But what form should this guidance take in order for it to be efficient and effective? There is a substantial body of literature that explains how contemporary learning theories can be implemented effectively in practice with the use of technology. The predominant form for this guidance is the text-based scholarly representation presented in journals, conference publications, and books where, through a range of descriptive and analytical case studies, lessons learned are documented and pedagogical design principles are distilled. The argument is mounting that this way of representing and disseminating guidance is difficult for practitioners to easily access and thus needs improvement (Goodyear, 2005; Oliver, 2006; Oliver & Littlejohn, 2006; Sharpe, Beetham, & Ravenscroft, 2004). Particularly in the area of e-learning, this issue needs to be addressed: "In the field of e-learning where there is pressure for rapid changes in response to emerging research, there is discussion on how we develop a more suitable and sophisticated discourse that is shared by researchers and practitioners, and which supports and promotes educational change" (Sharpe et al., 2004, p. 16). Oliver and Littlejohn (2006) have argued that the way practitioners currently document their practice is limited and there is a lack of examples in a form that practitioners can apply in their own teaching context. Botturi (2006, p. 267) concurred with respect to limited documentation and suggested that improvement in documentation is required:

After a course has been developed, usually the only documentation is the actual learning materials. This raises some issues in the case where a redesign or adaptation process is required for reuse, especially where the original designer is not available. Is it possible to produce a documentation that can guide the reuse and adaptation of the instruction?

Oliver and Littlejohn (2006) have called for more *appropriate guidance* on effective pedagogical practice provided in an *appropriate form* that teachers can easily apply, adopt, adapt, and reuse. Laurillard (2002, p. 1) suggested a similar idea: "There would be great value in a programme of work to identify effective learning activity models, and build standardized descriptions of the forms they take." Goodyear (2005, p. 82) too has agreed with these ideas but has argued that appropriate guidance is one that informs, not prescribes: "There is a substantial unmet demand for usable forms of guidance. In general, the demand from academic staff is for help with design—for customizable, reusable ideas, not fixed, pre-packaged solutions." Oliver (2006) has suggested that there is a need for a "language" that can be applied and consistently understood by practitioners (teachers), researchers (who propose effective pedagogical strategies), and developers (technical and infrastructure support people). Waters and Gibbons (2004) have presented the same argument by calling for a common language that will allow better communication of ideas and in turn could serve as a stimulus to improve the quality of teaching and learning. They suggest that a notation system, similar to that found in other disciplines such as music and dance, is needed for educational design.

Thus, a movement is growing for a more consistent or common way of documenting and describing teaching practice, which could serve as guidance for teachers to better communicate their ideas with each other and also compare and contrast ideas. There is currently, however, no consistent form used by practitioners to describe and represent their teaching ideas. But, the emergence of the "learning design" concept holds promise as one possible solution towards the quest for a common language that in turn could serve as an appropriate form of guidance for teachers. A learning design represents and documents teaching and learning practice using some notational form so that it can serve as a description, model, or template that can be adaptable or reused by a teacher to suit his/her context (Agostinho, 2006).

The concept of a "learning design" is relatively new with literature and projects emerging over the last 10 years. Whilst this idea is gaining momentum, the state of research in this area can be considered in the emergence stage (Conole, Oliver, Falconer, Littlejohn, & Harvey, 2007) as a community of researchers is beginning to develop but the field is still at the point of discussion with little research to support the optimism that it can indeed be effective. At this point, there is no consensus over the definition of a learning design or what constitutes a learning design, and thus no standard or consistent way of representing learning designs. As stated in a recent research study conducted by Falconer and Littlejohn (2006): "Despite significant enthusiasm…towards developing a language for describing learning designs that will enable sharing and reuse, researchers have yet to find ways to describe practice models so that practitioners in mainstream education can understand and apply them" (p. 1). Instead, there are several emerging learning design representations. These representations define a "learning design" in their own way using different forms of documentation; thus the representations serve different purposes. From the literature, six learning design representations have surfaced to dominate the current research work conducted. These six are:

- E^2ML
- IMS LD
- Learning Activity Management System (LAMS)
- Learning Design Visual Sequence (LDVS)
- LDLite
- Patterns

Whilst the body of literature is growing about each of these learning design representations, there is little if any literature that discusses all these representations in one publication. Thus, the purpose of this chapter is to address this gap by examining these six representations and presenting a summary of their key features to illustrate their purpose and point out similarities and differences. The structure of the remainder of this chapter is as follows: first, the various definitions of learning designs are discussed; second, a description of each of the six learning design representations is provided; third, a summary and comparison tables are presented; and finally, the chapter concludes with a discussion of current research and a proposed pathway for future research.

DEFINITIONS AND TERMS

As is characteristic in any new area of research, definitions assigned to terms and the terms themselves can vary. A range of words has surfaced in the literature relating to learning designs, and thus it is important that these terms and definitions be made explicit as well as discuss how the terms relate to each other. The term "learning design" can be considered in two ways: (1) as a *process* of designing learning experiences and (2) as a *product*, that is, the outcome or artifact of the design process. The Joint Information Systems Committee (JISC)-funded learning design projects make this distinction explicit by using the terms "design for learning"/"designing for learning" to refer to the process: "designing, planning and orchestrating learning activities as part of a learning session or programme" and using the term "learning design" (lower case) to refer to the product: "learning designs or patterns are the outcomes of the design process" (Background to the JISC Circular, 2006). However, in some JISC-funded reports, this distinction is not clear cut, as the term "learning design" is used interchangeably with "design for learning" to refer to the design process, and this creates some confusion (e.g., Designing for learning, n.d., p. 8; Masterman, 2006, p. 1). In Beetham's (2004) JISC report, the distinction between process and product is made by using the title case "Learning Design" to refer to the process and the lower case "learning design" to refer to the product, which is the evidence of the process: "Learning Design could more formally be defined, then, as the planning, structuring and sequencing of learning activities, and a 'learning design' as the plan, structure or sequence that resulted" (Beetham, 2004, p. 5). This creates further confusion as the difference between title case "Learning Design" and lower case "learning design" is being used to distinguish between the general concept of learning design and one specific learning design representation—IMS LD (e.g., Britain, 2004).

The product perspective of learning designs, that is, the documented representation of the outcome of the design process is the focus of this chapter. Within the "designing for learning" literature, the term "mediating artifacts" surfaces. This refers to the range of tools and resources practitioners use to help them when creating learning activities (Conole et al., 2007). These artifacts can be both diagrammatic or textual in form and can range from "contextually rich illustrative examples of good practice…to more abstract forms of representation that distil out the 'essences' of good practice" (Conole et al., 2007, p. 115). Examples of mediating artifacts are case study narratives, lesson plans, guidelines, patterns, models, and templates. A learning design (as a product) can also be considered as a mediating artifact. Mediating artifacts provide different aspects of support. Some intentionally provide guidance of good practice (e.g., model), whilst others serve more as illustrative examples which may or may not represent "good practice." A learning design can do either, but its overall intention is to document and describe a teaching and learning experience in some common way to enable teachers to understand it and be able to reuse in their teaching context in some way. As Oliver (2006, p. 1) has stated:

The term learning design is commonly used today to describe the representation(s) of a learning process and its outcomes in ways that might enable it to be replicated and reused. Learning designs are very much like lesson plans, involving descriptions of learner activities, the resources being used and the supports provided by the teacher.

A learning design can document various degrees of granularity, ranging from a course (or even multiple courses) down to an individual activity (Falconer & Littlejohn, 2006). A learning design can be highly contextualized or more abstract. Abstract learning designs can be referred to as *patterns*, *generic learning designs*, or *practice* *models.* Practice models, as explained by Falconer and Littlejohn (2006, p. 2), are:

generic approaches to the structuring and orchestration of learning activities. They express elements of pedagogic principle and allow practitioners to make informed choices. To be effective and sustainable practice models should be grounded in authentic practice and represented in ways that are meaningful to practitioners. In this sense practice models need to be both representations of effective practice…and effective representations of practice.

The development of "effective representations of practice" is currently a work in progress as there are several representations of practice (or learning design representations) that are being experimented with. The following section discusses six learning design representations.

LEARNING DESIGN REPRESENTATIONS

From the literature, six learning design representations have emerged as holding promise to be effective representations of practice. The six learning design representations were chosen because they have developed a standard way of describing and documenting a learning design. A description plus research conducted about each representation is provided below. A set of comparison tables is provided at the end of this section as a summary.

E^2ML

E^2ML stands for Educational Environment Modeling Language and it is a representation language for documenting the outcome of an instructional design process. It is used to document an educational environment, for example, either an entire course or subject or one or more activities in a course, using both visual and textual elements. It was developed as a documentation tool for instructional designers to enhance communication within large projects and is currently being used in large collaborative projects in Swiss universities (Botturi, 2006). E^2ML represents a learning design as a structured set of activities referred to as either learning or support actions aimed towards achieving a set of defined learning outcomes. Learning actions refer to activities designed for the learner such as lectures, discussions, and exercises, whereas support actions relate to the teacher's role in the instruction such as preparing materials and providing feedback on assignments (Botturi, 2006). Its purpose is to document in a visual way the object being designed, and in doing so, the assumption is that "being able to see the object being designed may improve the design itself by enabling communication and stimulating reflection" (Botturi, 2006, p. 268).

There are three types of documents that make up the complete E^2ML documentation set. They are:

1. Goal Definition. This document outlines clearly the educational goals or intended learning outcomes of the designed educational environment. It is comprised of two documents. First, a text-based goal statement document lists the learning outcomes in a table in order of importance and lists the type of instructional approach to be implemented to address the outcome. Second, a visual-based goal-mapping document presents the learning objectives in a visual graph-type diagram according to some learning outcomes taxonomy (for example, refer to Botturi, 2005, p. 341).
2. Action Diagram. This document set provides a description of all the activities designed for the instruction. Activities are considered actions. Every single activity, for example, a classroom tutorial session, is documented. Similar to a lesson plan, for each activity a

range of details is listed in a table format. Details include prerequisites, resources provided to students, expected learning outcomes, the artifacts students will produce, how each activity is to be performed such as the procedure and the location, and how the action/activity relates to the overall goal statement, that is, reference to particular goals.

3. Overview Diagram. This documentation set provides the "big picture" of the instruction intervention. This is presented in the form of two diagrams: the dependencies diagram that illustrates how the activities are related to each other, for example, whether one activity requires the completion of other sub-activities, and the activity flow diagram which is similar to a flow chart illustrating the order of activities in chronological order.

The overview diagrams do not explicitly illustrate the overall pedagogical approach used in the instruction. Instead these diagrams are more focused on how the various actions relate to each other, that is, how tutorials, lectures, online discussions, exams, and so forth, are linked to each other. For example, Lecture 2 depends on the outcome of Discussion 2, and so forth. Thus, it is difficult to determine visually the overall pedagogical approach of a course when documented in E^2ML. Botturi (2006, p. 285) alerted educators of this but explained that it is not the purpose of E^2ML: "Some may notice that there is no single place in E^2ML where the instructional strategy is overtly defined. E^2ML does not aim at that, yet it is flexible enough to represent a great variety of different strategies." Also, there is much detail at the action/activity level; thus an entire course documented using E^2ML would comprise a substantial set of documentation. Botturi (2006, p. 284) qualified this by explaining that E^2ML can be used "partially, without exploiting all its features, or using them for only some activities." As a learning design representation, its focus is therefore to document the mechanics of the instruction to aid communication and understanding *within* the project or teaching team so that the team members understand the design to be able to adapt and reuse the instruction.

Findings from a research study conducted about its perceived usefulness suggest that it is a useful tool to blueprint a course; although its complexity may impede its use by instructors (Botturi, 2005). Work is being conducted to integrate E^2ML with Patterns and IMS LD. Botturi and Belfer (2003) have explained how E^2ML's overview diagram (which also can be accompanied with action diagrams) can be incorporated within the solution section of a pattern (see Table 1, Botturi & Belfer, 2003, p. 882). They have argued that E^2ML's visual feature "may actually provide an important added value in making the pattern language easier to understand" (Botturi & Belfer, 2003, p. 881). There is also possibility of saving the pattern in an IMS LD compliant format in the extensible markup language (XML) form (Botturi & Belfer, 2003). The latest iteration of E^2ML—Advanced Version—complies with IMS LD, and the idea is that E^2ML could be used as a visual interface that designers and educators interact with to produce the IMS LD XML "unit of learning" (Botturi, 2006).

IMS LD

IMS Learning Design (2003) documents a learning design in a computer readable format (an XML file) so that it can be played in an IMS LD "player" to the end user in a similar way that HTML code can be played by an Internet browser application. IMS LD represents a learning design, referred to as a "unit of learning," as a sequence of activities described in the form of acts in a play. It describes the tasks learners are required to complete and the content resources to be made available and specifies in detail the roles that students and teachers assume for each activity. IMS LD is a formal computer language that both documents the final contextualized learning design and executes the learning design (that is, instruction) to the student. The purpose of this learning design representation is to promote technical interoperability. The aim is that IMS LD becomes the standard to enable online courses to be shared and reused easily. An example application of IMS LD would be that learning management systems could comply with this standard to enable an online course implemented in one learning management system (e.g., WebCT Vista) to be exported in IMS LD compliant format to be then imported into another learning management system (e.g., Janison Toolbox) and run without requiring major modification. Thus, in terms of reuse, the aim of IMS LD is to produce technically interoperable "units of instruction."

A significant amount of work exploring the potential of IMS LD has been conducted by The UNFOLD Project (Burgos & Griffiths, 2005). Because of its technical complexity, however, there is currently limited success with practitioners embracing this learning design approach because to produce an IMS LD unit of learning requires technical expertise and is time consuming (McAndrew & Goodyear, 2007). Practitioners need support to use IMS LD and avenues explored are the use of templates (similar to the idea proposed by using E^2ML) or patterns that can serve as a front-end interface with IMS LD being the "behind the scenes" computer engine (e.g., Botturi, 2006; Buzza, Richards, Bean, Harrigan, & Carey, 2005).

LAMS

The Learning Activity Management System (LAMS) is a software application that allows a teacher to both design and implement online learning activities using a visual authoring environment. A learning design is represented as a sequence of activities visually illustrated in the form of a flowchart. The activities are described in the form of the online tools used to run the activity. For example, if an activity involves asking students a question and then students discussing their answers in a group, this would be presented in LAMS as a flowchart consisting of a Question and Answer icon followed by a Chat icon. LAMS' focus is to promote student collaboration; thus it supports a range of group activities as well as individual activities. The drag and drop interface enables an online activity to be designed with relative ease, and the authoring environment enables a teacher to modify and adopt a LAMS sequence easily. Because of its visual interface, LAMS facilitates a learning design to be both human and computer interpretable. However, because the visual interface shows the sequence of tools used in an activity, the overall pedagogical design of a LAMS sequence is not made explicit.

LAMS is being used in many universities and schools within Australia, New Zealand, UK, and, more recently, China (http://www.lamsinternational.com/). Within the higher education sector, the use of LAMS is demonstrating great potential to document and represent pedagogical practice with the aim of facilitating the reuse of LAMS sequences (e.g., Lucas, Masterman, Lee, & Gule, 2006). Its visual authoring environment provides a "teacher-friendly" tool that can help teachers with lesson planning as they can see both a visual summary of their designs plus, importantly, try out their design via LAMS' Preview mode (e.g., Cameron, 2006). Work is also being conducted to investigate how LAMS can be used as a support tool (e.g., pedagogy planner prototype) to help lecturers design, implement, and refine learning activities (Laurillard, 2006a).

LDVS

A Learning Design Visual Sequence (LDVS) (Agostinho, Harper, Oliver, Hedberg, & Wills, 2008) was developed by an Australian team for a national project that focused on identifying and describing innovative educational practices employing the use of ICT. The project, referred to as the Learning Designs Project (www.learning-designs.uow.edu.au), produced generic learning design resources and tools for the purpose of helping academics in higher education implement innovative ICT-based learning designs in their own teaching contexts. The Web site, an extensive higher education resource (Hicks, 2004), documents a range of learning designs, in the form of contextualized learning design exemplars and generic learning design guidelines. A learning design comprises three elements: the tasks students are required to complete, the content resources provided to assist students in completing the tasks, and the supports provided to help students in their learning process (Oliver & Herrington, 2001). The LDVS illustrates the chronology of tasks, resources, and supports using symbols for each of the three learning design elements (squares/rectangles for tasks, triangles for resources, and circles for supports). The tasks are the focus of the diagram. They are positioned in the centre of the diagram and arranged vertically with accompanying resources and supports illustrated on the left and right, respectively. A summary of the intended learning outcomes and the time required to implement the learning design completes the diagram. For each task, there is a brief textual description that summarizes the aim of the task, for example, explore, reflect, and so on, and briefly describes what learners are required to do or produce.

The LDVS represents a visual summary of a learning design from the perspective of the teacher. It was initially devised as a tool to assist the project team to document the large number of learning design exemplars collected in a consistent format to facilitate comparison, contrast, and selection of learning design exemplars for development in a more generic form. On the project Web site, the visual sequence for each learning design is accompanied with detailed textual information that explains how the tasks, resources, and supports have been designed and implemented and the implementation context of the learning design.

The perceived usefulness of the LDVS is its relative simplicity in construction and informal approach in describing tasks, resources, and supports. Yet its structure allows it to be a form of communication, like a language. A study conducted by Agostinho (2006) found there is evidence that the LDVS is being used beyond the project in which it was developed. Practitioners are using the LDVS as a documentation, communication, and reflection tool. The visual feature of the LDVS is viewed as one of its main strengths. Similar findings are reported in Falconer, Beetham, Oliver, Lockyer, and Littlejohn (2007) where teaching practitioners in a workshop trialed the LDVS. Its visual characteristic and its simplicity made an immediate impact on perceived usefulness, but the definition of "supports" and how they are distinguished from "resources" created some confusion. Other research work focused on the LDVS has been to examine how the generic learning designs developed in the project have been reused and how reuse can occur (see Bennett, Agostinho, & Lockyer, 2005; Bennett, Lockyer, & Agostinho, 2004). There has been research conducted on embedding the LDVS as a support tool for teachers (see Bennett, Agostinho, Lockyer, & Harper, 2006; Harper, Agostinho, Bennett, Lukasiak, & Lockyer, 2005), and work is continuing in this area to develop a Learning Design Framework through an Australian national grant in collaboration with an Australian learning management system industry partner (Janison Toolbox) and the Open University of The Netherlands to explore synergies between the LDVS and IMS-LD for representing learning designs.

LDLite

LDLite offers a form of documentation, similar to a lesson plan, that teachers can use to help them design blended activities, that is, integrate face-to-face and online activities. Developed only in the last few years, this new initiative represents and documents a learning design based on five key elements of IMS LD: tutor roles, student roles, content resources, service resources, and assessment/feedback (Oliver & Littlejohn, 2006). Its focus is to help teachers think about how they can complement online activities with face-to-face components. For each activity, the teacher completes a row of the lesson plan matrix, first labeling the activity either as off-line or online and then summarising what the tutor will do, what the students are to do, what content resources will be provided, what online or off-line services will be provided to support students to complete the task, for example, discussion board, face-to-face tutorial, and so forth, and how feedback will be provided.

The lesson plan matrix serves as a summary and is accompanied with contextualized narratives of a learning activity similar to the LDVS representation. The latest research conducted about the perceived usefulness of LDLite found that although practitioners thought the representation is easy to understand, issues such as lack of detail about each activity, for example, the title of the activity and its intended learning objectives, confusion over the terms "off-line" and "online," and lack of clarity that the grid represents a sequence of activities influenced its usefulness (Falconer et al., 2007). A number of suggestions to improve this learning design representation have been provided by practitioners and work is continuing to incorporate these changes and conduct further evaluations (Falconer et al., 2007).

Patterns

Patterns are a way of capturing knowledge from designers and sharing them with practitioners (McAndrew & Goodyear, 2007). Unlike the previous learning design representations that have been devised specifically for use in the field of education, patterns are a representation being used in education but originally devised for use in another discipline—Architecture by Christopher Alexander (see Alexander, 1979, cited in McAndrew, Goodyear, & Dalziel, 2006). A pattern is considered a "rule of thumb" (McAndrew et al., 2006) as it offers a way of documenting a successful solution to a recurring design problem in a noncontextualized way so that the solution can be applied (reused) in many different contexts (Botturi & Belfer, 2003; Cowley & Wesson, 2000; Rohse & Anderson, 2006). Ironically, whilst the representation can be used to help share learning design expertise and solutions, the representation itself is being shared across disciplines. For example, patterns are being used in software engineering and computer-supported collaborative learning (Rohse & Anderson, 2006) as well as in instructional design (see Cowley & Wesson, 2000). Within e-learning, a pattern repository has been compiled by the E-LEN project (http://www2.tisip.no/E-LEN/).

Patterns are derived from experience and make sense when examined in context of neighbouring patterns that form a pattern language (Cowley & Wesson, 2000; Rohse & Anderson, 2006). The focus of patterns is to guide and teach but not prescribe (Goodyear, 2005; Rohse & Anderson, 2006). Patterns do not provide a complete contextualized solution. Instead their purpose is to provide guidance and thus human intervention is required in each reuse (McAndrew & Goodyear, 2007).

A design pattern is presented in the form of textual paragraphs containing the following minimum characteristics (Design expertise for e-learning centres, n.d.; Frizell, 2006; McAndrew & Goodyear, 2007):

- Pattern name
- Context for the pattern
- Description of the problem
- Solution

- Example
- Link to other patterns

Diagrams may be included to present the solution or introduce the pattern.

Patterns are gaining popularity as a strategy to share educational practice, bridge the divide between research and practice, and thus improve educational practice: "[Patterns] provide a common ground for researchers, practitioners, technologists and learners alike to understand, interpret, evaluate, and share educational practice. Used within a design-based research framework, design patterns offer a means to incrementally improve education practice" (Rohse & Anderson, 2006, p. 89). This rhetoric needs to be substantiated, as currently there is little research to support the claims of how useful patterns are in helping practitioners design learning experiences.

Falconer and Littlejohn (2006) stated there is not a lot of use of patterns by teachers at present. Frizell (2006) explained that whilst there are some studies that show patterns can be beneficial to users in areas of software maintenance, Web design and human-computer interaction, there is little research evidence on the effectiveness of design patterns in supporting the instructional design tasks of novice users. The study by Frizell (2006) involved 17 participants (novice e-learning designers) examining a design pattern collection of 16 patterns to support the design of an e-learning course. Participants had to state why they selected particular design patterns and what sections of the design pattern they thought were most useful. Selection of patterns was based on whether or not participants agreed with the pattern and the most useful section of the pattern was the example section. This study did not make any claims on the quality of course designs produced by participants who used design patterns nor did it explain how participants would use the design patterns. Whilst this study does add to the research body of patterns, it is small in scope and focus and more studies are needed.

Summary and Comparison Tables

These six learning design representations are documented in different ways and serve different purposes. Some representations are specifically designed for human interpretation (e.g., E^2ML, LDVS, LDLite, and Patterns) through the use of textual descriptions and visual diagrams, whereas others are tailored more for technical interoperability and thus represented in the form of computer readable language (e.g., IMS LD). LAMS, however, is able to serve both purposes as a teacher can design and run learning activities online using its visual flow chart type interface. All these representations define and document a "learning design" in their own particular way. Some representations, as also noted by Falconer and Littlejohn (2006), describe the mechanics of a learning design but do not clearly illustrate or make explicit the pedagogy of the actual design. For example, the purpose of LDVS is to provide a visual pedagogical summary of a learning design, whereas LAMS, E^2ML, and IMS LD are more focused on documenting the detail, the logistics, and the technical services/tools required to execute or run the learning design.

The following three tables present a summary of the focus, purpose, and key features of each of these six learning design representations. These three tables include characteristics based on the classification framework for emerging visual instructional design languages developed by Botturi, Derntl, Boot, and Figl (2006) and the comparison table presented by McAndrew, Goodyear, and Dalziel (2006). They serve as a useful comparison tool to tease out the philosophy and features of each representation. The contents of the tables represent the author's view in reviewing the literature, thus it is open to interpretation. The first three characteristics presented in Table 1 (*focus*, *purpose,* and *artifacts produced*) surfaced as defining features for the author when examining these representations. Table 2 includes three characterstics that are phrased as questions.

Table 1. Comparison of six learning design representations: focus, purpose, and artifacts produced

Characteristic:	Focus	Purpose	Artifacts produced
E^2ML	Document the outcome of an instructional design process	Enhance communication amongst team of large e-learning projects	Three document sets; Documentation is separate from execution of instruction /implementation environment
IMS LD	Document an online learning experience (a unit of learning) in a computer readable way	Offer technical interoperability by supplying a complete technical solution	XML unit of work; Documentation is integrated with implementation environment; Documentation is the executable code
LAMS	Create online collaborative activities for students	Provide a design and implementation platform for online collaborative activities	Computer based LAMS sequences; Documentation is integrated with implementation environment; Documentation is the computerized visual flowchart
LDVS	Provide a visual summary of a learning design from the teacher perspective	Document learning designs to encourage sharing and reuse of the pedagogical ideas	Two document sets: Visual Sequence and accompanying description; Documentation is separate from implementation environment
LDLite	Help teachers design and integrate blended (face-to-face and online) activities	Tool for teachers to design and document online and off-line learning activities	Two document sets: Text-based matrix and accompanying contextual narrative; Documentation is separate from implementation environment
Patterns	Present solutions to reoccurring design problems but not provide a complete prepackaged solution	To guide not prescribe; to teach; to offer "rules of thumb"	A pattern or a collection of patterns (pattern language); Documentation is separate from implementation environment

The first question, *Is pedagogical design made explicit?*, was informed by Falconer and Littlejohn (2006). The second and third questions, *How is reuse facilitated?* and *What can be reused?*, were informed by the comparison table presented by McAndrew et al. (2006). Table 3 includes the final three characteristics. *Notation system* and *Formalization of language* come from the classification framework developed by Botturi et al. (2006). Notation system refers to whether the representation is predominantly nonvisual (textual) or visual. If a representation uses a language to describe a learning design with stringent rules for composition and vocabulary, then it is referred to as a formal language, whilst representations that are more open to interpretation are considered informal. Some may include elements of both and thus classed as semiformal. The idea for including the last characteristic (*level of detail supported*) came from Conole et al. (2007).

Table 2. Comparison of six learning design representations: explicitness of pedagogical design and issues about reuse

Characteristic:	Is pedagogical design made explicit?	How is reuse facilitated?	What can be reused?
E^2ML	No – overview diagrams show relationships of actions, not overall pedagogical strategy	Human intervention required for reuse – mainly within the team	The contextualized ideas
IMS LD	No – documentation is computer interpretable	Human intervention not required for reuse – artifact produced is reusable	The artifact produced (XML unit of learning)
LAMS	No – shows the sequence of online tools used rather than overall pedagogical strategy	Human intervention not required for reuse – artifact produced is reusable	The artifact produced (LAMS sequence)
LDVS	Yes – the sequence of activities and thematic description of activities help to distil pedagogy	Human intervention required for reuse	The ideas
LDLite	No – details specific activities rather than distilling overall pedagogy	Human intervention required for reuse	The ideas
Patterns	Yes – patterns explain the pedagogical principles underpinning the problem and solution	Human intervention required for reuse	The ideas

Table 3. Comparison of six learning design representations: notation system, formalization of language, and level of detail supported

Characteristic:	Notation system	Formalization of language	Level of detail supported: contextually situated, more abstract/generic or both
E^2ML	Visual	Semiformal	Contextual – documents a specific learning environment
IMS LD	Textual	Formal	Contextual – Unit of Learning is a detailed contextualized description; work on templates to serve as generic guides is underway
LAMS	Visual	Formal	Contextual – LAMS sequence is a detailed contextualized description; work on templates to serve as generic guides is underway
LDVS	Visual	Informal	Both contextual and generic – learning design exemplars are contextual, learning design guidelines are generic
LDLite	Textual	Informal	Contextual – matrix and narrative detail contextually situated activities
Patterns	Textual	Informal	Generic – implementation details are deliberately left vague

DISCUSSION

Whilst the need for a consistent notation system in education has been argued to provide a common language for practitioners to better communicate ideas (Waters & Gibbons, 2004), what can be inferred from the summary tables presented above is that it seems unlikely that one all-encompassing notation system for representing and documenting learning designs will evolve. Instead, a toolkit of a number of representations each used at different times during the educational design process for different purposes seems to be a more plausible option. Work on how these different learning design representations could be integrated is emerging as demonstrated in the following examples. Rohse and Anderson (2006, p. 88) explained that design patterns could be used as a "common language between educators and technologists to help educators develop pedagogically sound IMS Learning Design scenarios." Botturi and Belfer (2003, p. 8834) proposed that elements from E²ML could be incorporated within patterns to assist in the explanation of a pattern using visual aids:

Most instructors are willing to try sound pedagogical strategies in their classes…but many are confounded by a lack of time and a need for specific and clear step-by-step guidelines that they can use or adapt to their own practice without a significant investment of time. The patterns offer variety, and provide a broader framework to assist the instructor in developing and delivering a successful and engaging learning experience with a sound educational foundation. The use of the E²ML to support the definition of a pattern provides instructors with visual tools.

Botturi (2006) explained how E²ML Advanced Version complies with IMS LD and how E²ML can serve as a visual interface for creating the IMS LD units of instruction. Oliver and Littlejohn (2006) proposed the idea of an "educational development wizard" which could incorporate the representations of patterns, LDVS, and LDLite.

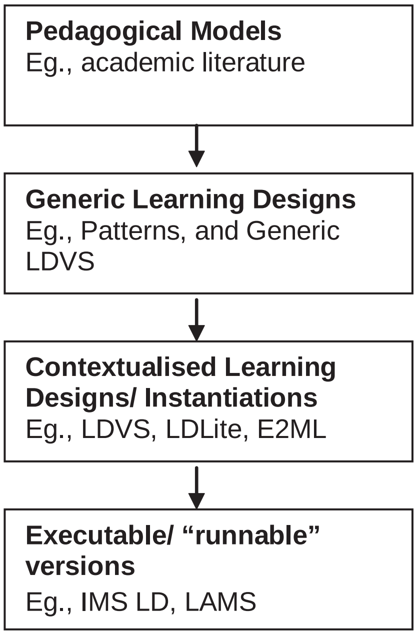
McAndrew et al. (2006) and McAndrew and Goodyear (2007) discussed how patterns, LAMS, and IMS LD could be unified by presenting a diagram that illustrates a hierarchical relationship amongst them from the abstract or generic at the top of the hierarchy (i.e., patterns) to more contextualised executable versions at the lowest end of the hierarchy (IMS LD and LAMS). McAndrew and Goodyear (2007, p. 97) explained that the hierarchy ranges from:

models of learning that can be drawn from theory, literature or existing examples…through to patterns that can abstract a number of generic designs. At a more local level are instantiations based on how these designs are interpreted and matched to relevant learning materials and tools, and finally executable versions in a suitable environment, e.g. LAMS, the Moodle virtual learning environment (VLE), or in a player for IMS Learning Design.

Figure 1 is an adaptation of the hierarchical model presented by McAndrew and Goodyear (2007) to illustrate a possible relationship amongst the six learning design representations discussed in this chapter. From this figure, it is apparent that each representation has a part to play in the overall design and implementation process of a learning design. Conole et al. (2007) explained that practitioners use a range of tools to support and guide their design of learning activities. A study by Masterman (2006) found that practitioners design activities in different ways and use different representations to suit their needs. Her report suggested a "wish list" of characteristics that a learning design environment/tool could encompass.

The JISC-funded project titled Mod4L (http://www.academy.gcal.ac.uk/mod4l/) conducted practitioner focus group sessions where partici-

Figure 1. Proposed relationship amongst six learning design representations



pants examined three learning design representations (LDVS, LDLite, and Patterns) in terms of perceived usefulness in their own teaching practice. The study concluded that no one single representation is adequate. Instead multiple representations are needed:

It was clear from the small group discussions, and stated explicitly by participants in the whole group discussion, that no single representation could encompass all practitioners felt they needed from a sharable learning design. The three representations all give different information and this would be too complicated to show within a single representation. Linking three representations together would give the ability to view the designs from different perspectives (Falconer & Littlejohn, 2006, p. 26).

So, if this is a suggested way forward, a proposed pathway for future research efforts involves a two-pronged approach. First, research work needs to focus on the following three areas:

1. How practitioners design activities. There are calls for research to investigate how practitioners express and share ideas about learning (Laurillard, 2006b). Britian (2004, p. 25) argued that "further work needs to be conducted to examine the range of approaches to 'designing for learning' in use by teachers and lecturers and the software tools that are or could be used to support these activities."
2. How current learning design representations are being used. There is little research evidence available that examines the usefulness of the learning design representations discussed in this chapter. We need more studies similar to the Agostinho (2006), Botturi (2005), and Frizell (2006) studies, but they need to be broader in scope and sample size and replicated in multiple contexts so that we can better understand the strengths and limitations of existing representations and how they could be potentially improved. Botturi (2005) presented an evaluation framework that could be considered when undertaking evaluation studies on the use and perceived usefulness of languages/notation systems/representation models. The framework provides guidelines on how to set up evaluation studies (e.g., provide detailed description of the context of use, explicitly state perceived expected benefits, consider the importance of time in the evaluation) and suggests elements that could be examined/observed (such as impact on communication, and expressive power of the representational model). Botturi (2005, p. 349) stated: "It is hoped that the framework provides a structure by which evaluations of the impact of different languages are

comparable, and that practitioners can find some support in selecting what language to use in their practice."

3. How existing learning design representations could be integrated. More research projects similar to that conducted by **Falconer et al. (2007)** are needed as well as research to support integration ideas as suggested by McAndrew and Goodyear (2007) to better understand how a range of learning design representation could complement each other. We need to widen the net and conduct research that compares and contrasts the learning design representations presented in this chapter.

Second, there is now a need to work together as one community rather than as isolated individuals or research teams. In order to move this body of research from the emergence phase to the next phase of diversification, where "the area starts to mature and different schools of thought emerge and the area begins to align or take place alongside more established areas" (Conole et al., 2007, p. 12), it is timely that an internationally based community of researchers forms to work together towards seeking understanding about how learning designs can be used in education. This is starting to happen through publications such as Beetham and Sharpe (2007) and Botturi and Stubbs (2007) as well as this handbook publication. But the establishment of an international network of colleagues would be an opportunity to foster collaboration amongst researchers to explore possibilities and ideas. A suggested way forward may be to consider reusing the collaboration model implemented by the UNFOLD community (Burgos & Griffiths, 2005).

CONCLUSION

This chapter has explored the concept of "learning design" by first explaining how the concept has gained momentum in the e-learning literature and how it is currently defined. There is currently no one standard mode of representation for learning designs in education. Instead several learning design representations have emerged, each documented in different ways and serving different purposes. This chapter has discussed six learning design representations prevalent in the literature: E^2ML, IMS LD, LAMS, LDVS, LDLite, and Patterns. Three comparison tables have been presented to explicate their purpose, structure, and key features. There is little literature that discusses and compares these representations together so it is hoped this chapter addresses this gap. A proposed pathway for future research was presented based on the idea that whilst Waters and Gibbons (2005) have called for a notation system similar to music and dance for educational design, it looks unlikely that one all-encompassing solution will be suitable. Instead a range of representations may be needed. As such, we need to learn more about each learning design representation and then explore how they could work together. To do this, a two-pronged research strategy is proposed: (1) individual studies are required to further investigate how current learning design representations are being used or could be used plus further the work in investigating how practitioners design, and (2) the formation of an international research community to better collaborate and explore how learning design representations could be improved and integrated.

REFERENCES

Agostinho, S. (2006). The use of a visual learning design representation to document and communicate teaching ideas. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds.), *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who's Learning? Whose Technology?* (pp. 3-7). Sydney: Sydney University Press.

Agostinho, S., Harper, B., Oliver, R., Hedberg, J., & Wills, S. (2008). A visual learning design representation to facilitate dissemination and reuse of innovative pedagogical strategies in university teaching. In L. Botturi & T. Stubbs (Eds.), *Handbook of visual languages for instructional design: Theories and practices* Information Science Reference.

Background to the JISC Circular. (2006). Retrieved March 22, 2008, from http://www.jisc.ac.uk/uploaded_documents/Backgrounddesignforlearningv3%20Final.doc

Beetham, H. (2004). *Review: Developing e-learning models for the JISC practitioner communities.* Retrieved March 22, 2008, from http://www.jisc.ac.uk/uploaded_documents/Review%20models.doc

Beetham, H., & Sharpe, R. (Eds.). (2007). *Rethinking pedagogy for a digital age: Designing and delivering e-learning.* Oxon: Routledge.

Bennett, S., Agostinho, S., & Lockyer, L. (2005, July 4-6). *Reusable learning designs in university education.* In *Proceedings of the IASTED International Conference on Education and Technology (ICET 2005)*, Calgary, Alberta, Canada (pp. 102-106).

Bennett, S., Agostinho, S., Lockyer, L., & Harper, B. (2006, July). Supporting university teachers create pedagogically sound learning environments using learning designs and learning objects. *IADIS International Journal on WWW/Internet, 4*(1), 16-26. Retrieved March 22, 2008, from http://www.iadis.org/ijwi/

Bennett, S., Lockyer, L., & Agostinho, S. (2004). Investigating how learning designs can be used as a framework to incorporate learning objects. In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds.), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference* (pp. 116-122). Perth, 5-8 December. http://www.ascilite.org.au/conferences/perth04/procs/bennett.html.

Botturi, L. (2005). A framework for the evaluation of visual languages for instructional design: The case of E2ML. *Journal of Interactive Learning Research, 16*(4), 329-351.

Botturi, L. (2006). E2ML: A visual language for the design of instruction. *Educational Technology, Research and Development, 54*(3), 265-293.

Botturi, L., & Belfer, K. (2003). Pedagogical patterns for online learning. In G. Richards (Ed.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2003*, Phoenix, Arizona (pp. 881-884). AACE.

Botturi, L., Derntl, M., Boot, E., & Figl, K. (2006). A classification framework for educational modeling languages in instructional design. In *Proceedings of IEEE ICALT 2006*, Kerkrade, the Netherlands (pp. 1216-1220).

Britain, S. (2004). *A review of learning design: Concept, specifications and tools.* Retrieved March 22, 2008, from http://www.jisc.ac.uk/uploaded_documents/ACF83C.doc

Botturi, L., & Stubbs, T. (Eds.) (2008). *Handbook of visual languages for instructional design: Theories and practices.* Information Science Reference.

Burgos, D., & Griffiths, D. (2005). *The UNFOLD Project: Understanding and using learning design.* Heerlen: Open University of The Netherlands. Retrieved 14 January, 2007, from www.unfold-project.net/project/UNFOLDbooklet.pdf

Buzza, D., Richards, L., Bean, D., Harrigan, K., & Carey, T. (2005). LearningMapR: A prototype tool for creating IMS-LD compliant units of learning. *Journal of Interactive Media in Education, 17.*

Cameron, L. (2006). Picture this: My lesson. How LAMS is being used with pre-service teachers to develop effective classroom activities. In R. Philip, A. Voerman, & J. Dalziel (Eds.), *Proceedings of the 1st International LAMS Conference 2006: Designing the Future of Learning* (pp. 25-34). Sydney: LAMS Foundation. Retrieved March 22, 2008, from http://lamsfoundation.org/lams2006/papers.htm

Conole, G., Oliver, M., Falconer, I., Littlejohn, A., & Harvey, J. (2007). Designing for learning. In G. Conole & M. Oliver (Eds.), *Contemporary perspectives in e-learning research: Themes, methods and impact on practice* (pp. 101-120). Oxon: Routledge.

Cowley, L., & Wesson, J. (2000). Design patterns for Web-based instruction. In P. Kommers & G. Richards (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2000,* Montreal, Canada (pp. 250-255). AACE.

Design expertise for e-learning centres: Design patterns and how to produce them. (n.d.). Retrieved March 22, 2008, from http://www2.tisip.no/E-LEN/documents/ELEN-Deliverables/booklet-e-len_design_experience.pdf

Designing for learning: An update on the pedagogy strand of the JISC eLearning programme. (n.d.). Retrieved March 22, 2008, from http://www.jisc.ac.uk/uploaded_documents/Overview.doc

Falconer, I., Beetham, H., Oliver, R., Lockyer, L., & Littlejohn, A. (2007). *Mod4L final report: Representing learning designs*. Retrieved March 22, 2008, from http://www.academy.gcal.ac.uk/mod4l/

Falconer, I., & Littlejohn, A. (2006). *Mod4L report: Case studies, exemplars and learning designs*. Retrieved March 22, 2008, from http://mod4l.com/tiki-download_file.php?fileId=2

Frizell, S. (2006). Evaluating the usefulness of design patterns in supporting novice course designers: First experiences. In T. Reeves & S. Yamashita (Eds.), *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2006,* Honolulu, Hawaii (pp. 1193-1197). AACE.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australian Journal of Educational Technology, 21*(1), 82-101.

Harper, B., Agostinho, S., Bennett, S., Lukasiak, J., & Lockyer, L. (2005). Constructing high quality learning environments using learning designs and learning objects. In P. Goodyear, D. G. Sampson, D. J.-T. Y.Kinshuk, T. Okamoto, R. Hartley, & N.-S. Chen (Eds.), *Proceedings of the 5th IEEE International Conference on Advanced Learning Technologies (ICALT 2005)* (pp. 266-270). Kaohsiung, Taiwan: IEEE Computer Society.

Hicks, O. (2004). Composite report on projects funded through the Australian Universities Teaching Committee 2000-2003. Australian Universities Teaching Committee. Retrieved March 22, 2008, from http://www.autc.gov.au/projects/completed/AUTC_funded_projects_00-03.pdf.

IMS learning design best practice and implementation guide version 1.0 final specification. (2003). IMS Global Learning Consortium Inc. Retrieved March 22, 2008, from http://www.imsglobal.org

Laurillard, D. (2002). Design tools for e-learning. In A. Williamson, C. Gunn, A. Young, & T. Clear (Eds.), *Winds of change in the sea of learning: Proceedings of the 19th Annual Conference of the Australasian Society for Computers in Tertiary Education*, Auckland, New Zealand, UNITEC Institute of Technology.

Laurillard, D. (2006a). Pedagogic planning support for lecturers. In *Proceedings of the 1st International LAMS Conference 2006: Designing the Future of Learning*, Sydney: LAMS Foundation. Retrieved March 22, 2008, from http://lamsfoundation.org/lams2006/keynotes.htm

Laurillard, D. (2006b). Learning design futures: What are our ambitions? In G. Minshull & J. Mole (Eds.), *Proceedings of Theme 1 of the JISC Online Conference: Innovating e-Learning 2006* (pp. 7-10). Retrieved March 22, 2008, from http://www.jisc.ac.uk/elp_conference06.html

Lucas, B., Masterman, L., Lee, S., & Gulc, E. (2006, December 6-8). Sharing and reuse of learning designs for English studies: A UK higher education perspective. In R. Philip, A. Voerman, & J. Dalziel (Eds.), *Proceedings of the First International LAMS Conference 2006: Designing the Future of Learning* (pp. 55-64). Sydney: LAMS Foundation. Retrieved March 22, 2008, from http://lamsfoundation.org/lams2006/papers.htm

Masterman, L. (2006). The Learning Designs Tools Project: An evaluation of generic tools used in Design for Learning, Learning Technologies Group, Oxford University Computing Services. Retrieved March 22, 2008, from http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_ldevaloxford.aspx

McAndrew, P., Goodyear, P., & Dalziel, J. (2006). Patterns, designs and activities: Unifying descriptions of learning structures. *International Journal of Learning Technology, 2*(2/3), 216-242.

McAndrew, P., & Goodyear, P. (2007). Representing practitioner experiences through learning design and patterns. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 92-102). Oxon: Routledge.

Oliver, R. (2006, July). Learning designs for ICT-based learning settings. *ASCILITE Newsletter*. Retrieved March 22, 2008, from http://www.ascilite.org.au/index.php/Newsletter:_July_2006

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Edith Cowan University: Western Australia.

Oliver, R., & Littlejohn, A. (2006). Discovering and describing accessible and reusable practitioner-focused learning. In G. Minshull & J. Mole (Eds.), *Proceedings of Theme 1 of the JISC Online Conference: Innovating e-Learning* 2006 (pp. 30-33). Retrieved March 22, 2008, from http://www.jisc.ac.uk/elp_conference06.html

Rohse, S., & Anderson, T. (2006). Design patterns for complex learning. *Journal of Learning Design, 1*(3), 82-91.

Sharpe, R., Beetham, H., & Ravenscroft, A. (2004). Active artefacts: representing our knowledge of learning and teaching. *Educational Developments, 5*(2), 16-21.

Transcript of the launch of the Carrick Institute for Teaching and Learning in Higher Education. (2004). Retrieved March 22, 2008, from http://www.dest.gov.au/Ministers/Media/Nelson/2004/08/n853110804.asp

Waters, S. H., & Gibbons, A. S. (2004). Design languages, notation systems, and instructional technology: A case study. *Educational Technology, Research and Development, 52*(2), 57-68.

KEY TERMS

E²ML: Stands for Educational Environment Modeling Language and is a representation language for documenting the outcome of an instructional design process.

IMS LD: IMS Learning Design (IMS Learning Design Best Practice and Implementation Guide Version 1.0 Final Specification, 2003) documents a learning design in a computer readable format (an XML file) so that it can be played in an IMS LD "player" to the end-user in a similar way that HTML code can be played by an Internet browser application.

LAMS: Learning Activity Management System (LAMS) is a software application that allows a teacher to both design and implement online learning activities using a visual authoring environment.

LDVS: The Learning Design Visual Sequence documents a learning design in a visual way by illustrating the chronology of tasks, resources, and supports using symbols for each of the three learning design elements (squares/rectangles for tasks, triangles for resources and circles for supports). It represents a visual summary of a learning design from the perspective of the teacher.

LDLite: LDLite offers a form of documentation, similar to a lesson plan, that teachers can use to help them design blended activities, that is, integrate face-to-face and online activities.

Learning Design: A learning design represents and documents teaching and learning practice using some notational form so that it can serve as a description, model or template that can be adaptable or reused by a teacher to suit his/her context

Learning Design Representation: The way in which a learning design is documented.

Pattern: A pattern is a way of documenting a successful solution to a recurring design problem in a non-contextualized way so that the solution can be applied (reused) in many different contexts. It can be considered a "rule of thumb."

Chapter II
Representing Models of Practice

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ABSTRACT

Practice models are generic approaches to the structuring and orchestration of learning activities for pedagogic purposes, intended to promote sharing of effective e-learning practice. This chapter surveys the background to the idea of practice models, and then examines the issues surrounding their representation that emerged from the UK Joint Information Systems Committee (JISC)-funded Mod4L project. These issues are ones of purpose, design as a process, granularity, community, and characterisation. It analyses the purpose and the metaphor for design, coupled with consideration of the audience for practice models, suggesting that while generic models are useful for technical developers, they may not be an effective way of sharing teaching practice. The possibility that a rich domain map coupled with community building activities and richly contextualised exemplars might be more effective is briefly discussed. The complex interactions of characteristics of a design representation underpin the necessity for different representations to fulfil different user needs.

INTRODUCTION

The concept of "design for learning" has arisen in the context of three challenges that face teachers in further and higher education: the increasing size and diversity of the student body; an increasing requirement for quality assurance; and the rapid pace of technological change that is fueling a demand for personalised learning and calling into question traditional ideas of the purposes of education and what constitutes knowledge (Beetham & Sharpe, 2007; CIHE, 2002; DfES, 2001).

The solution to these challenges is often sought in use of new technological tools for scaleable and flexible delivery and for sharing and reuse of teaching activities. Yet, despite substantial institutional investment in information and communication technologies (ICTs), there is little evidence that education has changed in any fundamental way at the level of teacher practice (Collis & Van der Wende, 2002; Seufert & Euler, 2004).

One reason suggested for the lack of impact is that e-learning development and e-learning research have followed parallel courses, with the development of tools, systems, and services and their associated standards on the one hand, and investigations into how these can support effective learning and teaching on the other (Beetham & Sharpe, 2007; JISC, 2006). To help bridge this gap, there is a perceived need for practitioner-focused resources describing a range of learning designs and offering guidance on how these may be chosen and applied, how they can support effective practice in design for learning, and how they can support the development of effective tools, standards, and systems with a learning design capability (see, e.g., Griffiths & Blat, 2005; JISC, 2006).

The recent UK Joint Information Systems Committee (JISC) Design for Learning programme aimed explicitly to bring the two areas of work together (http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_designlearn.aspx). JISC's overall remit is to support UK further and higher education by providing strategic guidance and advice about the use of information and communication technologies in learning and teaching. Among the aims of the Design for Learning programme were to (JISC, 2006):

- Help improve the quality of e-learning in the UK
- Assist teaching practitioners with gaining confidence and skills in managing and facilitating e-learning in different contexts and with different pedagogic approaches
- Provide easy access to high quality, flexible learning materials
- Identify effective approaches to e-learning practice
- Create examples of effective practice in learning, teaching, and supporting technology

Projects worked closely with teachers in exploring the processes of designing for learning, sharing and reusing designs, evaluating the tools used, and developing new planning tools that are grounded in teachers' existing practice and needs.

The idea of design for learning offers practical benefits to teachers in further and higher education in terms of improved teaching quality and efficiency. However, before these benefits can be realised, there are a number of issues to overcome. The issues can largely be classified as institutional and representational. This chapter explores the representational ones, considering issues of purpose and audience of a representation and the potential uses of generic "practice models." It is based largely on the findings of the Mod4L practice models project, one of the projects of the JISC Design for Learning programme (http://www.mod4l.com/tiki-index.php; Falconer, Beetham, Oliver, Lockyer, & Littlejohn, 2007).

The overall aim of the Mod4L project was to develop a range of practice models that can be used by teachers in real life contexts and have a high impact on improving teaching and learning practice. Practice models have been defined as *generic approaches to the structuring and orchestration of learning activities. They express elements of pedagogic principle and allow teachers to make informed choices* (JISC, 2006). To be effective and sustainable, practice models should be grounded in authentic practice and represented in ways that are meaningful to teachers. In this sense, practice models need to be both *representations of effective practice (signify* successful instances of good practice) *and effective representations of practice* (have high impact on practice).

In the UK, a number of initiatives have represented the structure and orchestration of effective learning designs in a variety of forms, such as case studies (e.g., JISC Effective Practive and Innovative Practice Guides: http://www.elearning.ac.uk/effprac/, http://www.elearning.ac.uk/innoprac/), concept maps (e.g., DialogPlus Toolkit, http://www.nettle.soton.ac.uk/toolkit/Default.aspx; DIDET project, http://www.didet.ac.uk/), and use cases (e.g., LADiE project, http://www.elframework.org/refmodels/ladie/ouputs/). International initiatives include the Learning Activity Management System (LAMS, http://www.lamsin-

Table 1. Some frameworks used by teachers to plan and document teaching

Representation	Description	Target users
Module plan or master folder	Text based overview of the module. Usually available as a Word document or in paper form.	Tutors Programme leaders External examiners
Case study	A narrative overview of a teaching and learning situation – ranging from an entire module to a single classroom activity.	Tutors Course developers
Briefing document	A narrative overview of a teaching and learning situation, focusing on class management issues.	Tutors Programme leaders External examiners
Pattern overview	A structured, text-based structured way of analysing a pedagogic problem and conveying best practice solution	Tutors Course developers Technical developers
Contents table	A list of contents of a module or a single class	Tutors Students
Concept map	A mapping of concepts and/or learning activities	Tutors Students
Learning design sequence	A sequence of learning activities, sometimes shown diagramatically	Tutors Students Technical developers
Storyboard	A mapping of concepts and/or learning activities	Tutors Audio visual/ instructional developers
Lesson plan	A matrix mapping learning activities against a timescale. Lesson plans are commonly used in Further Education.	Tutors

ternational.com/) and the AUTC Learning Design Framework (www.learningdesigns.uow.edu.au/), as well as IMS Learning Design (http://www.imsglobal.org/learningdesign/). Other more general representations include patterns (Goodyear, 2005) and lesson plans (Littlejohn & Pegler, 2007). Some of these representations and their potential use by teachers are summarised and described in Table 1. At the same time, developments in pedagogic theory over the last few decades have produced a wide variety of more abstract models of the constituents and operation of effective approaches to learning and teaching, such as Salmon's (2003) five-stage model, Laurillard's (2004) Conversational Framework, and the SeSDL taxonomy (http://www.sesdl.scotcit.ac.uk/).

Alongside collecting practical and theoretical examples of effective practice, several enquiries have explored the use of representations by teaching practitioners to communicate and improve understanding of practice (e.g., Beetham, 2001; Littlejohn, Falconer, & McGill, 2006; Sharpe, Beetham, & Ravenscroft, 2004). These suggested a number of challenges in developing and using representations that are meaningful to teachers, including:

- Ownership of representations. To be effective, representations need to be "owned" by, and meaningful within, each particular teacher or developer community.
- Different forms of representation are effective for different communities. In particular, tensions exist when teachers try to document and represent effective practice in a form that has meaning to technical developers (Falconer, 2007). This tension was also evidenced during the UNFOLD project which failed to establish a single unified community of practice, despite its avowed aim of bringing together standards and tools developers and teachers (Burgos & Griffiths, 2005). Making representations meaningful is complicated by the wide range of different practitioner communities that exist, characterised by factors such as role (e.g., teaching professionals, curriculum teams, designers, developers), type of institution, and discipline.
- Within a single community, there may be a number of different purposes a representation needs to fulfil. McAndrew, Goodyear, and Dalziel (2006) emphasise the need for representations at various levels and forms, supplementing learning designs with less formal "patterns" of activity, to meet various user needs.

Thus, the Mod4L project recognised the need for development of practice models to be grounded in authentic practice, alert to differences of community and of purpose. It adopted a teacher-led approach to learning design that has been tested in several countries, including the UK, Australia, New Zealand, and Hong Kong (Littlejohn & Pegler, 2007). Working closely with a focus group of 15 teachers from higher and further education, with a wide range of disciplinary backgrounds, the project identified, discussed, and evaluated different types of representation of learning designs and their potential for representing practice models (Falconer et al., 2007). These discussions took place at face to face workshops and online in the project wiki (http://www.mod4l.com/tiki-index.php). From them emerged five overarching issues with the representation of practice models and learning designs. Two of these issues, community and purpose, had already been highlighted in the literature; the project explored them and provided additional evidence for their importance. The remaining three issues, product vs. process, granularity, and characterising representations, had only been touched upon in earlier studies in a representational context, but emerged clearly from Mod4L discussions. Detailed analysis of these issues forms the main focus of this chapter, following a more detailed discussion of the background to the idea of practice models.

BACKGROUND

"Design for learning" has been defined as "designing, planning and orchestrating learning activities as part of a learning session or programme" (JISC, 2006). A "learning design" or "pattern" is the outcome of this design process. We follow emergent convention here in distinguishing between "learning designs" (lowercase "l" and "d") as defined above and Learning Designs, which are a specific representation of learning design conforming to the IMS LD (Learning Design) specification. The uses of learning designs are discussed by Bennett, Agostinho, and Lockyer (2005), while the distinction between learning designs and patterns is apparent in Goodyear (2005) and McAndrew (2004). A learning design may be of any degree of granularity, from a course to an individual activity. We will take it that the scope of the design is determined by the learning objectives to be met: a design contains the activities required to meet a learning objective. .

The design may exist purely in the head of the teacher implementing it, but, as pointed out by Vogel and Oliver (2006), "in order to be comprehended by others, designs must also be represented or articulated." The issue of representation of learning designs is then central to the concept of sharing and reuse. As discussed in the introduction, learning designs have been represented in a number of different ways. However, while many of these representations clearly convey the "orchestration and planning" aspects of the JISC definition, there is some debate over the extent to which they communicate the "design" aspect which is taken to encompass pedagogic intent (Griffiths, 2004). Thus, a learning design communicates more than just the sequence of activities; it expresses also the relationship between the activities and the path between them. This relationship reflects the pedagogic intent of the design and communicates why these particular activities are orchestrated in this particular way to achieve a specified purpose. For many teachers, pedagogic intent is the primary feature of a design; it comes first before any attempt is made to decide upon a methodology, activity, or pathway (Beetham, 2005; Griffiths & Blat, 2005). In a concrete, technical example, the distinction being made between "orchestration" and "design" is that made between a SCORM (Shareable Content Object Reference Model) content package (http://www.adlnet.gov/scorm/index.aspx) that specifies the orchestration of content resources and an IMS Learning Design unit of learning that describes the pedagogic relationship between roles, activities, and content resources (Britain, 2004). Thus, whether a representation of a lesson or course counts as a learning design depends on, among other things, whether it can convey this element of pedagogic intent and rationale.

The other crucial aspect of design is action to realise the intent. This action might be taken by the teacher or by a machine (computer). In traditional, face to face teaching, it is taken by the teacher when implementing the design with a class of students; that is, the teacher takes the action in real time when teaching a lesson. The design is a preliminary plan and the teacher on the spot has up to date information and is in a position to decide on appropriate action to realise pedagogical objectives.

When the action is largely taken by a computer, there is less scope for decision making during runtime. The possible actions have to be specified in advance, so decisions about action have to be separated from instantiation of the design. The difficulty many teachers find in doing this has been noted by advocates of IMS Learning Design, who view it as a "breakdown in design" (Griffiths, 2004; Griffiths & Garcia, 2003). They argue, though, that it is necessary to overcome this difficulty in order to automate learning designs to handle large numbers of students. They further argue that such a separation is beneficial to teachers in giving them a chance to reflect on their practice, and to share and reuse designs (e.g., Britain, 2004). Whether such a separation between decision and instantiation is even beneficial is contested by Engstrom (1999), Taylor and Richardson (2001), and Vogel and Oliver (2006) who contend that detailed specification of decisions in advance and out of the immediate teaching context reduces teachers' ability to be creative and to develop their own teaching constructively.

All seem to agree, though, on the potential benefits of "practice models." Unlike the specific instances of learning designs discussed above, practice models are generic and hence have a wider range of potential uses: they describe a range of learning designs that are found to be effective and offer guidance on their use; they support sharing, reuse, and adaptation of learning designs by teachers, and also the development of tools, standards, and systems for planning, editing, and running the designs. Acknowledging the importance of representation for communicating learning designs, an alternative definition is that practice models are: *"Common, but decontextualised, learning designs that are represented in a way that is usable by practitioners (teachers, managers, etc)"* (Falconer & Littlejohn, 2006).

Practice models could potentially fulfil the demands of technical developers for generic forms or patterns that model best practice without prescribing specific action, as evidenced in the discussions of the UNFOLD project (Burgos & Griffiths, 2005; Griffiths & Blat, 2005). These demands reflect a "plum pudding" model of practice models—a template that can be populated with specific resources for instantiation. They are attempting to find a representation of teaching practice that is technically specific enough to be machine operable, and yet expressive enough to encompass the entire range of teaching practice. The IMS Learning Design specification (http://www.imsglobal.org), which provides a language which has the ability to express many different pedagogical approaches, is currently the leading contender, but it is so expressive that it leaves the learning designer with too much choice. Practice models are seen as a way of limiting the choices to those that have been found to be effective (Griffiths & Blat, 2005). To be of use to these developers, any representation of practice models should be mappable to IMS Learning Design. Such a mapping has recently been undertaken for the learning design "nuggets" representation produced by the DialogPlus toolkit, an online resource intended to guide and support teachers as they create, modify, and share learning activities and resources (http://www.nettle.soton.ac.uk/toolkit/Default.aspx; Bailey, Zalfan, Davis, Fill, & Conole, 2006).

The problem of choice is particularly acute when modeling social constructivist or situative teaching practice, where a large element of the intent of the design is to pass control of decision about actions to the student: the action becomes a necessary part of realisation of the design and is context-specific (Jonassen, 1994). Any advance specification of action can provide only a framework and support environment based on general principles (Lefoe, 1998). This problem has not really been grappled with by teachers and learning designers who still tend to assume a need for teachers to control action (possibly mediated by computer) to realise the intent of the design (Dyke, Conole, Ravenscroft, & de Freitas, 2007). However, research in learning networks is beginning to tackle alternative approaches to enabling student-centred learning without teacher control (e.g., Van Bruggen, Rusman, Giesbers, & Koper, 2006). In response to these demands, a number of projects are establishing collections of learning design patterns. The E-LEN (http://www2.tisip.no/E-LEN/) and TELL (http://cosy.ted.unipi.gr/TELL/media/TELL_pattern_book.pdf) projects cover a wide range of educational activities, while the PADI project concentrates on patterns for assessment of inquiry-based activities (http://padi.sri.com/; DeBarger & Riconscente, 2005). Such patterns, however, are little used by teachers at present. As noted by Griffiths and Blat (2005), "the underlying concepts of the LD modelling language which make it possible to express a wide range of pedagogies are not complex. They are, however, not the same concepts that a teacher uses to think about in planning educational activities." To aid teachers in using IMS Learning Design, the TELL project has developed the Collage tool, a learning design editor based on patterns and aimed specifically at teachers (Hernandez-Leo, Villasclaras-Fernández, Asensio-Pérez, Dimitriadis, Jorrín-Abellán, Ruiz-Requies, & Rubia-Avi, 2006). The IMS LD for Practitioners project (http://www.hope.ac.uk/ld4p/index.htm) has a similar aim but is not patterns based.

From a teachers' perspective, the purpose of practice models is to save time and/or improve quality by providing guidance in moving away from conservative didactic methods of teaching towards more effective constructivist and situative approaches (Beetham & Sharpe, 2007). At the same time, the models should provide the freedom to be tailored to specific learning contexts. Suitable representations that prioritise the concepts and elements that teachers use would, it is envisaged, help teachers meet the demands of increasing student numbers and diversity, by supporting sharing and reuse of tried and tested learning designs. Attempting to find such representations was one of the original aims of the Mod4L project.

It appears then, from this discussion, that while teachers and learning technologists have a shared concern in practice models as an aid to scalability of teaching, their other interests in practice models are not necessarily convergent, and may, indeed, prove divergent. In the rest of this chapter, we discuss these needs in more detail in the light of the outcomes of the Mod4L project, looking at the issues that emerged from focus group discussions, of:

- Purpose
- Design: product vs. process
- Granularity
- Community
- Characterising representations of learning designs

MAIN FOCUS

Purpose of Practice Models

If we return to the initial definition of practice models as "*generic approaches to the structuring and orchestration of learning activities…[which] support effective practice in design for learning*" (JISC, 2006), with the implication that these would support sharing, reuse, and improved teaching practice, then practice models have at least three concurrent purposes. They are expected to:

- Be generic
- Detail sequence and orchestration
- Inspire teachers to implement them and hence change practice

There are plenty of examples to show that any two of these requirements can be realised together. However, achieving all three at once appears to be a holy grail. For example, the UML diagrams of IMS Learning Design (e.g., IMS, 2003) provide different visual representations of generic learning design sequences, while the use cases of the Learning Activity Design in Education (LADIE) project provide text-based generic sequences (http://www.elframework.org/refmodels/ladie/ouputs/usecases/). Both are primarily aimed at technical developers. Generic representations of sequences aimed at teachers have been less successful. Both LAMS (http://www.lamsinternational.com/) and the Australian Universities Teaching Council (AUTC) project (http://www.learningdesigns.uow.edu.au/) have found that teachers use generic designs far less than contextualised ones with a ratio of contextualised to generic sequence downloads of around 10:1 (Bennett et al., 2005; Dalziel, 2006). Teachers participating in the Mod4L project found generic descriptions generally uninspiring, a finding that mirrors experience in business contexts (Boisot, 1998). However, while the richly contextualised case studies that teachers are accustomed to using and which Mod4L participants advocated, such as the Otis or the JISC effective practice case studies (http://otis.scotcit.ac.uk/, http://www.elearning.ac.uk/effprac/, http://www.elearning.ac.uk/innoprac/) can provide sequencing information, they are not generic. Similarly, some generic pedagogic models, such as Laurillard's (2004) conversational model or Salmon's (2003) five stages for online discussions, have been widely adopted by teachers but lack information about orchestration and sequencing.

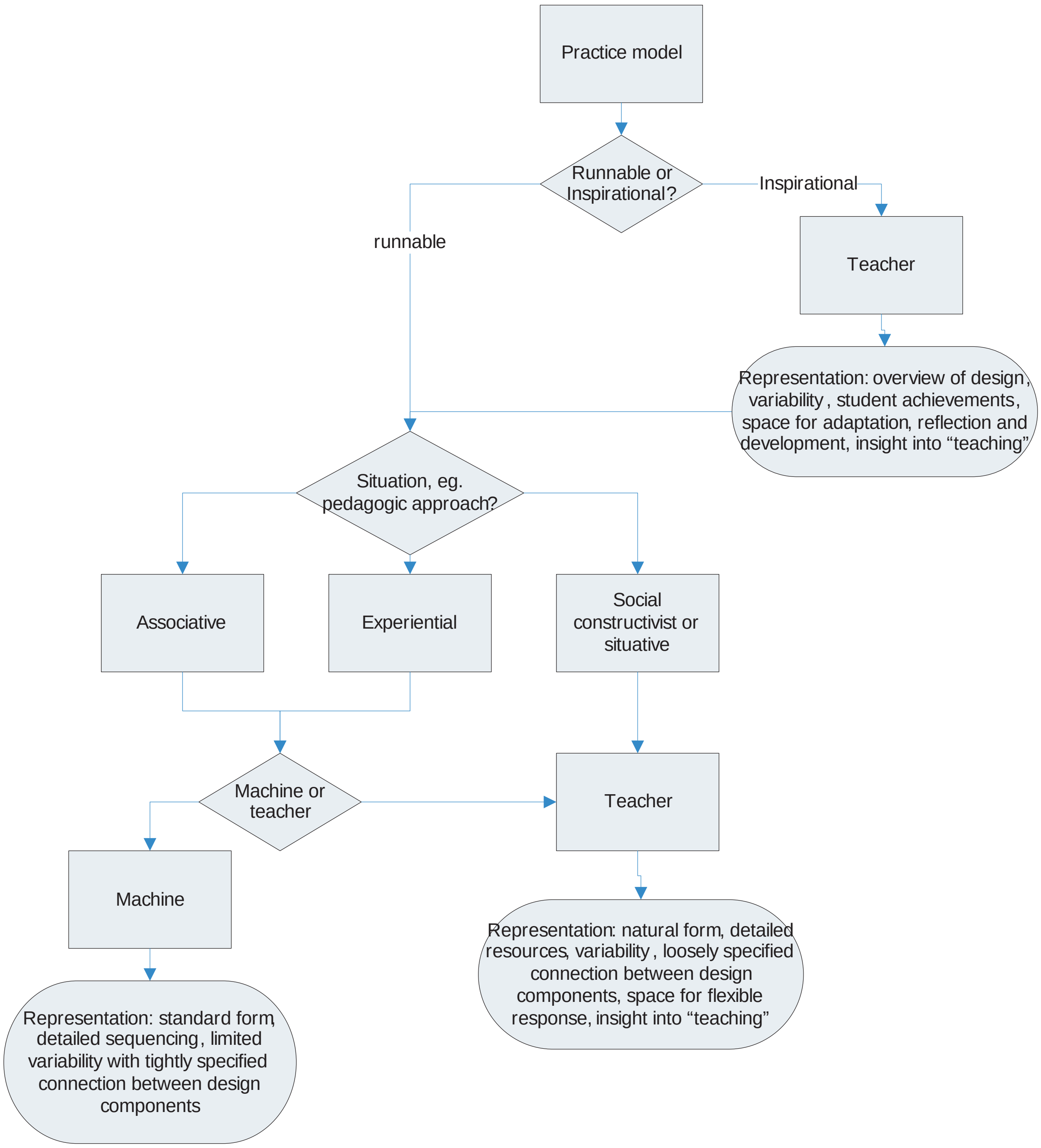
We can begin to understand the problems of achieving all three aims at once when we consider the purposes of practice models in more depth. The three ostensible purposes are superimposed upon a tension in purpose between representation for inspiration or staff development and representation in order to run a design, either using a teacher or a machine, which parallels a controversy that has surfaced at Design for Learning programme meetings over whether we are designing for learning (the runnable design) or designing for teaching (the inspirational design).

These distinctions raise the issue of the audience for the representation. Even if the purpose is to reproduce a runnable design, the needs of those implementing it—teacher or machine—are very different. For both audiences, the structure, sequencing, and orchestration need to be specified in minute detail. However, for the machine, they need to be represented in standardised ways, but the amount of information in any one representation and visual aesthetics of presentation are not a problem. For teachers, the converse is true. Teachers in the Mod4L focus group were very conscious of presentation aesthetics and of information overload and preferred flexible, tailored representations, for example, using natural language and free text.

Consideration of who, or what, is going to run a design raises a further question of purpose: for what purposes or situations might one choose a machine-runnable design and for what might one use a teacher? Adopting Mayes and de Freitas' (2004) characterisation of pedagogic approaches into associative, congntive/constructivist, and situative (amplified by Conole, Littlejohn, Falconer, & Jeffery, 2005), we suggest that purely machine runnable designs have, to date, proved successful generally in situations characterised by well defined problems where associative teaching approaches, presentation of information, and a drill and practice-type activity might be appropriate (Dyke et al., 2007). So far, machines have not achieved the semantic understanding and flexibility of response required by ill defined problems and social constructivist or situative learning designs in which control is passed largely to the students, and the teacher acts as guide, support, and facilitator, that is, in those approaches that are generally considered the most "student centred" and which preclude tightly specified sequences of actions on the part of the teacher or students. These are also the types of approaches that modern pedagogy is likely to be promoting, and hence the focus of "inspirational designs."

The structure of the argument in this section and the implications of considering purpose on the representation of learning designs and the usefulness of practice models is summarised in Figure 1. *The purposes and situations in which teachers might want to use representations of learning designs appear to be those in which detailed specification of sequencing is not particularly useful; insight into intrinsic and tacit aspects of teaching is required.* It seems that, for an audience of teachers, detailed sequencing

Figure 1. Overview of the implications of considering purpose for the representation of practice models (from Falconer et al., 2007)



information is unlikely to be appropriate in either runnable or inspirational designs.

Design Product vs. Process

In the previous section, we have suggested that the situations in which intervention by teachers is most likely to be needed, and which modern pedagogy deems most effective—hence those that practice models are intended to promote—are those in which problems are ill defined and rapid, adaptive, and infinitely variable engagement between teacher, learners, and resources is required.

We would argue that the current metaphor of learning design is ill-equipped to deal with these situations. The metaphor is of design as a product—an engineering or architectural blueprint which specifies the components of the design and the linkages between them. It fails to recognise that the linkages between components vary dynamically in response to a large number of contingent factors that cannot be predicted: the weather, a pertinent news item, and an inspirational remark made by a student are among the circumstances that can enable teacher and learners to make an unexpected jump to a much higher level of understanding than anticipated, or get bogged down in a morass from which they cannot extricate themselves. Even the components are seen not to have constant, specifiable properties when we consider that the meaning attached to them varies from individual to individual according to their pre-existing conceptual framework. This is evidenced in the education literature in debates about the distinction between intended and received learning outcomes, and conceptualised extensively in poststructuralist studies of signifying practices, representation, and meaning (for an overview, see Hall, 1997). In machine runnable learning designs, it is left to the learner to manage the contingency, complexity, and so forth, of how they feel, how they manage their goals and expectations, and how they cope with task demands in practice.

A more helpful approach might be to think of design for learning as two loosely coupled processes. Goodyear (2005) has made this point in distinguishing between the intent and action underlying his finer grained distinction between philosophy, high level pedagogy, pedagogical strategy, and pedagogical tactics. All four together comprise his pedagogical framework, but he notes that the first two are "declarative" or express intent, while the second two are "operational" or express action. However, the intent and action, or declaration and operation, are inextricably linked to each other. The teacher frequently has little time to debate the action and calls on tacit and experiential knowledge developed largely through practice (Eraut, 2004; Falconer et al, 2007; Toulmin, 1999). This active involvement in instantiating a design remains evident among e-learning practitioners as noted in two recent projects: Vogel and Oliver (2006) assessing VLEs as design tools note that their practitioners "rapidly slid off into insights about the experience of *running* the designs"; Masterman (2006), evaluating generic design tools, found a requirement for flexibility in plans allowing for contingency action during the lesson. Thus, teachers see a large part of their role managing the problems of contingency and complexity, enabling their students to learn in the most effective manner. As Goodyear (2005) notes, "it is not uncommon to find strategy [which may be decided in advance] which is really emerging from tactics [fine scale activity during run time]—thus strategy becomes a way of describing the common threads woven by intuitive tactical activity."

It seems then that the production of a plan or blueprint for a lesson is only one part of successful instantiation of a lesson—the plan is one part of a process of design and instantiation which calls upon contextual, tacit, and experiential knowledge. Specifying how to instantiate a design requires capturing intrinsic and tacit aspects of teaching and showing how the plan relates to them. In general, generic, sequenced models do not appear to do this effectively for practitioners: by their nature, they lack the contextual cues that might awaken tacit knowledge. If we take seriously Eraut (2004) and Toulmin's (1999) work on the importance of experience, practice and performance in developing procedural knowledge, we can see that this is not just an issue of not having yet found the right representation; instead it is a theoretical limitation on the usefulness of the practice model concept. In the rest of this chapter, we turn away from the generic and consider issues of representing learning designs for sharing and reuse among teachers more generally.

Granularity

Issues of granularity recur frequently in discussions of learning design. We take a broad view, considering that a learning design may be of any degree of granularity from a course down to an individual activity. Among Mod4L participants, the most common learning designs were of a lesson lasting between one and three hours or a course module of a number of sessions. However, a constant question among Mod4L participants was the amount of detail to include in a representation: too much and the design takes too long to comprehend; too little and vital information is omitted (Falconer et al., 2007). This also raised a major issue for sharing and reuse of designs—the amount of time it takes a teacher to document a design. This problem is exacerbated if teachers do not know who they are writing for—as is often the case when depositing in a repository:

This issue of detail is clearly related to that of granularity: a smaller design, consisting of just one simple activity, can be more easily described and comprehended in detail than a larger design of several complex activities (Boyle & Cook, 2001; Downes, 2000). However, the time burden of aggregating lots of reusable granular resources into a complete lesson or course is also a barrier to teachers. Thorpe, Kubiak, and Thorpe (2003) propose an "inverse" relationship between "size" and "educational usefulness." Furthermore, there is a link between the type of representation and the type of granularity it can usefully represent. Discussions between Mod4L participants suggested that the way in which an institution chooses to "chunk" learning, for example, into one hour sessions, is likely to impose a granularity on the design and thus on the useful representations (Falconer et al., 2007).

If the plan can call upon a teacher's existing knowledge of context, or experience, then these aspects need not be spelled out. But if it is new, either in the procedures it invokes or in the context of use, then these need to be described and their relationship to the plan made clear. This is a factor that limits the potential usefulness of learning designs for changing practice; Mod4L participants were emphatic that they needed to be able to "envisage" themselves teaching a new lesson before they would adopt it (Falconer et al., 2007). The larger the design gets, the worse the situation is likely to become. Thus, it seems that the most effective "designs" for changing practice—because the most readily describable in sufficient detail while remaining succinct—may be at the level of single activities (with associated briefing and feedback) if they use new teaching practices, or alternatively new combinations of familiar activity types.

Communities

It appears then that in representing practice models or learning designs, knowing one's audience is vital. Templates, such as the JISC Effective Practice planner (http://www.elearning.ac.uk/effprac/documents/casestudytemplate.doc) or the LADIE reference model pedagogy guide (http://www.elframework.org/refmodels/ladie/guides/LARM_Pedagogy30-03-06.doc) can provide guidance on what to include, but they need to be chosen with the target audience in mind. The JISC Effective Practice planner, for example, takes a relatively high level approach and is aimed at documenting for other teachers, whereas the LADIE guide elicits considerable detail about sequencing of activities and is aimed at helping teachers communicate with technical support staff.

Thus, the question of community of use appears to affect not only the size of the unit of learning which it might be effective to try to document but also the granularity and even the structure of the documentation. For example, while a teacher might see three components in a learning activity, initial briefing, main task, feedback and assessment, a learning design system such as LAMS would break the activity down by the technology or tool employed.

Documenting for other people is only one half of sharing and reuse, though. Community is equally important in adopting new practices from others. Teachers are in the position of learners as they change their practice, and the formation of a community and dialogue around a practice is essential to helping to internalise the practice so that it can be performed competently (Eraut, 2004; Toulmin, 1999). This theoretical view is supported by Sharpe et al.'s (2004) finding that the most effective representations in changing practice were those around which teachers could interact with colleagues. Our experience on the Mod4L project has been similar. The need for community was stated clearly by participants at our first workshop, and we found that to a large extent, the nature of the representation that we have confronted them with has been immaterial; what has been crucial is the role of the representation as a focus for discussion within the participant community. This conclusion is borne out by the success and amount of activity generated around the "Best Practice Models for e-Learning" Moodle site based at Staffordshire University (http://crusldi1.staffs.ac.uk/moodle/course/info.php?id=9).

Characterising Representations of Learning Designs

The features of a representation of a learning design that make it effective for sharing and reuse can be characterised in a number of ways. Littlejohn et al. (2006) have discussed a number of frameworks for characterising effective e-learning resources more generally, including:

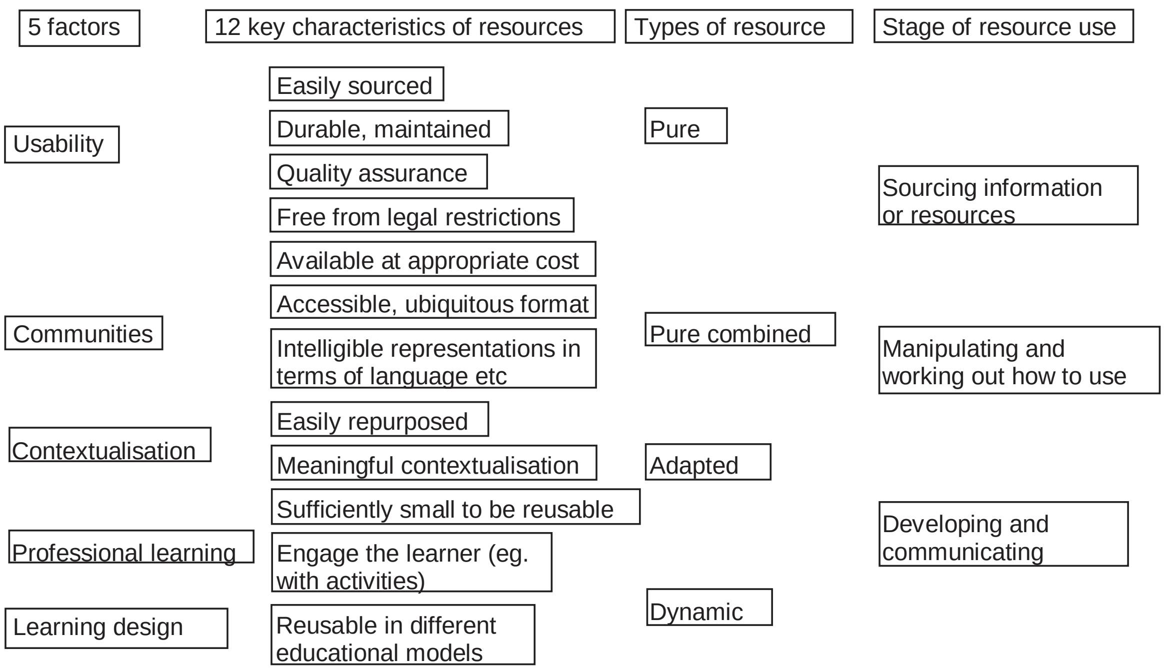
- Stages of a learning cycle
- Degree of embeddedness of information content (digital asset, information object, learning activity, learning design)
- Representation, medium, and format
- Mode of use based on Laurillard's conversational model (narrative, communicative, interactive, adaptive, productive)
- Degree of adaptation

They identify 12 pragmatic usability characteristics of effective resources. These are listed in Figure 2, where they are mapped against the five essential principles for effective resources identified by Sharpe and Oliver (2007) and the stage of use and degree of adaptation at which these characteristics become important. Learning designs are one type of resource for supporting e-learning practice, and this figure highlights the complex interaction of characteristics, including purpose and use of the resource as well as usability, necessary for their representation to be effective; what is effective for one purpose or use may not be effective for another.

The characteristics and factors identified in Figure 2 impact on the decisions made in documenting a design at the five layers of communication identified by Burn (in press) and Kress and van Leeuwen (2001):

1. **Knowledge:** of what is to be communicated (e.g., an innovative teaching practice). In general, the learning designs documented by teachers concentrate on factual information

Figure 2. Factors likely to positively influence the use of a resource (from Littlejohn et al., 2006)



and descriptions of processes (Falconer et al., 2007). Pedagogical knowledge or model is often included, either in a heading, or gloss or reflection on the approach.

2. **Design:** choice of mode of representation (e.g., language, visual, audio). Teachers' representations of learning designs generally use natural language to some extent, frequently in the form of narrative accounts. Concept maps, flow diagrams, and video are also occasionally used (Falconer et al., 2007; Falconer & Littlejohn, 2006).
3. **Production:** choice of medium (e.g., paper, Web site). Simple documents, either paper based or presented on a single Web page seem to be prevalent among teachers, although individual participants in the Mod4L project also used video created in MS Producer, and a computer-based concept map with drill-down facilities. One participant suggested a real-time instantiation using a fishbowl technique as the means of production, as described in Prideaux, Gannon, Farmer, Runciman, and Rolfe (2001), although noting that this was difficult to distribute in bulk (Falconer et al., 2007).
4. **Distribution:** choice of technology for distribution to audience (e.g., print, podcast, Web site). Text-based accounts are easy to disseminate either in print or on a Web site. Video and concept maps, comprising large numbers of linked files may be more problematic; for example, they proved impossible to upload to the Mod4L project wiki, although they could be distributed on CD or data stick.
5. **Interpretation:** by audience.

Our use of the term "representation" is encompassed by the design, production, and distribution layers as the teachers documenting their practice embeds the meaning they intend to convey in the representation. The way they do this has consequences for the ability of the audience to interpret the representation, and has three dimensions according to Lemke (2002):

1. **Presentational** (e.g., the information content, aims and objectives, evaluation). Lists of the elements necessary to provide a meaningful description of a learning design have been suggested by Currier, Campbell, and Beetham (2005) and Falconer et al. (2007, in press) who also map these elements against four stages of sharing and reuse at which they become important, and evaluate the ability of a number of types of representation to support these elements.
2. **Orientational** (e.g., cues that allow the audience to orient themselves to the practice represented, for example, by relating it to familiar experience or surfacing tacit knowledge). Such cues may relate the design to external resources used or the benchmarks met or alert the audience to their role in the design. For example, a design may contain instructions ("explain," "display students' work") that make clear that this is a representation for the teacher and that it is their responsibility to lead the lesson. A contents list of topics covered and links to resources contains no such cues and might be equally applicable to teacher, student, or programme leader. One problem for teachers with the AUTC temporal sequence method of representation (Oliver & Herrington, 2001) is that the student role forms the central focus, and teachers found it difficult to see where they fit in (Falconer et al., 2007).
3. **Organisational** (e.g., links and patterns that ensure coherence of the representation as a whole—this is particularly important in a multimodal representation of a learning design such as those proposed by pedagogic planner tools being developed as part of the JISC Design for Learning programme (http://phoebe-project.conted.ox.ac.uk/cgi-bin/trac.cgi, http://www.wle.org.uk/d4l/) or a hyperlinked representation with drill down features). In the majority of text-based designs, headings, standard templates, and matrix formats are used to organise the information and ensure coherence.

Organisational coherence is also very important to teachers at the higher level of the repository. A potential problem with richly contextualised case studies is the time taken to read and digest them—especially if they subsequently turn out not to be suitable for the purpose in mind. Our Mod4L participants were emphatic that case studies should have a brief overview to allow rapid diagnosis of likely suitability, and that they should be in a standard format to aid rapid discovery of required information. One participant recommended the ReadWriteThink Web site (http://www.readwritethink.org/index.asp*):*

Most lessons have a similar structure/sequence of activities. …The brief overview lets you quickly identify if this particular lesson is of use to you without having to waste time reading extensive notes before realising it isn't of use to you. The section on theory to practice outlines the pedagogical justifications. Each section has links to resources.

An alternative characterisation of learning designs, by pedagogic model, is often suggested and, indeed, was one of the original aims of the Mod4L project. However, an issue for such a characterisation is that most of the learning designs combine a number of different models, either explicitly or implicitly. This finding echoes that of other projects (see LADIE use cases, http://www.elframework.org/refmodels/ladie/ouputs/usecases/;

Phoebe pedagogic planner, http://phoebe-project.conted.ox.ac.uk/cgi-bin/trac.cgi; Seale, Boyle, Ingraham, Roberts, & Mcavinia, 2007). This sometimes happens for sound pedagogic reasons (such as providing for differentiation), but sometimes because of external constraints. One Mod4L participant commented explicitly that she would like to be more constructivist, but was constrained by Scottish Qualifications Authority requirements to teach to highly specified outcomes.

DISCUSSION

The idea of design for learning offers practical benefits to teachers in terms of improved teaching quality and efficiency. However, before these benefits can be realised, there are a number of organisational and representational issues to overcome.

Why Construct Representations? Identification of the Reasons for Representing Practice

Users exhibit a range of motivations for representing practice, most of which are related to quality and efficiency of learning and teaching. However, approaches to building practice models have thus far not taken into consideration the specific purposes of models. This is unhelpful, since the purpose is directly linked to the types of representations that will be useful. Therefore, careful consideration of the purposes of using representations should be an important aspect of design for learning.

Who Will Use the Representation?

Several studies have highlighted that teachers, educational or instructional designers, and technical developers require very different forms of representation. While generic, or decontextualised, designs may be interesting for technical developers, they do not appear to be very useful to teachers. A prerequisite for effective representations is that they should be meaningful and useful to their intended user community. While a range of representation types have proved useful for teachers, the precise form and combinations of these representations depends on the purpose and context of use.

Multiple Representations Needed to Meet Different User Needs

The type of representation that will be useful will vary according to the user needs. A major influencing factor is whether the user is seeking a “runnable” representation or a representation that will “inspire” his or her practice. These two situations require different types of representation: a runnable representation requires a degree of detail, whereas inspiration could be generated through a broad overview of design. This means that in order to be useful, the same design should be represented in different ways. In general, multiple perspectives are necessary—it is unlikely that one type of representation is sufficient to represent all aspects of practice at a range of levels of granularity. Even a single user generally requires multiple perspectives suited to differing processes during planning or adaptation of a design. Therefore, it is important to use effective combinations of representations to suit different user groups and contexts.

Representing Design As a Process

Few representations to date have succeeded in capturing the *essence* of a good piece of teaching. Ways of representing designs as dynamic processes, rather than static products, may need to be developed. These representations would provide insight into the tacit knowledge that informs flexible changes in teaching tactics that teachers adopt during real-time learning situations—for example, different ways in which they interact with students and offer feedback, depending on the context. From this, it could be contended that highly contextualised representations are most useful for many teachers and for a variety of purposes. It is unlikely teachers will gain insight from representations alone. There is strong evidence to suggest that the dialogue teachers engage in around representations is an important aspect of representing practice. Therefore, it is important that representations are used within and across communities of practice.

The implications for teachers and technical developers of viewing design for learning as a process, rather than production of a blueprint, need investigating. In particular, for purposes of staff development and representing designs for inspiration, the effectiveness of practice models appears limited; it might be more helpful to develop an enhanced domain map for learning design embedded in a discursive community of practice. Like Dyke et al. (2007), we suggest that teachers are operating in a rich and dynamic e-learning environment. Like any organism, they have to learn to adapt to their environment, knowing not only what features are there, but also how to gain maximum benefit from those features in a rapidly changing context (Falconer, in press). The domain map would extend that for learning activities developed by the LADIE project (http://www.elframework.org/refmodels/ladie/guides/), providing an account of learning design practices and a specification of the technological services supporting them. It should be allied to richly contextualised case studies of innovative practice, which would evidence both the design and the role of tacit and experiential knowledge and provide an indication of how expertise might develop and be supported by collaborative and community building activities and tools for teachers

This is not to say that practice models as conceived at the outset of the Mod4L project have no value. They do, but it seems unlikely that it will be in changing teaching practice. One area in which they may have considerable value is in communicating the needs and expertise of teachers to technical developers. The use cases of learning activities developed on the LADIE project are a type of practice model aimed at a technical audience and provide an example of such a use (http://www.elframework.org/refmodels/ladie/ouputs/usecases/). Here, they were used as a stage in the development of a learning activity domain map or reference model along the lines that we are suggesting.

CONCLUSION

We have surveyed the background to, and rationale for, the idea of practice models, intended to promote the sharing of effective e-learning practice, which informed JISC's decision to fund the Mod4L practice models project. This survey, though, reveals tensions in the underlying reasons for practice models, with teachers and technical developers expressing different interests in the models. The teacher-grounded methodology of the Mod4L project brought the teacher perspective into sharp focus from which five representational issues emerged: purpose, design as a process, granularity, community, and characterisation. The purpose of a practice model, in particular, appears critical to decisions about its representation. A fundamental distinction became evident in discussions between "runnable designs" and "inspirational designs"; the two have very differential representational needs. Teachers on the project were uninspired by generic designs of any description, and we have analysed the reasons for this in terms of the pedagogical contexts in which a model might be used and the prevailing metaphor of learning design as a product rather than a process, suggesting that this is a theoretical limitation on the usefulness of practice models rather than a matter of not yet having found the right representation.

Practice models remain of use to technical developers, but we suggest that contextualised learning designs are likely to be more effective in changing teaching practice. Issues of granularity and community, however, can qualify this statement, suggesting that effective models may be at the level of single activities if they use teaching practices that are new to a community, or alternatively new combinations of familiar activity types. Communities also play a second crucial role in embedding new practices, and we have emphasised the importance for the success of practice models or learning designs of supporting community discussion and interaction around them.

Finally, we have discussed a number of frameworks for characterising learning designs and practice models. In particular, we examined the Mod4L participants' discussions of the representation of learning design in terms of five layers of communication and three dimensions of interpretation. These communicative and interpretative characteristics interact with previously identified characteristics of effective resources; all need to be well aligned with the user's needs of a design or model in a given context, and it becomes why a number of different representations of the same design will be necessary to match different purposes.

REFERENCES

Bailey, C., Zalfan, M. T, Davis, H. C., Fill, K., & Conole, G. (2006). Panning for gold: Designing pedagogically inspired learning nuggets. *Educational Technology & Society*, *9*(1), 113-122.

Beetham, H. (2001). How do representations of practice enable practice to change? *Educational Developments, 2*(4), 19-22.

Beetham, H. (2005). *Draft template for describing a unit of (e)learning.* Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/Describing%20practice%20v12.doc

Beetham, H., & Sharpe, R. (Eds.). (2007). *Rethinking pedagogy for the digital age*. London: Routledge.

Bennett, S., Agostinho, S., & Lockyer, L. (2005). Reusable learning designs in university education. In T. C. Montgomery & J. R. Parker (Eds.), *Proceedings of Education and Technology (ICET) 2005.* ACTA Press.

Boisot, M. (1998). *Knowledge assets: Securing competititve advantage in the information economy.* Oxford: Oxford University Press.

Boyle, T., & Cook, J. (2001). Towards a pedagogically sound basis for learning object portability and re-use. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Proceedings of ASCILLITE 2001* (pp. 101-109). Retrieved March 25, 2008, from www.ascilite.org.au/conferences/melbourne01/pdf/papers/boylet.pdf

Britain, S. (2004). *A review of learning design: Concept, specifications and tools.* Report for the JISC E-learning Pedagogy Programme.

Burgos, D., & Griffiths, D. (2005). *Unfold booklet.* Heerlen: Open University of the Netherlands. Retrieved March 25, 2008, from www.unfold-project.net/project/UNFOLDbooklet.pdf

Burn, A. (in press). The case of *Rebellion*: Researching multimodal texts. In C. Lankshear, M. Knobel, D. Leu, & J. Coiro (Eds.), *Handbook of research on new literacies.* New York: Laurence Erlbaum.

CIHE. (2002). *The Council for Industry and Higher Education, Response to the joint consultation document from HEFCE and the Learning and Skills Council.* Retrieved March 25, 2008, from www.cihe-uk.com/partnershipsfor.php

Collis, B., & van der Wende, M. (2002). *Models of technology and change in higher education* (p. 85). Twente: Center for Higher Education Policy Studies (CHEPS).

Conole, G., Littlejohn, A., Falconer, I., & Jeffery, A. (2005). *Pedagogical review of learning activities and use cases*. LADIE project report. Retrieved March 25, 2008, from www.elframework.org/refmodels/ladie/ouputs/LADIE%20lit%20review%20v15.doc

Currier, S., Campbell, L., & Beetham, H. (2005). *JISC Pedagogical Vocabularies Project*. Report 1: Pedagogical Vocabularies Review. Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/PedVocab_VocabsReport_v0p11.doc

Dalziel, J. (2006). *The design and development of the LAMS Community*. Retrieved March 25, 2008, from www.lamscommunity.org/dotlrn/clubs/educationalcommunity/lamsresearchdevelopment/forums/message-view?message_id=311748

DeBarger, A. H., & Riconscente, M. (2005). *An example-based exploration of design patterns in measurement* (PADI Tech. Rep. No. 8). Menlo Park, CA: SRI International.

DfES (Department for Education and Skills). (2001). *Education and skills: Delivering results a strategy to 2006*. Norwich: TSO.

Downes, S. (2000). *Learning objects*. Retrieved March 25, 2008, from www.newstrolls.com/news/dev/downes/column000523_1.htm

Dyke, M., Conole, G., Ravenscroft, A., & de Freitas, S. (2007). Learning theory and its application to e-learning. In G. Conole & M. Oliver (Eds.), *Contemporary perspectives in e-learning research* (pp. 82-98). London: Routledge.

Engestrom, Y. (1999). The emergence of learning activity as a historical form of human learning (chap. 2). In *Learning by expanding*. Retrieved March 25, 2008, from http://communication.ucsd.edu/LCHC/MCA/Paper/Engestrom/expanding/toc.htm

Eraut, M. (2004). Informal learning in the workplace. *Studies in Continuing Education, 26*(2), 247-273.

Falconer, I. (2007). Mediating between practitioner and developer communities: The LADiE experience. *ALT-J, 15*(2), 155-170.

Falconer, I. (in press). Designing for learning: In search of a metaphor. *Computers and Education*.

Falconer, I., Beetham, H., Oliver, R., Lockyer, L., & Littlejohn, A. (2007). *Mod4L final report: Representing learning designs*. Retrieved March 25, 2008, from http://mod4l.com/tiki-download_file.php?fileId=7

Falconer, I., Beetham, H., Oliver, R., Lockyer, L., Pegler, C., & Littlejohn, A. (in press). Representing learning designs for sharing and reuse. *J-CAL on Supporting Sustainable e-Learning*.

Falconer, I., & Littlejohn, A. (2006). *Mod4L report on case studies, exemplars and learning designs*. Retrieved March 25, 2008, from http://mod4l.com/tiki-download_file.php?fileId=2

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology, 21*(1), 82-101. Retrieved March 25, 2008, from www.ascilite.org.au/ajet/ajet21/goodyear.html

Griffths, D. (Ed.). (2004). *UNFOLD: Transcript of the Barcelona CoP meeting*. Universitat Pompeu Fabra. Retrieved March 25, 2008, from www.unfold-project.net/project/events/cops/f2fbarcelona/transcript/

Griffiths, D., & Blat, J. (2005). The role of teachers in editing and authoring units of learning using IMS learning design [Special issue on Designing Learning Activities: From Content-based to Context-based Learning Services]. *International*

Journal on Advanced Technology for Learning (ATL), 2(3).

Griffiths, D., & Garcia, R. (2003). Commentary on Rob Koper: Combining re-usable learning resources to pedagogical purposeful units of learning (chap. 5). In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to eLearning. Journal of Interactive Media in Education,* Special Issue on Reusing Online Resources. ISSN:1365-893X. Retrieved March 25, 2008, from www-jime.open.ac.uk/2003/1/

Hall, S. (1997). *Representation: Cultural representations and signifying practices.* London: Sage in association with the Open University.

Hernández-Leo, D., Villasclaras-Fernández, E. D., Asensio-Pérez, J. I., Dimitriadis, Y., Jorrín-Abellán, I. M., Ruiz-Requies, I., & Rubia-Avi, B. (2006). COLLAGE: A collaborative learning design editor based on patterns. *Educational Technology & Society, 9*(1), 58-71.

IMS. (2003). *IMS learning design best practice and implementation guide*. Retrieved March 25, 2008, from www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html

JISC. (2006). *Circular for design for learning funding call*. Retrieved March 25, 2008, from www.jisc.ac.uk/index.cfm?name=funding_01_06

Jonassen, D. (1994). Thinking technology: Toward a constructivist design model. *Educational Technology, 34*(3), 34-37.

Kress, G., & van Leeuwen, T. (2001). *Multimodal discourse: The modes and media of contemporary communication*. London: Arnold.

Laurillard, D. (2004). *Rethinking university teaching* (2nd ed.). London: Routledge.

Lefoe, G. (1998). *Creating constructivist learning environments on the Web: The challenge in higher education*. Paper presented at the ASCILITE 1998, University of Wollongong.

Lemke, J. (2002). Travels in hypermodality. *Visual Communication, 1*(3), 299-325.

Littlejohn, A., Falconer, I., & McGill, L. (2006). Characterising effective e-learning resources. *Computers and Education*. Retrieved March 25, 2008, from www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VCJ-4M21SW7-1&_user=128597&_coverDate=10%2F05%2F2006&_alid=521904214&_rdoc=1&_fmt=full&_orig=search&_cdi=5956&_sort=d&_docanchor=&view=c&_acct=C000010621&_version=1&_urlVersion=0&_userid=128597&md5=f6fdcb190e3576b4a7f79a80ade2e108

Littlejohn, A., & Pegler, C. (2007). *Planning for blended learning.* London: Routledge.

Masterman, L. (2006). *The learning design tools project report: An evaluation of generic tools used in design for learning.* Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/LD%20Tools%20Report%20v1.1.pdf

Mayes, T., & de Freitas, S. (2004). *Review of e-learning frameworks, models and theories: JISC e-learning models desk study.* Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/Stage%202%20Learning%20Models%20(Version%201).pdf

McAndrew, P. (2004). *Representing practitioner experiences through learning designs and patterns.* Report to the JISC E-learning Programme. Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/practioner-patterns-v2.doc

McAndrew, P., Goodyear, P., & Dalziel, J. (2006). Patterns, designs and activities: Unifying descriptions of learning structures. *International Journal of Learning Technology, 2*(2), 216-242.

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Mt. Lawley: Edith Cowan University.

Prideaux, D., Gannon, B., Farmer, E., Runciman, S., & Rolfe, I. (2001). Come and see the real thing. In P. Schwartz, S. Mennin, & G. Webb (Eds), *Problem-based learning: Case studies, experience and practice* (pp. 13-19). London: Kogan Page.

Salmon, G. (2003). *E-moderating: The key to teaching and learning online* (2nd ed.). London: Taylor & Francis.

Seale, J., Boyle, T., Ingraham, B., Roberts, G., & Mcavinia, C. (2007). Designing digital resources for learning. In G. Conole & M. Oliver (Eds.), *Contemporary perspectives in e-learning research* (pp. 121-133). London: Routledge.

Seufert, S., & Euler, D. (2004). *Sustainability of e-learning innovations: Findings of expert interviews* (SCIL Report 2). University of St. Gallen.

Sharpe, R., Beetham, H., & Ravenscroft, A. (2004). Active artifacts: Representing our knowledge of learning and teaching. *Educational Developments, 5*(2), 16-21.

Sharpe, R., & Oliver, M. (2007). Supporting practitioners' design for learning: Principles of effective resources and interventions. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for the digital age* (pp. 117-128). London: Routledge.

Taylor, P. G., & Richardson, A. S. (2001). *Validating scholarship in university teaching: Constructing a national scheme for external peer review of ICT-based teaching and learning resources* (No. 01/3, DETYA No. 6683.HERC01A). Australia: Department of Education, Training and Youth Affairs, Evaluations and Investigations Programme, Higher Education Division. Retrieved March 25, 2008, from www.dest.gov.au/highered/eippubs/eip01_3/01_3.pdf

Thorpe, M., Kubiak, C., & Thorpe, K. (2003). Designing for reuse and versioning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to eLearning*. London: Kogan Page.

Toulmin, S. (1999). Activity theory in a new era. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 53-64). Cambridge: Cambridge University Press.

Van Bruggen, J., Rusman, E., Giesbers, B., & Koper, R. (2006). *Content-based positioning in learning networks*. Retrieved March 25, 2008, from http://dspace.ou.nl/handle/1820/576

Vogel, M., & Oliver, M. (2006). *Design for learning in virtual learning environments: Insider perspectives*. JISC Learning Design Tools Project Report. Retrieved March 25, 2008, from www.jisc.ac.uk/uploaded_documents/D4L_VLE_report_final.pdf

KEY TERMS

Design for Learning: Designing, planning, and orchestrating learning activities as part of a learning session or program.

Domain Map: Articulates and maps out an area of activity and its supporting systems and services.

Granularity: The size of a learning resource. The smaller the resource, the higher the level of granularity.

LAMS: A Learning Activity Management System is an electronic learning system that enables teachers to plan and deliver technology-supported learning activities (http://lamsfoundation.org/).

Learning Outcome: Statement of what a learner is expected to know, understand, or be able to do at the end of a period of learning.

Practice Models: Generic approaches to the structuring and orchestration of learning activities. They express elements of pedagogic principle and allow practitioners to make informed choices.

Representation: A way of communicating an idea or concept using text, pictures, audio, and so forth.

Tacit Knowledge: Unarticulated knowledge often acquired unconsciously and through experience.

Chapter III
Using the IMS LD Standard to Describe Learning Designs

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ABSTRACT

IMS learning design (IMSLD) is an open standard that can be used to specify a wide range of pedagogical strategies in computer-interpretable models. Such models then can be played in any learning design (LD) compatible execution environment to support teachers and students to conduct online teaching–learning. This chapter introduces the basic knowledge required to effectively use LD. First of all, we present fundamental principles behind LD. Then, we introduce main concepts and their relations in LD and discuss some technical issues about how to make a learning design executable in a computer-based environment. Finally, how to model learning designs using LD is explained through demonstrating the whole procedure to model a use case in Extensible Markup Language (XML). We expect that the readers of this chapter can apply LD to create simple learning designs and understand learning designs with sophisticated features.

INTRODUCTION

IMS learning design (IMSLD, 2003) is an open standard that is used to code a wide variety of digital courses (called "units of learning" or "units of study") in a formal, semantic, interoperable, and machine readable way. In comparison with other e-learning technical specifications like SCORM (sharable content object reference model), in which a learning process is modeled as a sequence of learning material, LD is strong in the support for the wide range of modern pedagogical approaches that are used today, like active learning, collaborative learning, adaptive learning, and competency based learning. It can also be used to support more informal learning that takes place in communities of practice and learning communities (Koper & Manderveld, 2004a; Koper & Olivier, 2004b; Koper & Tattersall, 2005).

Digital courses developed with LD differ in many aspects from the ones we are currently using in the regular Learning Management Systems (LMSs). The major difference is that it enables an author to specify the complete learning design of a course with all its details explicitly, instead of selecting a restricted set of hardwired designs in the LMS. This means that the designer can specify:

1. the desired type of learning activities, including the related content and services;
2. the desired sequence of learning activities, including adaptation and personalization aspects;
3. the desired way that learning activities are marked as completed (e.g., through self-assessment, a classical test or exam, by a teacher, an advanced assessment procedure or when a certain group result is attained);
4. the desired interaction between different persons in different roles (learners, teachers, designers, experts, assessors, mentors, etc.) and the interaction between these roles and learning objects and learning services (chats, wikis, forums, etc.);
5. the desired reporting of (aggregated) results to an e-portfolio or a student administration, and so forth.

The authored courses can be used for many different course runs in many different situations. Also, before they are used they can be adapted to local needs (e.g., by deleting some of the learning activities or changing aspects of the workflow).

The basic challenge with LD is in the authoring aspects: you can design highly complex courses and implement many different pedagogical interactions, but this requires that you are able to design these interactions (most teachers are not highly skilled as instructional designers) and that you will need to learn to design and to use LD tools in order to produce the learning designs. In this chapter, we will introduce you into the fundamental principles behind LD. To give you a kind of advanced organisor: the basic ideas behind LD before it was developed was the question whether it would be possible to make a kind of standard notation, like the music notation, that enables you to write down learning designs (compose music) at one place and to interpret the learning designs in many places for different users (different musicians, orchestras, bands, etc., all can reproduce songs and music that has been written in a rather similar way). LD is introduced as such a kind of standard notation, which is machine readable (although it is also human readable) to help the users of computers to organize, adapt, and orchestrate their different learning and teaching activities and the access to learning objects and services to an efficient, effective, and synchronized whole for each individual user in any role. In order to explain how to create learning designs using LD clearly, we present the whole procedure to model a learning design by using an use case. We further discuss the issues to model complicated learning designs using LD. In summary, the purpose of this chapter is to answer three questions: why develop LD, what is LD, and how does one use LD?

BACKGROUND

This section discusses the theoretical background to develop LD and the context of the learning design. As a convention, we use "LD" to refer to the IMS LD specification and use "learning design" to refer to the description of a course, a workshop, a seminar, and so on. The central assumption behind LD is that the activities that learners undertake are central in any learning process, for instance, activities like exploring, thinking, discussing, reading, and problem solving. The primary role of any instructional agent, whether it is a teacher, the learners themselves, or a computer, is to stimulate the formulation and execution of learning activities that will gradually result in the attainment of the learning objectives. The instructional agent defines the tasks, provides the contexts and resources to perform the tasks, supports the learner during task performance, and provides feedback about the results. The learning activities that are needed to obtain some learning objectives are in most cases carefully sequenced according to some pedagogical principles. This sequence of learning activities that learners undertake to attain some learning objectives, including the resources and support mechanisms required to help learners to complete these activities, is called a learning design.

LD is based on an abstract model of learning designs, the pedagogical "metamodel" which enables us to represent many different concrete examples of learning designs. Like all models, this model abstracts reality. It must not be confused with the reality itself, and it is not the only model possible describing learning and instruction. This is also true for the learning design in general. Learning designs are something different from what actually happens when they are executed and used in real practice. It is not the intention of a learning design to capture all the details of a course, but only its major points.

Figure 1 provides the context of learning design and indicates the relations among the unit of learning, the learning model, the domain model, and theories of learning and instruction. The unit of learning is the result of learning design. The learning model describes how learners learn based on commonalities (consensus) in learning theories. The domain model describes the type of content and the organization of that content, for example, the domain of economics, law, biology, and so forth. Theories of learning and instruction describe the theories, principles, and models of instruction as they are described in literature or as they are conceived in the head of practitioners. In this section, we will discuss the three aspects related to a unit of learning in detail.

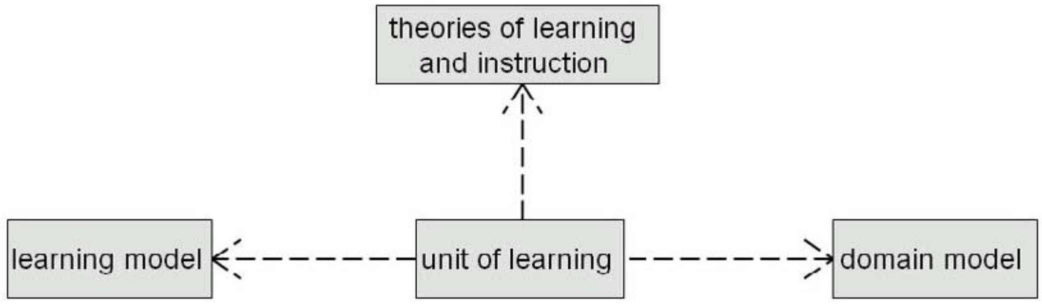
The Learning Model

Figure 2 provides a summary of the learning model.

The learning model is based on the following axioms:

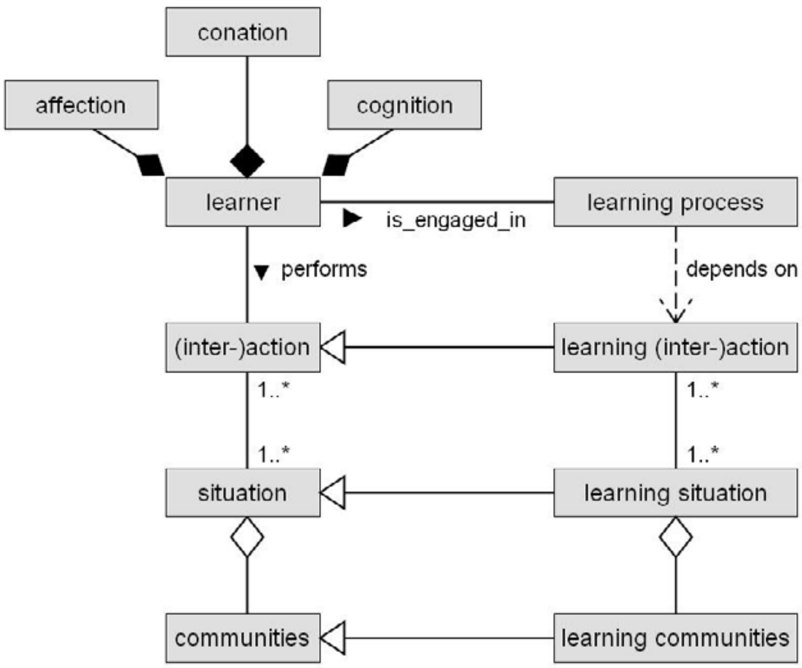
1. A person learns by (inter-)acting in/with the external world.

Figure 1. The context of learning design



2. The real world could be considered to be composed of social and personal situations, which provide the context for actions.
3. A situation is composed of a collection of things and living beings in a specific interrelationship.
4. One part of situations is communities of practice and, more specifically, learning communities.
5. There are different types of learning; the one of interest to us is learning invoked by instructional measures.
6. Learning can be considered a change in the cognitive or metacognitive state. However, changes in the conation and affection can also be considered the result of learning. When a person has learned, he or she can (a) carry out new interactions or carry out interactions better or faster in similar situations or (b) carry out the same actions in other situations (transfer).
7. A person can be urged to carry out specific interactions, if:
   - a person is willing to do so or stimulated to do so (conation/motivation factor);
   - a person is able to do so (cognition factor);
   - a person is in the mood to do so (affection/emotional factor);
   - a person is in the right situation to do so (situational factor).
8. What has been set out here regarding an individual is also valid for a group of people or an organization, even though this does not have to be reducible to individuals.

Figure 2. The learning model



The essence here is that no value judgment is made in these axioms about the following questions:

1. What does a person or a group learn (knowledge, competencies, skills, insight, attitudes, intentional behavior) and in which domain?
2. What kinds of activities must be carried out to learn, for example: observing, describing, analyzing, experiencing, studying, problem solving, experimenting, predicting, practicing, exploring, and answering questions?
3. How should a learning situation be arranged (context, which people, which objects) and what relationship does the situation have to the teaching–learning process?
4. To what extent are the components of the situation present externally and to what extent are they represented cognitively-internally?
5. How, precisely, do the learning and transfer processes occur?
6. How is motivation stimulated?
7. How is the learning result captured?
8. How should activities be stimulated?

The answers to precisely these questions determine the educational philosophy, the instructional model and the more practical design of the units of study. The metamodel provides the semantic framework for the units of study's notational system, alongside the structure of learning environments that was dealt with earlier.

A citation from Duffy and Cunningham (1996, p. 171) in this area:

As the quote from Skinner suggests, everyone agrees that learning involves activity and a context, including the availability of information in some content domain. Traditionally, in instruction, we have focused on the information presented or available for learning and have seen the activity of the learner as a vehicle for moving that information into the head. Hence, the activity is a matter of processing the information. The constructivists, however, view the learning as the activity in context. The situation as a whole must be examined and understood in order to understand the learning. Rather than the content domain sitting as central, with activity and the 'rest' of the context serving a supporting role, the entire gestalt is integral to what is learned.

The Domain Model

Every pedagogical model must take into account the characteristics of the content domain. For example, content domains are mathematics, cultural science, economics, psychology, electrical engineering, law, and so forth. Every content domain has its own structuring of knowledge, skills, and competencies. There are different cultures and communities of practice. Often there are also specifically designed pedagogical models for the domain, for instance, in mathematics teaching. We do not intent to discuss any specific domain model deeply in this chapter.

Theories of Learning and Instruction

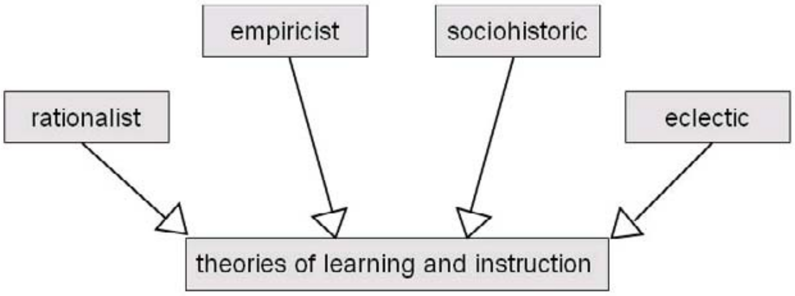
Figure 3 provides a model of the generalization relationships between instruction models.

In educational technology, there are different streams in which the characteristics appear to have what Thomas Kuhn (1962) describes as scientific paradigms. In a meta-analysis, Greeno, Collins, and Resnick (1996) make a distinction between three major streams of instructional theories:

1. empiricist (behaviorist)
2. rationalist (cognitivist and constructivist)
3. pragmatist–sociohistoric (situationalist).

All stances have different views on topics such as knowledge, learning, transfer, and motivation. We will shortly address some of the differences. According to the empirical approach, as typified

Figure 3. Theories of learning and instruction



by Locke and Thorndike, all reliable knowledge is based on experience. Locke said: "There is nothing in the mind that was not in the senses." The assumption is that behavior is predictable, given the specific environmental conditions, and that processes can be analyzed in isolation. The idea is that learning can influence outside of its context and without knowledge of the internal learning processes.

In the rationalist approach, as typified by Descartes and Piaget, thinking is considered the only reliable source of knowledge. In this case, it is supposed that cognition mediates the relationship between a person and the environment. As there is the possibility of large individual differences in cognitive processing, for example, because of differences in prior knowledge (Dochy, 1992), metacognition (Brown, 1980; Flavell, 1979), motivation (Malone, 1981), and learning styles (Vermunt, 1996), the assumption of predictable behavior falls away, and those involved must work with more open, authentic environments in which students themselves can build knowledge. The student is given a central, self-managing role in the educational process (Schunk & Zimmerman, 1994; Shuell, 1988).

The third approach is called the pragmatic and cultural-historic approach, as typified respectively by James, Dewey, Vygotsky, Leont'ev, or in educational theory as social constructivism (Simons, 1999). In this approach, the situation and the cultural-historical context that a learner is in are given primary attention (Cole & Engestrom, 1993; Lave & Wenger, 1991). Knowledge is distributed among individuals, tools, and communities, such as those of professional practitioners. The assumption is that there is collective as well as individual knowledge. Learning is considered the adaptation of behavior to the rules of the community. An important instrument for adapting and acquiring common views is discussion and cooperation in the communities. According to most scholars and practitioners, these streams, or stances, are supplementary and offer different perspectives on the same themes (see also: De Boer, 1986; Greeno et al., 1996; Jonassen, 1999; Molenda, 1991; Roblyer & Edwards, 2000; Sfard, 1998). Just as psychology, economy, and biology look at human behavior in different ways.

Based on these stances, there are, in literature, descriptions of hundreds of more theoretical or practical theories and models of learning and instruction: competency based learning, project based learning, mastery learning, problem based learning, case based learning, experiential learning, action learning, and so forth (see literature like Jonassen, 1999; Kearsley 1987; Merrill, 1980, 1983, 1987, 1988, 1999; Reigeluth, 1983, 1987, 1999). Also lots of more informal teaching plans are available (see, e.g., Eric's lesson plans at: http://ericir.syr.edu/Virtual/Lessons/). Another approach is based on human resource management, mostly referred to as performance improvement (sometimes human performance technology, see Stolovitch & Keeps, 1999, for an overview).

We have also added a fourth type of model: the eclectic model. These are instructional design models using principles from different stances, just for the practical occasion. These models can be explicitly formulated, but mostly they are implicit.

We studied and analysed most of these models. We mapped the commonalities and listed the differences in order to derive the pedagogical metamodel. The metamodel is the core of LD, which will be presented in the The Conceptual Model subsection below.

THE IMS LEARNING DESIGN SPECIFICATION

Above, we presented the theoretical background to develop LD. In this section, we briefly introduce the basic knowledge about LD.

The Requirements

The major requirement for the development of LD is to provide a containment framework that uses and integrates existing specifications as much as possible, and which can represent the teaching–learning process in a unit of learning (UoL), based on different pedagogical models—including the more complex and advanced ones—in a formal way. More specifically, an LD specification must meet the following requirements:

1. The notation must be comprehensive. It must describe the teaching–learning activities of a unit of learning in detail and include references to the learning objects and services needed to perform the activities. This means describing:
    - How the activities of both the learners and the staff roles are integrated.
    - How the resources (objects and services) used during learning are integrated.
    - How both single and multiple user models of learning are supported.
2. The notation must support mixed mode (also called blended learning) as well as pure online learning.
3. The notation must be sufficiently flexible to describe learning designs based on all kinds of theories and so must avoid biasing designs towards any specific pedagogical approach.
4. The notation must be able to describe conditions within a learning design that can be used to tailor the learning design to suit specific persons or specific circumstances.
5. The notation must make it possible to identify, isolate, decontextualize, and exchange useful parts of a learning design (e.g., a pattern) so as to stimulate their reuse in other contexts.
6. The notation must be standardized and in line with other standard notations.
7. The notation must provide a formal language for learning designs that can be processed automatically.
8. The specification must enable a learning design to be abstracted in such a way that repeated execution, in different settings and with different persons, is possible.

The LD specification, following common IMS practice, consists of: (a) a conceptual model that defines the basic concepts and relations in an LD, (b) an information model that describes the elements and attributes through which an LD can be specified in a precise way, and (c) a series of XML schemas (XSD) in which the information model is implemented (the so-called "binding"); (d) a best practices and implementation guide; and (e) a binding document and example XML document instances that express a set of learning requirement scenarios. In the following sections, we will focus on the conceptual analysis work that informed the LD.

The Conceptual Model

LD has been based on the analysis of many different pedagogical models described in the last section and in addition many different lesson plans that can be found on the Internet (Van Es, 2004). We realized that we had to create an abstraction of all these examples because there are so many and also because teachers and designers will not stop formulating new models all the time. Modeling each separate example and then developing tools to support it would be a very inefficient path to follow. For this reason, we aimed at the development of a more abstract notation that is sufficiently general to represent the common structure found in these different pedagogical models. With such a notation, learning designs for concrete courses can be specified that are applications of a specific pedagogical approach.

The pedagogical metamodel that has been developed to represent different kinds of learning designs is at the heart of the LD. It provides the conceptual structure of the specification as well as its underlying theoretical model (see Figure 4).

The core concept of LD, as expressed in Figure 4, is that a learning design can be represented by using the following core concepts: A *person* takes on a *role* in the teaching–learning process, typically a *learner* or a *staff* role. In this role, he or she works towards certain *learning objectives*

Figure 4. Conceptual structure of the LD specification

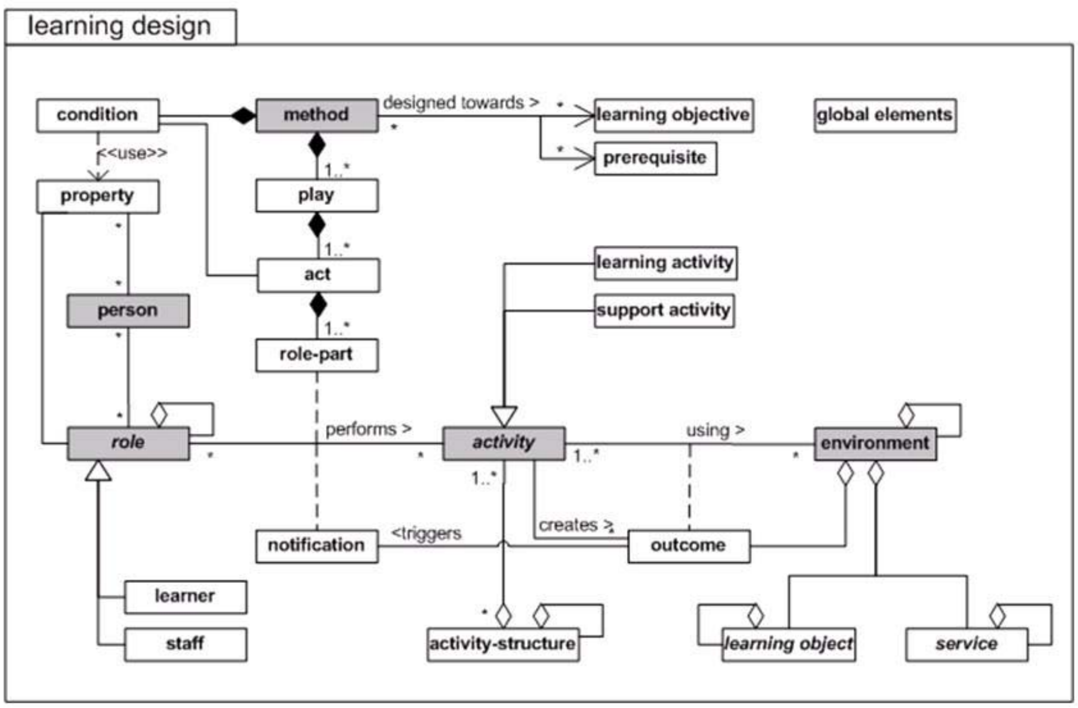
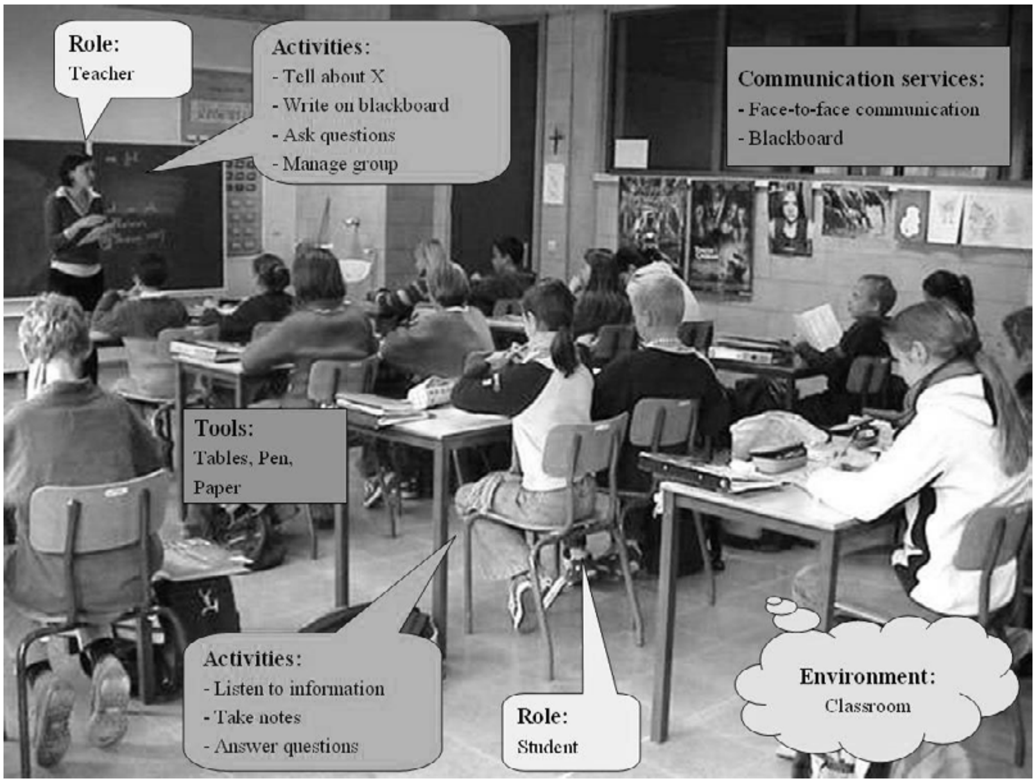


Figure 5. Labeling a classroom setting with LD concepts



by performing *learning* and/or *support activities* within an *environment.* The environment consists of the appropriate *learning objects* and *services* to be used during the performance of the activities. Figure 5 contains an example of the use of these labels in a photograph of a classical learning design: a classroom setting.

You can imagine that this type of labeling is possible on any photograph of any teaching–learning event, whether this is classroom teaching, self-study, group collaborations, field experiments, and so forth. However, photographs are static and the teaching–learning process is dynamic, so labeling of the visible entities is not sufficient. What is needed is an additional process description. This process description is provided in the *method* section of LD. The method is designed to provide the coordination of roles, activities, and associated environments that allow learners to meet *learning objectives* (specification of the outcomes for learners), given certain *prerequisites* (specification of the entry level for learners).

The *method* section is the core part of the LD specification in which the teaching–learning process is specified. All the other concepts are referenced, directly or indirectly, from the method. The teaching–learning process is modeled using the metaphor of a theatrical play. A play has acts, and each act has one or more *role-parts.* Acts follow each other in a sequence, although more complex sequencing behavior can take place within an act. The roles within an act associate each role with an activity. The activity in turn describes what that role is to do and what environment is available to it within the act. In the analogy, the assigned activity is equivalent to the script for the part that the role plays in the act, although less prescriptive. Where there is more than one role within an act, these are "on stage at the same time," that is, they run in parallel. Thus, a method consists of one or more concurrent *play(s)*; a play consists of one or more sequential *act(s)*; an act consists of one or more concurrent *role-part(s)*, and each role-part associates exactly one role with one activity or activity-structure.

The *roles* specified are those of *learner* and *staff*. Each of these can be specialized into subroles. It is left open to the designer to name the roles or subroles and specify their activities. In simulations and games, for example, different learners can play different roles, each performing different activities in different environments.

Activities can be assembled into *activity structures*. An activity structure aggregates a set of related activities into a single structure, which can be associated with a role in a role-part. An activity-structure can model a sequence or a selection of activities. In a *sequence*, a role has to complete the different activities in the structure in the order provided. In a *selection*, a role may select a given number of activities from the set provided in the activity structure. This can, for instance, be used to model situations in which learners have to complete two activities, which they may freely select from a collection of five activities contained in the activity structure. Activity structures can also reference other activity structures and external UoLs, enabling elaborate structures to be defined if required.

Environments contain the resources and references to resources needed to carry out an activity or a set of activities. An environment contains three basic entities: learning objects, learning services, and sub-environments. *Learning objects* are any entities that are used in learning, for example, Web pages, articles, books, databases, software, and DVDs. The *learning services* specify the setup of any service that is needed during learning, for example, communication services, search services, monitoring services, and collaboration services. An example of setup information is the specification of which LD roles have user rights in the learning service. This, for instance, enables automatic setup of dedicated forums each time a LD is instantiated.

A method may contain *conditions*, that is, If-Then-Else rules, that further refine the assignment of activities and environment entities for persons and roles. Conditions may be used to personalize LDs for specific users. An example of such a personalization condition could be: "If the person has an exploratory learning style, then provide an unordered set of all activities," or "If the person has prior knowledge on topic X, Then learning activity Y can be skipped."

The *If* part of the condition uses Boolean expressions on the *properties* that are defined for persons and roles in the LD. Properties are containers that can store information about people's roles and the UoL itself, for example, user profiles, progression data (completion of activities), results of tests (e.g., prior knowledge, competencies, learning styles), or learning objects added during the teaching–learning process (e.g., reports, essays, or new learning materials). Properties can be either global or local to the run of a unit of learning. Global properties are used to model portfolio information that can be accessed in any other unit of learning that is modeled with LD and has access to the same persistent storage for property data. Local properties are only accessible within the context of a specific run of a unit of learning and are used for temporary storage of data.

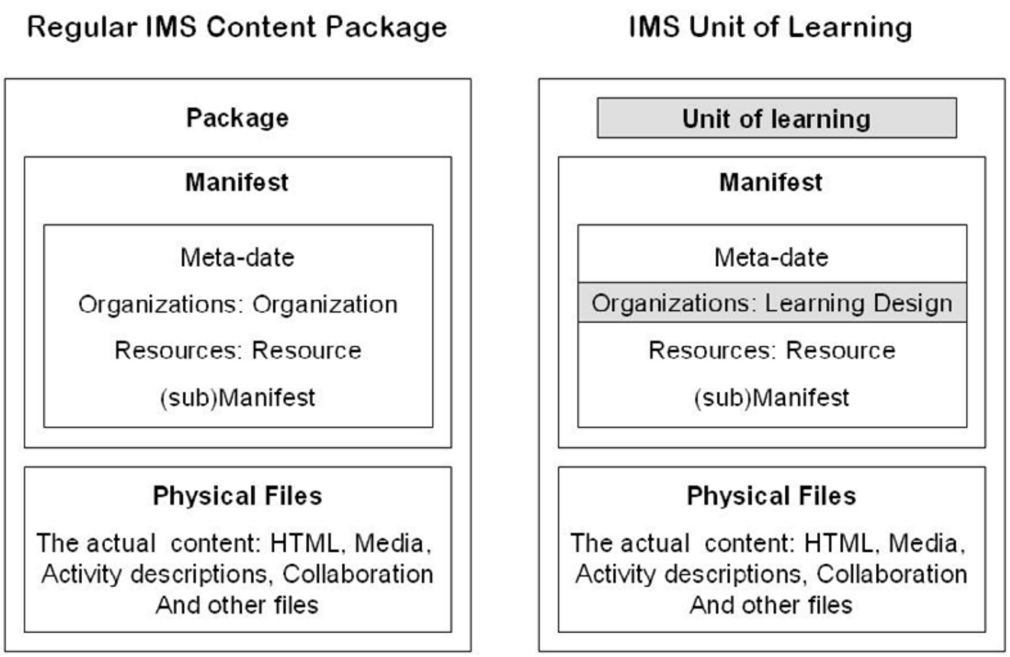
In order to enable users to set and view properties from content that is presented to them, so-called *global elements* are present in LD. These global elements are designed to be included in any content schema through namespaces. Content that includes these global elements is called "imsldcontent." The preferred content schema is XHTML. Global elements can be included in the XHTML document instances to show (or set) the value of a property, for instance, a table with progression data, a report added by a learner, a piece of text or URLs added by a teacher, and so forth.

LD also contains *notifications*, that is, mechanisms to make new activities available for a role, based on certain outcome triggers. These *outcomes* are, for example, the change of a property value, the completion of an activity, or certain patterns in the user profiles. The person getting the notification is not necessarily the same person as the one who triggered the notification. For instance, when one learner completes an activity, then another learner or the teacher may be notified and set another activity as a consequence. This mechanism can be used to model adaptive task setting LDs, where the supply of a consequent activity may be dependent on the outcome of previous activities. General pedagogical rules can also be implemented using the combination of conditions and notifications, for example, "If a user has profile X, Then notify learning activity Y."

The Information Model and XML Binding

The conceptual model has been implemented in XML schemas. With XML, it is possible to codify a concrete learning design in a machine interpretable way. A learning design language is a notation that describes learning designs in a machine interpretable way using any of the standard languages available. IMS has a preference for XML schema, so the LD language we use in practice is in XML. The most obvious use of such a learning design language is that it can be used to codify the learning design of a course (as a

Figure 6. In LD, the organization element of a regular IMS content package is replaced with the learning design elements

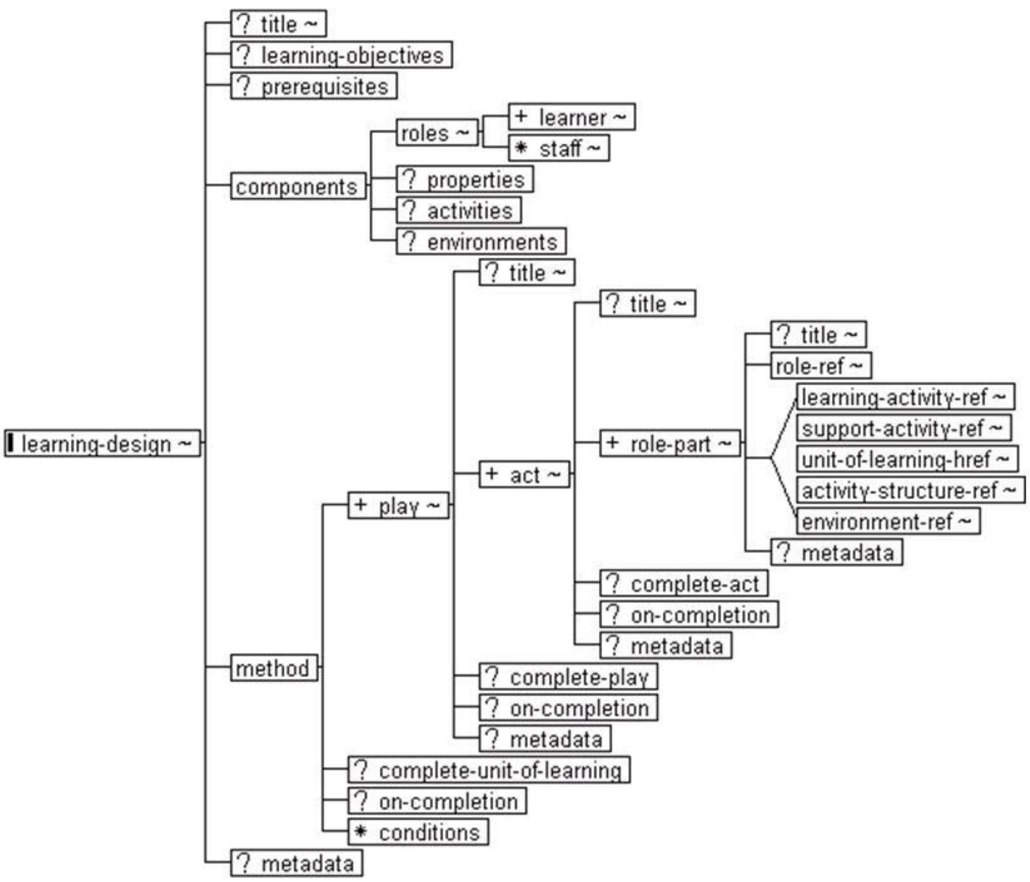


flow of activities) and then this code is interpreted with a runtime engine that can repeat the course over and over again for different users in different situations, adapted to the characteristics of the individual users in the course. When the course is designed well, the different actors do not have to be concerned much about the management of activities and information flow within the course: this is done automatically. Also, the adaptation rules that are specified are applied automatically and consistently within the course runs. Furthermore, the necessary content and services are set up automatically and made available to the users at the right moment.

Concretely speaking, the conceptual model is implemented as follows. A UoL is represented as an IMS Content Package (CP). A CP has an organization part that represents how items are organized in the package. Normally, the organization part represents nothing more than a hierarchy of items, but the CP specification allows replacement of the organization structure by any other structure. In LD, the organization part of a CP is replaced with a <learning-design> element (see Figure 6).

The <learning-design> element is a complex structure that includes elements that represent the conceptual model already outlined. The details

Figure 7. The LD schema represented as a tree



of these elements are detailed in the information model document, together with their behavioral specifications. The information model describes the core aspects of the specification and contains details of: semantics, structure, data types, value domains, multiplicity, and obligation (e.g., whether mandatory or optional).

The learning design elements have an XML schema binding that can be represented as the tree in Figure 7. The XML binding is the preferred transformation of the UML to XML instances. The permitted syntax and semantics of the XML binding is defined using the appropriate XML schemas.

The properties, activities, and environments of the *components* element and the conditions of the *method* element all, in turn, have complex substructures, but these are not shown here for the sake of simplicity.

A distinction is always made between the package (reflecting the UoL at the *class* level) and the run of that package (an *instance*). In creating instances from a package, some customization and localization may typically take place. A UoL package represents a fixed version of a UoL, with links to the underlying learning objects and service types. It may further contain XML document instances valid against the other appropriate schemas (e.g., IMS Content Package, IMS Question and Test Interoperability, etc.) along with the physical files that are referred to in a fixed version and URIs (uniform resource identifiers) to other resources, including services. Such a package can be instantiated and run many times for different learners in different settings. If desired, it can also be adapted prior to instantiation in order to reflect local needs. This will create another version of the UoL and accordingly another UoL package.

Authoring LD

As mentioned above, by using LD, a teaching–learning process has to be formalized as a computational model in XML format, which is a platform-independent Web-standard notation for describing arbitrary structured data. This means that a learning design, encoded in XML, can be read and run by any LD-aware player. The problem is that authoring a learning design in XML is a time-consuming and error-prone task. Especially for the authors who do not have knowledge about XML, it is impossible to create a learning design using XML.

In order to empower people to create learning designs, many LD authoring tools have been developed. At the moment, there are more then 20 different tools available (see Griffiths, Blat, García, Vogten, & Kwong, 2005, for a discussion and overview). To be mentioned are Reload (2005), MOT+ (Paquette, Léonard, Ludgren-Cayrol, Mihaila, & Gareau, 2006), ASK-LDT (Karampiperis & Sampson, 2005), CopperAuthor (2005), and CoSMoS (Miao, 2005). Compared to common XML editors, these LD authoring tools provide user-friendly interfaces for learning designers to create, reuse, and customize UoLs. It is important to note that LD is divided into three parts, known as Level A, Level B, and Level C. Separate XML schemas are provided for each level, with Levels B and C each integrating and extending the previous level. Among existing tools, Reload and CoSMoS provide full functions to edit learning design at levels of A, B, and C.

As illustrated in Figure 8, the Reload LD editor consists of several edit pages, and each page supports editing a type of element such as role, activity, environment, method, and so forth. An element tree on each page enables to navigate through all elements with the same type. If an element is selected, the editor presents a form which provides a user-friendly interface for authoring the element in a series of panels. It facilitates to include resources and create UoL packages. The Reload LD editor is regarded as a reference implementation of LD authoring tool. CoSMoS is also implemented in a tree-form design. However, the tree includes all elements defined in the learning

Figure 8. A screenshot of environment page in Reload LD editor (Reload, 2005)

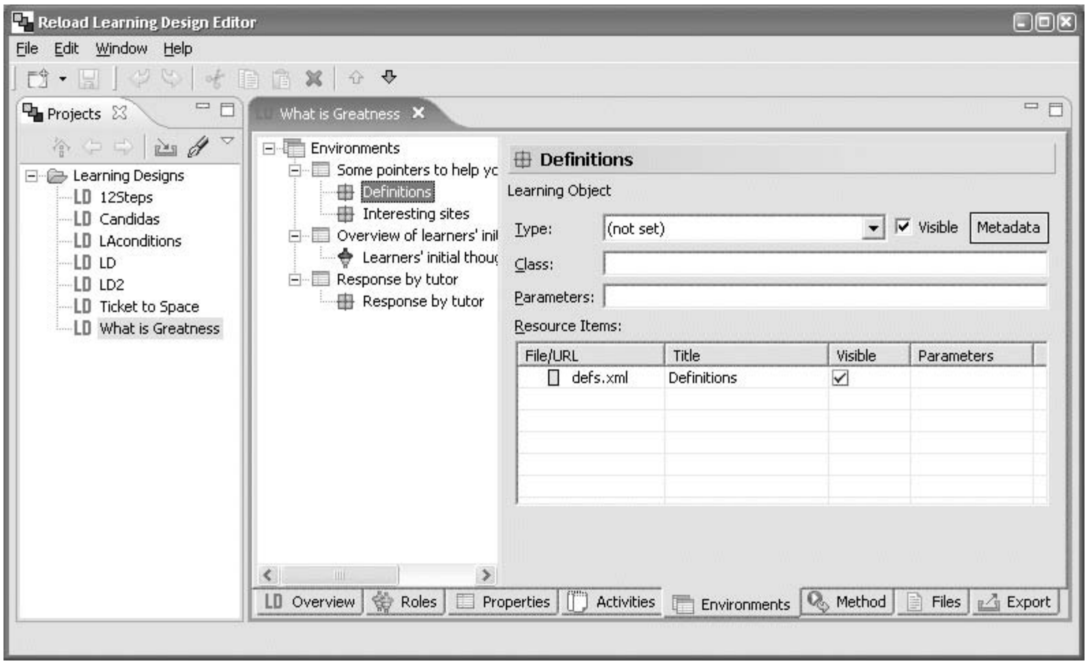
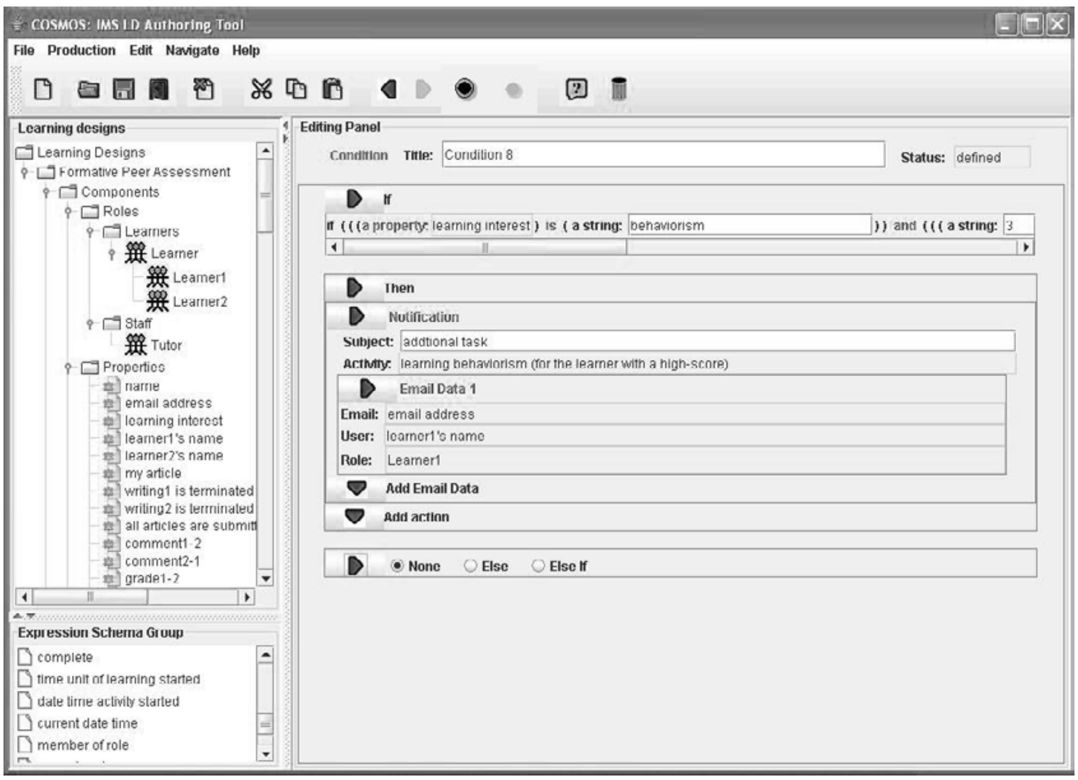


Figure 9. A screenshot of CoSMoS used to define a condition shown in Figure 22



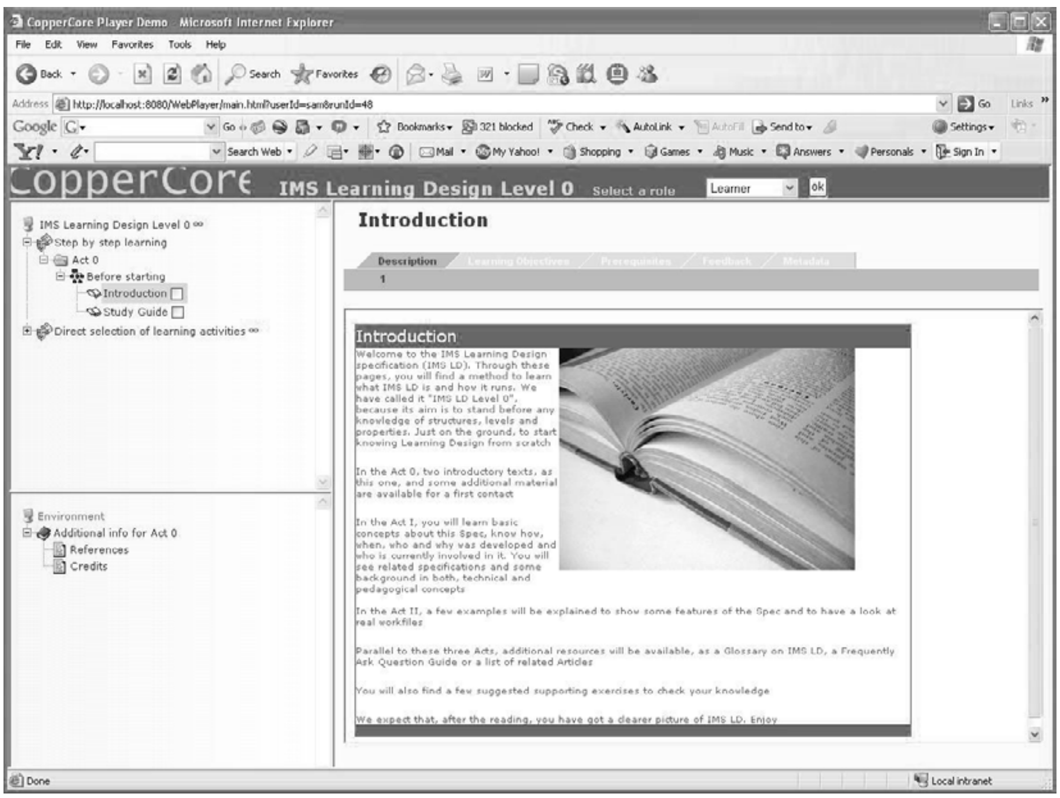
designs currently edited so that the definition of references can be implemented by using drag and drop. The tool supports to define conditions easily and to do constructive and destructive editing work intuitively. Figure 9 shows a screenshot of CoSMoS used to define a condition showing in Figure 22, and the code shown in this chapter is generated using this tool.

Interpreting LD

When a UoL is specified in LD, the result is a zip file. Running this zip file requires a runtime engine that handles at least the following five tasks:

1. A validation of the zip file to ensure that only valid LD is processed. Validation includes both technical and semantic checks and the validation results are reported.
2. Creation of one or more instances of the zip-file (this is called a "run").
3. Assignment of persons to the specific roles in the run and setup of the required communication and collaboration services like forums, chats, and wikis.
4. Interpretation of the LD and delivery of personalized and sequenced learning activities, content, and services according to the rules defined in LD. This is achieved by keeping track of the user's progress and settings.
5. The concept of a run is described in Tattersall, Vogten, Brouns, Koper, van Rosmalen, Sloep, and van Bruggen (2005); Vogten, Koper, Martens, and Tattersall (2005); and

Figure 10. The CopperCore player



Vogten, Tattersall, Koper, van Rosmalen, Brouns, Sloep, et al. (2006) and is comparable with parallel classes in a school. A school may have different parallel classes: each with the same objectives and content, but with different learners and teachers. The same classes (runs) are also repeated year after year with different students (and sometimes different teachers), although the versions of the learning design may be adapted in between different runs. So, a run is an instance of a course with specific learners and teachers and is executed in a specific timeframe. A runtime engine must be able to set up and manage runs of UoLs packages.

An LD runtime engine must be able to interpret every LD zip file package. The challenge is that LD is a declarative language, meaning that it describes what an implementation must do. It does not specify how this should be done. Furthermore, LD is an expressive, that is, semantically, language that enables expression of learning designs in a clear, natural, intuitive, and concise way, closest to the original problem formulation. This expressive and declarative nature complicates the implementation of an engine that can interpret the specification. For this reason, we implemented an open source runtime engine, called CopperCore (Martens & Vogten, 2005; see also www.coppercore.org) to serve as a reference implementation of LD handling. CopperCore can be used by any LMS to handle LD packages or be used as an example for the recoding of an LMS native runtime engine.

The CopperCore runtime engine does not provide user interfaces: it only provides APIs to build a dedicated user interface. For demonstration purposes, CopperCore is provided with a simple user interface (CopperCore Player, see Figure 10), but a better implementation of a player is the SLED player (see McAndrew, Nadolski, & Little, 2005; see also sourceforge.net/projects/ldplayer).

USING LD TO MODEL LEARNING DESIGNS

As introduced above, LD is a process modeling language for specifying teaching–learning processes. A learning design is a resulting process model to represent an educational process in LD. Before we develop learning designs using LD, we should consider what a kind of process we model, whether LD is suitable for modeling such a process, and what is the purpose to model a learning design. Then, we should know how to develop a learning design in LD. This section discusses some general issues to model learning designs and presents the procedure to model learning designs through using a use case. In addition, we present how to model complicated learning designs.

Some General Issues to Model Learning Designs

In this section, we discuss some general issues that should be taken into account in modeling learning designs.

Descriptive Process Model and Prescriptive Process Model

Process modeling can be understood in two ways: A descriptive model describes how a process is performed in a particular environment and a prescriptive model describes how a process should be performed. LD can be used to model learning designs as both descriptive models (called descriptive learning designs) and prescriptive models (called prescriptive learning designs). When developing a descriptive learning design, learning designers first observe what actually happens during teaching–learning processes. Then, they can abstractly describe the teaching–learning processes in an inductive manner. Thus, a descriptive learning design is specific for certain teaching–learning processes observed and then generalized through systematic comparative analysis. A descriptive learning design should be sufficiently general to characterize a range of particular teaching–learning processes and sufficiently specific to allow reasoning about them.

When developing a prescriptive learning design, learning designers intuitively define many idiosyncratic details for articulating a desired teaching–learning process. Then, it will be used in practice as guidelines or frameworks to organize and structure how learning activities and support activities should be performed, and in what order. An initiative prescriptive learning design can be improved according to the experiences got in practice.

The Levels of Granularity

Granularity refers to the detail level of the process model. High granularity limits guidance and explanation to a rather coarse level of detail, whereas fine granularity provides more detailed capability, but sometimes restricts the fluidity of the teaching–learning process to some extent. Striving for an appropriate level of granularity will maximize ease of use, reuse, and manageability.

In theory, LD can be used to describe an educational process at any level of granularity. The coarse level of granularity is to represent an educational program consisting of a series of courses. The invocation of a single course, workshop, or seminar forms a medium level of granularity, whereas the execution of a lessen forms the fine level of granularity. In practice, LD is suitable for modeling educational processes at the medium and fine levels of granularity. A learning design serves normally like a lesson plan.

The Coercion Degrees

Coercion refers to the flexible level of the process model. Rigid process models are completely predefined and leave little scope for adapting them to the situation at hand. On the other hand, flexible process models provide freedom for actors to select and augment to fit a given situation. Choosing an appropriate level of coercion is a trade-off in design. A certain degree of coercion is required for efficiency reasons, but too much might decrease the motivation of the staff and the learner involved. LD enables to specify learning designs with varied degrees of coercion. At the high end of the spectrum, many constraints such as the timing and duration of an activity, the accessibility of activities, the visibility of information items, the sequence of activities, and the intervention of the tutors can be precisely defined at design time, and learners will be guided and controlled in runtime accordingly. On the other hand, LD allows specifying learning designs with a high degree of flexibility. For example, participants can decide when to terminate activities, select some activities from a set of candidate activities, access to completed activities, and perform activities without following the suggested sequence, and so on. In addition, LD provides mechanisms to support computational adaptation, which will be discussed at the end of this section.

The Uses of Process Models

Process models can be used for varied purposes, ranging from communication and analysis at design time to guidance and control at runtime. The use of learning designs can cover the whole spectrum:

1. A learning design as a description of a use case represented in a standardized language facilitates communication, understanding, and reuse.
2. A learning design provides a base for analyzing the description of the actual or desired teaching–learning processes by using formal techniques (e.g., validation and simulation) for a deeper understanding, comparisons, and improvement.

3. A running learning design can scaffold staff and learners by providing indirect support through information which helps them to perform their tasks, such as the current status of the process, the suggested next steps to be executed, the appropriate learning objects and services, decision points (e.g., terminating activities and entering environment), and so forth.
4. A running learning design can enforce staff and learners through execution environment by providing certain services to carry out prescriptive tasks such as doing a test with an IMS Question and Test Interoperability (IMSQTI, 2006) player, by controlling the sequence of activities, and by orchestrating the actions performed by varied roles.

The Procedure to Model a Learning Design

As suggested in LD (IMSLD, 2003), modeling a learning design is a three-stage process: informal modeling in natural language, semiformal modeling in UML activity diagrams, and formal modeling in XML. In this section, we illustrate the general procedure to model a learning design through a use case.

Informal Learning Designs

Modeling a learning design starts with elicitation. The goal of elicitation is to acquire all information needed to describe the desired learning design. Such process information involves the objectives and context of the learning design, the learning content and facilities used in the learning process, the principal entities such as roles and activities, and any relationships among them in terms of workflow. It is expected to describe behavior features of the process (e.g., under which conditions an activity can start or complete), if necessary and possible. In LD, it is suggested to describe process information in a structured manner. In order to explain it clearly, the informal model of the use case is presented below in the form of a narrative.

Title: Learning various learning theories

Provided by: Yongwu Miao, Open University of the Netherlands

Pedagogy/type of learning: A formative peer assessment

Description/context: This course is a fictitious example representing a part of a pedagogical curriculum. It is assumed that the learner will have a course that familiarizes the learners with various learning theories prior to taking this course. In this course, the learners in pairs help each other to remedy weaknesses by providing feedback. The tutor is involved in the assessment process as well.

Learning objectives: The objective is that the learner acquires compensatory knowledge about learning theories and can summarize and comment relevant articles.

Roles: The tutor and the learner.

Different types of learning content used: Web pages which contain content about various learning theories.

Different types of learning services/facilities/tools used: A monitor service is used to view the work of learners. A searching service is used to collect relevant learning materials. A forum is used for learners to discuss.

Different types of collaborative activities: Learning from each other by assessing peers' work. Discussing in a discussion forum.

Learning activity workflow (how actors/content/services interact): The course is comprised of four phases.

- *Phase 1: Registration*
  Each learner registers to a formative assessment process by providing personal information and by choosing one item from a list of learning theories (including behaviorism, cognitivism, and constructivism) as her/his specific

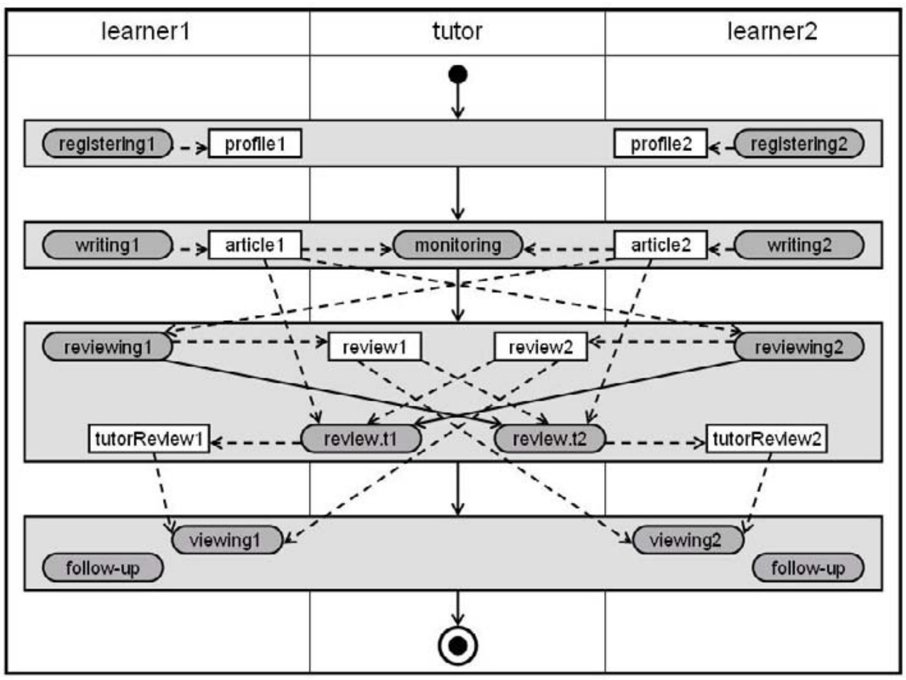
learning interest. When both learners have finished registration, this phase is complete.

- *Phase 2: Provision with evidence*
  Each learner reads predefined learning materials about learning theories. Each learner is required to write an article in an hour and a half about a learning theory in which the learner has special interest. The tutor monitors the state of learners' work and can decide to terminate this phase.
- *Phase 3: Assessment*
  Each learner reviews the article of her/his peer by commenting on and grading the article. After the peer's review is finished, the tutor will review the article with the consideration of the peer's review by commenting on and grading the article as well.
- *Phase 4: Follow-up activities*
  When the tutor has finished the review of the article of a learner, the comments of both the peer and the tutor are visible for learners. The final score of a learner is calculated in a way that tutor's weight is 0.6 and the weight of peer students is 0.4. According to the final score, an appropriate follow-up learning activity will be arranged for the learner.

Semiformal Learning Designs

The process information gathered serves as input when the semiformal model is developed as a UML activity diagram. Since activities are the entities which can be identified easily, the semiformal process modeling should start by defining activities as box nodes. Next, the different roles such

Figure 11. The semiformal model of the use case



as the learner and the tutor should be identified and the responsibilities of each role should be defined by attaching the role to certain activities. In order to precisely model the interaction between the learners, it is necessary to distinguish them further as “learner1” and “learner2.” Thus, activity nodes can be grouped using swim lanes based on the different roles. The suggested activity sequences can be drawn as solid arrows between activities. The artifacts produced and consumed in activities can be specified as data objects linked from/to the activities as dashed arrows. Complicated process control flow can be depicted using process control nodes such as branches, forks, and joins. Complicated activity structure can be depicted as embedded boxes. Figure 11 illustrates a semiformal model of the use case as a UML activity diagram.

Formal Learning Designs

A UML activity diagram does not fully and precisely cover detailed information needed for an executable process model. A formal model represented in LD has to be specified in the form of XML. Both bottom-up and top-down development approaches can be adopted to transform a UML activity diagram into a unit of learning. The bottom-up edit approach is to define components such as roles, activities, environments, and properties first and then to organize them as a learn-flow. The top-down edit approach is to specify a playlike scenario using the theatric metaphor first and then to define the missing components. In practice, these two approaches are used in a hybrid manner. In this chapter, we demonstrate how to develop a formal model of the use case by adopting bottom-up approach. Because two learners have the same behaviors, sometimes we just show the code of entities relevant to learner1. Note that the code is restricted XML code (e.g., removing the name space) based on LD for the purpose of simplicity and readability.

Modeling Roles

First, we should specify who will participate in the teaching–learning process to be modeled. As illustrated in Figure 12, there are two roles: “tutor” and “learner.” The learner role is refined as “learner1” and “learner2.” The maximum and minimum number for each role has been restricted as one. It means that in an actual execution of the learning design each role has to be assigned by one and only one person. The corresponding LD code (in the form of XML) is presented in Figure 12.

Modeling Properties

As described in the last section, properties are containers that can store information about people’s roles and the UoL itself or learning objects added during the teaching–learning process. We can define a list of properties to represent various information units, which will be referred by definitions of other elements in the model. The definitions of properties relevant to learner1 is listed in Figure 13 as “learnerName1” (learner1’s name), “isWriting1Terminated” (whether has learner1 finished the writing activity), “review1.comment” (the comment of learner2’s article provided by learner1), “review1.grade” (the grade of learner2 given by learner1), “tutorReview1.grade” (the comment of learner1’s article provided by the tutor), “tutorReview1.comment” (the grade of learner1 given by the tutor), and “score1” (learner1’s final score). Note that the definitions of properties relevant to learner2 (learnerName2, isWriting2Terminated, review2.comment, review2.grade, tutorReview2.grade, tutorReview2.comment, and score2) are omitted.

The definitions of other properties are listed in Figure 14: “myName,” “myEmail,” “myInterest,” “myProfile,” “hasAllRegistered” (whether all learners finish the registration), “myArticle,” “articlesSubmitted” (whether both learners have

Figure 12. The definitions of roles

```
<!-- the definition of the role: learner -->
  <learner create-new="not-allowed" identifier="learner">
    <title>Learner</title>
    <!-- the definition of a sub-role of the learner: learner1 -->
      <learner create-new="not-allowed" identifier="learner1" match-persons="exclusively-in-roles" max-persons="1" min-persons="1">
        <title>Learner1</title>
    </learner>
    <!-- the definition of another sub-role of the learner: learner2 -->
      <learner create-new="not-allowed" identifier="learner2" match-persons="exclusively-in-roles" max-persons="1" min-persons="1">
        <title>Learner2</title>
    </learner>
  </learner>
  <!-- the definition of the role: tutor -->
  <staff identifier="tutor" create-new="not-allowed" match-persons="exclusively-in-roles" max-persons="1">
    <title>Tutor</title>
  </staff>
```

submitted articles), "learnerWeight" (the weight of learner's grade), "tutorWeight" (the weight of tutor's grade), and "ourProtocol" (the discussion record).

Note that some properties (e.g., "myName" and "myInterest") are defined as global personal properties, which capture personal profile information and will be maintained permanently. In comparison with the property "myName," the property "learnerName1" (see Figure 13) is defined as a local property, because it is defined just for providing group-awareness information in an execution, which will be explained in detail later. The values of these two properties are identical. The property "myProfile" is defined as a property-group containing three properties with the same type. The property "myArticle" capturing learner's article is defined as a local personal property. The property "ourProtocol" is defined as a role property and stores the chat protocol of the learners. In addition, different data types (e.g., string, boolean, real) are used in the definitions of properties. The restriction type (e.g., enumeration) is used to define "myInterest" (e.g., behaviorism, cognitivism, and constructivism).

Modeling Activities

Figure 15 lists the definitions of activities irrelevant to any specific learner. "LA-reading" is a learning activity performed by both learners. "SA-monitoring" is a support activity performed by the tutor. The reminder two learning activities provide additional learning opportunities for better learners and average learners interested in behaviorism. Note that the definitions of similar activities for cognitivism and constructivism are omitted. The last activity is defined for the tutor

Figure 13. The definitions of properties relevant to learner1

```
<!-- the definition of a property representing the name of learner1 for providing awareness information  -->
  <loc-property identifier=”learnerName1”>
    <title>learner1’s name</title>
    <datatype datatype=”string”/>
  </loc-property>
<!-- the definition of a property representing the status of the activity in which learner1 writes an article -->
  <loc-property identifier=”isWriting1Terminated”>
    <title>writing1 is terminated</title>
    <datatype datatype=”boolean”/>
    <initial-value>false</initial-value>
  </loc-property>
<!-- the definition of a property representing learner1’s comment on learner2’s article -->
  <loc-property identifier=”review1.comment”>
    <title>comment1-2</title>
    <datatype datatype=”string”/>
  </loc-property>
<!-- the definition of a property representing the grade of learner2 given by learner1 -->
  <loc-property identifier=”review1.grade”>
    <title>grade1-2</title>
    <datatype datatype=”real”/>
    <initial-value>0</initial-value>
  </loc-property>
<!-- the definition of a property representing tutor’s comment on learner1’s article -->
  <loc-property identifier=”tutorReview1.comment”>
    <title>tutor’s comment1</title>
    <datatype datatype=”string”/>
  </loc-property>
<!-- the definition of a property representing the grade of learner1 given by the tutor -->
  <loc-property identifier=”tutorReview1.grade”>
    <title>tutor’s grade1</title>
    <datatype datatype=”real”/>
    <initial-value>0</initial-value>
  </loc-property>
<!-- the definition of a property representing the final score of learner1 -->
  <loc-property identifier=”score1”>
    <title>final score1</title>
    <datatype datatype=”real”/>
    <initial-value>0</initial-value>
  </loc-property>
```

Figure 14. The definitions of properties irrelevant to a specific learner

```
<!-- the definition of a property representing the user name as a piece of profile information -->
  <globpers-property identifier=”myName”>
    <global-definition uri=”http://coppercore.org/name”>
      <title>name</title>
      <datatype datatype=”string”/>
    </global-definition>
  </globpers-property>
<!-- the definition of a property representing the email address of the user for sending notification -->
  <globpers-property identifier=”myEmail”>
    <global-definition uri=”http://coppercore.org/email”>
      <title>email address</title>
      <datatype datatype=”string”/>
    </global-definition>
  </globpers-property>
<!-- the definition of a property representing the learning need of the user -->
  <globpers-property identifier=”myInterest”>
    <global-definition uri=”http://coppercore.org/interest”>
      <title>learning interest</title>
      <datatype datatype=”string”/>
      <restriction restriction-type=”enumeration”>behaviorism</restriction>
      <restriction restriction-type=”enumeration”>cognitivism</restriction>
      <restriction restriction-type=”enumeration”>constructivism</restriction>
    </global-definition>
  </globpers-property>
<!-- the definition of a property representing an aggregated information object about the profile of the user -->
  <property-group identifier=”myProfile”>
    <title>personal information</title>
    <property-ref ref=”myName”/>
    <property-ref ref=”myEmail”/>
    <property-ref ref=”myInterest”/>
  </property-group>
<!-- the definition of a property representing the article of the user -->
  <locpers-property identifier=”myArticle”>
    <title>my article</title>
    <datatype datatype=”text”/>
  </locpers-property>
<!-- the definition of a property representing whether all learners have submitted articles -->
  <loc-property identifier=”articlesSubmitted”>
    <title>all articles are submitted</title>
    <datatype datatype=”boolean”/>
    <initial-value>false</initial-value>
  </loc-property>
```

continued on following page

Figure 14. The definitions of properties irrelevant to a specific learner (continued)

```
<!-- the definition of a property representing the weight of the learner used to calculate the final score  -->
  <loc-property identifier="learnerWeight">
    <title>learner's weight</title>
    <datatype datatype="real"/>
    <initial-value>0.40</initial-value>
  </loc-property>
<!-- the definition of a property representing the weight of the tutor used to calculate the final score  -->
  <loc-property identifier="tutorWeight">
    <title>tutor's weight</title>
    <datatype datatype="real"/>
    <initial-value>0.60</initial-value>
  </loc-property>
<!-- the definition of a property representing the chat protocol  -->
  <locrole-property identifier="ourProtocol">
    <title>protocol</title>
    <role-ref ref="learner"/>
    <datatype datatype="text"/>
  </locrole-property>
```

Figure 15. The definitions of activities irrelevant to a specific learner

```
<!-- the definition of an activity to read learning material  -->
  <learning-activity identifier="LA-reading">
    <title>reading</title>
    <environment-ref ref="ENV-search-room"/>
    <activity-description>
      <title>reading material</title>
      <item identifier="ITEM-behaviorism-intro" identifierref="RESO-behaviorism-intro">
        <title>behaviorism</title>
      </item>
      <item identifier="ITEM-cognitivism-intro" identifierref="RESO-cognitivism-intro">
        <title>cognitivism</title>
      </item>
      <item identifier="ITEM-constructivism-intro" identifierref="RESO-constructivism-intro">
        <title>constructivism</title>
      </item>
    </activity-description>
  </learning-activity>
<!-- the definition of a following-up activity for the learner who chooses the topic "Behaviorism" and has a high
score -->
```

continued on following page

Figure 15. The definitions of activities irrelevant to a specific learner (continued)

```
  <learning-activity identifier="LA-following-up-behaviorism-high">
    <title>learning behaviorism (for the learner with a high-score)</title>
    <activity-description>
      <title>additional material</title>
      <item identifier="ITEM-behaviorism-material-high" identifierref="RESO-behaviorism-material-high">
        <title>for students with a high grade</title>
      </item>
    </activity-description>
  </learning-activity>
  <learning-activity identifier="LA-following-up-behaviorism-low">
    <title>learning behaviorism (for the learner with a low-score)</title>
    <activity-description>
      <title>additional material</title>
      <item identifier="ITEM-behaviorism-material-low" identifierref="RESO-behaviorism-material-low">
        <title>for students with a low grade</title>
      </item>
    </activity-description>
  </learning-activity>
<!-- the definition of a monitoring activity performed by the tutor -->
  <support-activity identifier="SA-monitoring">
    <title>monitoring</title>
    <environment-ref ref="ENV-monitoring-articles"/>
    <activity-description>
      <item identifier="ITEM-AD-1169591657609-33" identifierref="RESO-terminate-writing">
        <title>monitor and complete writing articles</title>
      </item>
    </activity-description>
    <complete-activity>
      <when-property-value-is-set>
        <property-ref ref="articlesSubmitted"/>
        <property-value>true</property-value>
      </when-property-value-is-set>
    </complete-activity>
  </support-activity>
```

who monitors the work progress of the learner and can terminate the writing activities of all learners.

Figure 16 illustrates some learning activities (LA-registering1, LA-writing1, LA-reviewing1, and LA-viewing1), a support activity (SA-review-

Figure 16. The definitions of activities relevant to learner1

```
<!-- the definition of a registration activity performed by learner1 -->
  <learning-activity identifier="LA-registering1">
    <title>registering1</title>
    <activity-description>
      <item identifier="ITEM-AD-registration1" identifierref="RESO-registration-form" />
    </activity-description>
    <complete-activity>
      <user-choice/>
    </complete-activity>
    <on-completion>
      <feedback-description>
        <item identifier="ITEM-FD-instruction" identifierref="RESO-1171624455265-87" />
      </feedback-description>
      <change-property-value>
        <property-ref ref="learnerName1"/>
        <property-value>
          <property-ref ref="myName"/>
        </property-value>
      </change-property-value>
    </on-completion>
  </learning-activity>
<!-- the definition of an activity in which learner1 writes an article -->
  <learning-activity identifier="LA-writing1">
    <title>writing1</title>
    <activity-description>
      <item identifier="ITEM-AD-writing1" identifierref="RESO-learner-write-article-form">
        <title>write an article</title>
      </item>
    </activity-description>
    <complete-activity>
      <time-limit>P0Y0M0DT1H30M0S</time-limit>
    </complete-activity>
  </learning-activity>
  <learning-activity identifier="LA-reviewing1">
    <title>reviewing1</title>
    <environment-ref ref="ENV-monitoring-articles"/>
    <activity-description>
      <item identifier="ITEM-AD-review1-2" identifierref="RESO-review1-2">
        <title>review article</title>
      </item>
    </activity-description>
    <complete-activity>
```

continued on following page

Figure 16. The definitions of activities relevant to learner1 (continued)

```
      <user-choice/>
    </complete-activity>
  </learning-activity>
<!-- the definition of an activity in which learner1 view feedback from the peer and the tutor -->
  <learning-activity identifier=”LA-viewing1”>
    <title>viewing1</title>
    <environment-ref ref=”ENV-monitoring-articles”/>
    <environment-ref ref=”ENV-for-discussion”/>
    <activity-description>
      <item identifier=”ITEM-AD-view1” identifierref=”RESO-view1”>
        <title>view feedback</title>
      </item>
    </activity-description>
    <complete-activity>
      <user-choice/>
    </complete-activity>
  </learning-activity>
<!-- the definition of an activity in which the tutor view information about the work of learner1 -->
  <support-activity identifier=”SA-review-t1”>
    <title>t.reviewing1</title>
    <environment-ref ref=”ENV-monitoring-articles”/>
    <activity-description>
      <item identifier=”ITEM-AD-review-t1” identifierref=”RESO-review-t1”>
        <title>Reviewing</title>
      </item>
      <item identifier=”ITEM-1171619763078-71” identifierref=”RESO-1171621288109-72”>
        <title>student’s review</title>
      </item>
    </activity-description>
    <complete-activity>
      <user-choice/>
    </complete-activity>
  </support-activity>
<!-- the definition of an activity-structure which consists of two sequential activities: reading and writing -->
  <activity-structure identifier=”AS-work1-structure” structure-type=”sequence”>
    <title>work1</title>
    <learning-activity-ref ref=”LA-reading”/>
    <learning-activity-ref ref=”LA-writing1”/>
  </activity-structure>
```

t1), and an activity-structure (AS-work1-structure), which are relevant to learner1. The activity structure "AS-work1-structure" consists of two sequential activities. The same set of definitions of tasks relevant to learner2 is omitted.

Note that an activity can be terminated by using user-choice (e.g., LA-registering1), time-limit (e.g., LA-writing1), and by evaluating a property (e.g., SA-monitoring). An activity may have no control for completion (e.g., LA-following-up-cognitivism-low). After being completed, an activity may have effect. For example, after "LA-registering1" is finished, an instruction about how to conduct this peer assessment will be provided as feedback, and the name of the learner1 is assigned as my name. The environments (e.g., ENV-search-room, ENV-for-discussion, and ENV-monitoring-articles) associated with activities "LA-reading," "LA-viewing1," and "SA-review-t1" are defined below.

Modeling Environments

Figure 17 shows the definitions of three environments: "ENV-search-room," "ENV-monitoring-articles," and "ENV-for-discussion." An environment may contain learning objects (e.g., LO-protocol) and/or services (e.g., search, monitor, or conference).

Figure 17. The definitions of environments

```
<!-- the definition of an environment which contains a searching service -->
  <environment identifier=”ENV-search-room”>
    <title>search room</title>
    <service identifier=”INDEX-search-service”>
      <index-search>
        <title>search material</title>
        <index>
          <index-class index-class=”learning theories”/>
        </index>
        <search search-type=”free-text-search”/>
      </index-search>
    </service>
  </environment>
<!-- the definition of an environment which contains a monitoring service -->
  <environment identifier=”ENV-monitoring-articles”>
    <title>environment for viewing articles</title>
    <service identifier=”MONI-S-articles”>
      <monitor>
        <role-ref ref=”learner”/>
        <title>Monitor learners’ articles</title>
        <item identifier=”ITEM-RE-monitor-articles “ identifierref=”RESO-monitor-articles”>
          <title>view articles</title>
```

continued on following page

Figure 17. The definitions of environments (continued)

```
        </item>
      </monitor>
    </service>
  </environment>
<!-- the definition of an environment which contains a conferencing service -->
  <environment identifier="ENV-for-discussion">
    <title>discussion room</title>
    <learning-object identifier="LO-protocol">
      <title>protocol</title>
      <item identifier="ITEM-RE-create-protocol" identifierref="RESO-create-protocol" />
    </learning-object>
    <service identifier="CONF-conference">
      <conference conference-type="asynchronous">
        <title>conference service</title>
        <participant role-ref="learner"/>
        <item identifier="ITEM-conference" identifierref="RESO-create-protocol">
        <title>discuss</title>
      </item>
      </conference>
    </service>
  </environment>
```

Modeling Plays, Acts, and Role-Parts

After defining all components of the learning design, we connect them together into a work procedure. As shown in Figure 18, a play (PL-procedure) consists of four acts. The first act (ACT-registration) contains two role-parts. Each role-part specifies that a learner registers to the assessment process. When both role-parts are completed, the act will complete, and the value of the property "hasAllRegistered" becomes true. The second act (ACT-providing-evidence) has two role-parts representing that two learners work individually targeting an article. It finishes when both learners submit articles. Then peer learners and the tutor review the articles in the third act (ACT-assessment). Finally, learners do follow-up activities such as viewing feedback and reading additional learning material.

Modeling Conditions and Notifications

Conditions can be used to conditionally tailor content, control the accessibility of an activity, and change the value of a property. Notification can be used to send message and trigger activities. Let us see how visibility of different pieces of content in the resource are controlled by conditions. As shown in Figure 19a, if learner1 has or has not finished writing article1 then the text fragments (see Figure 19d) controlled using classes "C-writing1-completed" and "C-writing1-not-completed" will be visible or not, accordingly. Similarly, Figure 19b shows a definition of a complicated

Figure 18. The definition of main learn-flow

```
<!-- the definition of the whole work procedure of a tutor-involved peer assessment -->
<play identifier=”PL-procedure”>
  <title>peer assessment procedure</title>
  <!-- the definition of an act representing the first phase, in which two learners register to the assessment -->
  <act identifier=”ACT-registration”>
    <title>registration</title>
    <role-part identifier=”RP-learner1-registers”>
      <title>learner1 registers</title>
      <role-ref ref=”learner1”/>
      <learning-activity-ref ref=”LA-registering1”/>
    </role-part>
    <role-part identifier=”RP-learner2-registers”>
      <title>learner2 registers</title>
      <role-ref ref=”learner2”/>
      <learning-activity-ref ref=”LA-registering2”/>
    </role-part>
    <complete-act>
      <when-role-part-completed ref=”RP-learner2-registers”/>
      <when-role-part-completed ref=”RP-learner1-registers”/>
    </complete-act>
    <on-completion>
      <change-property-value>
        <property-ref ref=”hasAllRegistered”/>
        <property-value>true</property-value>
      </change-property-value>
    </on-completion>
  </act>
  <!-- the definition of an act representing the second phase, in which two learners read learning material according
his/her selected topic and write an article, while the tutor monitors the work progress -->
  <act identifier=”ACT-providing-evidence”>
    <title>providing evidence</title>
    <role-part identifier=”RP-learner1-work”>
      <title>learner1 works</title>
      <role-ref ref=”learner1”/>
      <activity-structure-ref ref=”AS-work1-structure”/>
    </role-part>
    <role-part identifier=”RP-learner2-work”>
      <title>learner2 works</title>
      <role-ref ref=”learner2”/>
      <activity-structure-ref ref=”AS-work2-structure”/>
    </role-part>
```

continued on following page

Figure 18. The definition of main learn-flow (continued)

```
    <role-part identifier="RP-tutor-monitors">
      <title>tutor monitors</title>
      <role-ref ref="tutor"/>
      <support-activity-ref ref="SA-monitoring"/>
    </role-part>
    <complete-act>
      <when-property-value-is-set>
        <property-ref ref="articlesSubmitted"/>
        <property-value>true</property-value>
      </when-property-value-is-set>
    </complete-act>
  </act>
  <!-- the definition of an act representing the third phase, in which each learner evaluates the article of his/her
peer. The tutor will assess the learners' articles as well  -->
  <act identifier="ACT-assessment">
    <title>assessment</title>
    <role-part identifier="RP-learner1-reviews">
      <title>learner1 reviews</title>
      <role-ref ref="learner1"/>
      <learning-activity-ref ref="LA-reviewing1"/>
    </role-part>
    <role-part identifier="RP-learner2-reviews">
      <title>learner2 reviews</title>
      <role-ref ref="learner2"/>
      <learning-activity-ref ref="LA-reviewing2"/>
    </role-part>
    <role-part identifier="RP-tutor-review1">
      <title>tutor review1</title>
      <role-ref ref="tutor"/>
      <support-activity-ref ref="SA-review-t1"/>
    </role-part>
    <role-part identifier="RP-tutor-review2">
      <title>tutor review2</title>
      <role-ref ref="tutor"/>
      <support-activity-ref ref="SA-review-t2"/>
    </role-part>
  </act>
 <!-- the definition of an act representing the fourth phase, in which each learner will perform a following-up activity
according to the assessment result -->
  <act identifier="ACT-following-up-activities">
    <title>following-up activities</title>
    <role-part identifier="RP-viewing1">
```

continued on following page

Figure 18. The definition of main learn-flow (continued)

```
            <title>learner1 views</title>
            <role-ref ref="learner1"/>
            <learning-activity-ref ref="LA-viewing1"/>
        </role-part>
        <role-part identifier="RP-viewing2">
            <title>learner2 views</title>
            <role-ref ref="learner2"/>
            <learning-activity-ref ref="LA-viewing2"/>
        </role-part>
    </act>
</play>
```

Figure 19. The definition of conditions and tailorable content

Figure 19a. The definitions of a condition showing/hiding classes representing state

```
<if>
    <is>
        <property-ref ref="isWriting1Terminated"/>
        <property-value>true</property-value>
    </is>
</if>
<then>
    <show>
        <class class="C-writing1-completed" />
    </show>
    <hide>
        <class class="C-writing1-not-completed" />
    </hide>
</then>
<else>
    <hide>
        <class class="C-writing1-completed" />
    </hide>
    <show>
        <class class="C-writing1-not-completed" />
    </show>
</else>
```

Figure 19b. The definition of conditions showing/hiding classes representing learning interests

```
<if>
    <is>
        <property-ref ref="myInterest"/>
        <property-value>behaviorism</property-value>
    </is>
</if>
<then>
    <show>
        <class class="C-behaviorism" />
    </show>
    <hide>
        <class class="C-cognitivism" />
    </hide>
    <hide>
        <class class="C-constructivism" />
    </hide>
</then>
<else>
    <if>
        <is>
            <property-ref ref="myInterest"/>
```

Figure 19. The definition of conditions and tailorable content (continued)

Figure 19b. The definition of conditions showing/hiding classes representing learning interests (continued)

```
      <property-value>cognitivism</property-value>
    </is>
  </if>
  <then>
    <hide>
      <class class="C-behaviorism" />
    </hide>
    <show>
      <class class="C-cognitivism" />
    </show>
    <hide>
      <class class="C-constructivism" />
    </hide>
  </then>
  <else>
    <if>
      <is>
        <property-ref ref="myInterest"/>
            <property-value>constructivism</property-
value>
      </is>
    </if>
    <then>
      <hide>
        <class class="C-behaviorism" />
      </hide>
      <hide>
        <class class="C-cognitivism" />
      </hide>
      <show>
        <class class="C-constructivism" />
      </show>
    </then>
  </else>
</else>
```

Figure 19c. The declaration of the resource which presents content

```
<resource identifier="RESO-learner-write-article-form"
type="imsldcontent" href="learner1-write-article-form.
html">
  <file href="learner1-write-article-form.html"/>
</resource>
```

Figure 19d. The content of the resource file

```
<body>
  <h3>Hi, <ld:view-property ref="myName" view="value"
/></h3>

  <div class="C-writing1-not-completed">

     <div class="C-behaviorism">Please write an article
about behaviorism.</div>
     <div class="C-cognitivism">Please write an article
about cognitivism.</div>
    <div class="C-constructivism">Please write an article
about constructivism.</div>

     <p>After you finish the article, your article will be
reviewed by your peer learner and your tutor:</p>
    <ld:set-property ref="myArticle" property-of="self" />
  </div>
  <div class="C-writing1-completed">
    <p>The writing activity is completed. The following is
what you write:</p>
   <p><ld:view-property ref="myArticle" view="value"/></
p>
  </div>
</body>
```

condition controlling the visibility of text fragments according to the user's learning interests. Note that the value of a property like "myArticle" is submitted and accessible by using set-property and view-property. After the writing activity is finished, the learner cannot change her/his article anymore.

Conditions can be used to control the accessibility of an activity. As shown in Figure 20, accessibility of an activity "SA-review-t1" is controlled by a condition. This piece of code illustrates that after learner2 finishes reviewing2, the tutor then can start to review.

Conditions can be used to conditionally change the value of a property. As shown in Figure 21, after learner2 and the tutor grade article1, the final score of learner1 is calculated as a weighted sum of the grade given by learner1 and the grade given by the tutor.

Figure 20. The definition of a condition triggering an activity

```
<if>
   <complete>
      <learning-activity-ref ref="LA-reviewing2"/>
   </complete>
</if>
<then>
   <show>
      <support-activity-ref ref="SA-review-t1"/>
   </show>
</then>
<else>
   <hide>
      <support-activity-ref ref="SA-review-t1"/>
   </hide>
</else>
```

Figure 21. The definition of a condition changing the value of a property and triggering an activity

```
<if>
   <and>
      <greater-than>
         <property-ref ref="review2.grade"/>
         <property-value>0</property-value>
      </greater-than>
      <greater-than>
         <property-ref ref="tutorReview1.grade"/>
         <property-value>0</property-value>
      </greater-than>
   </and>
</if>
<then>
   <change-property-value>
      <property-ref ref="score1"/>
      <property-value>
         <calculate>
            <sum>
               <multiply>
                  <property-ref ref="review2.grade"/>
                  <property-ref ref="learnerWeight"/>
               </multiply>
               <multiply>
                  <property-ref ref="tutorReview1.grade"/>
                  <property-ref ref="tutorWeight"/>
               </multiply>
            </sum>
         </calculate>
      </property-value>
   </change-property-value>
   <show>
      <learning-activity-ref ref="LA-viewing1"/>
   </show>
</then>
```

Conditions and notifications can be used together to implement a flexible task-assignment as shown in Figure 22. It means that if learner1's learning interest is "behaviorism" and his/her final score is less than 3 and larger than 0, then learner1 will be informed to perform a follow-up activity by e-mail. Figure 9 shows the interface of CoSMoS to define this condition.

So far, the formal model is almost completed. The resources used in the learning design and some complicated process control will be represented in the next subsection when discussing how to model advanced learning designs below.

Model Advanced Learning Designs

As mentioned before, LD can be used to formalize advanced learning designs that represent complicated teaching–learning processes such as collaborative learning, assessment, and adaptive learning. How to model sophisticated features using LD has been discussed before (Koper &

Figure 22. The definition of a condition sending a notification

```
<if>
  <and>
    <is>
      <property-ref ref="myInterest"/>
      <property-value>behaviorism</property-value>
    </is>
    <and>
      <greater-than>
        <property-value>3</property-value>
        <property-ref ref="score1"/>
      </greater-than>
      <greater-than>
        <property-ref ref="score1"/>
        <property-value>0</property-value>
      </greater-than>
    </and>
  </and>
</if>
<then>
  <notification>
    <email-data email-property-ref="myEmail" username-property-ref="learnerName1">
      <role-ref ref="learner1"/>
    </email-data>
    <learning-activity-ref ref="LA-following-up-behaviorism-high"/>
    <subject>additional task</subject>
  </notification>
</then>
```

Burgos, 2005). In this chapter, we can further discuss this issue based on the use case described above. Within a complete context, it will be easy to understand how to model advanced learning designs. In order to explain sophisticated features, we sometimes extend the use case.

Collaborative Learning

The literature (Dillenbourg 1999, 2002; Fischer, Kollar, Mandl, & Haake, 2007; Weinberger, Ertl, Fischer, & Mandl, 2005) on collaborative learning shows that learners can often benefit from some guidance about how best to participate. One way that guidance can be provided is through collaboration scripts. In this part of the chapter, we now turn to show how LD notation can be used to represent group formation, group awareness, and group interactions which are crucial design issues for designing effective collaborative learning.

Modeling Groups

In LD, the notation "role" can be used to model groups. Normally, a role can be defined to represent a group. The minimum number and maximum number of a group can be specified as well. If group members have different behaviors in the process, it is necessary to distinguish them using subroles like "learner1" and "learner2" defined in the use case. In LD, roles can be defined as a tree-structure with arbitrary levels. Such a structure can meet the requirements in most cases for modeling group structure. Because subroles can be specified as "not-exclusively," a group can be divided into subgroups using more than one criterion, and an actor can become members of several subgroups at the same time.

If we extend the use case in a way that 10 pairs in a class conduct the same peer assessment, the pairs can discuss in a shared forum in the last phase. In such an extended use case, we have to define 10 roles to represent 10 groups, respectively. The problem is how many pairs should be modeled if the number of learners is unpredictable or too large. A possible solution is to use role and local personal properties together. For example, using a role "pair" with two subroles "learner1" and "learner2" distinguishes the learners with different responsibilities in each pair and using a local personal property "pair_number" to represent a distinct pair to which a learner belongs. Thus, it is required that each participant has to input a pair number while registering. With such a pair number, a learner can be referred by using the definitions of the role and the property. As shown in Figure 23, a conditional expression represents a user who plays the role of "learner1" in pair number 4.

Figure 23. The definition of a condition sending a notification

```
<if>
  <and>
    <is>
      <property-ref ref="pairNumber"/>
      <property-value>4</property-value>
    </is>
    <member-of-role ref="learner1"/>
  </and>
</if>
<then>
  ......
</then>
```

Providing Group Awareness Information

In a virtual collaborative learning environment, physical contact and many rich communication channels are lost. It would be nice to provide group awareness information in the e-learning environment such as who does what in which status. With such information, group members may adjust their behavior in a coordinated and harmonious

Figure 24. The definition of a condition sending a notification

```
......
<h1>Your peer <ld:view-property ref="learnerName2" view="value"/> has reviewed your article.  The feedback and grade is shown below:</h1>

   <h3>Comment:</h3>
   <p><ld:view-property ref="review2.comment" view="value"/></p>
   <p>The grade given by your peer is <ld:view-property ref="review2.grade" view="value"/></p>

<h1>Feedback from your tutor:</h1>

   <h3>Comment:</h3>
   <p><ld:view-property ref="tutorReview1.comment" view="value"/></p>
   <p>The grade given by your tutor is <ld:view-property ref="tutorReview1.grade" view="value"/></p>

<h1>Your final score is <ld:view-property ref="score1" view="value"/></h1>
......
```

manner to achieve a shared goal. Figure 24 shows a piece of code in resource “RESO-view1,” in which the information about who does what in which status is explicitly provided. This file will be visible for learner1 after learner2, and the tutor grades his/her article. Learner1 will be informed that learner2 reviewed his/her article and what learner2’s comments and grade are. Moreover, tutor’s comments and grade are shown. Finally, the final score is presented.

Modeling Group Interaction

In a virtual collaborative learning environment, group members usually interact with each other using services and artifacts. LD allows modeling synchronous and asynchronous communication and collaboration using conference services. Figure 17 shows the definition of a conference service in the environment “ENV-for-discussion,” which is associated with learning activities such as “LA-viewing1” (see Figure 16). LD can be used to model sharing and exchanging artifacts. Figure 25 shows a piece of code (taken from the resource “RESO-create-protocol”) concerting a shared artifact modeled as a role-property “ourProtocol” which can be written and viewed by the learner.

Transference of artifact between group members can be modeled using *set-property* and *view-property*. Figure 26 shows two code fragments taken from the resource “RESO-

Figure 25. The definition of a sharing artifact

```
......
   <h3>Protocol:</h3>
   <ld:set-property ref="protocol" property-of="self" />
......
```

Figure 26. The definition of transferring an artifact

```
<!—taken from RESO-learner-write-article-form -->
......
    <ld:set-property ref="myArticle" property-of="self" />
......

<!—taken from RESO-monitor-articles -->
......
  <ld:view-property ref="myArticle" property-of="supported-person" />
```

learner-write-article-form" (see Figure 19) used by activity "LD-writing1" (see Figure 16) and from the resource "RESO-monitor-articles" referred by environment "ENV-monitoring-articles" (see Figure 17), which is used in activity "LD-writing2." These code fragments illustrate a way to specify the transference of an article written by "learner1" and viewed by "learner2."

In addition, some other mechanisms can be used to coordinate group interaction. For example, Figure 20 illustrates an example of the task-driven mechanism, where the completion of an activity will trigger the start of another activity. Figure 21 illustrates an example of the data-driven mechanism, where the availability of expected data will trigger the accessibility of an activity. With all mechanisms, a collaborative learning process can be carried out in a way that group members can perform tasks in parallel or in turn in a coordinated manner.

Assessment

Assessment is an essential component of instruction. In a typical e-learning environment, assessment is conducted independently from learning processes and using multiple-choice, fill-in-the-blank, and other forms of questions as summative assessment. Most assessment tools (e.g., QTI compatible tools) can support such assessment. Recently, it is more and more emphasized to integrate assessment with learning and to develop competence. LD can support formative assessment in an integrated learning process and support competence assessment in competence-based learning.

Formative Assessment

Formative assessment refers to the use of a broad range of instruments and procedures during a course of instruction by feeding information back to learners and instructors for the purpose of improving teaching and learning. Characteristics of effective formative assessment are analyzed and identified in literature (Bell & Cowie, 2001; Sadler, 1989). From a perspective of process modeling, these characteristics can be summarized as assessing what is actually taught and learned at the right time; actively involving both teachers and students; using multiple and varied measures; and providing constructive and personalized feedback (Miao, Vogten, Martens, & Koper, 2007b).

The use case as a whole is an example of formative assessment. This example demonstrates how to model a formative assessment process with these four identified characteristics to enhance effectiveness of learning. First, assessment is integrated in a learning process. The mastery of learning theories to be assessed is exactly the learning objective of this instruction. Second, both the tutor and the learner are engaged in the assessment. Third, learners provide evidence by writing an article. Such an open question has no standard and correct answer. Fourth, the peer learner and the tutor provide feedback in forms of comment and rating. Rather than a predefined feedback according to a predictable answer, the comment is more constructive and personalized.

Figure 27 shows a resource "RESO-review1-2" which is an QTI assessment item referred by an activity "LA-reviewing1" (see Figure 16).

Figure 27. The definition of a condition sending a notification

```
<!-- The definition of an assessment item -->
<assessmentItem xmlns="http://www.imsglobal.org/xsd/imsqti_v2p0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.imsglobal.org/xsd/imsqti_v2p0 imsqti_v2p0.xsd"
  identifier="review1" title="review form" adaptive="false" timeDependent="false">
 <!-- The definitions of outcome variables and response variables -->
  <outcomeDeclaration identifier="comment" cardinality="single" baseType="string"/>
  <outcomeDeclaration identifier="grade" cardinality="single" baseType="float"/>
  <responseDeclaration identifier="comment-article" cardinality="single" baseType="string"/>
  <responseDeclaration identifier="grade-article" cardinality="single" baseType="identifier"/>

  <itemBody>
     <!-- The definition of an open-question for capturing comment-->
    <extendedTextInteraction responseIdentifier="comment-article" expectedLength="1500">
      <prompt>Please comment on this article and give a score on the next page.</prompt>
    </extendedTextInteraction>
    <!-- The definition of a multiple-choice question with five choices for grading-->
    <choiceInteraction responseIdentifier="grade-article" shuffle="false" maxChoices="1">
        <prompt>How do you think about this article?</prompt>
        <simpleChoice identifier="1">outstanding</simpleChoice>
        <simpleChoice identifier="2">very good</simpleChoice>
        <simpleChoice identifier="3">good</simpleChoice>
        <simpleChoice identifier="4">acceptable</simpleChoice>
        <simpleChoice identifier="5">unacceptable</simpleChoice>
     </choiceInteraction>
  </itemBody>
  <-- The value of the outcome variable is the response of the user -->
  <responseProcessing>
    <setOutcomeValue identifier="comment">
      <variable identifier="comment-article" />
    </setOutcomeValue>
    <-- calculate outcome based on responses -->
    <responseCondition>
      <responseIf>
        <match>
          <variable identifier="grade-article"/>
          <baseValue baseType="identifier">1</baseValue>
        </match>
        <setOutcomeValue identifier="grade">
          <baseValue baseType="integer">1</baseValue>
        </setOutcomeValue>
```

continued on following page

Figure 27. The definition of a condition sending a notification (continued)

```
      </responseIf>
    </responseCondition>
  ......

  </responseProcessing>
</assessmentItem>
```

Learner1 uses it as an assessment form answering two questions: an open question and a multiple-choice question. Learner1's response to the first question "comment-article" will be treated as an outcome "comment." Learner1's response to the second question "grade-article" will be handled as an outcome "grade." The code fragment processing "choice 1" means if learner1's response is the first choice, then grade is 1. The code fragments processing other choices are omitted.

It is important to note that the identifier of the property coupled with an outcome of the assessment item must be defined as a combination of the identifier of the item and the identifier of the outcome. For example, the identifier of the property "review1.comment" (see Figure 13) is defined exactly by combining the identifier of the item "review1" and the identifier of the outcome "comment." If the identifiers of LD properties and the identifiers of outcome variables in QTI assessment items are specified in this way, the runtime environment will transfer data from QTI variables to LD properties automatically. The values of the properties can be viewed using global-element view-property like the code fragment shown in Figure 24. As a consequence, a seamless integration of assessment with instruction can be supported.

Competence Assessment

Competence assessment is an integral component of any competence development program. Although traditional forms of assessment are still useful, competence assessment is usually based upon more advanced forms of assessment (e.g., self- and peer assessment, 360 degree feedback, progress testing, and portfolio assessment). In comparison with traditional assessment, both judgment making and administrative processes are more problematic in new forms of assessment, which are process-based and with involvement of multiple roles and multiple persons. Thus, rather than a test sheet, an assessment design for competence development is a description of an assessment process consisting of a set of coordinated activities (e.g., collecting information about a certain competence, assessing the competence, etc.) with necessary resources (e.g., assessors, assessment items, and assessment-specific tools).

The use case as a whole is a peer assessment, one of the key forms of competence assessment. Note that the use case itself is not an example of competence assessment. It is just a traditional assessment, which aims at testing whether the knowledge and skills taught in a course have been acquired. Normally, the separation of learning and assessment is basic to competence assessment. The competence referred in this chapter is "effective overall performance within an occupation, which may range from the basic level of proficiency through to the highest level of excellence" (Cheetham & Chivers, 2005). If we remove the reading activities and follow-up activities from the use case and replace the questions about mastery of learning theories with questions about possession of a specific competence, then the modified use case would look like a competence assessment. That is, we can use LD to model a peer assessment for assessing competence. In fact, the peer assessment and other new forms of assessment have some common characteristics such as process-oriented and with the involvement of multiple roles/users. Other forms of innovative assessment can be modeled using LD in the same way to model the peer assessment.

It is important to note that some specific application tools such as certain simulators and computer games may be needed in competence assessment. Although LD defines only four kinds of services, it is left open to integrate any application tools as services such as a concept-mapping tool, a latent semantic analysis (LSA) tool, or a simulator. Thus, through a combined use of LD, QTI, and assessment-specific tools, we can model a competence assessment as a unit of assessment, a specific unit of learning containing assessment items and/or assessment-specific services (Miao, Tattersall, Schoonenboom, Stevanov, & Aleksieva-Petrova, 2007a).

Adaptive Learning

Traditional approaches to adaptive learning are adjusting contents, their structures, and presentations to learner's characteristics and learning requirements. Based on LD, it is possible to support adaptive learning by adjusting learning activities and other process elements within a unit of learning to personal characteristics and requirements. In this subsection, we discuss how to support adaptation using LD in a more general view.

Personalized Learning

In LD, personal properties are often used to represent learner's personal learning objectives, prior knowledge, proficiency level of competence, interests, preferences, performances, and other characteristics. The adaptable objects are learning/support activities, activity structures, content fragments, information items, environments, plays, and even other units of learning. The condition can be used as an adaptation model that specifies adaptation logics and adaptation actions.

In the use case, as shown in Figure 9, learner's task is adapted to the learning interest. This adaptation is implemented through a conditional tailoring of content fragments. Another example is illustrated in Figure 12; if the learner's learning interest is behaviorism and the final score is better than the average level, then a learning activity with appropriate learning material will be assigned to the learner. Readers interested in supporting personalized learning in LD can see the papers (Burgos & Specht, 2006; Burgos, Tattersall, & Koper, 2006).

"Groupalized" Learning

Corresponding to the term of personalized learning, "groupalized" learning is a kind of learning design tailored for individual groups according to the diversity in group characteristics. Role properties can be used to model group's characteristics such as group size, homogeneous/heterogeneous in background and learning interest, preferred interaction modes, and so on. The adaptable objects and adaptation models are similar to those used in personalized learning.

The use case is not a "groupalized" learning. However, if we extend it in a way that 10 pairs conduct peer assessment and the tutor is not engaged in the assessment process of any pair at the beginning. Each pair is defined as a role and a role property is defined for each role. The role property with a Boolean type represents whether learners in a pair have consensus after discussion. The learners in the pair can set the value of the property as true or false. If the value is false, the tutor will be involved in the assessment process of this pair. As a consequence, a pair may or may not have a need and a chance to interact with the tutor according to whether the pair achieves a consensus in peer assessment. Such an extension may be not a good design, because a pair may have an incorrect consensus. However, this extension just demonstrates how to support "groupalized" learning using LD. More discussion about supporting "groupalized" learning in LD can be found in Miao and Hoppe (2005).

General Adaptive Learning

Adaptation can be defined in a more general level. Not only factors relevant to persons and groups are considered as the base of adaptation, but also some other factors can be used for the purpose of adaptation. Because a property can be defined to represent anything or any status, in theory, adaptation can be modeled technically in a way to adapt the values of some properties to the value of other properties.

We can show such examples by extending the use case. For instance, we can define an adaptation model as:

If today is a working day, then use conference service A, else use conference service B

The value of the property "today" can be set by the tutor or the learner. The configuration of work environment will be adapted to the weekday, having nothing to do with any person or group.

Another example is adapting types of conference services to the number of participants involved in a run. The adaptation model is defined:

If (3 >= number of participants > 1) then using chat,
else if (6 >= number of participants > 3) then using audio tool with floor control,
else if (number of users > 6) then using discussion forum

In fact, more possibilities for adaptation can be supported at runtime. This issue is beyond the scope of this chapter.

CONCLUSION

In this chapter, we presented the pedagogical metamodel behind LD, basic knowledge of LD, and the procedure to model learning designs using LD. From a design perspective, the course is the aggregate containing all the necessary features to make learning successful. It is at this level that educational modeling takes place, and it is at this level that the pedagogical models are implemented. LD makes the use of pedagogical models explicit. This is one of the factors needed to enhance the quality of a pedagogical design. Thus, the combination of good design and good structuring of the design in a notation will bring us the quality of learning we are searching for. LD provides the framework to notate and communicate the designs in a complete form, validates them on completeness in structure, makes it possible to identify the functionality of learning objects within the context of a unit of learning, and provides means for real interoperability and reusability. LD can be used to model learning designs as descriptive models and prescriptive models. It can be used to describe an educational process at any level of granularity and with varied degrees of coercion. LD can be used for varied purposes ranged from communication and analysis at design time to guidance and control at runtime. In this chapter, we presented the whole procedure to create a learning design through modeling a use case from an informal model in nature language, a semiformal model in UML activity diagrams, to a formal model in XML. In particular, we demonstrated how to model advanced learning designs such as collaborative learning, new forms of assessment, and adaptive learning in LD.

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REFERENCES

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education*, *85*, 536–553.

Brown, A.L. (1980). Metacognitive development and reading. In R.J. Spiro, B.C. Bruce, & W.F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale: Lawrence Erlbaum Associates.

Burgos, D., & Specht, M. (2006, July). Adaptive e-learning methods and IMS learning design: An integrated approach. In *Proceedings of ICALT2006* (pp. 1192-1193). Kerkrade, The Netherlands: IEEE.

Burgos, D., Tattersall, C., & Koper, K. (2006, March 30-31). Representing adaptive eLearning strategies in IMS learning design. In *Proceedings of TENCompetence Conference*, Sofia, Bulgaria. Retrieved March 26, 2008, from http://hdl.handle.net/1820/601

Cheetham, G., & Chivers, G. (2005). *Professions, competence and informal learning* (p. 54). Cheltenham: Edward Elgar Publishing.

Cole, M., & Engestrom, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions*. New York: Cambridge University Press.

CopperAuthor. (2005). *CopperAuthor Learning Design editor*. Retrieved March 26, 2008, from http://sourceforge.net/projects/copperauthor/

De Boer, Th. (1986). *Grondslagen van een kritische psychologie* (2nd ed.). Baarn: Ambo.

Dillenbourg, P. (Ed.). (1999). *Collaborative-learning: Cognitive and computational approaches*. Oxford: Elsevier.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P.A. Kirschner (Eds.), *Three worlds of CSCL: Can we support CSCL* (pp. 61-91). Heerlen, Open Universiteit Nederland.

Dochy, F.J.R.C. (1992). *Assessment of prior knowledge as a determinant for future learning*. Hearken: Open Universiteit.

Duffy, Them., & Cunningham, D.J. (1996). Constructivism: Implications for the design and delivery of instruction. In D.H. Janssen (Ed.), *Handbook of research for educational communications and technology* (pp. 170-198). New York: Macmillan.

Fischer, F., Kollar, I., Mandl, H., & Haake, J. (Ed.). (2007). *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives*. Springer.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Greeno, J.G., Collins, A.M., & Resnick, L.B. (1996). Cognition and learning. In D.C. Berliner & R.C. Calfee (Eds.), *Handbook of educational psychology* (pp. 15-46). New York: Simon & Schuster Macmillan.

Griffiths, D., Blat, J., García, R., Vogten, H., & Kwong, K.-L. (2005). Learning design tools. In R.

Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 109-135). Heidelberg: Springer-Verlag.

IMS, http://imsglobal.org/

IMSLD. (2003). *IMS Learning Design*: *Information model, best practice and implementation guide, binding document, schemas.* Retrieved March 26, 2008, from http://www.imsglobal.org/learningdesign/index.cfm

IMSQTI. (2003). *IMS question and test interoperability*: Information model, best practice and implementation guide, binding document, schemas. Retrieved March 26, 2008, from http://www.imsglobal.org/question/index.cfm

Jonassen, D.H. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (vol. II, pp. 215-240). Mahwah: Lawrence Erlbaum Associates Publishers.

Karampiperis, P., & Sampson, D. (2005). Designing learning services for open learning systems utilizing learning design. In V. Uskov (Ed.), *Proceedings of the 4th IASTED International Conference on Web-based Education* (pp. 279-284). Grindelwald, Switzerland: ACTA Press.

Kearsley, G. (Ed.). (1987). *Artificial intelligence and instruction*. Addison-Wesley.

Koper, E.J.R., & Burgos, D. (2005). Developing advanced units of learning using IMS learning design level B. *International Journal on Advanced Technology for Learning, 2*(4), 252-259.

Koper, E.J.R., & Manderveld, J.M. (2004a). Modelling reusable, interoperable, rich and personalised units of learning. *British Journal of Educational Technology, 35*(5), 537-552.

Koper, E.J.R., & Olivier, B. (2004b). Representing the learning design of units of learning. *Educational Technology & Society, 7*(3), 97-111.

Koper, E.J.R., & Tattersall, C. (Eds.). (2005). *Learning design: A handbook on modeling and implementing network-based education & training.* Heidelberg: Springer Verlag.

Kuhn, T.S. (1962). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Malone, T.W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4,* 333-369.

Martens, H., & Vogten, H. (2005). A reference implementation of a learning design engine. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 91-108). Berlin-Heidelberg: Springer-Verlag.

McAndrew, P., Nadolski, R., & Little, A. (2005). Developing an approach for learning design players. *Journal of Interactive Media in Education, 14.* Retrieved March 26, 2008, from http://www-jime.open.ac.uk/2005/14/

Merrill, M.D. (1980). Learner control in computer-based learning. *Computers & Education, 4*, 77-95.

Merrill, M.D. (1983). Component display theory. In Ch.M. Reigeluth (Eds.), *Instructional design theories and models: An overview of their current status.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Merrill, M.D. (1987). A lesson based on the component display theory. In C.M. Reigeluth (Ed.), *Instructional theories in action.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Merrill, M.D. (1988). Applying component display theory to the design of courseware. In D.H. Jonassen (Ed.), *Instructional designs for microcomputer courseware* (pp. 61-96). Hillsdale, NJ: Lawrence Erlbaum Associates.

Merrill, M.D. (1999). Instructional transaction theory (ITT): Instructional design based on knowledge objects. In C.M. Reigeluth (Ed.*), Instructional-design theories and models: A new paradigm of instructional theory* (vol. II, pp. 397-424). Mahwah: Lawrence Erlbaum Associates Publishers.

Miao, Y. (2005). CoSMoS: Facilitating learning designers to author units of learning using LD. In *Towards Sustainable and Scalable Educational Innovations Informed by the Learning Sciences: Proceedings of the 13th International Conference on Computers in Education* (pp. 275-282). Singapore: IOS Press.

Miao, Y., & Hoppe, U. (2005). Adapting process-oriented learning design to group characteristics. In *Proceedings of the 12th Conference on Artificial Intelligence in Education* (pp. 475-482). Amsterdam, The Netherlands: IOS Press.

Miao, Y., Tattersall, C., Schoonenboom, J., Stevanov, K., & Aleksieva-Petrova, A. (2007a, January). Using open technical e-learning standards and service-orientation to support new forms of e-assessment. In *Proceedings of the 2nd TENCompetence Open Workshop on Service Oriented Approaches and Lifelong Competence Development Infrastructures,* Manchester, UK (pp. 83-90).

Miao, Y., Vogten, H., Martens, H., & Koper, R. (2007b, October). The complementary roles of LD and QTI in supporting effective Web-based formative assessment. In *Proceedings of International Conference on Advanced Technologies in Education (CATE 2007)*, Beijing, China.

Molenda, M. (1991). A philosophical critique on the claims of "constructivism." *Educational Technology, 31*(9), 44-48.

Paquette, G., Léonard, M., Ludgren-Cayrol, K., Mihaila, S., & Gareau, D. (2006). Learning design based on graphical modelling. *Educational Technology & Society, 9*(1), 97-112.

Reigeluth, Ch.M. (Ed.). (1983). *Instructional design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Reigeluth, Ch.M. (Ed.). (1987). *Instructional theories in action*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Reigeluth, C.M. (1999). What is instructional-design theory and how is it changing? In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (vol. II, pp. 5-29). Mahwah: Lawrence Erlbaum Associates Publishers.

Reload. (2005). *Reusable e-learning object authoring and delivery project*. Retrieved March 26, 2008, from http://www.reload.ac.uk/

Roblyer, M.D., & Edwards, J. (2000). *Integrating educational technology into teaching (*2nd ed.). Upper Saddle River, NJ: Merrill, Prentice Hall.

Sadler, D.R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*, 119-144.

Schunk, D.H., & Zimmerman, B.J. (1994). *Self-regulation of learning and performance. Issues and educational applications*. Hillsdale, NJ: Erlbaum.

Sfard, A. (1998). One-two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4-13.

Shuell, Th.J. (1988). The role of the student in learning from instruction. *Contemporary Educational Psychology*, *13*, 276-295.

Simons, P.R.J. (1999). Competentiegerichte leeromgevingen in organisaties en hoger beroepsonderwijs. In K. Schlusmans, R. Slotman, C. Nagtegaal, & G. Kinkhorst (Eds.), *Competentiegerichte leeromgevingen* (pp. 31-46). Utrecht: Lemma.

Stolovitch, H.D., & Keeps, E.J. (Eds.). (1999). *Handbook of human performance technology*. San Francisco: Jossey-Bass Publishers.

Tattersall, C., Vogten, H., Brouns, F., Koper, R., van Rosmalen, P., Sloep, P., & van Bruggen, J. (2005). How to create flexible runtime delivery of distance learning courses. *Educational Technology & Society, 8*(3), 226-236.

Van Es, R. (2004). *Overview of online databases with lesson plans and other learning design methods*. Retrieved March 26, 2008, from http://hdl.handle.net/1820/102

Vermunt, J.D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. *Higher Education, 31*, 25-50.

Vogten, H., Koper, R., Martens, H., & Tattersall, C. (2005). An architecture for learning design engines. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 75-90). Berlin- Heidelberg: Springer-Verlag.

Vogten, H., Tattersall, C., Koper, R., van Rosmalen, P., Brouns, F., Sloep, P., van Bruggen, J., & Martens, H. (2006). Designing a learning design engine as a collection of finite state machines. *International Journal on E-Learning, 5*(4), 641-661.

Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer-supported collaborative learning. *Instructional Science, 33*(1), 1-30.

KEY TERMS

IMS Learning Design: A specification released by the IMS Global Learning Consortium. It is a learning design language which can be used to specify a wide range of pedagogy strategies. The approach has the advantage over alternatives in that only one set of learning design and runtime tools then need to be implemented in order to support the desired wide range of pedagogies.

Learning Design: A description of a sequence of learning activities that learners undertake to attain some learning objectives, including the resources and support mechanisms required to help learners to complete these activities and their temporary relations.

Learning Design Language: A notation that describes learning designs in a machine interpretable way. The most obvious use of such a learning design language is that it can be used to codify the learning design of a course (as a flow of activities), and then this code is interpreted with a runtime engine that can repeat the course over and over again for different users in different situations, adapted to the characteristics of the individual users in the course. When the course is designed well, the different actors do not have to be concerned much about the management of activities and information flow within the course: this is done automatically. Also, the adaptation rules that are specified are applied automatically and consistently within the course runs. Furthermore, the necessary content and services are set up automatically and made available to the users at the right moment.

Unit of Learning: An abstract term used to refer to any delimited piece of education or training, such as a course, a module, a lesson, and the like. It represents more than just a collection of ordered resources to learn; it includes a variety of prescribed activities, assessments, services, and support facilities provided by teachers, trainers, and other staff members. In the context of LD, it refers to the result of modeling a learning design.

Chapter IV
Opportunities, Achievements, and Prospects for Use of IMS LD

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ABSTRACT

The IMS LD specification is internally complex and has been used in a number of different ways. As a result users who have a basic understanding of the role of the specification in interoperability may nevertheless find it difficult to get an overview of the potential of the specification, or to assess what has been achieved through its use. This chapter seeks to make the task simpler by articulating the modes of use of the specification and analysing the work carried out in each. The IMS LD specification is briefly introduced. Four aspects of the IMS Learning Design specification are identified and described: modeling language, interoperability specification, modeling and methodology, and infrastructure. The different opportunities provided by each mode of use are explored and the achievements of work so far carried out are assessed. A number of valuable contributions are identified, but the practical and widespread use of the specification to exchange learning activities has not so far been achieved. The changing technological and organisational environment in which IMS LD operates is discussed, and its implications are explored. Conclusions are offered which summarise achievements with IMS LD to date, with comments on prospects for the future.

INTRODUCTION

The Questions Addressed by This Chapter

Within the field of learning design and learning objects, IMS Learning Design (IMS LD) (IMS Global Learning, 2003) is the only interoperability specification which enables users to implement learning activities for multiple users while maintaining the flexibility to implement a wide range of pedagogical structures. Because of this, IMS LD based approaches and systems have rightly received a great deal of attention as a possible solution to a number of different challenges facing education in the early years of the twenty-first century. This multifaceted relevance, however, creates its own problems. The experience of the authors is that many people when they first come to IMS LD see it in terms of the problems which they themselves would like to solve. For example, they may see it as being a modeling language, or as a data format, or as "what you do when you use an IMS LD compliant application?" As a result, it is often difficult for users to get an overview of the full potential of the specification, or to assess what has been achieved with it. This chapter does not provide an introduction to IMS LD, as this is available in Koper (2005b) and Olivier and Tattersall (2005). Nor does it focus on classifying and describing tools for IMS LD, as analysed by Griffiths, Blat, Garcia, Vogten, and Kwong (2005). Rather it seeks to support relative newcomers to the specification in understanding the opportunities which IMS LD offers, the achievements which have been made, the constraints under which it operates, and the prospects for the future. It also aspires to offer reflections which will provide some new perspectives for those who have worked with the specification for some time.

From one perspective, it might seem that the contribution made IMS LD and its predecessor educational modelling language (EML) is straightforward, as described in the preface to Koper and Tattersall (2005, p. viii):

The basic idea of EML and LD...is in essence simple. It represents a vocabulary which users of any pedagogical approach understand, and into which existing designs can be translated. The core of LD can be summarised as the view that, when learning, people in specific groups and roles engage in activities using an environment with appropriate resources and services.

In the same volume, Koper sets out the requirements for a learning design language (Koper, 2005b). These include that it should provide sufficient detail for the teaching–learning activities to be carried out, be sufficiently flexible to be able to describe learning designs based on all kinds of theories, and should provide a formal language for learning designs that can be processed automatically. Thus, IMS LD is a language which can be used to define designs for teaching and learning activities. Nevertheless, the specification itself is not as straightforward as this might suggest. As Olivier and Tattersall (2005, p. 21) point out: "To be usable by computers, this language has to be given a concrete syntax and semantics, and this is provided by the Learning Design specification. The documents which make up the specification can be quite daunting."

IMS specifications are typically composed of a set of three documents: a *best practice and implementation guide*, an *information binding*, and an *information model*, and in the case of IMS LD, these documents are considerably more extensive and complex than most of those produced by IMS. According to Olivier and Tattersall (2005, p. 23) who were involved in the authorship of the documents, they are "intended to be read by technical domain specialists, learning technologists and learning and instructional designers." It should be noted that end users, such as teachers, learners, and those running educational institutions, are not mentioned in this list. These end users would no doubt find the LD specification opaque, and indeed the experience of the UNFOLD project (Burgos & Griffiths, 2005), which we discuss below, suggests that this is the case for many “learning and instructional designers” too. Thus, it was always intended that most actors would use IMS LD through the mediation of a layer of tooling. In this, LD is similar to other document formats which are rarely edited or even seen by anyone other than a technical expert, even in the case of a relatively simple mark up language such as HTML. Consequently, the degree to which IMS LD tools have succeeded in hiding the complexity of the specification from the user has been, and remains, a key factor in constraining or enabling the achievements and opportunities for effective use of the specification.

In an earlier publication (Griffiths, Blat, Garcia, Vogten, & Kwong, 2005), we discussed the categories of tools which are required to work with IMS LD, the factors which influence their development, and types of tools which were being produced. The categorisation of tools which is provided there remains applicable, although readers interested in an alternative approach are also directed to Sodhi, Miao, Brouns, and Koper (2007). Since 2005, a substantial effort has been put into the development of IMS LD tooling, and in this chapter, we will be mentioning much of the key work carried out. The development of IMS LD compliant tools and specifications is not, however, an end in itself. To be of significance, they should be used by someone for a purpose, and make a difference in the world, and so our discussion is informed by the questions:

1. Have the original goals of IMS LD been achieved?
2. What opportunities for use have emerged from applications of IMS LD beyond those envisaged by the authors of the specification?

With this in mind, we do not here tell the story of the work carried out, and the software engineering, design, and usability issues which have arisen (interesting though these topics may be). Rather, we identify the ways in which IMS LD can be used, giving illustrative examples of the tools and implementations which have been developed. On the basis of this discussion, we offer our assessment of the current status of IMS LD for each of the modes of use. We then move on to engage with a critical reflection on the role that IMS LD is equipped to play in the evolving technical context, discussing the question:

3. To what extent have there been changes in the technological and organisational environment within which IMS LD is situated, and what are the implications for future use of the specification?

The Authors’ Engagement with IMS LD

This chapter is strongly informed by our own work with the IMS LD specification. Both authors are members of the Institute for Educational Cybernetics (IEC) at the University of Bolton, directed by Professor Oleg Liber, which is heavily involved in IMS LD. First, it is home to the JISC-CETIS project which represents UK Higher and Further Education in the IMS Global Learning Consortium and advises universities and colleges on the strategic, technical, and pedagogical implications of educational technology standards. Second, it has developed the Reload Learning Design Editor (Milligan, Beauvoir, & Sharples, 2005), which is widely recognised as the reference editor for IMS LD. Third, as part of its contribution to the TENCompetence project, the IEC is developing a number of IMS LD related applications. In his previous post at Universitat Pompeu Fabra, David Griffiths was coordinator of the UNFOLD project, in which the IEC (under its former name of CETIS) was also a partner.

The UNFOLD project was an ICT coordination action funded by the European Commission which supported communities of practice for systems developers, learning designers, and learning providers who were using the IMS LD specification. The four partner organisations ran a series of seven face to face events and numerous online activities over a period of two years, as described in the UNFOLD Communities of Practice Report (Griffiths, Burgos, Kew, Dias, Tattersall, Girardin, et al., 2006). UNFOLD engaged with a wide range of actors in the field, working with the specification in many different ways. The activities of the project responded to this breadth of interest, and included activities around systems such as learning activity management system (LAMS) and Moodle. Education is a huge and varied field, and although hundreds of people participated in UNFOLD, they cannot be considered representative of teachers and educationalists as a whole. On the other hand, they did represent a large scale sample of those interested in new perspectives on learning and in exploring the possibilities which they offered. The data and documentation generated by the interactions in these communities and events provided an opportunity to establish the ways in which the specification was being used, and the benefits which this use could offer. This provides a solid grounding for answering the first two of the questions raised above. Indeed most of the information we present here was gathered directly or indirectly from the network of documents and contacts generated in the course of UNFOLD, and its sister project the Learning Network for Learning Design (LN4LD) (OTEC (OUNL), 2005) which was created by the Open University of the Netherlands to provide a platform to learn and exchange information about the IMS Learning Design specification and its application.

As well as providing the basis for establishing what had been achieved, the activities of the UNFOLD project also addressed a number of open questions based on concerns expressed by users and identified issues which were repeatedly raised but not resolved. These form the basis for our more hypothetical discussion of the changes in the technological and organisational environment, which is inevitably more open ended. Small scale studies may be able to demonstrate obstacles or encouraging lines of work in this regard. However, in order to obtain grounded insight into the way in which these factors impact on the use of IMS LD in the education and lifelong learning sectors as a whole, we propose that an approach similar to that carried out in UNFOLD would be valuable in order to achieve a sufficiently wide range of participation and data.

The Structure of This Chapter

As described above, this chapter addresses three questions:

1. Have the original goals of IMS LD been achieved?
2. What opportunities for use have emerged from applications of IMS LD beyond those envisaged by the authors of the specification?
3. To what extent have there been changes in the technological and organisational environment within which IMS LD is situated, and what are the implications for future use of the specification?

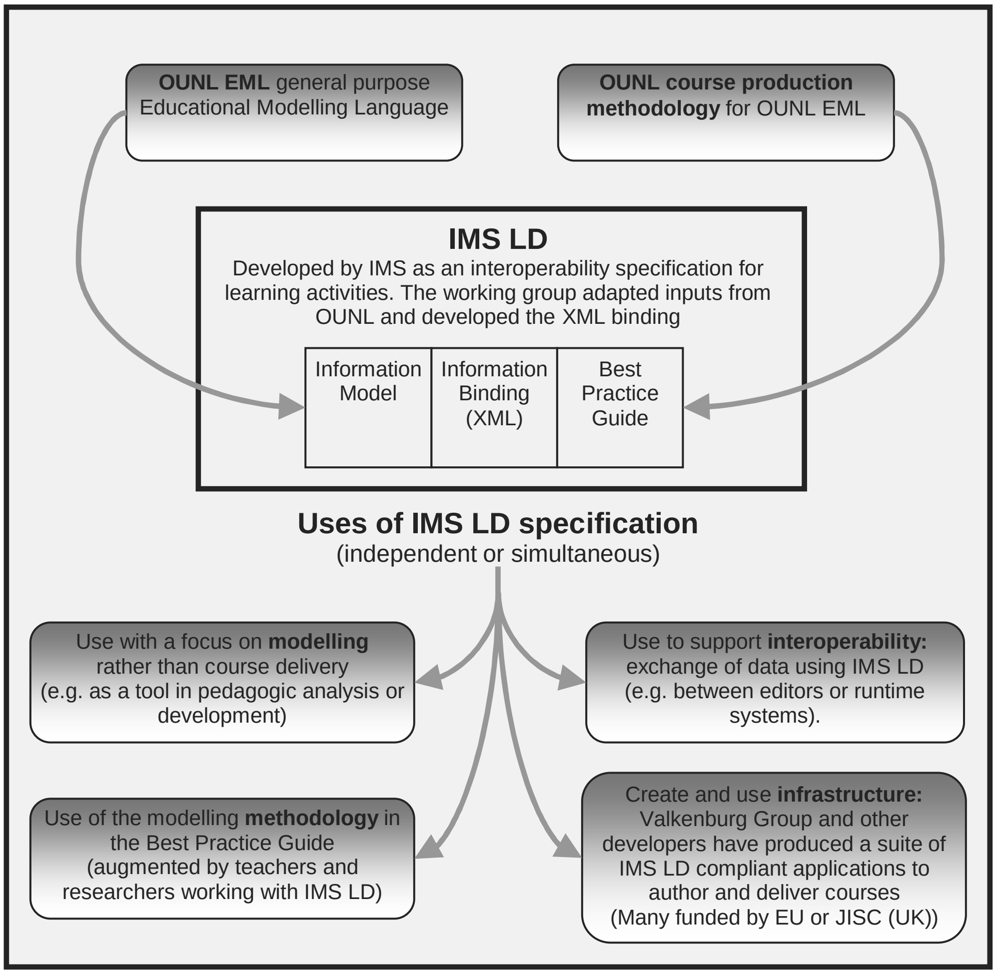
We address these questions in the following sections: We begin by discussing the various Modes of Use of IMS LD, and focus on its role as a modeling language, interoperability specification, methodology, and infrastructure of computer programs. We move on to discuss the Achievements of IMS LD in each of these areas. We then reflect on the role of IMS LD in a changing world, identifying technological developments, changes in underlying assumptions, and institutional changes as the main drivers. Finally, we offer our conclusions.

MODES OF USE OF IMS LD

The Multifaceted Nature of IMS LD

In seeking to address the questions introduced in the previous section, we have to consider (a) the original goals of IMS LD and (b) ways in which the specification has been used. These two aspects are more complex than might be thought at first glance, and a number of different opportunities for use can be identified. First, as regards the declared goals of the specification, it is important to understand that the specification has its origins in two quite separate initiatives which served different purposes, as described in Olivier and Tattersall (2005). On the one hand, IMS Global Learning Inc. identified a need for a specification which would support the export and import of learning activities between different applications. On the other hand, the Open University of the Netherlands had developed an Educational Modeling Language (OUNL EML) in order to facilitate the design and execution of a wide range of pedagogical designs in their inter-

Figure 1. Development and modes of use of IMS LD



nal provision (Hermans, Manderveld, & Vogten, 2004). It was proposed that OUNL EML could be adapted and adopted by IMS as their specification for learning activities, and this started the process which led to the publication of IMS LD in 2004. Thus, from the very beginning, IMS LD was able to facilitate two quite different purposes: it could be used to model pedagogical processes, or it could provide a means of transferring data between applications.

Second, each of these two aspects of the specification has its own enabling processes and infrastructure. As regards modeling pedagogical processes, the specification includes a best practice guide, which proposes a procedure for the creation of pedagogical models. Independently of IMS, this practice has been extended through methodological contributions from users of the specification. On the other hand, interoperability has been supported by the development of a number of applications which work directly with IMS LD, or which import and/or export it. Thus, in this analysis, we propose that user activity around the IMS LD specification may be focused on one or more of four modes of use, as shown in the following bullets and in Figure 1:

- The purposes of IMS LD as originally formulated:
  - *Modeling language*: use of the specification to model pedagogical processes
  - *Interoperability*: transmission of data between applications
- Enabling structures developed to support IMS LD:
  - *Modeling methodology*: the methodology which is used to create and use units of learning (UOLs)
  - *Infrastructure*: the applications which have been developed to work with IMS LD

Users may work with all four of these modes of use, or with one alone, and all are in some way working with an application of IMS LD. Each of these enables users to achieve different ends, and so there is no single answer as to whether IMS LD has achieved its goals. We now describe each of these modes of use and, in the following section, outline what has been achieved through the use of IMS LD in each.

IMS LD As a Modeling Language

IMS LD is an adaptation of the OUNL's Educational Modeling Language (EML) and so the origin of the specification in modeling is clear. It should be pointed out, however, that the term "model" as applied to pedagogy is often poorly defined, as has been discussed by Beetham (2004) who identifies five distinct uses of the word in education. In the case of EML and its successor IMS LD, the need addressed is for "a good notational system for recording the content and occurrences in the learning environment" (Koper, 2000, p. 19). When this notational system is used to describe a particular teaching process, the result is a pedagogical model as we understand it here. Note that when used in this sense, a model is descriptive rather than predictive. In other words, it is useful for describing, planning, and implementing an educational process, rather as a map is useful to a taxi driver or a lesson plan is useful to a teacher. It does not provide a means of predicting how the cognitive outcomes for learners will be different if a teaching procedure is changed, in the way that a model of climate change predicts the results of raised levels of CO^2 in the atmosphere.

IMS LD is therefore a metamodel, as defined by Koper (2001) with regard to EML. In another publication, Koper (2005a, p. 68) states that to be effective as such, it is necessary that it should have a sufficient level of pedagogical expressiveness: "While it must be sufficiently flexible to describe Learning Designs based on all kinds of pedagogies, it must avoid biasing designs towards any specific pedagogical approach." In other words, the implied claim made by IMS LD is that almost any teaching approach can be described effectively by specifying how people in roles perform activities within an environment. For some users, this formal notation of pedagogy may be an end in itself, perhaps for research purposes, rather than as a means to practical development of courses.

IMS LD as an Interoperability Specification

IMS Global Learning Inc. is not in the business of developing modeling languages, but rather its primary goal is to promote the development of global distributed learning by formulating open technical specifications (IMS Global Learning Inc., 1999). Why then should the organisation have taken an interest in a modeling language such as EML? The context within which the IMS LD initiative was commenced was that the organisation had published specifications for the description and delivery and use of digital learning resources or "learning objects" (IMS Learning Object Metadata, IMS Content Packaging, IMS Simple Sequencing, IMS Question and Test Interoperability), but had no specification for describing what activities could be carried out with these resources. As a result, a user who had used learning resources described and packaged with IMS specifications in developing a course in one virtual learning environment (VLE) could not move to another VLE without reconstructing all the work done in creating learning activities around these learning resources. VLEs are also referred to as learning management systems (LMSs), especially in the USA, but both terms refer to the same type of application, as discussed in Weller (2007). This focus on pedagogical activities is reflected in the IMS Learning Design Information Model (IMS Global Learning Consortium Inc., 2003b, p. 4) which states that a key task for the Learning Design Working Group was "the development of a framework that supports pedagogical diversity and innovation, while promoting the exchange and interoperability of e-learning materials." In this context, there were obvious attractions to a developed and tested solution such as EML, described in the IMS LD Information Model as "a relatively concise 'meta-language' that could capture this diversity" (IMS Global Learning Inc., 2003b, p. 4).

This may well have been the best approach to have taken, but it is not surprising that the use of a modeling language as an interoperability specification has created some degree of confusion. While there is a strong argument for using readable data structures wherever possible, there should be no need for a human to inspect an exported file from one IMS LD compliant application before it is imported by another. On the other hand, from a modeling point of view, this human engagement with the specification is a reasonable approach, if not the only one. For example, the IMS LD Best Practice Guide provides the advice that "If you want to design a learning scenario, the element to start with is the method element" (IMS Global Learning Inc., 2003a, p. 22). The result has been that the specification has sometimes been perceived as presenting teachers with insurmountable problems, when there is in principal no reason why they should ever encounter its concepts and syntax. Indeed when using IMS LD as an interoperability specification, the user does not need to be aware of any of the other aspects of IMS LD discussed here, or even of the specification itself.

IMS LD As a Methodology

The IMS LD specification Best Practice Guide recommends a methodology for the development of UOLs and draws substantially on practice at the OUNL in developing courses with EML. A number of alternative methodologies have been proposed, and some have been put into practice. This methodological reflection, integration, and innovation is associated with IMS LD, but is best viewed as an independent factor, as the specification can be used without these methodologies, and similarly the methodologies can be used (directly or in adapted form) without the specification.

IMS LD as an Infrastructure

Without appropriate tooling, the IMS LD specification could achieve little, and potential adopters would find it very hard to understand the advantages which it can offer. As a result, there has been a significant effort by a large number of institutions to develop an infrastructure to make the specification usable. This was coordinated following the publication of the specification by the Valkenburg Group, as described in the preface to Koper and Tattersall (2005). This group set out to coordinate and promote the creation of a technical infrastructure to support use of the specification, and subsequently its role was expanded by the UNFOLD project. Much of this infrastructure has been developed specifically to support the adoption of IMS LD as an interoperability specification and/or modeling language. Nevertheless, users may choose to use these applications because of the facilities they offer, rather than the technology on which it is based (indeed it could be maintained that the future of the specification would be bleak if this were not the case).

THE ACHIEVEMENTS OF IMS LD

In the previous section, we identified four distinct ways in which the specification can be used, each of which may be found in isolation, or in combination with any of the others. In this section, we will move on to discuss the work which has been carried out in each area. It should be remembered that this division into four areas is intended to clarify our understanding of patterns of use, but it does not imply that users necessarily categorise their work in this way. This is for two principal reasons.

First, at the technical level there is no clear division in practice between creating a model and using the infrastructure. Almost always when a user makes a model using IMS LD, they use the technical infrastructure developed for the specification, unless they choose to author in a generic XML editor. On the other hand, when an author creates a UOL using an editor, they are creating an IMS LD model at some level, even if they are not aware of it. Similarly, an export from an IMS LD compliant application constitutes a model, even if to the user it is simply a file format.

Second, at the level of users understanding of their own activity, some users would find it unnatural to separate their modeling activities from their use of the infrastructure to deliver courses. Indeed EML was initially developed to support the delivery of courses. Similarly, for some other users, interoperability might be subsumed in the other attractive features of the infrastructure. We would argue, however, that this lack of clarity is not an artefact of the approach which we are taking in this chapter, but rather a reflection of the problem which we are examining: the mixed motivations for use of IMS LD. It is this confusion which makes it valuable to clarify the underlying patterns of use proposed here. We now outline what has been achieved in relation to each of the modes of use identified and offer our assessment for each.

The Achievements of IMS LD in Modeling

Validation of IMS LD As a Modeling Language

As described by Koper and Manderveld (2004, p. 539), OUNL EML was validated by a programme of research into pedagogical modeling.

The development process of EML consisted of separate iterations of analysis, design, implementation, test and evaluation. The complete development process of EML took about three years and was conducted by a large variety of experts such as educational technologists, ICT-experts, XML-experts, etc.

The specification was then used operationally in a number of courses with a wide range of pedagogies at the OUNL with satisfactory results. To this extent, it is clear that EML was validated as an effective modeling language within the context for which it was designed.

The adaptation of OUNL EML in creating IMS LD does not seem to have reduced the expressivity of the language. It is, however, arguably more complex to work with, because it has to work together with other IMS specifications, such as Question and Test Interoperability (QTI) and Content Packaging (CP). This has come about because functionality corresponding to prior IMS specifications was taken out of OUNL EML in the process of adapting it as IMS LD in order to avoid duplication. The coordination of these various specifcations has to be handled by the infrastructure and by the learning designer. OUNL EML, on the other hand, was a single integrated specification including all the necessary elements.

The pedagogical expressiveness of IMS LD was evaluated by Van Es and Koper who took 16 lesson plans and expressed them in LD. They conclude that "Although several lesson plans needed a work around, the main educational processes could all be described sufficiently with LD" (Van Es, 2005, p. 248). An additional useful test was the implementation in IMS LD of the "What is Greatness?" use case which informs the development of LAMS (Dalziel, 2003).

Practical validation of IMS LD as a modeling language can best be provided by analysis of its use in delivering courses in different contexts. This use has, however, not been as great as might have been hoped when the specification was published. Nevertheless, the work so far carried out, in particular by Liverpool Hope University and also by projects such as OpenDock (OpenDock, 2006), has not yet shown up any major deficiencies in the specification as a modeling language.

Use of IMS LD As a Modeling Language

An interesting use of IMS LD as a modeling tool is the LearningMapR project (Buzza, Richards, Bean, Harrigan, & Carey, 2005, p. 4). This project provides computer support for the T5 Model which "guides the instructor in the design of learning activities, supports reuse of resources, and helps make the instructional design and its rationale apparent to students." The two core components of LearningMapR provide help for instructors in defining

- What they want the learner to know and do as they cover a topic
- The instructional challenges for a given topic and their occurrence patterns in terms of the proportion of students involved

The resulting design is modeled using IMS LD.

The ACETS project also used IMS LD as the basis for modeling pedagogy, although in this case, the use was descriptive rather than prescriptive, and created a semistructured learning design using a subset of IMS LD elements, rather than the XML binding.

Following a base line survey, the project researchers carry out semi-structured interviews in an attempt to create a user-friendly way of formally expressing a teaching scenario that can be analysed and reused. The questions asked map closely onto the structure of the LD specification. In this way the focus remains on the interviewees practice, but the results are formulated with a *structure which lends itself easily to expression as a Learning Design, at least for the scenario stage of the Best Practice recommended in the specification. This instrument is intended as a means of documenting existing practice.* (Griffiths & Blat, 2005, p. 246)

This enabled the project to produce a set of codifications of what the teachers involved thought should or did happen (Ellaway, Dewhurst, Quentin Baxter, Hardy, & Leeder, 2005).

Work is being done by various projects to create, gather, and disseminate pedagogical models expressed as UOLs, for example, Implementation and Deployment of the Learning Design Specification (IDLD) (IDLD, 2006). This repository presents the pedagogical models in terms of patterns, drawing on the MISA method developed by Télé-université's LICEF Research Centre in Quebec, Canada (Paquette, de la Teja, Léonard, Lundgren-Cayrol, & Marino, 2005), and on IEEE-Learning Object Metadata (LOM). They provide the following example:

Here, this object is a learning design for a collaborative LD pattern entitled "FORUM SYNTHÈSE."

For this LD, the user has selected metadata from the learning design classification: the delivery model is "Asynchronous Online Training," the pedagogical strategy is "Debate/Discussion," and the evaluation model is "summative," based on "learner productions" that are "mostly individual." (Lundgren-Cayrol, Marino, Paquette, Léonard, & De la Teja, 2006, p. 19)

A less formal approach is taken by OpenDock (Griffiths, Elferink, & Veenendaal, 2006), in which it is seen as more practicable that the classification of pedagogical models should emerge from patterns of use and comment, rather than from expert analysis. While these are promising initiatives, they are both in relatively early stages, and neither yet has a critical mass of units of learning which can effectively showcase IMS LD modeling.

Modeling Services with IMS LD

One of the problems encountered in modeling, which was raised repeatedly in UNFOLD, was the representation of a wider range of services in units of learning than the very limited set provided by the specification. We have observed two types of explanation being given for this difficulty. First, it can be argued that the particular services used may be incidental to the pedagogical model and should not be included in the model itself. For example, if we ask learners to participate in a discussion about a book or a scientific experiment, then the prompts which we give them and the structure which we provide for the discussion are clearly pedagogical interventions which we should model. It can be argued that the choice of a forum or e-mail for actually carrying out the discussion has relatively few pedagogical implications, and also changes in its meaning as the technology develops (for example, the boundary between a forum and e-mail becomes blurred once users can post and read messages from their e-mail client). Rather than such choices being made by a designer, it is perhaps more appropriate for them to be taken at runtime by the teacher or by the learners themselves.

Second, the difficulty of representing services can be ascribed to the use of IMS LD as an interoperability specification, rather than its inherent capabilities as a modeling language. In its earlier incarnation as EML, it was an easy matter to keep the specification and the target implementation in step. For example, if a need was identified to support wikis, then the specification and the target platform could both be updated in a coordinated way. In IMS LD, this cannot be done because the specification keeps the range of services required as low as possible so as to avoid making setting barriers in the way of platforms which would like to be compliant. Consequently, there is no way to be sure what services will be available on the target platform. We discuss this aspect further in the following section.

Both these explanations have merit, but note that the logic of the second one (EML was a more effective modeling environment than IMS LD because it was tightly bound with a set of services) runs counter to the first (it is not appropriate to bind a pedagogical model to a specific set of services, because these may be incidental and/or change rapidly). An initiative which sets out to resolve the problem of modeling services is Learning Design Language (LDL), led by Christian Martel and Laurence Vignollet of the University of Savoie. This provides a generic means of modeling the use of services (Martel & Vignollet, 2007). LDL does not, however, make use of IMS LD, and while the approach taken is consistent with and complementary to IMS LD, it is by no means clear how the two specifications might work together. We also comment on this aspect in discussing IMS LD infrastructure.

The Purpose of Pedagogical Modeling

Despite the effectiveness of IMS LD as a pedagogical modeling language which the above examples indicate, we have not been able to identify widespread use of IMS LD with a focus on modeling per se, as opposed to the use of IMS LD as an enabling technology in the delivery of courses. On the other, we have not identified any reports of significant shortcomings of the specification in this respect. This suggests that demand for a formal system to represent pedagogical models as such has so far not been high, despite the potential it seems to offer educational researchers in documenting practice and plans.

One explanation of why this should be so is offered by the ELEN project, which set out to establish a pattern language for education following the model of Alexander's (1979) architectural pattern language. The conclusion which they came to was that "currently used design patterns in the pedagogical domain are not always suitable solutions to instructional design problems" (Niegemann & Domagk, 2005, p. 6). On the other hand, it must be the case that patterns regularly used in teaching are in some sense satisfactory for the teachers and institutions using them, or they would have disappeared. This suggests the possibility that:

- The problems addressed in a pedagogical pattern may not always be the highest priorities of teachers working with specific classes, where the challenges are more concrete and conditioned by the individual learners.
- The key factors in determining if use of a pedagogical pattern is effective may be external to the pattern itself. For example, among the factors which may influence the outcomes of using a UOL are cultural context, institutional context, the skills of the teacher, the attitudes and previous learning experiences of the learners, and so forth. These factors could in principle be modeled, but IMS LD does not go into this level of detail (which would involve a level of complexity which would make a specification extremely difficult to understand or to implement).

In view of this, we propose that an alternative way forward for use of IMS LD as a modeling language per se may be to use the specification to represent the organisational aspects of pedagogical plans and/or practice in a standardised way in a UOL, and to use other methods to identify the factors which lead to different outcomes when the UOL is repeated. These methods could include, for example, ethnography, conversation theory (Pask, 1976), and positioning theory (Harré & van Langenhove, 1999). In light of the above discussion, our assessment regarding the use of IMS LD in modeling is that:

a. The examples provided demonstrate the effectiveness of IMS LD as a general purpose pedagogical modeling language.
b. Despite some interesting initiatives, there has not been widespread use of IMS LD with a focus on modeling per se. However, while this was a goal of EML, it was not a goal of IMS in creating IMS LD.

The Achievements of IMS LD in Interoperability

In order for interoperability to be demonstrated, there has to be a range of applications available which can exchange IMS LD data and process them at runtime. As we have discussed elsewhere (Griffiths, Blat, Elferink, & Zondergeld, 2005), in this respect reference implementations have had a key role. However well written a specification may be, there will always be points at which developers can interpret it in different ways. Even minor differences in interpretation by developers can combine to produce radically different behaviours, or even a failure to run. Reference implementations resolve this by providing a widely accepted interpretation of the specification and the behaviours which may be expected from compliant applications. To be effective, they should be published as open source code which can be inspected by other developers. In the case of IMS LD, the key reference implementations are widely recognised to be the Reload Learning Design Editor (CETIS, 2006; Milligan et al., 2005) and the CopperCore Learning Design Engine (Martens & Vogten, 2005). The coordination carried out through the Valkenburg Group, the UNFOLD Project, Learning Networks for Learning Design, and the more recent events and publications sponsored by the TENCompetence project, have also been a significant factor in aligning implementations and promoting interoperability.

As regards runtime, a significant achievement is the release of an IMS LD module for .LRN (.LRN, 2006; Griffiths, Burgos, et al., 2006), which is the first full VLE to adopt the specification. Moodle has also committed to becoming IMS LD compliant (Burgos, Tattersall, Dougiamas, & Vogten, 2006; Moodle, n.d.). A number of different editors have been created or are under development, such as the learning design toolkit (ADK LDT) developed by the Advanced e-Services for the Knowledge Society Research Unit in Athens (Sampson, Karampiperis, & Zervas, 2005), COLLAGE (Hernández-Leo, Asensio-Perez, Dimitriadis, Jorrín-Abellán, Ruiz-Requies, & Rubia-Avi, 2006), and systems under development such as the COSMOS editor and the Prolix Project tools. No significant problems have been encountered in importing UOLs from these tools into Reload. It should be noted, however, that the process does not always work in reverse. For example, ASK LDT has a graphical user interface which supports teachers by enabling them to manipulate information about the UOL they are designing. As this additional information is not part of IMS LD, it cannot be inferred when importing a UOL which was created by another application into ASK LDT. The team responsible for the development of ASK LDT is investigating a generalisable solution to the problem of exchanging graphical representations of UOLs, involving the use of Business Process Modeling Notation (BPMN) as a common representation notation for learning flows (Karampiperis & Sampson, 2007).

One particularly interesting example of design time interoperability is the IMS LD export capability of the MOT+ editor. As described in de la Teja, Lundgren-Cayrol, and Paquette (2005), this system uses the MISA method for defining pedagogical scenarios, which was developed entirely independently from IMS LD. Nevertheless, it has proved possible to transpose between the two systems with all three levels, including the output of the MOT+ graphic function editor.

The export to IMS LD level A from the popular LAMS system is also an encouraging development, although the richness of the services provided in LAMS cannot at present be reproduced from the exported UOL. Indeed the management of services remains a significant outstanding issue for IMS LD, as discussed in relation to modeling in Modeling Services with IMS LD earlier in this chapter. The problem was well summarised by Olivier and Tattersall (2005, p. 38):

Clearly many more services could be added to the LD specification, and it is desirable that they should be, from chat, instant messaging and white boards, through virtual classrooms and more sophisticated collaborative services, such as virtual design environments, to sophisticated simulation and multi-user game-playing systems.

The Key issue that needs to be addressed is how to add services in such a way that key learning designs that use them still retain a reasonable degree of portability across different LD-compliant platforms. If all the above services were included, could any system be expected to be compliant? Or should the specification stick to the lowest common denominator for services…?

Some progress has been made in the development of the Service Based Learning Design Player (SleD) player (McAndrew, Little, & Nadolski, 2005), which now integrates IMS QTI. On the whole, however, the problem remains as stated by Olivier and Tattersall. The TENCompetence project built on the approach established by SleD in their integration of a SCORM player with CopperCore (Sharples & Griffiths, 2007). More recent work within TENCompetence, however, has focused on development of a Widget engine and architecture to provide services, as described in Wilson, Sharples and Griffiths (2007). The mechanism used does not infringe on the current XML binding of IMS Learning Design, and instead utilises a specific attribute, namely parameters. The Widget Server is able to advertise which widgets it can support, and so an authoring tool is able to obtain this information and make the authoring process for these services much easier. This approach has been implemented in the ReCourse editor, also produced by TENCompetence, which, like the Widget server, is freely available as open source on SourceForge.

An alternative approach notes that a metamodel of services could be used to resolve problems in separating out services in IMS LD, just as a modeling language (EML) was used as a solution to an interoperability problem in IMS LD. Learning Design Language, briefly discussed in Modeling Services with IMS LD earlier in this chapter, is an example of this approach, albeit one which is some distance from being a practical solution for IMS LD interoperability.

The creation of compatible IMS LD authoring systems and runtime systems are promising developments and essential steps towards making IMS LD interoperability a reality. Nevertheless, it seems unlikely that at the time of writing the total number of available UOLs exceeds a few hundred (excluding technical examples and "hello world" exercises). In view of this, there clearly remains a great deal of progress to be made if widespread practical interoperability is to be achieved.

In the light of the above discussion, our assessment is that:

a. Interoperability using IMS LD has been demonstrated
b. More interoperable IMS LD systems are gradually appearing
c. New solutions to the problem of interoperability of services are being developed
d. Large scale practical interoperability in the delivery of learning activities using IMS LD has not been achieved

The Achievements of IMS LD Methodology

The methodology set out in the IMS LD Best Practice Guide closely reflects the practice of the OUNL in using EML. It involves four stages:

analysis leading to development of a narrative, UML activity diagram, development of resources and XML document, and evaluation. We will not discuss here its relationship to other methodologies which address the same goals, and it suffices to note that it is not unique to IMS LD.

The methodology recommended in the Best Practice Guide inevitably makes certain implicit assumptions about the actors who will be carrying out the development of UOLs, and these naturally reflect the context of the OUNL where it was developed. For example, familiarity is assumed with use cases and UML. It is, therefore, not surprising that feedback from participants in UNFOLD project activities indicated that this methodology was appropriate in situations where technical specialists are part of the team. This is typically the case in large scale distance education and also in research projects, for example, the JISC funded SLiDE project, where IMS LD has been used to support an authentic course at Liverpool Hope University (Barrett-Baxendale, Hazlewood, Oddie, Anderson, & Franklin, 2005). On the other hand, it was not seen as a viable approach when teachers find that they need to engage with the design process. This proved one of the key areas for work in the UNFOLD project, and readers interested in this aspect are directed to Griffiths and Blat (2005) for a discussion of the outcomes. Among the practical and ongoing initiatives involved in UNFOLD which offered alternative methodologies it is worth mentioning in particular:

- The University of Southampton, which developed the Dialog Plus editor for learning activity "nuggets." This uses taxonomies and concept maps to support teachers in defining educational activities. The tool has been integrated with Reload and can generate IMS LD (Bailey, Fill, Zalfan, Davis, & Conole, 2006).
- The University of Wollongong has carried out valuable work on the identification of proven learning designs, with the provision of Web based exemplars and tools for teachers (University of Wollongong, 2003). This work was aligned with IMS LD during the UNFOLD project, and Wollongong are currently collaborating with OUNL to investigate the way in which teachers design processes and decision making can be supported and embedded in their work environment.
- The Collage editor provides teachers with activity templates based on collaborative learning flow patterns (Hernández-Leo et al., 2006).
- The use of the MISA methodology in MOT+, and the use of the T5 methodology in LearningMapR, both mentioned in previous sections.

These methodologies are presented to users by means of tools, and so clearly this discussion is closely related to the wider issues of tooling and interoperability. This relationship is explored in the paper 'Using the Personal Competence Manager as a complementary approach to IMS Learning Design authoring' (Vogten, Koper, Marten, & van Bruggen, 2008). The authors discuss how users can carry out actions and create plans in a collaborative environment where the distinction between design time and runtime is not apparent. It is proposed that the sum of these actions be exported as a UOL, which represents the results of decisions taken by the actors involved. This can be modified in an IMS LD editor, with the enhanced UOL then being referenced and run by the personal competence manager infrastructure.

In the light of this discussion, our assessment is that:

a. The methodology proposed in the IMS LD Best Practice Guide has not proved to be universally applicable.
b. Discussion of the appropriate methodologies for use with IMS LD in different circum-

stances has stimulated the analysis, development, and implementation of pedagogical approaches. This may be of value not only in the development of new IMS LD compliant tooling, but also in the wider context of educational modeling.

c. It is not yet clear to what extent it will be possible to create design time systems which are truly user friendly for teaching practitioners, rather than the professional learning designers described in the Best Practice Guide.

The Achievements of IMS LD in Providing an Infrastructure of Computer Applications for Education

The tool set for IMS LD is discussed in Griffiths, Blat, et al. (2005) and the set of applications described there, together with the development work since carried out, provides users with the basic functionality needed to deliver courses. Many of these applications are available as open source, including the reference implementations mentioned in an earlier sections. These have provided a basis for other applications to build on. Some of the development work has been carried out by individual researchers and institutions, but a substantial proportion has been funded either by the European Commission or by the eFramework for Education and Research. The eFramework is an initiative of the UK's Joint Information Systems Committee (JISC) and Australia's Department of Education, Science and Training (DEST) which is documented by services, service usage models, and guides (e-Framework, 2006) and views IMS LD as an important enabling technology.

The CopperCore Learning Design Engine was a key development providing "a reusable kernel dealing with the intricacies of processing LD. Since this kernel should be able to be integrated in a learning management system, it is not a standalone product" (Martens & Vogten, 2005). CopperCore has been the reference implementation as regards runtime and the principal means of running UOLs, and it has been leveraged by the SLeD Service Oriented Learning Design Player (McAndrew et al., 2005). The TENCompetence Widget server mentioned above builds on this architecture and provides much improved flexibility in providing runtime services, as described in Wilson et al. (2007)

The approach investigated…uses a Widget engine (the Widget Server) as an add-on to an existing Learning Design runtime system, in this case the CopperCore engine combined with the SleD rendering layer. The Widget Server, like a desktop or web Widget engine, offers a scripting API for widgets, and is responsible for instantiating Widgets required by users within the presentation context. The overall design follows the initial work of the W3C Widgets specification combined with aspects of the Apple Dashboard Widget API, but is applied within a web context rather than a desktop context.

A fully featured implementation of an IMS LD runtime system which is not based on CopperCore has been developed for the widely used .LRN Virtual Learning Environment. Similarly, the NetUniversité Project is an example of a non-CopperCore based portal system for creating and delivering UOLs defined in IMS LD, developed for research purposes (Giacomini Pacurar, Trigano, & Alupoaie, 2005).

A wider range of editors is available than is the case for runtime systems. The Reload Learning Design Editor has provided the basis for the Collage, the Dialog Plus tool, a tool developed by theCo.de for schools in Germany (theCo.de, 2005), and the Prolix tools currently under development. Other editors include Collage, Cosmos, MOT+, ASK LDT (all mentioned and referenced in previous sections) as well as the editor currently under development in the Prolix project, and the ReCourse editor released by the TENCompetence project. This latter development is of particular significance because the team which produced the Reload Learning Design Editor is developing a successor to this reference implementation. Not only does ReCourse have a redesigned and simplified authoring interface with a substantially richer graphical interface, it also provides an integrated authoring environment with authoring of services made available on the TENCompetence Widget server, browsing and management of the OpenDocument.net repository, publishing of UOLs to CopperCore, and population of runs.

Work on repositories with special features to support the storage and description of UOLs has also been carried out, including the IDLD Repository of Learning Designs (IDLD, 2006) and the development of the opendocument.net repository in the context of the OpenDock project (Griffiths, Elferink, et al., 2006), both mentioned above. Opendocument.net is of interest in terms of the infrastructure provided, because it includes a parser which can return information about the UOLs held in the repository through an API.

While the range and capabilities of the infrastructure described above are undoubtedly impressive, some notes of caution are necessary. First, many of the applications described are primarily research implementations and at present only pilot use has been made of this infrastructure. The best evidence available is that provided by the work done by Liverpool Hope University who have used Reload and SLeD in authentic activities with students. They report performance issues, bugs, and the need for work-arounds, but none severe enough to discourage them from continuing to use the infrastructure in further courses. As they point out, this is not surprising in new and complex applications (Barrett-Baxendale et al., 2005), but this does suggest, however, that the infrastructure is not yet validated for large scale roll out.

Second, it should be noted that it would be possible for the some IMS LD applications to become widely adopted and used without any other IMS LD applications becoming established. This would validate the usefulness of IMS LD and its associated methodologies, and support modeling activities, but would not in itself contribute to meeting the goal of interoperability.

Third, the CopperCore Learning Design Engine is the reference implementation for runtime systems, and by far the most widely used. This is a tribute to its importance and usefulness, but inevitably, however, decisions taken in the design of a particular system place constraints on the user. For example, IMS LD has been criticised for not supporting runtime adaptation of pedagogical models. It may be argued that this is not a characteristic of the specification, but rather of CopperCore which compiles the UOL when a run is commenced. It would be interesting to see if different advantages and constraints (including runtime adaptability) might emerge if a system were developed in which the UOL was interpreted rather than compiled. As matters stand, it is not an easy matter to be sure if any given limitation in available runtime functionality is a result of an implementation decision, or the nature of the specification itself (Dodero, Zarraonandia, & Camino, 2005).

In the light of the above discussion, our assessment is that:

a. An extensive infrastructure to facilitate the use of IMS LD has been established.
b. Reference implementations and open source applications have been a positive factor in the development of the infrastructure.
c. The infrastructure is not yet validated as being of industrial strength.

IMS LD IN A CHANGING WORLD

In the previous section, we have seen that there is so far little evidence of significant progress towards the publicly stated goal of IMS LD, that of "promoting the exchange and interoperability of e-learning materials" (IMS Global Learning

Consortium Inc., 2003b, p. 4). On the other hand, it is also clear that IMS LD has stimulated a wide range of opportunities for use and further development in the areas of research into pedagogical modeling, pedagogical methodologies, and the creation of an open source infrastructure for delivering courses. On the basis of the evidence reviewed here, it is not yet clear if IMS LD will in future be widely adopted for delivering courses, or if it will remain primarily a research tool.

To supplement this discussion of the status quo, we now turn to examine the opportunities for further progress in use of the specification, and the factors which may constrain these developments. We consider three inter-related aspects: the changing technological environment, the underlying assumptions of the specification and their continuing relevance in the evolving discourse of education, and the institutional context within which the specification is used.

Technological Change

Interoperability specifications were first discussed when multimedia and CD ROM were the dominant technologies in education. Indeed it is possible to view content packaging and simple sequencing as an effort to enable the material produced for CD ROMs to be sold over the Web. This perspective explains why it was important to include all the resources in a single zip file, which could be delivered either on a CD ROM, or downloaded, with no difference to the educational materials offered to the learner.

This zip based solution sat uncomfortably with Web based VLE systems, where pages were delivered one at a time, and where linked pages could easily take the user out of one site and into another. Nevertheless, IMS LD and the suite of related specifications which is available from IMS, plus some extensions and additions, provide a solid basis for interoperability between VLEs. At present, however, the future of monolithic VLE applications with a clearly defined functionality does not appear entirely secure. First, we should note the increasing popularity of open source VLEs such as Moodle, .LRN, Claroline, and so forth. The fact that these applications are open source makes it possible for developers to extend them, and so encourage significant adaptation of functionality by institutions. The increased variety of systems resulting from these adaptations means that the target platforms to be addressed by IMS LD are more diverse, and that effective interoperability may therefore be harder to achieve. The increasing use of service oriented architectures, however, has the potential to have a much more radical impact. Paulsen (2002) defines a learning management system (essentially the same as a VLE) as being "a broad term that is used for a wide range of systems that organize and provide access to online learning services for students, teachers and administrators." One of the advantages which a VLE provides an institution is that it can take responsibility for coordinating these services and delivering them to learners and teachers. The attractiveness of this proposition is, however, being impacted by the development of environments in which the coordination of services can also be achieved through an underlying architecture. Moreover, it is no longer technically challenging for institutions to set up open source systems which enable them to offer and combine wikis, forums, and so on (see, for example, Feldstein & Masson, 2006), making it much easier for institutions to build their own in house infrastructure. These trends are documented by a report funded by JISC into the use of VLEs in UK universities (Farmer & Tilton, 2006) which showed that from 2001 to 2005:

- The use of proprietary VLEs—those with fee-for-use licenses—declined from 93% to 57%.
- The use of open source systems increased from zero to 11% with 8% of that increase from 2003 to 2005. At the same time, the number of locally developed VLEs in use increased from 7% to 30%.

To support these locally developed systems, a growing number of tools are available to create mashups, that is, combinations of software and services from multiple sources which create new Web based applications. These include Netvibes, iGoogle, and Yahoo Widgets. A range of services are available to feed into mashups, such as Del.icio.us, Flickr, Google Maps, and so forth. This approach is in line with the logic behind the eFramework, which proposes that a range of services could be provided by different providers in different locations. In this context of educational activities which are carried out with a range of distributed services, the use of a zip file to deliver a UOL which is a self contained study package can be seen as a historical oddity

The way in which these developments will impact on the use of VLEs is not yet clear. Weller (2007) takes the view that the VLE may still provide a framework for integrating services in an SOA environment, envisaging that in a possible "VLE 2.0," "the medical school in a university may have a different configuration of tools than the business school, but both are using the same underlying VLE." Alternatively, the use of mashups and social web applications can be seen as being more disruptive, and it can be argued that there is no longer such a compelling reason to concentrate functionality in a single application, such as a VLE. The argument can be taken one step further by proposing that the responsibility for integrating and coordinating these services can be taken on by learners, using a personal learning environment (see the following section). From this perspective, the role of the VLE as it has so far been understood becomes sidelined or at least radically transformed.

No doubt, the integrated VLE will not entirely disappear, especially in the large distance teaching institutions which were the principal user group for OUNL EML. Nevertheless, when IMS LD was published it was natural to assume that most computer support for education would be delivered through monolithic VLE applications, and the hope was that the specification would become the means of exchanging learning activities between them. If such VLEs were to lose their dominant position or became more heterogeneous, then it would be reasonable to expect that use of IMS LD as an interoperability specification would also be affected and possibly constrained to a smaller section of the education market than was foreseen when the specification was published. The challenge for IMS LD in this scenario is to demonstrate that it can provide the basis of a service providing formally planned and structured learning as part of a wider set of services to be consumed by teachers and learners. There is no reason in principal why this should not be possible, but it will require a revised approach to the implementation of infrastructure and a view of the specification which sees it as part of the solution to a wider problem of interoperability and collaboration, rather than as the one single answer.

Changes in Underlying Assumptions

The XML code which is generated when IMS interoperability specifications are used is a technical and seemingly objective and neutral description of a resource or an activity. Nevertheless, the choice of what to represent and how to represent it is informed by theory and assumptions. As noted above, IMS LD has its roots in large scale distance education, and this leads naturally to the assumptions and focus adopted by the specification authors which in turn determine the limits of its applicability. This focus is largely shared by VLEs, which like IMS LD are characterised by, for example, planned activities, the concept of the cohort, the distinction between design time and runtime, restriction of the scope of operation to a single institution, and on protecting learning materials from unauthorised access. These aspects are discussed in Wilson, Liber, Beauvoir, Johnson and Sharples (2006), while a more extensive treatment is available in a report detailing the findings of the JISC funded Personal Learning

Environments project (Johnson, Wilson, Beauvoir, Sharples, Milligan, & Liber, 2006) and in (Johnson & Liber, 2008). In these papers the argument is developed that there is a need for a change in the dominant design and a shift towards a concept of a personal learning environment (PLE). The proposal is that a learner should not have to adapt to the delivery systems used by the various institutions in which they participate. Rather learners should be provided with PLE software which can draw on services made available by learning providers to cover the full breadth of learning activities of the user. These should be integrated and presented in a way which suits the individual learner's preferences and practice, and integrated with their social networks. This is the approach which was implemented in the PLEX system developed by CETIS as part of the personal learning environment project (Johnson & Liber, 2006). The idea of the personal learning environment and the initial proof of concept implementations developed to demonstrate it have created considerable interest, especially in the UK. Moreover, as noted by Wilson (personal communication, 2007), the ability of learners to structure their own data, whether or not their institutions plans for this to occur, has already led to some conflict over institutional boundaries. This can be seen in the action taken by Harvard University to ensure that factual information about courses from the official my.harvard.edu portal was not republished by the CrimsonConnect.com student run portal created using Netvibes (Marks, 2007). Similarly, there have been cases of teachers using Widgets to deliver their courses to bypass the institutional VLE. It seems likely that these issues will increase in importance as mashup systems such as Netvibes become more widely used.

The strengths of IMS LD lie in modeling and exchanging pedagogical activity, and it should not be assumed that it should necessarily form the foundation of the personal learning environment and similar approaches, which have rather wider functionality. Rather it can complement them by providing formal learning opportunities, which can be contextualised within a personal learning environment. It may also have a role in recording users activities with the application when these constitute the coordination of activities towards a learning goal. Both these approaches are taken by the TENCompetence Personal Competence Manager infrastructure, which is available for download on SourceForge. The degree to which such innovative approaches enable IMS LD to function within a wider and more flexible context will only be shown once they are used in practice, but it is certainly encouraging that strategies are being developed to enable the specification to meet this challenge.

Institutional Changes

The world of education is changing rapidly. The authors have observed how in the UK there is a continuing expansion of higher education, which has inevitably had an impact on the nature of institutions. There has also been an increase in student mobility and competition between universities, both within the UK and internationally, while the role of corporate universities and education is increasing. Similarly, from a pedagogical perspective, the ideas of the learning organisation and of communities of practice are becoming more widely accepted and are undermining the certainties of traditional teaching methods. These changes mean that interoperability specifications are being developed in relation to a shifting set of educational needs. Moreover, the impact of IT and of the successful interoperability specifications themselves is also changing the way in which education institutions think about themselves and do their business. So interoperability specifications could be entirely successful in meeting the needs of education institutions, only for it to be found that they needed to be adapted or extended because their very success changed the nature of the needs of education. The eFramework, for example, has the potential to enable institutions to collaborate on joint degrees and validated modules to a much greater degree than is currently the case. Were this to be adopted across the sector it would probably change the nature of higher education institutions significantly, and perhaps the nature and structure of qualifications. The degree to which this occurs, of course, depends on a host of political and ideological factors which are beyond the scope of this discussion.

TENCompetence project is also relevant in this context because it focuses on supporting users in planning, defining, and carrying out their lifelong learning, treating courses provided by institutions as one of the entities to be contextualised and managed. Projects such as this in which specifications are used together to enable learning which may not be based on a single institution, nor, necessarily, on a conventional qualification structure, may reveal the degree to which interoperability specifications are tied to the assumptions about the institutional context for which they were designed.

CONCLUSION

The original goals of IMS LD were twofold: to provide a means of modeling pedagogy (in the OUNL's Educational Modeling Language) and a specification to promote the exchange and interoperability of learning materials. In our discussion of the work carried out in each of these two modes of use, we have provided evidence that at the technical level both these goals have been met.

The effectiveness of the specification in modeling educational processes is supported by direct evidence from some small scale but systematic studies demonstrating that IMS LD can model a wide range of pedagogies. IMS LD has been used as a modeling language by a substantial number of research projects, but it has not been adopted extensively by the education community at large (although it should be noted that this was not an objective for this mode of use). Some indirect evidence for the effectiveness of the specification is provided by the fact that we have not identified any cases of projects which decided to use IMS LD and then abandoned the specification on the basis of lack of modeling expressivity. The modeling of services remains an outstanding issue. As we have commented above, this is in part a result of the need for IMS LD to be effective at both modeling (for which more detailed specification of services would be useful) and interoperability (for which more detailed specification of services would make compliance more difficult). The TENCompetence Widget Server appears to provide an effective technical solution to this problem, although it is not yet clear to what extent this implementation may be able to square the circle.

Interoperability has been demonstrated in a sufficiently large number of applications to enable us to affirm that import and export of UOLs between a range of editors and the reference runtime engine has been achieved. Consistency of UOLs between different players at runtime is still an open question because of the dominance of the CopperCore LD Engine. On the other hand, the use of the specification in the exchange of computer based learning materials has been largely restricted to research projects and trials of applications and to this extent the goal of promoting interoperability in educational practice in has not been achieved.

Opportunities for use of the specification have also emerged in terms of educational methodologies and in developing an applications infrastructure for delivering courses. As regards methodology, the IMS LD Best Practice Guide has not proved to be universally applicable. This has led to valuable exchanges between practitioners, pedagogy experts, and implementers which have enriched all parties understanding and provided a fertile environment for the development of new approaches to engaging practitioners in the design of courses. The degree to which these will be successful in practice remains to be seen.

As regards infrastructure, a large number of applications have been developed to facilitate the use of IMS LD. Because this is (a) based on a specification which is designed to support the widest possible range of pedagogy and (b) all the key implementations are open source, the infrastructure provides a valuable foundation for delivering courses. It is not yet, however, validated as being of industrial strength. As we have described, current work is being carried out within both the eFramework and the TENCompetence project (among others) to situate the IMS LD infrastructure in the context of a wider open source and service based infrastructure for higher education and for lifelong learning. It seems likely that the degree of success of these initiatives will have a strong bearing on the ongoing development and use of the infrastructure created to date.

We have argued that the technological environment within which IMS LD is situated is changing significantly and that organisational changes are also likely to flow from demographic and policy changes. In this context, the dominance of monolithic VLEs is no longer the only possible approach, and this will condition the future use of the specification. No doubt, there is still a role for IMS LD in exchanging learning activities between monolithic VLEs, but we have shown that the way in which the specification is being used is not only, or even primarily, as an interoperability specification.

We believe that a key factor in the future of IMS LD will be the production of innovative applications which support modeling by practitioners as well as technical experts, and/or correspond to disaggregated and service based approaches. The fact that IMS LD has well structured data facilitates the creation of imaginative applications which may resolve many of these challenges. To take a simple example, a UOL is contained in a zip file, but this can be disaggregated, stored, processed, and re-aggregated for transmission in a way which is transparent to the user. Similarly, UOL fragments can perhaps be transparently handled by specially coded applications, so that models at a lower level of granularity than a UOL could be exchanged. Nevertheless, when extending an established methodology and code base, there is always a danger that the load of legacy methods and code may be too heavy, and users could be attracted to nonstandard but simpler solutions. In addition to the nature of the specification itself, we propose that the outcome will depend not only on the imagination and skill of developers and funding agencies, but also on the degree to which the strengths of IMS LD for delivering planned formal learning can be integrated into wider frameworks which support more flexible approaches.

Finally, looking back at over four years of intensive work on IMS LD, we are struck by the huge contribution made by a wide range of researchers, developers, teachers, education administrators, and pedagogy experts. This has been characterised by creativity and a culture of collaboration and openness which has greatly enhanced the effectiveness of the work carried out. Our thanks go to all those who brought these values to their participation in the UNFOLD, CETIS, and TENCompetence events and activities which have informed this chapter.

REFERENCES

.LRN. (2006). *New version of the .LRN IMS-LD 1.1.0 tagged and released.* Retrieved March 27, 2008, from http://dotlrn.org/news/one-entry?entry_id=156663

Alexander, C. (1979). *The timeless way of building.* New York: Oxford University Press.

Bailey, C., Fill, K., Zalfan, M., Davis, H. C., & Conole, G. (2006). Panning for gold: Designing pedagogically-inspired learning nuggets [Special issue on learning design]. *IEEE Journal of Educational Technology and Society, 9*(1), 49-59.

Barrett-Baxendale, M., Hazlewood, P., Oddie, A., Anderson, M., & Franklin, T. (2005). *SliDe Project Final report*. JISC.

Beetham, H. (2004). *Review: Developing e-learning models for the JISC practitioner communities*. JISC.

Burgos, D., & Griffiths, D. (Eds.). (2005). *The UNFOLD project: Understanding and using learning design*. Open University of the Netherlands, Heerlen, Educational Technology Expertise Centre.

Burgos, D., Tattersall, C., Dougiamas, M., & Vogten, H. (2006). *Mapping IMS learning design and Moodle: A first understanding*. Paper presented at the Simposo Internacional de Informática Educativa. Retrieved March 27, 2008, from http://hdl.handle.net/1820/696

Buzza, D., Richards, L., Bean, D., Harrigan, K., & Carey T. (2005). LearningMapR: A prototype tool for creating IMS-LD compliant units of learning. *Journal of Interactive Media in Education* (Advances in Learning Design. Special Issue, Eds. C. Tattersall and R. Koper). Retrieved from jime.open.ac.uk/2005/17

CETIS. (2006). *RELOAD reusable eLearning object authoring & delivery*. Retrieved March 27, 2008, from http://www.reload.ac.uk/

Dalziel, J. (2003). *Implementing learning design: The learning activity management system (LAMS)*. Paper presented at the ASCILITE Conference.

de la Teja, I., Lundgren-Cayrol, K., & Paquette, G. (2005). Transposing MISA learning scenarios into IMS units of learning [Special issues on advances in learning design]. *Journal of Interactive Media in Education, 1*.

Dodero, J. M., Zarraonandia, T., & Camino, F. (2005). *Crosscutting runtime adaptations of LD execution*. Paper presented at the UNFOLD/Prolearn Joint Workshop: Current State on IMS Learning Design, Valkenburg.

e-Framework. (2006). The e-framework for education and research: A briefing paper. Retrieved March 27, 2008, from http://www.e-framework.org/Portals/9/docs/papers/Briefing060802.pdf

Ellaway, R., Dewhurst, D., Quentin Baxter, M., Hardy, S., & Leeder, D. (2005). *ACETS final report*. JISC Developement Programmes.

Farmer, J., & Tilton, J. (2006). *The use of virtual learning environment software in UK universities 2001-2005*.

Feldstein, M., & Masson, P. (2006, January 27). Unbolting the chairs: Making learning management systems more flexible. *eLearn Magazine*.

Giacomini Pacurar, E., Trigano, P., & Alupoaie, S. (2005). *A QTI editor integrated into the netUniversité Web portal using IMS LD*. Paper presented at the Current State on IMS Learning Design: The UNFOLD/Prolearn Joint Workshop, Valkenburg.

Griffiths, D., & Blat, J. (2005). The role of teachers in editing and authoring units of learning using IMS learning design. *International Journal on Advanced Technology for Learning, 2*(3).

Griffiths, D., Blat, J., Elferink, R., & Zondergeld, S. (2005). *Open source and IMS learning design: Building the infrastructure for eLearning*. Paper presented at the The First International Conference on Open Source Systems, Genova.

Griffiths, D., Blat, J., Garcia, R., Vogten, H., & Kwong, K. (2005). Learning design tools. In R. Koper & C. Tattersall (Eds.), *Learning design: Modelling and implementing network-based education & training* (pp. 109-135). Springer-Verlag.

Griffiths, D., Burgos, D., Kew, C., Dias, A., Tattersall, C., Girardin, F., et al. (2006). *UNFOLD communities of practice report*. UNFOLD Project.

Griffiths, D., Elferink, R., & Veenendaal, E. (2006). *The OpenDock project: Putting in place the infrastructure for sharing learning activities*. Paper presented at the Learning Networks for Lifelong Competence Development, Sofia.

Harré, R., & van Langenhove, L. (Eds.). (1999). *Positioning theory*. Oxford: Blackwell Publishers Ltd.

Hermans, H., Manderveld, J., & Vogten, H. (2004). Educational modelling language. In W. Jochems, J. van Merrienboer, & R. Koper (Eds.), *Integrated e-learning* (pp. 80-99). London: Routledge Falmer.

Hernández-Leo, D., Asensio-Perez, J. I., Dimitriadis, Y., Jorrín-Abellán, I. M., Ruiz-Requies, I., & Rubia-Avi, B. (2006). COLLAGE: A collaborative learning design editor based on patterns. *Educational Technology & Society, 9*(1), 58-71.

IDLD. (2006). *The Canadian LD repository*. Retrieved March 27, 2008, from http://www.idld.org/

IMS Global Learning (2003a). *IMS Learning Design Best Practice and Implementation Guide, Version 1.0 Final Specification*. IMS Global Learning Consortium, Inc.

IMS Global Learning (2003b). *IMS Learning Design Information Model, Version 1.0 Final Specification*. IMS Global Learning Consortium, Inc.

IMS Global Learning Consortium Inc. (2005). *IMS question and test interoperability information model version 2.0 final specification.* Retrieved March 27, 2008, from http://www.imsglobal.org/question/qti_v2p0/imsqti_infov2p0.html

IMS Global Learning Inc. (1999). *Certificate of incorporation*. Retrieved March 27, 2008, from http://www.imsglobal.org/certificateofincorporation.pdf

IMS Global Learning Inc. (2003a). IMS learning design best practice and implementation guide: Version 1.0 final specification. Retrieved March 27, 2008, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html#1501849

IMS Global Learning Inc. (2003b). IMS learning design information model: Version 1.0 final specification. Retrieved March 27, 2008, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_infov1p0.html

Johnson, M., & Liber, O. (2006). *Personal learning environments: Final project report*. JISC.

Johnson, M., Wilson, S., Beauvoir, P., Sharples, P., Milligan, C., & Liber, O. (2006). *Personal learning environments project report*. Retrieved March 27, 2008, from http://wiki.cetis.ac.uk/Ple/Report

Johnson, M., & Liber, O. (2008) The personal learning environment and the human condition: From theory to teaching practice. *Interactive Learning Environments, 16*(1), 3-15.

Karampiperis, P., & Sampson, D. G. (2007). *Towards a common graphical language for learning flows: Transforming BPEL to IMS learning design level A representations*. Paper presented at the 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007), Niigata, Japan.

Koper, R. (2000). From change to renewal: Educational technology foundations of electronic learning environments (inaugural address) (pp. 41). Heerlen: Oppen Universiteit Nederland.

Koper, R. (2001). *Modeling units of study from a pedagogical perspective: The pedagogical meta-model behind EML*. Heerlen: OUNL.

Koper, R. (2005a). Introduction to IMS learning design. In D. Burgos & D. Griffiths (Eds.), *The UNFOLD project: Understanding and using learning design*. Heerlen: Open University of the Netherlands.

Koper, R. (2005b). An introduction to learning design. In R. Koper & C. Tattersall (Eds.), *Learning design: Modelling and implementing network-based education & training* (pp. 3-20). Springer Verlag.

Koper, R., & Manderveld, J. (2004). Educational modelling language: Modelling reusable, interoperable, rich and personalised units of learning. *British Journal of Educational Technology, 35*(5), 537-552.

Koper, R., & Tattersall, C. (Eds.). (2005). *Learning design: Modelling and implementing network-based education & training.* Springer.

Marks, C. M. (2007). Administrators limit student site's content. *The Harvard Crimson*. Retrieved March 27, 2008, from http://www.thecrimson.com/article.aspx?ref=518631

Martel, C., & Vignollet, L. (2007). *Learning design language to model the activity supported by services.* Paper presented at the TENComptence Open Worshop on Service Oriented Approaches and Lifelong Competence Development Infrastructures, Manchester.

Martens, H., & Vogten, H. (2005). A reference implementation of a learning design engine. In R. Koper & C. Tattersall (Eds.), *Learning design: Modelling and implementing network-based education & training* (pp. 91-108). Springer Verlag.

McAndrew, P., Little, A., & Nadolski, R. (2005). Developing an approach for learning design players [Special issue on advances in learning design]. *Journal of Interactive Media in Education, 14.*

Milligan, C., Beauvoir, P., & Sharples, P. (2005). *The Reload learning design tools.* Paper presented at the Current State on IMS Learning Design: The UNFOLD/Prolearn Joint Workshop, Valkenburg.

Moodle. (n.d.). *Roadmap.* Retrieved March 27, 2008, from http://docs.moodle.org/en/Roadmap

Niegemann, H., & Domagk, S. (2005). *ELEN project Evaluation Report.* Retrieved 13th May, 2008, from http://www2.tisip.no/E-LEN/documents/ELEN-Deliverables/Evaluation_Report_E_LEN.pdf

Olivier, B., & Tattersall, C. (2005). The learning design specification. In R. Koper (Ed.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 21-40).

OpenDock. (2006). *OpenDock: Sharing active learning.* Retrieved March 27, 2008, from http://www.opendockproject.org/

OTEC (OUNL). (2005). *Learning networks for learning design*. Retrieved March 27, 2008, from http://imsld.learningnetworks.org/

Paquette, G., de la Teja, I., Léonard, M., Lundgren-Cayrol, K., & Marino, O. (2005). An instructional engineering method and tool for the design of units of learning. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 161-183).

Paquette, G., Marino, O., Lundgren-Cayrol, K., Léonard, M., & de la Teja, I. (2006, March, 30-31). Learning design repositories—Structure ontology and processes. In *Proceedings of International Workshop in Learning Networks for Lifelong Competence Development.* Sofia, Bulgaria

Pask, G. (1976). *Conversation theory: Applications in education and epistemology.* Elsevier.

Paulsen, M. F. (2002). *Online education systems: Discussion and definition of terms.* Web Education Systems Project (Web-edu).

Sampson, D., Karampiperis, P., & Zervas, P. (2005). A Web-based learning scenarios authoring environment based on IMS learning design. *Advanced Technology for Learning, 2*(4).

Sharples, P., & Griffiths, D. (2007). Integrating IMS learning design and ADL SCORM using

CopperCore service integration. In R. Koper, O. Liber, & D. Griffiths (Eds.), *Service Oriented Approaches and Lifelong Competence Development Infrastructures: Proceedings of the 2nd TENCompetence Open Workshop* (pp. 83-91). Bolton, UK: Institute for Educational Cybernetics. Retrieved March 27, 2008, from http://hdl.handle.net/1820/1023

Sodhi, T., Miao, Y., Brouns, F., & Koper, R. (2007). *An alternate classification of LD authoring approaches*. Paper presented at the TENCompetence Open Workshop on Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures, Barcelona.

theCo.de. (2005). *SchulCMS*. UNFOLD COP Meeting, November 28-29. Retrieved from http://www.unfold-project.net/project/events/cops/berlin/presentations/codeSubmission.pdf

University of Wollongong. (2003). Learning designs. Retrieved March 27, 2008, from http://www.learningdesigns.uow.edu.au

Van Es, R. (2005). Testing the pedagogical expressiveness of LD. *Educational Technology & Society, 9*(1), 229-249.

Vogten, H., Koper, R., Martens, M., & van Bruggen, J. (2008). Using the personal competence Manager as a complementary approach to IMS learning design authoring. *Interactive Learning Environments, 16*(1), 83-100.

Weller, M. (2007). *Virtual learning environments: Using, choosing and developing your VLE*. Routledge.

Wilson, S., Liber, O., Beauvoir, P., Johnson, M., & Sharples, P. (2006). *Personal learning environments: Challenging the dominant design of educational systems*. Paper presented at the 2nd International Workshop on Learner-Oriented Knowledge Management and KM-Oriented Learning (LOKMOL 06), in conjunction with the 1st European Conference on Technology-Enhanced Learning (ECTEL 06), Crete, Greece.

Wilson, S., Sharples, P., & Griffiths, D. (2007). *Extending IMS learning design services using widgets: Initial findings and proposed architecture*. Paper presented at the TENCompetence Open Workshop on Current research on IMS Learning Design and Lifelong Competence Development Infrastructures, Barcelona.

KEY TERMS

Design Time: As regards IMS LD, the planning and creation of a unit of learning.

Educational Modeling Language (EML): A language developed by the Open University of the Netherlands to facilitate the design and execution of a wide range of pedagogical designs.

IMS Learning Design (IMS LD): An interoperability specification focused on the exchange and interoperability of e-learning materials and activities, published by IMS Global Learning Inc. It is in itself also a modeling language, and is strongly based on OUNL's EML.

Pedagogy: In this chapter, pedagogy is understood to be a conscious practice (which may be informed by theory) aimed at the effective organization of learning activities.

Personal Learning Environment (PLE): A system which enables the user to manage all their learning activities (which may be carried out in various organizations). The system focuses on coordinating connections between the user and a wide range of services offered by organizations and other individuals.

Reference Implementation: An implementation of a specification which represents an accepted version of the behaviours which should be shown by a compliant application.

Run: An instance of a unit of learning, executed by a runtime system, and populated with identified users.

Runtime: As regards IMS LD, the execution of a unit of learning using a player application.

Unit of Learning (UOL): A pedagogical scenario addressing a learning goal, expressed in IMS LD.

Chapter V
A Critical Perspective on Design Patterns for E-Learning

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ABSTRACT

"A design pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander et al., 1977). In the field of e-learning, design patterns are frequently advocated as a powerful way of providing structured, teacher-friendly, textual representations of learning designs, or of expressing the design rationale underlying learning objects. The purpose of this chapter is to look at e-learning design patterns from a critical perspective. We provide a historical, multidisciplinary excursus of the notion of design patterns. We propose a taxonomy of e-learning design patterns, providing examples in the various categories. Finally, we discuss both the benefits of design patterns for e-learning professionals (particularly, novice ones) and their drawbacks, and investigate how such pros and cons may affect the role of patterns for learning designs.

INTRODUCTION

Designing effective technology-enhanced learning environments in an efficient and affordable way is a demanding task, which requires creativity and a significant amount of expertise (Goodyear, 2002). People new to e-learning design need advice from experts, experienced peers, and users to avoid investing a large amount of resources in "reinventing the wheel" or in creating solutions that may yield an educationally ineffective result.

E-learning design experience is often shared informally in the every day language of teaching practice, or through published research and evaluation studies, or even through sets of action-oriented guidelines. A number of initiatives have been launched in the last decade to foster exchange of experiences and to help instructional designers reuse effective learning design solutions. Among them, a remarkable one is the Australian University Teaching Committee (AUTC) Project. This initiative was set up in an attempt to collect and share generic/reusable learning design resources in order to assist instructional designers, teachers, or academics to create high quality, flexible learning experiences for students (http://www.learningdesigns.uow.edu.au/).

While the existing definitions of "learning design" vary, the main common elements comprise a focus on "context" dimensions of e-learning (rather than simply "content"), an "activity"-based view of e-learning, greater recognition of the role of "multilearner" (rather than just single learner) environments, and an attempt to make the design solutions related to all the above aspects easily reusable. In order to standardize the description of learning designs, the IMS Learning Design specification (IMS LD) has been proposed (IMS LD, 2003). Rather than attempting to capture the specificities of the various pedagogical strategies, IMS LD provides a notation to describe a "metamodel" of instructional design; it offers educators a generic and flexible machine readable language to specify the design of online and off-line activities that involve interaction between learners and learning resources, learners and other learners, as well as learners and teachers. IMS LD gives more emphasis on instructional design as a "product" than on the "process" of developing educational design solutions that has evolved out of the (positive or negative) experience of a number of designers. This may imply that one who reuses an IMS LD artifact might not easily grasp its rationale and perspective. In addition, IMS LD is mainly shaped to foster the collaboration between experienced instructional designers and professionals who may need to repurpose the design specifications As such, it is less appropriate to leverage the exchange of knowledge, practices, and expertise between educational experts and novices.

Instructional designers may need new ways of sharing and transmitting to novices their instructional "philosophy" and their pragmatic approaches, which consist of how their e-learning experiences are designed, built, and associated to the specificities of the subject matter, the environmental context, the human actors, the educational strategies, and the available learning resources and tools (Laurillard, 2002). For this purpose, an important contribution can be offered by *e*-learning design patterns, which are the main focus of this chapter. A design pattern "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander, 1979). This provides a descriptive structure to integrate the analysis and the solution to a recurring problem, in such a way that it becomes context-sensitive, informed by theory and evidence, and reusable with a minimum degree of customization.

Increasing attention has been paid to design patterns in the e-learning research community. Design patterns are all about reusability, which seems to be the key word in achieving the economies of scale for developing affordable and usable e-learning courses (Goodyear, Avgeriou, Baggetun, Bartoluzzi, Retalis, Ronteltap, et al., 2004) in a more effective way. Researchers and practitioners in many educational fields are attracted by the potential of design patterns as means to facilitate the capturing and sharing of different aspects of e-learning design expertise, to provide a "lingua franca" for joint course design (McAndrew et al., 2005). In the specific arena of learning designs and learning objects, design patterns are frequently advocated as a powerful way of providing structured, still teacher-friendly, textual representations of learning designs, or of expressing the design rationale underlying learning objects.

In spite of the academic popularity and the enormous amount of existing literature, the "real" success of design patterns in e-learning (in terms of effective adoption and usage in "real" educational design settings) is marginal, particularly if compared to the popularity of patterns among professional designers in other domains such as architecture/urbanistics or software engineering. The main contribution of this chapter is to look at the current state of the art in e-learning design patterns from a critical perspective. We pinpoint the benefits of design patterns for e-learning professionals (particularly novice ones) but we also address the issue "What has gone wrong? Why have e-learning design patterns 'failed' to meet the requirements and expectations of their target users?" and investigate their current drawbacks. In addition, we investigate how such pros and cons may affect the role of design patterns for learning designs. Our ultimate goal is to stimulate a reflection among design pattern "fans" as well as those who are skeptical, and to foster an in-depth theoretical and empirical investigation of e-learning design patterns in the educational community.

The rest of this chapter is organized as follows. We first provide a historical, multidisciplinary excursus of the notion of design patterns, which starts out with Aristotle's rhetoric and then develops with architecture, software engineering, human computer interaction, and Web design. We then introduce a taxonomy for e-learning design patterns by providing examples of patterns in the various categories and by highlighting why a taxonomic approach is important in the general process of e-learning design and in the definition of learning designs in particular. The main point of the chapter is the analysis of the benefits of design patterns for e-learning professionals (particularly novice ones) and of their drawbacks. Here we also discuss how such pros and cons may affect the role of design patterns in learning designs. Finally, we investigate future and emerging trends in this field, identify future research opportunities, and draw some conclusions.

BACKGROUND

How Old Is the Art of "Design-by-Patterns"?

The concept of "design-by-patterns," or of creating design artifacts by reusing, adapting, and composing existing design solutions, is indeed very old and general. In this historical overview, we aim at highlighting the profound nature of the concept of design pattern and how this notion is strongly rooted in the human processes of design, decision making, and problem solving. It represents a "cognitive" paradigm that is frequently adopted, consciously or unconsciously, in every day life contexts as well as in professional situations.

A number of empirical and theoretical studies (e.g., Gagne & Medsker, 1996; Grimaldi, 1998; Jonassen, 2003; Koshman, 1994; Mayer & Wittrock, 1996) show that, in front of a problem in a given domain, an "expert" in that domain instinctively tends to: (i) associate the problem to a class of "similar" problems that she/he has already encountered; (ii) identify how the problem was previously solved; and (iii) capture the general characteristics of the solution and adapt them to the concrete situation. The basic difference between a novice and an expert—what helps an expert generate a solution more quickly and makes it more reliable—is that an expert can rely upon a much wider "knowledge base" of structures—problem class, solution—than a novice, and that the former knows better how to adapt a solution to the current context.

These considerations provide a cognitive argument to support the effectiveness of a "design-by-patterns" approach. The availability of a wide body of design problems associated to design solutions potentially makes a design process faster for expert designers and easier for novice ones. The more accurate the patterns (in terms of quality of problem shaping and effectiveness and clarity of solutions) the more effective the design process will be.

It is interesting to notice that, although with a different terminology, the idea of pattern as a reusable schema to achieve a specific scope or a documented solution to a recurrent problem, is indeed very old. Bolchini (2002) investigated patterns in communication sciences and traced back the origins of the concept to *ancient rhetoric*, namely, the art of persuading by means of speech, as it was defined by Aristotle and ancient orators. In his basic books *Rhetoric* and *Topics*, Aristotle lists a number of well-known and shared *rhetorical schemas*—which he calls *topics*—that represent the tools for an orator to gain the approval of his thesis from a crowd of hearers (Aristotle, 350 BC). A topic is a named, ready-to-use, general form of reasoning that provides arguments (i.e., "rhetorical design solutions") to employ when a recurrent problem to be debated arises and persuasion must be achieved. Topics are usually socially acknowledged and can be accepted and reused as agreed rules. They are intended to provide the orator with a commonly used catalogue of arguments whose validity is commonly accepted and taken for granted both by the orator (who employs it) and by the hearers (who are persuaded through it). Furthermore, Aristotle distinguishes between "common" topics—28 very general patterns of reasoning, for example, "a fortiori"—and "specific" topics—suitable to build up a persuasive discourse in specific communicative situations.

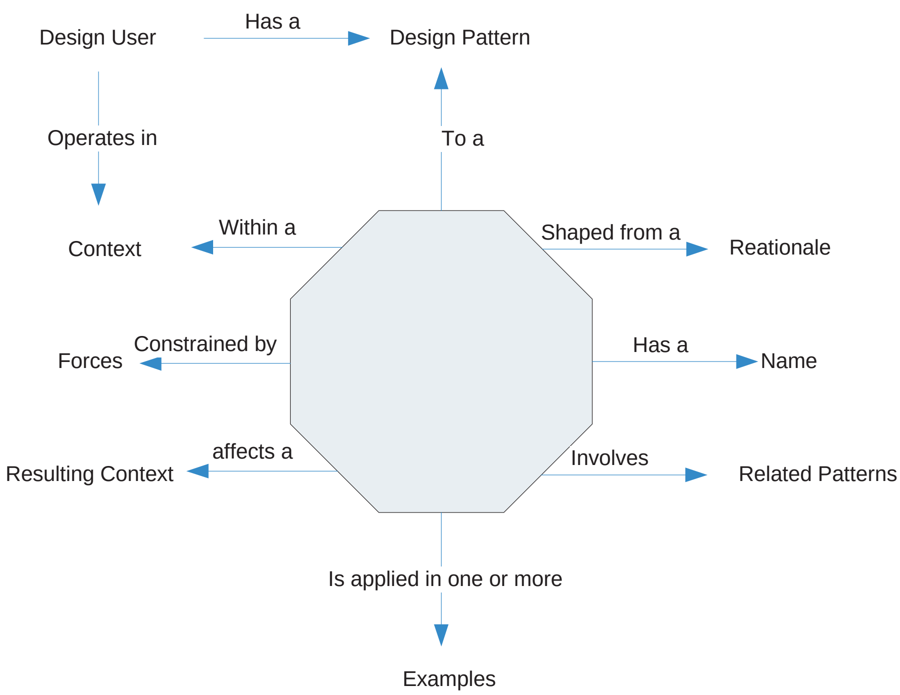
The analogy between Aristotle's topics and the concept of design pattern is self-evident. It is also interesting to observe that Aristotle's distinction between common and specific topics reflects typical classification criteria that are used in many design pattern catalogues (discussed in the next sections), which distinguish between domain-independent and domain-dependent patterns. Finally, it is surprising to discover that Aristotle's works often define Topics through a "name," a "context of use," "forces," one or more "examples," and "related topics" by using a description template similar to that proposed in the twentieth century by the father of design patterns C. Alexander, introduced in the next section.

The Origins of the Term "Design Pattern"

The (semi)formalization of the concept of design pattern and its systematic use for the design of concrete artifacts is quite recent. It dates back to the late 1960s and originates from the domain of architecture and urbanistics. Architect Christopher Alexander coauthored with Sara Ishikawa and Murray Silverstein the much-cited book titled *Pattern Language: Towns, Buildings, Construction* in 1977 (Alexander et al., 1977). The book is a substantive presentation of a *pattern language*, providing a set (253) of interrelated design patterns derived from traditional architecture. The book also proposes a description template stating nine essential pattern elements (see Figure 1) and includes some guidelines to build them.

- **Name:** The name is a meaningful and memorable identifier that succinctly grasps the essence of a problem so that it can be clearly understood by all the members of a design community and a sudden association with the core feature of the referred design solution can be easily made.
- **Problem:** By knowing the problem, the designer should be able to evaluate the relevance and the applicability of that pattern to the situation he is coping with, and to achieve a better understanding of the potential effectiveness of the pattern.
- **Context:** By clearly defining the environment in which the problem and the solution is likely to recur, a designer can understand

Figure 1. The conceptual structure of Alexander's design pattern

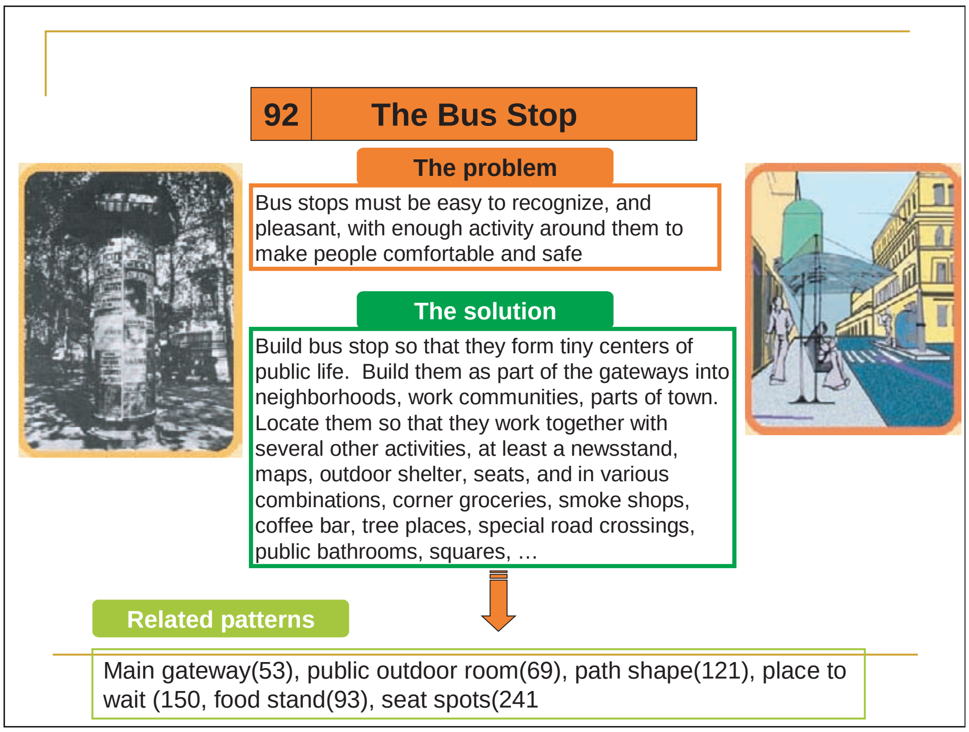


the preconditions under which she will probably meet the problem, thus improving the problem-matching process.

- **Forces:** Forces defining the constraints, relationships, contrasts, and conflicts permeating the scene in which the pattern acts. Describing forces gives a more precise idea of the *scenario* in which the application of the pattern is justified. Explaining forces may help to realize which *trade-off* must be considered while adapting the pattern to a specific design situation.
- **Solution:** The solution is the *essence* of the design experience the pattern wants to convey. A solution is composed of a list of rules describing how to shape a desired artifact. In order to explain the structure of the pattern, it is advisable to use some visual aids (diagrams, figures, graphs, charts) with adequate commentaries. The solution of the pattern should also provide easy-to-remember guidelines that can help the designer while implementing the pattern in a similar situation.
- **Examples:** To help the designer to understand the use of a pattern and its applicability, it could be extremely useful to provide one or more sample implementations of the pattern in specific contexts.
- **Resulting Context:** Applying a pattern has effects and consequences on the application context. The designer should be able to foresee the kind of side effects and which good or bad consequences the pattern may cause. A good pattern description should provide both advantages and disadvantages of the design solution.

- **Rationale:** The rationale should explain the key factors that make the pattern solution very useful, effective, and valuable. The rationale tells us how the pattern actually works and why it is a "good" solution to a design problem. It also describes the actual basic strategies by which forces and constraints are managed in order to achieve a certain task. While the pattern solution can be viewed as the *body* of the pattern which operates, the rationale can be considered to be the *soul* of the pattern, its inner motivation of behaving.
- **Related Patterns:** Since a pattern can accomplish a specific task within a larger design strategy, its synergy with other patterns can more effectively achieve the goal of supporting design. Thus, the relationships between different patterns whose orchestration aims at realizing one scope need to be pointed out. Relationships among patterns can be established for different reasons. Two or more patterns can be related because they try to solve the same design problem, or because they can be considered slightly different variants of the same design solution. Different patterns applicable in different contexts can share key factors or design elements, which is another reason why a relationship may be established. A short illustrative version of design pattern #92, called Bus Stop in Alexander et al. (1977), is shown in Figure 2.

Figure 2. Illustrative representation of Alexander's design pattern #92: "Bus Stop"



DESIGN PATTERNS IN SOFTWARE ENGINEERING AND OTHER COMPUTER SCIENCE FIELDS

Since the essence of a pattern is to express a relationship between a problem in a certain context and a solution, this notion is perfectly applicable to a broad range of design contexts and disciplines. In the late 1980s, Alexander's idea took root in the distant soil of computer science, starting from software engineering, where the original Alexandrian definition was rephrased in multiple ways, such as "a design pattern is a named nugget of insight that conveys the essence of a proven solution to a recurring problem within a certain context amidst competing concerns" (Appleton, 2000). In software engineering, design patterns have been progressively acknowledged as powerful means for implementers to support communication, sharing, and reuse of design experience in the development process of software systems. In this domain, patterns are used both as a language to represent flexible and modular design solutions at a high level of abstraction, and as customizable building blocks to create software applications in a more systematic way.

In 1987, Ward Cunningham and Kent Back, while designing user interfaces with the programming language Smalltalk, decided to exploit some of Alexander's concepts to define a small catalogue of five patterns for novice programmers. In the same year, they presented the idea of software patterns in a paper titled "Using Pattern Languages for Object-Oriented Programs" (Beck & Cunningham, 1987). Soon afterwards, Jim Coplien began defining a number of specific patterns for C++ programming language and published them in 1995 (Coplien & Schmidt, 1995). In the early 1990s, these publications began to raise questions regarding the relevance and the utility of patterns for software development and their definition process. One of the most important pattern communities was born in 1993 with the name of Hillside Group, and it is currently promoting the use and the effort to catalogue software patterns (see http://www.hillside.net/patterns/onlinepatterncatalog.htm).

The ultimate success of patterns was confirmed in 1994 with the publication of the "cult" book *Design Patterns: Elements of Reusable Object-Oriented Software* by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides, also known as the Gang of Four (GOF) (Gamma, Helm, Johnson, & Vlissides, 1994). This book is a de facto reference for any object-oriented (OO) software developer, professional, or researcher. GOF distilled their OO design patterns into three main subject areas: creational, structural, and behavioral. Unlike an Alexandrian pattern, which is usually rather abstract and high level, an OO pattern is much more detailed (oftentimes covering 10–12 pages), and finer-grained structured (composed by intent, motivation, applicability, structure, participants, collaborations, consequences, implementation, sample code, known uses, and related patterns). It is not code, per se, but a "plan of attack" to solve a common software development problem, which provides straightforward guidelines for implementing a solution into software. After Gamma et al. (1994), several other books were published. They helped popularize patterns (e.g., Buschmann, Meunier, Rohnert, Sommerlad, & Stal, 1996), also called the POSA book, and the book *Pattern Languages of Program Design*. Many of them are published by Addison-Wesley in its Software Patterns Series and collected selected papers from the various editions of the *Conference on Patterns Languages of Program Design* (PLoP or PLoPD).

With the increasing interest of software design patterns in academia, their adoption in curricular courses, and their progressive use by programmers, the concept was investigated for specific programming languages such as Java (Cooper, 2000). It also received increasing attention in some technology fields outside traditional software engineering, such as hypermedia engineering (Garzotto, Paolini, Bolchini, &

Valenti, 1999; Rossi, Schwabe, & Garrido, 1997), business modeling (Eriksson & Penker, 2000), human–computer interaction (Bayle, Bellamy, Casaday, Erickson, Fincher, Grinter, et al., 1998; van Duyne, Landay, & Hong, 2003; van Welie & van der Veer, 2003), and e-business (http://www.ibm.com/framework/patterns).

This trend has also been witnessed by a proliferation of efforts in creating paper-based and digital online catalogues of design patterns in specific domains. Some examples are the Hypermedia Design Patterns Repository (http://www.designpattern.lu.unisi.ch/PatternsRepository.htm); the "Design Patterns for Web, GUI, and Mobile Interfaces" by M. van Welie (http://www.welie.com); T. Erickson's Interaction Design Patterns Web site, which also provides some domain specific patterns for game interfaces and social applications (http://www.pliant.org/personal/Tom_Erickson/InteractionPatterns.html); the 90 Web design patterns by K. Van Duyne (van Duyne et al., 2003); the 30 user interface patterns by J. Tidwell, who structures interface and interaction design as a pattern language, featuring real-live examples from desktop applications to Web sites, Web applications, mobile devices, and everything in between (http://designinginterfaces.com/).

DESIGN PATTERNS IN (E-)LEARNING

In the field of education, the investigation of the concept of design pattern is quite recent (less than 10 years old). One of the first publications in this field was Lilly (1996), while the first research and development (R&D) project that explicitly focused on patterns was the "The Pedagogical Patterns Project," which ended in 1998 (Manns, Sharp, McLaughlin, & Prieto, 1998). These projects address design problems in "traditional" learning contexts, where learning is not mediated nor enhanced by ICT (information and communication technology).

With the increasing availability of ICT in schools and at home, e-learning has emerged as an autonomous discipline, which appears to be separate and distinguished from education and instructional design. E-learning has also become an important issue of discussion, investigation, and experimentation by teachers and instructional designers, as well as a subject for high-level education and academic research. E-learning is a very general and broad concept, which deserves multiple definitions. For the purpose of this chapter, the following definition is proposed (from Goodyear, 2002): "E-learning is the systematic use of (networked) multimedia computer technologies to empower learners, improve learning, connect learners to people and resources supportive of their needs, and to integrate learning with performance and individual with organizational goals."

As the technology supporting e-learning has matured, in the community of e-learning researchers and practitioners, there has been a shift of focus from technological to methodological issues. We have progressively realized that proper conceptual tools are needed to master the complexity of using ICT tools and digital resources in a real educational context in order to achieve effective teaching and learning. This trend has paved the way for an in-depth reflection on design methods in e-learning and for the advent of patterns in this domain. One of the first attempts in this direction was the Pointer Project (http://www.comp.lancs.ac.uk/computing/research/cseg/projects/pointer/pointer.html). It explored the appropriateness of patterns as a means of communicating information about how people interact with one another through technology, addressing educational contexts as case studies. Later, the European Projects ELEN (http://www2.tisip.no/E-LEN/) and TELL (http://cosy.ted.unipi.gr/tell) investigated, from both a theoretical and an empirical perspective, design patterns for technology enhanced education in different domains, with TELL having a special focus on collaborative e-learning.

Academics started writing about the use of design pattern in e-course design (e.g., Frizell & Hubscher, 2002; Garzotto, Retalis, Tzanavari, & Cantoni, 2004; Goodyear 2005; Goodyear et al., 2004; Hernandez-Leo, Villasclaras-Fernández, Jorrín-Abellán, Asensio-Pérez, Dimitriadis, Ruiz-Requies, & Rubia-Avi, 2006), learning objects design (Jones, 2004; Roderick, Farmer, & Baden Hughes, 2006), as well as e-learning management system design (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2002; Georgiakakis & Retalis, 2005; Schuemmer, 2003). Recently, a number of workshops on e-learning design patterns (e.g., Garzotto & Retalis, 2004) have been organized. These have involved design patterns writing's sessions and have brought together the various R&D groups who wish to develop more mature e-learning design patterns. The most recent workshop was organized within the Computer Support for Collaborative Learning Conference 2007 (http://cosy.ted.unipi.gr/CSCL_DPatterns_workshop.htm).

A number of attempts have been carried out to use design patterns as representation means for learning designs (Koper, 2006) and learning objects (De Moura Filho & Derycke, 2005). Some authors (e.g., Brouns, Koper, Manderveld, Van Bruggen, Sloep, Van Rosmalen, et al., 2005; Hernández-Leo et al., 2006; Rusman, van Bruggen, & Koper, 2007) have presented some ideas on how to link IMS LD with learning design patterns. They investigate the ways of using design patterns to describe the interactions and exchange of learning objects among participants in computer supported collaborative learning activities. Thus, they suggest that the solution to the design problem that a pattern tries to solve should be specified by a template with IMS LD elements. In this handbook, Goodyear and Yang pinpoint that patterns primarily have a communicative function, that is, of textual, teacher friendly descriptions of learning designs that educational professional with limited ICT expertise can easily grasp and use, and of expressing the design rationale underlying learning objects. As we mentioned in the introduction, patterns are best suited to foster learning and sharing design ideas and to stimulate reflection among technically unsophisticated teachers and novice designers. On the contrary, learning design and learning objects are more supportive of downstream "technical" activity—detailed design and development work, regarded as appropriate by technical experts. As suggested by Goodyear and Yang in this handbook, patterns help with understanding and design decision making, while learning design and learning objects help with "performance."

A TAXONOMY FOR E-LEARNING DESIGN PATTERNS

Based on an extensive survey of the literature, and our expertise in defining, using, evaluating, and teaching e-learning patterns, we propose a taxonomy for them, which will be discussed and exemplified in the rest of this section.

Motivation

Why is a taxonomical approach important; that is, why should we try to classify e-learning design patterns? Since we are dealing with collections of solutions concerning such a complex object of study as e-learning, suggesting a possible classification of design patterns helps a pattern developer to (i) analyze more systematically the problem and solution he is trying to express in a pattern format; (ii) isolate the different aspects to consider; and (iii) identify the proper level of abstraction and granularity. In addition, a taxonomy provides developers of pattern repositories with criteria to organize a large amount of patterns more systematically.

At the same time, it supports e-learning designers (both expert, less-experienced and inexperienced) in an easy search of useful patterns in the repositories. Designers can compare different patterns grouped within the same class, identify hidden similarities or mutual conflicts or inconsistencies. A taxonomical approach supports a better isolation of the problem statement by facilitating the identification of a specific pattern that better fits with the current designer's problem within a set of patterns addressing "near" problems.

Moreover, a proper classification could be useful to better understand the relationships between design patterns for analysis and reuse purposes. Since taxonomy classes might not be mutually exclusive—that is, the same pattern is classified under different criteria—a taxonomic approach provides a framework for studying the same design pattern from different perspectives. Since design patterns are discovered and defined by designers or researchers who often have specific perspectives on that design problem and solution, they tend, when dealing with the same or similar pattern, to stress some aspects more than others. By classifying the same design pattern in different ways, it is possible to highlight other aspects (not explicitly stated in the description) that might be useful to consider for a more effective use and adaptation of patterns. Moreover, since patterns are considered a complementary representation for learning design specifications, their taxonomic approach could improve identification, retrieval, and understanding of the associated learning designs, and it could indirectly support their use during the development process of an e-learning experience.

Defining a Taxonomy for E-Learning Design Patterns

We define an e-learning experience as a "situation" in which people learn or attempt to learn something, individually or in group, using ICT technologies. This concept models e-learning situations having any temporal or organizational granularity, and it is more general than the frequently used notion of "course" (which has a more bureaucratic flavor). For example, an e-learning experience can refer to an individual interaction session with an educational CD-ROM, as well as a short collaboration session with remote peers, or a set of long-term technology-mediated (individual or collaborative) activities staggered over a period of several weeks or months.

Designing an effective e-learning experience is a complex process involving a number of interdependent "aspects," dictated by the concrete needs and design requirements that a designer is dealing with. They range from the design of tasks/activities, content resources, convivial spaces, organizational forms for "learning as a social process," to the design of e-learning software tools and systems. We will discuss some of these aspects, and use some of them as criteria to classify e-learning design patterns.

In order to understand the complexity and the multiple dimensions of an e-learning design space, let us consider the following scenario, or "story of use," narrated according to Carrol (2002).

"Mary, a teacher at a secondary school, is looking for an effective way(s) to teach racism to the students of her third grade classes. She is looking for an instructional strategy that could stimulate students to actively participate to the learning experience rather than passively study a bunch of pre-packed material. She knows that her students' learning style demands active learning and they like group work. She consults with her colleagues, receiving various suggestions on how to organize students' activities, and conceives a workflow applying different learning strategies, such as "web quest" and "peer reviewing," and involving various learning tasks. She also starts browsing the web searching for proper online learning resources. She finds some really nice movie clips from films that deal about racism, as well as speeches, concept maps, and self-assessment tests which could be combined with traditional text-based learning resources that the school curriculum suggests. Then she wants to find out how the learning experience under design could be supported by the use of learn-

ing tools. She has heard about asynchronous computer supported collaborative learning tools such as Synergeia (http://bscl.fit.fraunhofer.de/). So she opens Synergeia online manual, in order to see which features of this tool could be used and how. Finally, she considers the way she could evaluate the educational benefits of the e-learning experience under design. She consults the web again, discovering some papers and reports that recommend the adoption of "mixed" evaluation methods, such as the use of pre & post questionnaires along with analyzing the quality of the students' deliverables."

As the above "story" highlights, a teacher needs a lot of support about various aspects in order to design an e-learning experience which proves to be suitable students. It must be an e-learning experience in which she can reuse existing learning "resources" (learning contents, or "learning objects," and tools) created by other colleagues and R&D groups but at the same time she can exploit her creativity and enthusiasm. This scenario highlights that the design process of an e-learning experience involves a wide spectrum of decisions (underlined in the narrative) which includes:

i. Determining and understanding the **student audience**:
   - What is students' level of knowledge?
   - What are their initial interests likely to be?
   - What are their learning and cognitive styles?

ii. Defining, finding, building, or organizing the **digital** (and paper-based) **learning resources,** or the content needed by, or used for, carrying out the e-learning experience under design:
   - What contents will students need to master?
   - What learning objects (text-based, multimedia, interactive media, etc.) will help students to carry out the learning experience effectively?
   - What optional material will be provided for students with special skills or needs or interests?
   - What order of content will aid students' understanding of the experience subject matter and will help them achieve the intended learning benefits?

iii. Planning learning **activities** to enable students to achieve the objectives of the e-learning experience:
   - What technology-mediated learning activities will students do, and in which environment (e.g., at school—in class or in the computer lab—or at home)?
   - What kind of feedback will students receive about their activities?
   - How will "off-line" learning activities be related to or integrated with online activities?
   - What order of activities will better foster the achievement of the intended learning benefits?

iv. Finding the proper ICT **learning technology and services:**
   - What technological tools will support the use of the digital content resources and the execution of the various learning activities?

v. Planning **methods of assessing and evaluating** learning benefits:
   - What learning activities will be graded?
   - What types of evaluation methods are more appropriate for the educational objectives of a learning experience?
   - How can these methods be customized to a specific learning context and to the expected benefits of a specific learning experience?

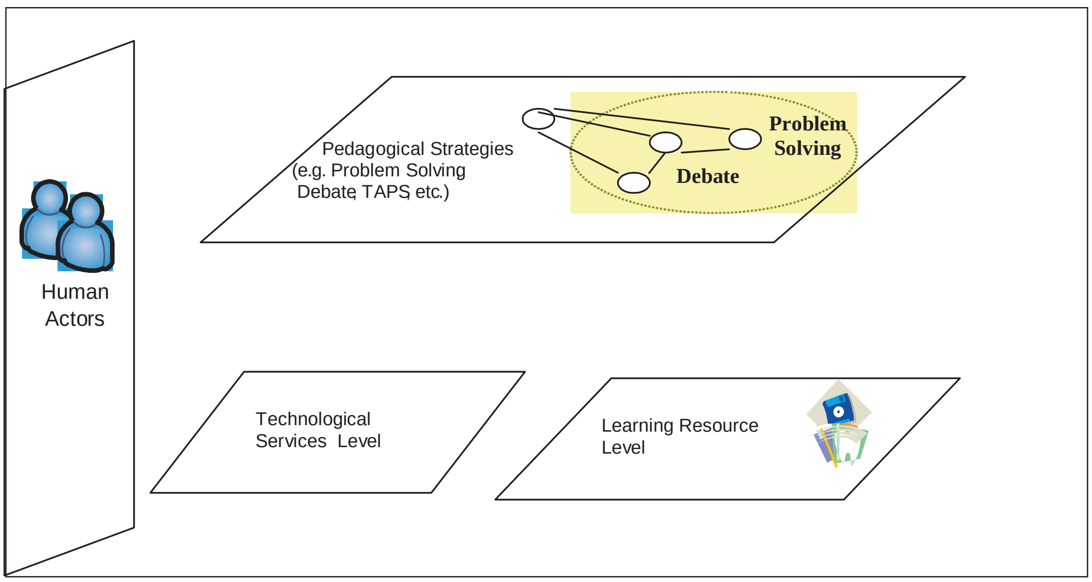
In the literature, we can find patterns about all the aforementioned interrelated aspects that define the "decision space" for an educational designer. Unfortunately, these patterns are scattered, and they have not been systematically classified in a coherent classification framework. One attempt in this direction has been recently been proposed by Hernández-Leo et al. (2006), but their taxonomy is mainly focused on the domain of computer-supported collaborative learning and does not apply to all educational settings.

A more general taxonomy for design patterns that can be used for the entire domain of e-learning is shown in Figure 3. It defines the following categories, which, at a coarser granularity, comprise all the aspects above discussed:

- Patterns about **human actors**
- Pattern about **pedagogical strategies**
- Patterns about **learning resources**
- Patterns about **technological tools and services**

The above categories can be further refined, according to various criteria, as discussed in the rest of this section. We will present some published illustrative examples of patterns for the various categories or subcategories. It is important to notice that they will be reported in the same format published in the literature. The reader will notice that their structure is sometimes inconsistent with the original Alexander's template. All examples include the four core components: "Name," "Problem," "Solution," and "Examples" (in this chapter, we may omit to report the "Examples" component, if too long). Still, the presence of other elements is sometime missing in the published formulation, or some new components have been included by a specific pattern author. This inconsistency is quite common in the e-learning design pattern literature, as we will discuss in E-Learning Design Patterns: Virtues and Drawbacks section. The Alexandrian prose-style format is a rather abstract way of describing patterns, as it

Figure 3. A taxonomy of e-learning design patterns



does not delve into implementation details, but it rather expresses a generic solution. On the contrary, the GOF format (Gamma et al., 1994) is more complete and provides straightforward guidelines for implementing the patterns. As Fowler (2006) states, "There are several other forms of writing patterns. Different forms work for different authors, because different writing styles work with different personalities."

DESIGN PATTERNS ABOUT HUMAN ACTORS

The patterns in this class aim to help designers in creating exemplar designs of e-learning experiences where there is a "good matching" between learning styles and the different ingredients of an educational experience—educational resources, activities, social setting, or physical environment. A learning style is the particular and different way of perceiving and organizing information (Honey & Mumford, 1986; Woolfolk, 2000). Some researchers suggest that a learning style

Figure 4. The "diverger" learner design pattern (Garzotto et al., 2004)

Pattern Name: Designing Learning Tasks in a hypermedia environment for a "Diverger" Learner
Problem: Learners characterised as Divergers (Reflective observer/Concrete Experience) are motivated to discover the relevancy or "why" of a situation. They like to reason from concrete, specific information and to explore what a system has to offer, and they prefer to have information presented to them in a detailed, systematic, reasoned manner. Thus the instructional problem is "How can I design an educational hypermedia material in order to address the needs of a **"diverger"** learner"
Solution:

- *Content Issues*
  - Create a study plan. For each learning task highlight its goals. They want to know how the learning material relates to them personally (experiences, interests, and in the future).
  - Provide "the big picture" about a topic with references to their personal experiences and examples
  - Do not lecture them.
  - The material should be short either text-based, observations (videos, pictures, shapes, figures) that make sense for their current level of knowledge, motivation and experiences
  - Provide material that simulate lab work so that they will have hands-on experiences
  - Provide them with a variety of case studies so that they can see situations from many perspectives
  - Give them tasks for organizing relationships between a variety of similar case studies into meaningful wholes
  - Include exercises-problems at a high level of detail with guidelines for solving them step by step.
  - Organise field work on topics highly related to his/her interests
- *Navigation and Interaction Issues*
  - Use "Guided tour" (see "Index Hypermedia Pattern" (Isakowitz et al. 1995))
  - Support "bottom-up" processing of learning (simple to complex, inductive process, a stimulus or a specific information that will activate the intellectual processing)
- *Activities Issues*
  - Offer learners tasks for searching for information evaluating current information
  - Allow student to brainstorm in interacting with peers in small groups. Be their motivator
  - Give them tasks for reflection especially through talking and feeling. Give them time for reflection
- *Lay-out Issues*
  - Text will be given in small chunks
  - The style of writing should be highly specific
  - Use a lot of pictures, figures, shapes will illustrative captions
  - In the different pages, highlight relevant topics and make links to hints

refers to an individual way of gaining, absorbing, acquisition processing, storing, and retaining information (De Bello, 1990; Dunn, Beaudry, & Klavas, 1989).

A number of studies in traditional class-based education (Claxton & Murrell, 1987; Lee, 1992; Pask, 1976) show that a learning style can be strengthened by proportional strategies and techniques of learning and teaching. Some researchers also highlight that students whose learning styles match the instructional approach of a course "tend to retain information longer, apply it more effectively, and have more effective post course attitudes towards the subject than do their counterparts who experience learning/teaching mismatch" (Felder & Silverman, 1988). Applied to the e-learning domain, the above results suggest that a technology-mediated educational experience should provide personalized views over learning activities and exploit digital contents based on students' learning styles.

Patterns that address the above aspects may be further classified according to the specific learning style or preference that the designer, or the application, needs to address. For example, Garzotto et al. (2004) proposed a design pattern named "diverger learner," shown in Figure 4. Here we include only the components Name, Problem, and Solution, omitting the examples for the sake of brevity—the reader can find them in Garzotto et al. (2004). In this pattern, the problem component deals with the instructional goal of supporting learning for students who are reflective observers and are more reactive to concrete experiences (defined in literature as "divergers," Felder & Silverman, 1988). The solution component sketches the desired design properties that an e-learning hypermedia course should have to better capture the characteristics of this kind of students, in terms of content, content organization structures, and its interaction or navigation capabilities.

DESIGN PATTERN ABOUT PEDAGOGICAL STRATEGIES

This type of design pattern deals with a number of elements, such as the design of educational strategies, the specification of the type and workflow of activities that will be performed by learners during the e-learning experience, teacher's assignments that can be adopted to enforce learning and assessment techniques tasks to evaluate educational benefits. In the current state of the art, the patterns falling into this category focus on heterogeneous elements and significantly vary in the levels of granularity. This class of patterns can be further refined according to the "context" in which learning occurs (in its various aspects, e.g., multilearner vs. single learner experience, "stationary" learning vs. "mobile" learning). Specifically for collaborative learning, several examples can be found on the Web site of the TELL project (http://cosy.ted.unipi.gr/tell/). A pattern that describes general flows of collaborative (or not) learning activities is Jigsaw CLFP—Collaborative Learning Flow Pattern (Hernandez-Leo, Asensio-Pérez, Dimitriadis, Bote-Lorenzo, Jorrín-Abellán, & Villasclaras-Fernández, 2005), reported in Figure 5. A pattern that addresses the dynamic "situation" in which learning occurs, or mobile learning, can be found in Winters (2007).

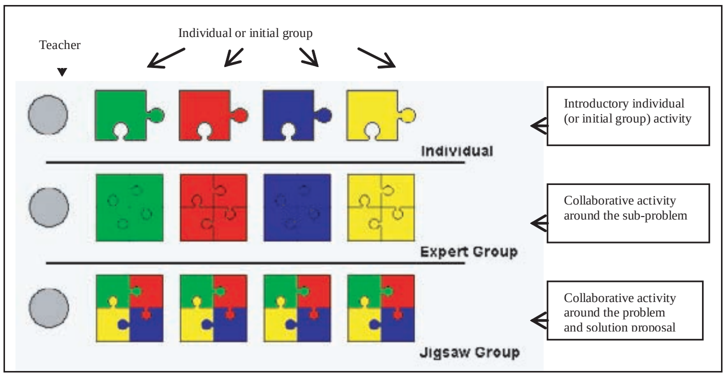
To support the design of teachers' assessment activities, a large amount of patterns (40) have been developed by the PADI project (http://padi.sri.com/). Their patterns aim at providing guidance in the creation of high-quality assessments of inquiry skills in science education at the middle school level (Baxter & Mislevy, 2005), and at helping practitioners organize their assessment thinking and processes in such a way that it leads to a coherent evaluation argument.

Patterns about pedagogical strategies can also be classified according to their level of abstraction. At a low level of abstraction, we find patterns that describe sequences or flows of fine-grained

Figure 5. The jigsaw e-learning design pattern. Information used to generate this image is from Hernandez-Leo et al. (2005)

Name : Jigsaw CLFP	
(super-context and relations with other high-level patterns)	… within a collaborative learning scenario in which the use of collaboration scripts designed according to DESIGNING SCRIPTS BASED ON BEST PRACTICES IN CL STRUCTURING is seen as a solution to situations where forming groups does not lead necessarily to learning, these best practices should be identified and formulated.
CONTEXT	This pattern gives the collaborative learning flow for a context in which several small groups are facing the study of a lot of information for the resolution of the same problem.
PROBLEM	**The collaborative learning flow must enable the resolution of a complex problem/task that can be easily divided into sections or independent sub-problems.**
(DISTINCTIVE) EDUCATIONAL BENEFITS	Objectives regarding proceeding: o To promote the feeling that team members need each other to succeed (positive interdependence) o To foster discussion in order to construct students' knowledge o To ensure that students must contribute their fare share (individual accountability)
COMPLEXITY	High-risk: more appropriate for collaborative learning experienced individuals
SOLUTION	**Each participant (individual or initial group) in a group ("Jigsaw Group") studies or works around a particular sub-problem. The participants of different groups that study the same problem meet in an "Expert Group" to exchange ideas. These temporary focus groups become experts in the section of the problem given to them. At last, participants of each "Jigsaw group" meet to contribute with its "expertise" in order to solve the whole problem.**

(diagram representing the solution)

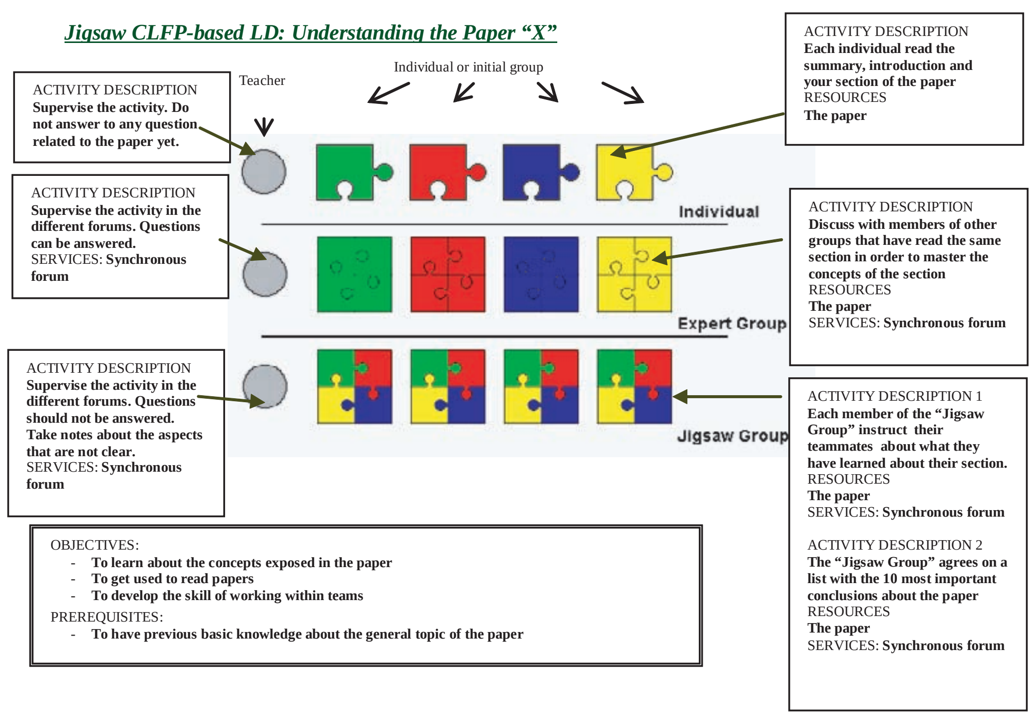


(relations with other patterns)	The individual phase, the expert-group phase or the jigsaw group phase can be structured according to PYRAMID CLFP. The phases of the Jigsaw can also follow any pattern of the "(Collaborative) Learning Activity level"
(guidelines and) recommendations for particularization / customization, instantiation and execution	Particularization/customization of the pattern into a learning design (script): Provide experts with a tool so that they can take notes during the focus group that provide support when the original group re-assembles. During particularization, several tasks should be performed: global problem definition, division of the problems in subproblems, provision of necessary resources (contents and tools), decisions about control of time. Instantiation of the Jigsaw CLFP-based learning design (script): Being the only expert in a sub-problem in the "Jigsaw Group" can be a demanding experience for students. This can be mitigated if two group

continued of following page

Figure 5. The jigsaw e-learning design pattern. Information used to generate this image is from Hernandez-Leo et al. (2005) (continued)

	members share the same section of the problem. During instantiation, several tasks should be performed: creation of particular jigsaw groups, assignment subproblems to each member of the groups (and thus creating expert groups).
EXAMPLE	Collaborative understanding of a paper where each subsection (excluding the summary and introduction) is assigned to each member or every "Jigsaw Group". Face to face scenario, in which each person has available a PC.



(references)	- Aronson, E., Patnoe, S. (1997). The Jigsaw classroom: building cooperation in the classroom, (2th ed.)United States: Addison-Wesley Educational Publishers Inc. - Clarke, J. (1994). "Pieces of the puzzle: The jigsaw method" In Sharan, S. (Ed.), Handbook of cooperative learning methods, Greenwood Press. - Johnson, D.W., Johnson, R.T. (1999). Learning together and alone: cooperative, competitive and individualistic learning. (5th ed.) Needham Heights, MA: Allyn and Bacon.

learning activities and give detailed guidelines on how to apply them (e.g., scripts for argumentative knowledge construction; Weinberger, Stegmann, & Fischer, 2005), or the "seminars" design pattern (Voelter & Fricke, 1999). Other examples can be found on the Web sites of the ELEN project (http://www2.tisip.no/E-LEN/).

DESIGN PATTERNS ABOUT LEARNING RESOURCES

The availability of high quality, well-organized educational resources is a key component of any learning experience. There are basically two types of approaches that an instructional designer may exploit (possibly combining them) to address the above problem. He can design and build his own digital resources from scratch. Or, given the enormous amount of content today available on the web, he may decide to search and retrieve existing resources and reuse/adapt them. In the latter case, his design problem is basically to sift through the huge mass of content that may return from search, to select high-quality, appropriate material, and to understand how to use it for the e-learning experience under design.

These two approaches lead to two main subcategories of e-learning design patterns for learning resources: patterns for content creation, and patterns for content selection and reuse. As far as we know, in the current state of the art, few e-learning design patterns fall into the second subcategory and help teachers to select, organize, and customize existing educational resources. Such patterns are the PUBLISH and TUTORIAL patterns (Derntl, 2004) which are contained in the Person-Centered e-Learning Pattern Repository (http://elearn.pri.univie.ac.at/patterns/). Quoting Derntl (2004), "the PUBLISH pattern generically describes disclosure of an information item (e.g., text, file) to a certain target person, role, or group of roles and/or persons."

Most of the existing efforts have focused on patterns that help an instructional designer design and build her own digital resources from scratch. Many existing patterns in this subcategory are largely domain-dependent; that is, they are strongly linked to the specificities of a discipline or subject matter, such as the typical methods that are used in that discipline or the kind of skills that

Figure 6. A design pattern about learning resources (Lyardet et al., 1998)

Name: Information Factoring
Problem: How can we present information needed by the reader to understand a given topic/Information unit?
Motivation: This problem is of a particular interest in educational multimedia systems (EMS). Many times, for example when introducing a new topic, it is necessary to refer to related concepts. The author has the possibility of adding links to the nodes of the referred concepts. But, if the reader is forced to navigate back and forth the original topic to read about complementary ones, the navigation overhead is high and the users' focus desegregated through a number of nodes, instead of concentrating in one topic at time.
Thus the effectiveness of having links with related information is reduced by the distraction penalty it imposes over the reader.
Solution: This problem has been devised in hypertext systems from the early days. The usual technique is to activate those nodes of related information inside the current node. The user sees this "in-place activation" as a pop-up window that generally can be easily dismissed with an escape keystroke. In this way, the reader does not have to navigate to other nodes avoiding the inherent context switch and cognitive overhead.
Known Uses: In the "The Way Things Works", complementary concepts are shown in this way in the figure below, where the concept of "energy" is mentioned in both topics, and a reference to a node containing its definition is given. Notice that the definition of energy is not a part of the topics but rather an independent node that is activated as a pop-up window. Also, the MS-Windows Help System, provides different ways of specifying anchors, depending whether the result of activating the anchor is navigation or in-place activation of the target node (these are called: jump-anchors and popup-anchors).
Related Pattern: Information on demand, since additional information enriches the contents by activating other nodes in pop-up windows. The difference with Information On Demand relies in that information is not part of the current node, that is, it is not part of the node's attributes and might be accessed from other ways, not only from the current node. The user activates simultaneously other nodes of information.
Relevance to EMS: This pattern addresses a common concern in EMS: how to provide background information to the reader without distracting his attention.
Examples: omitted in this chapter, but available in **(**Lyardet et al., 1998)

its practice requires. For example, Bergin (2001) proposed a design pattern language for computer science (CS) course development (although some of his patterns are applicable via some adaptation to other technology fields as well). Similar efforts in the CS domain can be found in Eckstein, Manns, and Volter (2001) and in the results produced by the Effective Projectwork in Computer Science (http://www.cs.ukc.ac.uk/national/EPCOS/). Some more hesitant attempts have been made in other domains like mathematics (Naeve, 2002).

Lyardet, Rossi, and Schwabe (1998), Boyle (2003), and Jones (2004) have published some design patterns that address the problem of creating digital multimedia resources from a more general perspective, and deal with the way a unit of multimedia content, or learning object (LO), should be built in order to meet specific instructional requirements. A nice example is reported in Figure 6.

DESIGN PATTERNS ABOUT TECHNOLOGICAL TOOLS AND SERVICES

Today technology provides a wide amount of tools and integrated environments that support the interaction between learners and learning objects or learners and teachers, facilitate the formation of virtual learning communities (either large or small), and maintain common spaces for sharing and reusing resources. Design patterns about technological tools can address two major categories of problems:

i. Helping teachers choose the most appropriate "products" that suit their course objectives, student audience, preferable learning strategies, or
ii. Aiding system designers and developers in building more usable tools.

To our knowledge, the existing patterns about technological tools neglect to consider the first category of problems, and rather focus on the design problems concerning system development. Several examples of design patterns of this type can be found (Avgeriou et al., 2002; Georgiakakis & Retalis, 2005; Guerrero & Fuller, 1999; Schümmer, 2003). One example is shown in Figure 7, which addresses the problem of designing annotation mechanisms on posted messages in an asynchronous conferencing system for e-learning (Georgiakakis et al., 2005).

E-LEARNING DESIGN PATTERNS: VIRTUES AND DRAWBACKS

Design patterns as a design medium potentially provide a number of benefits for e-learning designers. The ELEN Project (http://www2.tisip.no/E-LEN/) has identified some virtues that are specific of e-learning patterns, pinpointing that they can help practitioners, thanks to their "empirical foundation," their "democratic nature," and their "action-oriented, evidence based advice" format. In addition, e-learning patterns benefit from a number of other virtues that are common to design patterns in any field and are implicit in the reusability nature of these conceptual tools.

In spite of all these positive characteristics, patterns for e-learning design have partially failed to catch on so far. As we mentioned in the introduction, a design-by-patterns approach is currently adopted by a minority of "patterns fans" but not by the majority of educational designers. Indeed, existing approaches to e-learning patterns development suffer from various fundamental problems and many patterns that we can find in the literature or in online repositories do not meet the requirements for the quality that an educational designer should expect. In this section, we discuss the positive aspects of e-learning design patterns as well as their drawbacks. Finally, we analyze how these pros and cons may affect the role of patterns for learning designs.

Figure 7. The "Annotation_On_Posted_Messages" design pattern. Information used to generate this image is from Georgiakakis et al. (2005)

Name: AnnotationOnPostedMessage (52)

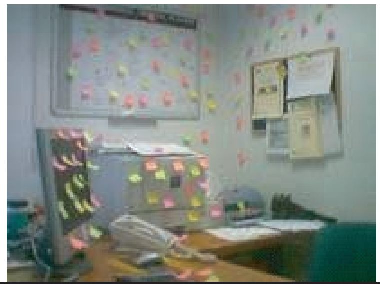
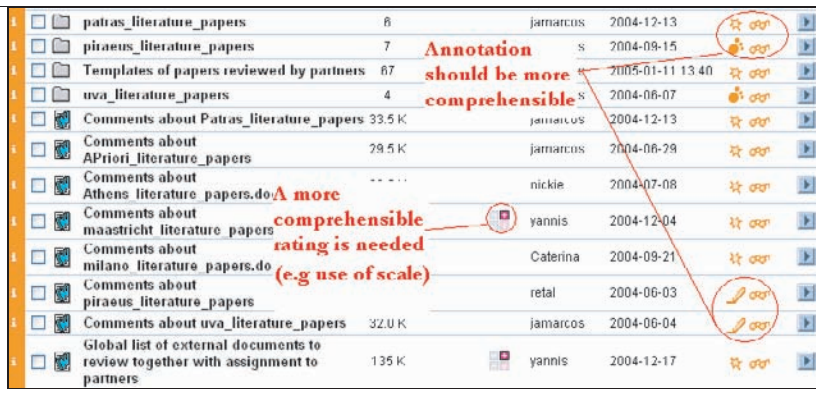
PROBLEM	How can the user decide if a message is interesting, urgent, or just junk? Does the user have to read all the messages that arrive in the inbox?	
FORCES	• The user needs to know the characteristics and/or the modifications of each message, without spending time opening the messages and reviewing their contents • Users need reminders for actions taken on past messages (especially those opened long time ago) • Users need information on the usefulness of the contents of each message • Users need to get (notification) about every alteration in the material or the contents of the postings • Users need comprehensive annotations so that they don't spend more time trying to understand what each icon means than the time needed to read the message • Users must be notified whether community members have posted remarks or questions on a specific topic	
SOLUTION	**Inform the users of actions taken in previous sessions (either by themselves or by other participants).** Each message must be annotated regarding its importance (e.g. urgent, innovative) in order for community members to be able to choose and access those that are closer to their interests. Also in the cases when posted messages have been modified from their initial version, new data are contained, they have already been read, remarks have been made by other members of the community or notes have been placed on their contents, annotation should exist, in order to avoid wasting time reading or trying to remember what the previous interactions with each posting were.	
EXAMPLE(s)	 The BSCW annotation: System categorizes postings as: read, unread, contain new data, contain invents inside, changed. Even if the system provides for each annotation meta-data, the annotation itself is not very descriptive. We suggest the use of more comprehensible annotations, even the provision of a "pool" of acceptable annotations that each user is familiar with. There should also be a pop-up	

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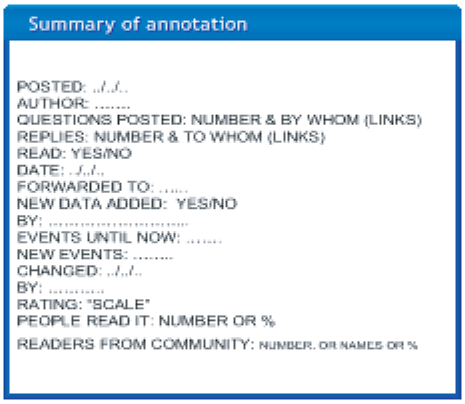
Figure 7. The "Annotation_On_Posted_Messages" design pattern. Information used to generate this image is from Georgiakakis et al. (2005) (continued)

	acceptable annotations that each user is familiar with. There should also be a pop-up window, as shown below, with the summary of the annotations on the messages. 

Virtue 1. Bridging Theory and Practice

Design patterns constitute a reusable base of experience for designing e-learning experiences. They refer to recurrent practical problems of e-learning design and bridge theory, empirical evidence, and tacit knowledge of experienced practitioners.

Virtue 2. Offering Well-Supported Guidelines

Patterns are not a prescription nor a set recipe. They guide designers to act in a certain way, bringing forward the proposed solution and giving explanations of the underlying rationale.

Virtue 3. Fostering Creativity

Patterns help designers/practitioners who develop them to innovate and to become creative. The solution to a given design problem is backed up by references to research literature and proper examples. Still, based on the various circumstances and design constraints that have been codified as "forces," the designer can offer an appropriate solution to a given design problem that will not be identical to the ones created by other designers.

Virtue 4. Supporting Collaboration

Patterns are effective means of augmenting the collaboration among e-learning practitioners and researchers. Design patterns are not created by one person. Pattern writing is in reality a team effort (Retalis, Georgiakakis, & Dimitriadis, 2005). A pattern is usually drafted by someone and then shared, analyzed, commented on, assessed-evaluated in action, and refined through an extended process of collaboration often referred to as "shepherding" in the pattern community (Mezaros & Doble, 1998). Moreover, researchers and practitioners specialized in different educational fields can highlight different aspects of e-learning design that could correspond to different types of e-learning design patterns.

Virtue 5. Supporting Communication

Patterns are effective means of communicating educational design experience democratically. Designing an e-learning environment requires the synergy of a multiskilled, multidisciplinary group of people, most of the times with a wide variety of backgrounds. Because of this multidisciplinarity, a common ground is difficult to build, thus making communication within a design team complex and time-consuming. Since design patterns have a number of standardized representational properties such as memorable names, well-defined format, associated images, or examples, they can provide a shared conceptual framework and can be used as a lingua franca in e-learning design.

Virtue 6. Quality Improvement

Patterns may improve the quality of design. Let us assume that a large collection of design patterns is available; let us also assume that they are of good quality, having been tested in several situations. An inexperienced designer using good quality patterns potentially produces a better design than he could obtain without adopting any pattern, since they provide a "reference model" that guides design and enables a designer to compare his solution to existing ones of acknowledged quality.

Virtue 7. Cost-Effectiveness

Patterns may reduce the time and cost of design. With the same arguments used above, we should expect that an inexperienced designer, using a good library of patterns, should be able to complete his design with less time and less cost than it would be otherwise required.

Drawback 1. Lack of a Systematic Development Cycle

Differently from other domains where patterns have a longer tradition (e.g., architecture and software engineering), the definition process of e-learning patterns has not been sufficiently studied and formalized. Only few proposals can be found that suggest a systematic pattern development cycle, which is a prerequisite for fostering pattern quality. The most interesting papers about the actual processes of pattern identification and derivation ("pattern mining") that are helpful to construct a pattern can be found in Baggetun, Rusman, and Poggi (2004) and Kreimeier (2002). The most recent pattern mining approach has been proposed in Retalis et al. (2006). It is innovative in the fact that it suggests the use of authentic scenarios in order to identify ideas for patterns, most often interrelated, that provide deep insights into design. The above authors claim that patterns are discovered, not invented, implicitly suggesting that not only the validation but also the identification of a pattern is largely founded on the frequency of use, or the degree of recurrence of a given design solution. Still, there is not a common agreement that this is "the" right approach for pattern definition.

In the different domain of Web engineering, for example, Bolchini et al. (1999) provides some arguments against pattern mining by frequency of use, based on the analysis of design solutions in a wide set (42) of Web sites. These authors claim that a "frequency-of-use procedure," even when performed in a wide sample of cases, does not highlight the objective relationships of the discovered solutions with a common underlying problem, which is usually unknown and must be arbitrarily guessed. In addition, they argue that this method may lead to deviating results. Their empirical analysis shows that many of the most frequently used navigation design solutions, for example, are "bad," as they violate some elementary usability criteria. These authors emphasize that "good" patterns can only be produced by a team of expert designers who reflect on their own experience, select the best possible solutions, and compare them with other designers' proposals. Rather than a method of a-priori definition, they propose that frequency of use is useful for a-posteriori validation of pattern quality.

Drawback 2. Lack of a De-facto Notational Standardization

As highlighted by the examples in the section titled, A Taxonomy for E-Learning Design Patterns (and differently from other disciplines such as software engineering), there is not "the" pattern template adopted by all authors of e-learning patterns, in spite of the fact that all of them quote Alexander. In some cases even the same author adopts different pattern formats in different publications. This situation is clearly confusing for an educational designer, and it gives a sense of inaccuracy to the whole field of e-learning design patterns, thus potentially reducing its appeal.

Drawback 3. Limited Quality Assessment

Differently from the aforementioned fields of architecture and software engineering, where the assessment process is very systematic and strict, the validation process for in e-learning patterns is less codified and surely less documented. In addition, in the above domains, there is a well-established pattern community and a set of reference "places" (books or online repositories) where a designer can find patterns of "certified quality."

Unfortunately, the same is not true in the e-learning domain. If an educational designer has a design problem and looks for patterns that address it, she does not know how to identify a reference community (being it very small and scattered), and she does not have refereed books. In addition, googling the Web or searching for e-learning conferences libraries may produce such a wide mass of results, some of which of debatable quality, that she can get discouraged. Even when she is lucky and finally finds the pointers to a good set of resources, it might be difficult to identify the patterns she needs. Many good online repositories of e-learning patterns are not well organized; patterns might be too specific or too general to be useful; or they may deal with the wrong area of interest (e.g., they emphasize a given aspect or domain that is outside the designer's scope).

Drawback 4. Limited Empirical Evidence

Little empirical evidence is available in the current state of the art to prove the efficacy of e-learning design patterns. To our knowledge, very few empirical studies have been made which prove that the adoption of e-learning design patterns is beneficial. Unfortunately, they consider a very limited set of patterns and might not be enough to convince the skeptics.

Di Blas, Paolini, and Poggi (2006) and Poggi and Torrebruno (2007) have adopted, in three different projects, some patterns of the category "pedagogical strategies" which address the design of collaborative e-learning activities in 3D shared worlds. They provide qualitative and data (collected from over 1500 students in Europe) that show the educational effectiveness of the design solutions, in terms of improvements of collaboration skills, better understanding of the subject matter by students, and high degree of students' satisfaction. (Rusman et al., 2007) shows some preliminary results from a verification and evaluation study of the pattern: "Provide personal identity information." This pattern has been used in a European Virtual Seminar to improve trust among learners within mediated collaborative settings. The experiences with the implementation of that pattern have been highly positive.

Other empirical contributions can be found in the BioKIDS project, which developed assessment instruments to provide measurable evidence of the development of inquiry skills over multiple curricular units. Within this project, Mislevy, Hamel, Fried, Gaffney, Haertel, Hafter, et al. (2003) reused patterns, produced by the PADI project (http://padi.sri.com/), that support the design of evidence-centered assessments in the domain of science inquiry. Along the same line, DiGiano, Yarnall, Patton, Roschelle, Tatar, and Manley (2002) used design patterns in order to analyze, talk about, and offer effective design solutions for a technology-supported collaborative learning environment where students and teachers use wireless and mobile devices. They created e-learning scenarios and they identified several design patterns of different types and granularity, empirically proving that e-learning design patterns can become "a conceptual tool that can elevate design conversations to a higher level" (DiGiano et al., 2002). Finally, Hernández-Leo et al. (2006) and Dimitriadis (2007) tried to evaluate if teachers, with experience in collaborative learning but without IMS LD knowledge, could successfully design real collaborative learning experiences using design patterns (in their case, CSCL flow patterns) and a supportive authoring tool called Collage. They provided some empirical data about the benefits of the design-by-patterns approach.

Drawback 5. Difficulty of Adaptation

A critical issue can be seen as the ease of pattern reuse, or how easy it is for the designer to apply a pattern in situations different from the context where it was originally conceived. It is obvious that the adoption of a design pattern should be (relatively) agile and fast, otherwise it may turn out to be not worthwhile. If the problem tackled by the pattern is too vast or too narrow, and, consequently, the solution is too generic or too specific, it is difficult for another designer to match his current problem to the pattern problem and to adapt the solution to his current context. A "good" formulation of the pattern and of the "examples" component in particular, is important, but in order to support adaptation, a designer also needs to reuse guidelines and examples of the reuse process. To our knowledge, both these issues have not been addressed so far in the current state of the art.

As a final consideration in our analysis of e-learning patterns drawbacks, we may wonder whether the "failure" of these conceptual tools has to do with something more profound, related to the intrinsic difficulty of designing effective teaching and learning experiences. Designing an architectural artifact or a software module is a matter of creativity and rationality. Designing a learning experience involves creativity and rationality, but also deep understanding of human beings, of their cognitive and emotional processes—something much more complex and demanding. Framing problems in the (e)learning domain, isolating/composing into a schematic format the multiple factors that determine the success of an educational experience, has a higher order of difficulty than specifying design problems and solutions for computer behaviors or buildings/urban spaces functionality.

THE ROLE OF DESIGN PATTERNS FOR LEARNING DESIGN REVISITED

E-learning design patterns are a useful medium for representing in a uniform language best practices and experiences in learning design, as well as for supporting designers to develop new learning designs (e.g., collaborative learning scripts). Sharing knowledge, experiences, and best practices is the only way to create more effective learning designs following a more efficient process. Design patterns focus on educational problems and propose solutions with a given rationale. It seems that a trend in implementing the suggested solutions is the use of IMS LD. As a consequence, on the one hand, the IMS LD "slogan" that it "is designed to represent any pedagogical approach" will be tested and validated. On the other hand, new research and development efforts in the area of learning design authoring tools will be made. These tools will try to better support the reuse of learning design best practices as well as help teachers become designers and implementers.

FUTURE TRENDS

Having mentioned the pros and cons of e-learning design patterns as well as looking into the recent research and development efforts, we foresee a long path ahead before we reach maturity, and through maturity, we achieve acceptability and adoption of patterns in ICT enhanced education in the same way as design patterns are recognized in other domains. In software engineering, for example, design patterns have revolutionized the way one thinks about, designs, and teaches object-oriented design. We are definitively far from this stage in the e-learning domain. On the other hand, this situation creates a number of challenges and suggests many directions of work that can be attractive for both design practitioners and researchers in e-learning:

- **Empirical studies**
  Empirically studies on how design patterns affect an e-learning design process and the quality of the resulting e-learning experience can support the evidence of patterns benefits (or confute it).
- **Pattern-based Process Models and Methodologies**
  People who develop e-learning patterns should try to promote their adoption among e-learning practitioners and designers, indicating in a systematic way how they can become part of the instructional design process. In software engineering, design patterns have been proven to be applicable in many stages of the design process: initial design, reuse, and refactoring. Some research attempts should be made in the e-learning domain. An interesting attempt has been made by the Learning Patterns project of the Kaleidoscope Network of Excellence (http://lp.noe-kaleidoscope.org/). They have proposed a language of patterns for the design, development, and deployment of games for learning math (Winters & Mor, 2007). We definitely need pattern-based instructional design process models, as well as pattern-based authoring tools such as Collage (Hernandez-Leo et al., 2006). Such models and tools could help us to better understand the nature of e-learning design patterns, to put them into real design practice as well as to validate their impact on e-learning development projects.
- **Quality assessment**
  If the e-learning patterns presented in section 3 (A Taxonomy for E-Learning Design Patterns) are quite accurate, many others that can be found in the literature or in online repositories are relatively low quality, so they should be evaluated and systematically revised. With regards to e-learning patterns for LO design, for example, scarce quality may be partially due to the limited availability of generally acknowledged design methodologies and quality criteria for LOs, and of documentation of their design process. In such a context, even from the analysis of large quantities of LOs, it is difficult for a pattern developer to identify general design guidelines and to propose general and reusable design solutions. In order to develop good patterns for LO design, the LO development approach should be consistent with this goal (Mohan & Daniel, 2006): better quality LOs should be available, and their design rationale should be documented. Similar considerations apply to e-learning patterns in other categories of our taxonomy. A quality-oriented approach requires the

definition of systematic quality evaluation strategies for e-learning patterns, which are currently missing.

- **Improvements of existing e-learning patterns resources**
  We should not only revise individual patterns, but also the organization and usability of existing bodies of resources. In most repositories, design patterns vary in their granularity and level of abstraction, which share common properties, but are not organized accordingly. As we mentioned in section 3 (A Taxonomy for E-Learning Design Patterns), defining sound classification criteria and structuring patterns catalogues consistently, will make it easy for pattern developers to refer to families of related patterns, and for pattern users to retrieve them. Cunningham (1994) and Lukosch and Schümmer (2004), among others, suggest the use of mind maps in creating associations among patterns.
- **Teaching e-learning patterns**
  Although designing effective e-learning design experience is difficult, teaching others how to do it is even worse. E-learning design patterns can be a valuable means of teaching e-learning design, such as teaching object oriented design (Della & Clark, 2000) or interaction design (Borchers, 2001).
- **Developing Anti-patterns**
  Tracking and recording design experience means capturing both good and bad design solutions. A structured description of a bad design solution for a frequent design problem, applied in one or more concrete situations, is usually referred to as an "antipattern." This notion can be considered a pattern describing the tactic to get out of a bad design situation and to proceed towards a good solution. In this respect, this can be interpreted in a positive sense. Antipatterns are as useful as "conventional" patterns; in e-learning, where the concept is unexplored, they open an entire new stream of research.

CONCLUSION

Designing effective e-learning experiences is a complex problem solving task. The designers need to make decisions taking into consideration various interrelated issues such as students' learning styles, the preferable teaching strategies, the available resources, and the social and organizational forms in the different educational settings. We need design methods which promote effective design, teach new designers how to design well and how to standardize the way designs are developed (Gamma et al., 1994).

Unfortunately, classical instructional design models are not adequate for e-learning practitioners (teachers and e-learning designers, particularly novice ones) (Goodyear et al., 2004). These models basically mention what to do and do not give enough support about "how" to do it. So, practitioners need guidance, which should be based on sound research and empirical evidence, about what will support effective e-learning. However, if advice is too prescriptive, or based on a single model, it does not help them to create innovative designs that have to suit their particular context and exploit new and evolving technology in the most effective way.

In this chapter, we have investigated the concept of "design-by-patterns" as an approach to e-learning design that addresses the above issues and balances guidance and creativity, prescriptivity and flexibility, practice and theory, thus providing a valuable support for practitioners who wish to share and reuse expertise in a continuous effort to create effective e-learning experiences.

The content of this chapter distills the collective experience of the EC funded projects ELEN and TELL, as well as the authors' individual expertise in defining, using, and evaluating e-learning patterns in the contexts of these and other national or international projects. In particular, the first author and her research team have been applying patterns in the development of successful collaborative learning experiences in shared 3D worlds (Poggi & Torrebruno, 2007) for high school students, and in the development of learning objects and educational tools for multimedia storytelling for primary school children. The second author and his team try to identify ways of eliciting and creating patterns for e-learning systems design (Retalis et al., 2006). They have created an initial version of a pattern language for CSCL systems (Georgiakakis & Retalis, 2005). Their efforts have been influenced by the human computer interaction domain.

In addition, e-learning design patterns have been the subject of a number of graduate courses in our universities (in the School of Computer Engineering and the School of Industrial Design at Politecnico di Milano, and at the University of Piraeus, Department of Technology Education and Digital Systems). Within these classes, students experimented and evaluated the use of various types of patterns for designing and building educational online environments (e.g., educational games, at the School of Industrial Design in Milan, and tools for collaborative learning at University of Pireus). E-learning patterns have also been the subject of a number of master and PhD theses in our universities.

We have explored the notion of e-learning design pattern from multiple viewpoints. We have placed it into a historical perspective and discussed a taxonomy that allows us to systematically classify the various types of patterns that can be found in the literature and in online repositories. In doing so, we provided the reader with a more systematic view of the overall field. We have also presented pros and cons of a design-by-patterns approach. On the one hand, we highlighted how e-learning patterns hold certain values that make them valuable conceptual design tools for practitioners; on the other hand, we expressed our concerns regarding the level of maturity of the overall field.

As it emerges from this chapter, the domain of e-learning design patterns is young, rapidly evolving, and stimulating. It represents a challenge both for e-learning practitioners, who might be motivated to create sustainable repositories/collections of good quality patterns, and for researchers, who may find in e-learning design patterns a fertile ground for empirical studies as well as for theoretical research.

REFERENCES

Alexander, C. (1979). *The timeless way of building.* New York: Oxford University Press.

Alexander, C. Ishikawa, S., & Silverstein, M. (1977). *A pattern language*. New York: Oxford University Press.

Appleton, B. (2000). *Patterns and software: Essential concepts and terminology.* Retrieved March 29, 2008, from http://www.enteract.com/~bradapp

Aristotle. (350 BC). *Rhetoric: Book 3* (W. Rhys Roberts, Trans.). The Internet classics archive. Massachusetts Institute of Technology. Retrieved March 29, 2008, from http://classics.mit.edu/Aristotle/rhetoric.html

Avgeriou, P., Papasalouros, A., Retalis, S., & Skordalakis, M. (2003). Towards a pattern language for learning management systems. *Educational Technology & Society, 6*(2), 11-24.

Baggetun, R., Rusman, E., & Poggi, C. (2004). Design patterns for collaborative learning: From practice to theory and back. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications*, Lugano, Switzerland (pp. 2493-2498).

Bayle, E., Bellamy, R., Casaday, G., Erickson, T., Fincher, S., Grinter, B., Gross, B., Lehder, D., Marmolin, H., Potts, C., Skousen, G., & Thomas,

J. (1998). *Putting it all together: Towards a pattern language for interaction design* [CHI 97 Workshop, SIGCHI Bulletin, 30(1), 17-23].

Baxter, G., & Mislevy, R. (2005). *The case for an integrated design framework for assessing science inquiry* (PADI Tech. Rep. No. 5). Menlo Park, CA: SRI International.

Beck, K., & Cunningham, W. (1987, September). *Using pattern languages for object-oriented programs* (Tech. Rep. No. CR-87-43).

Bergin, J. (2001). A pattern language for initial course design. In *Proceedings of SIGCSE 2001* (pp. 282-286).

Bolchini, D. (2002). *Web design patterns: Improving quality and performance in Web application design*. Master's Thesis, University of Lugano, Switzerland

Borchers, J. (2001). *A pattern approach to interaction design*. Chichester, UK: John Wiley & Sons.

Boyle, T. (2003) Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology*, *19*(1), 46-58.

Brouns, F., Koper, R., Manderveld, J., Van Bruggen, J., Sloep, P., Van Rosmalen, P., Tattersall, C., & Vogten, H. (2005). A first exploration of an inductive analysis approach for detecting learning design patterns. *Journal of Interactive Media in Education*. Retrieved March 29, 2008, from http://www-jime.open.ac.uk/2005/03/brouns-2005-03.pdf

Brouns, F., Koper, R., Manderveld, J., Bruggen, J., Sloep, P., & Rosmalen, P. (2005). A first exploration of an inductive analysis approach for detecting learning design patterns. *Journal of Interactive Media in Education*, *3*.

Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P., & Stal, M. (1996). *Pattern-oriented software architecture*: *A system of patterns*. Addison-Wesley.

Carroll, J. (2002). *Making use: Scenario-based design of human-computer interactions*. MIT Press.

Claxton, C. S., & Murrell, P. H. (1987). *Learning styles: Implications for improving educational practice* (ASHE-ERIC Higher Education Report 4). Washington, DC: ASHE.

Coplien J. O., & Schmidt, D. C. (1995). *Pattern languages of program design*. Addison-Wesley.

Cooper, J. (2000). *Java design patterns*. Addison-Wesley.

Cunningham, W. (1994). *Tips for writing pattern languages*. Retrieved March 29, 2008, from http://c2.com/cgi/wiki?TipsForWritingPatternLanguages

De Bello, T. (1990). Comparison of eleven major learning styles models: Variables, appropriate populations, validity of instrumentation, and the research behind them. *Journal of Reading, Writing and Learning Disabilities International*, *6*(3), 203-222.

Della, L., & Clark, D. (2000). *Teaching object-oriented development with emphasis on pattern application*. In *Proceedings of the Australasian Conference on Computing Education*, Melbourne, Australia (pp. 56–63).

De Moura Filho, C., & Derycke, A. (2005). *Pedagogical patterns and learning design: When two worlds cooperate*. Paper presented at the UNFOLD-PROLEARN Joint Workshop, Valkenburg, The Netherlands.

Derntl, M. (2004). *The person-centered e-learning pattern repository: Design for reuse and extensibility*. Paper presented at the EDMEDIA'04 World Conference on Educational Multimedia, Hypermedia, & Telecommunications, Lugano, Switzerland.

Di Blas, N., Paolini, P., & Poggi, C. (2005). Educational benefits: Testing and evaluation of a collaborative 3D world. In *Proceedings of ED-MEDIA 2005,* Montreal, Canada. AACE.

DiGiano, C. Yarnall, L., Patton, C., Roschelle, J., Tatar, D., & Manley, M. (2002). Collaboration design patterns: Conceptual tools for planning for the wireless classroom. In *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education*, IEEE Computer Society, Washington, DC (pp. 39-47). ISBN: 0-7695-1706-4.

Dimitriadis, Y. (2007, January 23). *Modeling and computacional representation of CSCL scripts using authoring tools and patterns: Some findings from evaluation studies.* Presentation at the Computer-Supported Scripting of Interaction in Collaborative Learning Environments Workshop. Retrieved March 29, 2008, from http://www.iwm-kmrc.de/cossicle/workshop/Dimitriadis.pdf

Dunn, R., Beaudry, J., & Klavas, A. (1989). Survey of research on learning styles. *Educational Leadership, 46*(6), 50-58.

Eckstein, J., Manns, M. L., & Voelter, M. (2001, Spring). Pedagogical patterns: Capturing best practices in teaching object technology. *Software-Focus, 2*(1). Wiley.

Eriksson, H., & Penker, M. (2000). *Business modelling with UML, business patterns at work*. John Wiley & Sons.

Farmer, R.A., & Hughes, B. (2006). A pattern-based design approach to end-user development with learning objects. In *Proceedings of IEEE International Conference on Advanced Learning Technologies* (pp.794-798) (ICALT 2006). IEEE Computer Society Press.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Fowler, F. (2006). *Writing software patterns.* Retrieved March 29, 2008, from http://www.martinfowler.com/articles/writingPatterns.html

Frizell, S. S., & Hubscher, R. (2002). Supporting the application of design patterns in Web-course design. In *Proceedings of Ed-Media.* Retrieved March 29, 2008, from http://www.auburn.edu/~frizess/frizell-edmedia.pdf

Gagne, R. M., & Medsker, K. L. (1996). *The conditions of learning* (Training Applications). Fort Worth, TX: Harcourt Brace College Publishers.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1994). *Design patterns: Elements of reusable object-oriented software.* Addison-Wesley.

Garzotto, F., Paolini, P., Bolchini, D., & Valenti, S. (1999, November). Modeling-by-patterns of Web applications. In *Proceedings of the International Workshop on the World Wide Web and Conceptual Modeling, WWW CM'99*, Paris.

Garzotto, F., & Retalis, S. (2004, June). Symposium on design patterns for e-learning. In *Proceedings of the 2004 World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA 2004),* Lugano, Switzerland.

Garzotto, F., Retalis, S., Tzanavari, A., & Cantoni, I. (2004, June). *From pedagogical paradigms to hypermedia design patterns: Where to start.* In *Proceedings of the 2004 World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA 2004),* Lugano, Switzerland.

Georgiakakis, P., & Retalis, S. (2005). Desmistifying the asynchronous network supported collaborative learning systems [Special issue on patterns for collaborative systems]. *International Journal of Computer Applications in Technology, 25*(2/3), 116–127.

Goodyear, P. (2002). Psychological foundations for networked learning. In C. Steeples & C. Jones (Eds.), *Networked learning*. London: Springer.

Goodyear, P. (2005). Educational design and networked learning: patterns, pattern languages and design practice. *Australian Journal of Educational Technology, 21*(1), 82-101.

Goodyear, P., Avgeriou, P., Baggetun, R., Bartoluzzi, S., Retalis, S., Ronteltap, F., et al. (2004). Towards a pattern language for networked learning. In S. Banks, P. Goodyear, V. Hodgson, C. Jones, V. Lally, D. McConnell, & C. Steeples (Eds.), *Networked learning 2004* (pp. 449-455). Lancaster: Lancaster University.

Grimaldi, W. M. A. (1998). *Landmark essays on Aristotelian rhetoric*. Mahwah: Lawrence Erlbaum Associates.

Guerrero, L., & Fuller, D. (1999). Design patterns for collaborative systems. In *Proceedings of SPIRE/CRIWG 1999* (pp. 270-277).

Hernández-Leo, D., Asensio-Pérez, J. I., Dimitriadis, Y., Bote-Lorenzo, M. L., Jorrín-Abellán, I. M., & Villasclaras-Fernández, E. D. (2005, October). Reusing IMS-LD formalized best practices in collaborative learning (extended version of the WBE05 paper). *Structuring Advanced Technology for Learning, 2*(4), 223-232.

Hernández-Leo, D., Villasclaras-Fernández, E. D., Jorrín-Abellán, I. M., Asensio-Pérez, J. I., Dimitriadis, Y., Ruiz-Requies, I., & Rubia-Avi, B. (2006, January). Collage: A collaborative learning design editor based on patterns [Special issue on learning design]. *Educational Technology & Society, 9*(1), 58-71.

Honey, P., & Mumford, A. (1986). *A manual of learning styles*. Maidenhead: Peter Honey.

IMS LD. (2003). *IMS learning design v1.0 final specification*. Retrieved March 29, 2008, from http://www.imsglobal.org/learningdesign

Jonassen, D. H. (2003). Designing research-based instruction for story problems. *Educational Psychology Review, 15*(3), 267-296.

Jones, R. (2004, December 10). Designing adaptable learning resources with learning object patterns. *Journal of Digital Information, 6*(1), Article No. 305.

Koper, R. (2006). Current research in learning design. *Educational Technology & Society, 9*(1), 13-22.

Koshmann, T. D. (1996). *CSCL, theory and practice of an emerging paradigm*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kreimeier, B. (2002). *The case for game design patterns*. Retrieved March 29, 2008, from http://www.gamasutra.com/features/20020313/kreimeier_03.htm

Laurillard, D. (2002). *Rethinking university teaching*. Routledge Falmer.

Lee, Y.-B. (1992). Effects of learning style in a hypermedia instructional system. In *Proceedings of the Association for Educational Communications and Technology* (14th ed., pp. 505-509).

Lilly, S. (1996, January). Patterns for pedagogy. *Object Magazine, 5*(8), 93-96.

Lukosch, S., & Schümmer, T. (2004). Patterns for managing shared objects in groupware systems. In *Proceedings of the Ninth European Conference on Pattern Languages and Programs*, Irsee, Germany (pp. 333-378).

Lyardet, F., Rossi, G., & Schwabe, D. (1998). Using design patterns in educational multimedia applications. In T. Ottman & I. Tomek (Eds.), *EdMedia and EdTelecom '98: Proceedings of the 10th World Conference on Educational Multimedia and Hypermedia*.

Manns, M. L., Sharp, H., McLaughlin, P., & Prieto, M. (1998, March/April). Capturing successful practices in OT education and training.

In *Journal of Object Oriented Programming, 11*(1), 29-34.

Mayer, R. E., & Wittrock, M. C. (1996). *Problem-solving transfer.* In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 47-62). New York: Simon & Schuster Macmillan.

McAndrew, P., Goodyear, P., & Dalziel, J. (2005). *Patterns, designs and activities: Unifying descriptions of learning structures.* Retrieved March 29, 2008, from http://kn.open.ac.uk/public/document.cfm?docid=5295

Mezaros, G., & Doble, J. (1998). A pattern language for pattern writing. In *Pattern languages of program design 3* (pp. 529-574). Reading, MA: Addison-Wesley.

Mislevy, R., Hamel, L., Fried, R. G., Gaffney, T., Haertel, G., Hafter, A., Murphy, R., Quellmalz, E., Rosenquist, A., Schank, P., Draney, K., Kennedy, C., Long, K., Wilson, M., Chudowsky, N., Morrison, A., Pena, P., Songer, N., & Wenk, A. (2003). *Design patterns for assessing science inquiry* (PADI Technical Report 1). Menlo Park, CA: SRI International. (Also presented at American Education Research Association (AERA) in April 2003)

Mohan, P., & Daniel, B. K. (2006). Towards object-oriented design patterns for reusability of learning objects. In *Proceedings of ICALT 2006* (pp. 1025-1027).

Naeve, A. (2002). *Presentation on design patterns in mathematics education*. Stockholm: Royal Institute of Technology.

Pask, G. (1976). Styles and strategies of learning. *British Journal of Educational Psychology, 46*(2), 128-148.

Poggi, C., & Torrebruno, A. (2007, June). From the Dead Sea Scrolls to social sports, passing through European history: An effective pedagogical format based on 3D worlds. In *Proceedings of ED-Media 07: World Conference on Educational Multimedia, Hypermedia & Telecommunications,* Vancouver, Canada.

Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns in e-learning systems. *Computer Science Education, 16,* 105-118.

Rossi, G., Schwabe, D., & Garrido, A. (1997). Design reuse in hypermedia application development. In *Proceedings of ACM Hypertext'97,* Southampton, UK.

Rusman, E., van Bruggen, J., & Koper, R. (2007, July 16). *From pattern to practice: Evaluation of a design pattern fostering trust in virtual teams.* Paper presented at the Workshop on Linking CSCL Design Patterns to Authentic Educational Case Studies, New Jersey.

Schümmer, T. (2003). *GAMA:* A pattern language for computer supported dynamic collaboration. In *Proceedings of the 8th European Conference on Pattern Languages of Programs, EuroPLoP 2004,* UVK, Konstanz, Germany.

van Duyne, D., Landay, J., & Hong, J. (2003). *The design of sites.* Addison-Wesley.

van Welie, M., & van der Veer, G. C. (2003, September 1-5). Pattern languages in interaction design: Structure and organization. In Proceedings of Interact '03, Zürich, Switserland (pp. 527-534). Amsterdam, The Netherlands: IOS Press. ISBN: 1-58603-363-8.

Voelter, M., & Fricke, A. (1999). SEMINARS: A pedagogical pattern language about teaching seminars effectively. In *Proceedings of EuroPLOP 1999.* Retrieved March 29, 2008, from http://www.voelter.de/seminars

Wasson, B., & Mørch, A. I. (2000). Identifying collaboration patterns in collaborative telelearning scenarios. *Educational Technology & Society, 3*(3). Retrieved March 29, 2008, from http://ifets.ieee.org/periodical/vol_3_2000/c04.html

Weinberger, A., Stegmann, K., & Fischer, F. (2005). Computer-supported collaborative learning in higher education: Scripts for argumentative knowledge construction in distributed groups. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.), *Computer supported collaborative learning 2005: The next 10 years!* (pp. 717-726). Mahwah, NJ: Erlbaum.

Winters, N. (2007). *Design patterns for mobile learning.* In I. Arnedillo-Sanchez, M. Sharples, & G. Vavoula (Eds.), *Proceedings of the Beyond Mobile Learning Workshop.* Dublin: Trinity College Dublin Pres

Winters, N., & Mor, Y. (2007, March). Developing design patterns for game-based learning environments. In *Proceedings of CAL'07*, Dublin, Ireland.

Woolfolk, A. E. (2000). *Educational psychology.* Allyn & Bacon.

KEY TERMS

Design-by-Pattern: The process of creating design artifacts by reusing, adapting, and composing existing design patterns

Design Pattern: Describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that one can use this solution a million times over without ever doing it the same way twice.

E-Learning: The systematic use of networked multimedia computer technologies to empower learners, improve learning, connect learners to people and resources supportive of their needs, and integrate learning with performance and individuals with organizational goals.

E-Learning Experience: A "situation" in which people learn or attempt to learn something, individually or in group, using (networked) multimedia computer technologies.

IMS LD (Learning Design): Provides a notation to describe a "metamodel" of instructional design; it offers educators a generic and flexible machine readable language to specify the design of online and off-line activities that involve interaction between learners and learning resources, learners and other learners, as well as learners and teachers.

Learning Design Process: Concerned with research and theory about instructional strategies and the development and implementation of those strategies.

Learning Style: A composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to a learning environment.

Learning Tool/Service: A set of functionalities incorporated into a (networked) multimedia computer system that supports one or more activities involved in e-learning (e.g., the interaction between learners and learning objects or learners and teachers, the formation of learning communities) and maintains a common space for sharing and reusing educational resources.

Pattern Language: A collection of patterns with the rules that interrelate them.

Pattern Taxonomy: A classification or categorization of design patterns according to certain criteria, with the aim of providing a conceptual framework for discussion, analysis, or search and retrieval of patterns.

Chapter VI
Using Design Patterns to Support E-Learning Design

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ABSTRACT

Design patterns have received considerable attention for their potential as a means of capturing and sharing design knowledge. This chapter provides a review of design pattern research and usage within education and other disciplines, summarizes the reported benefits of the approach, and examines design patterns in relation to other approaches to supporting design. Building upon this work, it argues that design patterns can capture learning design knowledge from theories and best practices to support novices in effective e-learning design. This chapter describes the authors' work on the development of designs patterns for e-learning. It concludes with a discussion of future research for educational uses of design patterns.

INTRODUCTION

The instructional design of e-learning course materials directly affects student learning outcomes, but research suggests that many of the instructors developing online courses have not received training in interaction or instructional design (Braxton, 2000; Clark, 1994; Tennyson & Elmore, 1995). Hirumi (2002) found that novice course designers find it difficult to incorporate the types of meaningful interactions needed in online courses. Also, inexperienced educators can have difficulties in the application of learning theories to course design. According to Wilson (1997), theories are written as hard science, and novices require a different type of representation to support their initial learning needs. As further stated in Wilson (1999), "the plurality and multiplicity of models and theories can be daunting to both researcher and practitioner." As a result, making the transition from this wealth of information to actual design practice can be difficult for all but experienced educators and instructional designers.

Design patterns have emerged as an approach for capturing design knowledge from theories and best practices in a form that is understandable and useful for novices (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdhl-King, & Angel, 1977). Design patterns and their use in the development of effective learning designs are currently important areas of research.

The purpose of this chapter is to introduce design patterns as a strategy for representing and disseminating instructional design and learning theory research. First, a review of the literature provides a definition for a design pattern and gives the history of design patterns usage and reported benefits in other disciplines. We then examine how design patterns can be used in education to represent and disseminate learning theory research and educator best practices in the context of e-learning design. We discuss our current research with design patterns for e-learning design, which advocates the development of an underlying design framework and support environment for design pattern development and use. Examples of design patterns developed from this work are provided. Finally, we conclude with areas of future research.

BACKGROUND

What Is a Design Pattern?

Design patterns have been defined in the literature in a number of ways. As provided in one of the earliest definitions from the field of architecture, a design pattern "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander et al., 1977). They further describe a design pattern as "a three part rule, which expresses a relation between a certain context, a problem and a solution" (Alexander, 1979). In a definition almost 20 years later from the field of software engineering, a design pattern is described as a "particular prose form of recording design information such that designs which have worked well in the past can be applied again in similar situations in the future" (Beck, Coplien, Crocker, Dominick, Meszaros, Paulissch, & Vlissides, 1996).

Originating in the field of architecture, design patterns have been used to capture expert knowledge, experiences, and design best practices within many different domains (Alur, Crupi, & Malks, 2001; Borchers, 2001; Gamma, Helm, Johnson, & Vlissides, 1995; Graham, 2003; Tidwell, 2005). A large part of their value is attributed to their ability to serve as a design aid to disseminate this knowledge to a novice designer. Although many formats and templates exist for formulating a design pattern, four elements are typically present:

1. The *pattern name* identifies the pattern and provides a way to communicate about the pattern. Choosing a good name is considered vital as it becomes a part of the design vocabulary (Gamma et al., 1995).
2. The *problem* section describes when to apply the pattern explaining both the design problem that is addressed and the context surrounding it.
3. The *solution* section describes the elements that make up the design to solve the problem. References to other design patterns that support the solution are also typically provided.

4. An *example* section provides specific implementations of the solution. Depending on the discipline, the examples may be textual descriptions or pictures.

Formulating design knowledge in terms of problems and solutions is regarded by some to provide designers with more concrete design information not readily available in other forms of design knowledge representation such as design guidelines or design principles (Mahemoff & Johnston, 1998a; van Welie, van der Veer, & Eliens, 2000). The objective of most design pattern research is in the development of a collection of design patterns that provide a vocabulary for representing and communicating design knowledge in a field. Different classifications have been used to describe a pattern collection often depending on the degree of structure and connectivity the pattern collection possesses (Appleton, 2000). A *pattern language* is a collection of design patterns that have been connected and interlinked (Alexander et al., 1977). Mahemoff and Johnston (1998a) assert that generativity is the chief benefit of a pattern language. Because the patterns in the language form a cohesive structure, the designer is able to begin with a certain context and work through all of the relevant patterns to generate a design. A *pattern catalog* typically refers to a pattern collection that has a relatively low level of structure and organization. Little cross-referencing exists among patterns, and each pattern gives a relatively independent solution (Appleton, 2000; Schmidt, Johnson, & Fayad, 1996). Derntl and Botturi (2006) also discuss the notion of a *pattern system*, which includes a pattern language and tools to support use of the language. They define a pattern system as "a conceptual system, which consists of the pattern language and some formulation of meta-language features, e.g., instructions about how to use the patterns, the underlying value system and philosophical background, as well as other relevant information and requirements."

A key question in examining the literature on design patterns is: Why patterns? Three main benefits for pattern usage are often cited: (1) they serve as a *design tool*; (2) they provide for concise and accurate *communication among designers*; and (3) they *disseminate expert knowledge to novices* (Viljamaa, 1997). The reuse of design solutions is one of the most cited rationales for the use of design patterns (Erickson, 2000). Another cited reason for the popularity of design patterns as discussed in Erickson (2000) is in their ability to provide a "lingua franca," a common language that can be read and understood by those even outside the design profession the pattern language addresses.

In many disciplines including education, design guidelines and principles have been used to represent design knowledge. It has been argued that guidelines suffer problems involving selection, validity, and applicability (van Welie et al., 2000). Mahemoff and Johnston (1998b) state that design patterns are concrete in contrast to abstract design guidelines and principles and when based on underlying design principles, they can capture the philosophies of good design. Chung, Hong, Lin, Prabaker, Landay, and Liu (2004) describe three ways design patterns differ from other formats such as guidelines and heuristics for capturing and presenting design knowledge:

First, patterns offer solutions to specific problems rather than providing high-level and sometimes abstract suggestions. Second, patterns are generative, helping designers create new solutions by showing many examples of actual designs. Third, patterns are linked to another hierarchically, helping designers address high-level problems as well as low-level ones.

USAGE OF DESIGN PATTERNS

Architecture Design Patterns

Design patterns originated in the field architecture as an approach for improving the design of modern architectural structures (Alexander et al., 1977). The objective was to create a body of knowledge of design solutions to reoccurring problems encountered in architectural design and to present this knowledge in an understandable and useful form that could be used by architects and the general public. Christopher Alexander and colleagues represented this knowledge in what they termed a “pattern,” a narrative form consisting of textual descriptions and pictures that describe a design problem and its solution. A pattern language consisting of 253 design patterns was developed to support both architects and the public in designing quality architectural structures, a quality they contend was being lost in modern architectural design. The design patterns range from addressing large design issues such as the design of neighborhoods and communities to smaller scale patterns that deal with the design of houses and rooms. The patterns were ordered hierarchically within a pattern language with each pattern referencing the smaller scale patterns that support it and the larger scale patterns that it supports. All patterns are presented in the same narrative structure and format consisting of the following elements:

- The name of the pattern
- A validity ranking indicating the degree to which the authors have confidence in the pattern’s solution
- A picture showing an archetypical example of the pattern
- The context for the pattern
- The problem statement and description
- The solution to the problem
- A diagram of the solution
- References to smaller scale patterns needed to complete the pattern

In one of the volumes of this work, *The Oregon Experiment*, readers are provided with the application of the design patterns in an experiment to redesign the campus of the University of Oregon (Alexander, Silverstein, Angel, Ishikawa, & Abrams, 1975).

Software Engineering Design Patterns

The greatest impact of design pattern usage can be seen within the software engineering community. The goal has been to use design patterns to create a collection of design best practices to support software architecture and design. Gamma et al. (1995), often referred to as the Gang of Four (GoF), published the first influential collection of design patterns in the software engineering community. They developed a catalog of 23 design patterns that capture and present solutions to problems in object-oriented software design. More than a decade later from the GoF text, design patterns and resulting research have a strong presence within software engineering, most notably to support object-oriented software development (Alur et al., 2001; Metsker & Wake, 2006).

The presentation of design patterns changed with their adaptation to software engineering. Gamma et al. (1995) introduced a new format for presenting design patterns (see Table 1). Instead of the narrative format used in architecture, a longer and more explicitly labeled template was used. Another change is the lack of the strict hierarchical ordering that existed in the architecture design patterns. According to Viljamaa (1997), this change can be contributed to the iterative nature of software development, which makes it difficult to impose a hierarchical structuring.

Software engineering design patterns also contain software code to illustrate an implementation of the pattern, and due to their technical content, they are not easily understood by users without some software development training.

Design Patterns in Interaction Design

Design patterns have been used within the human–computer interaction (HCI) field to support different levels of interaction design ranging from user interface and hypermedia design to social and cognitive design issues (Borchers, 2001; Thomas, Danis, & Lee, 2002; Tidwell, 2005). One objective has been to use design patterns to embody HCI guidelines and design principles, which have been considered by some as not very useful in solving specific design problems (Mahemoff & Johnston, 1998a; van Welie et al., 2000).

Van Welie et al. (2000) introduced a categorization for HCI design patterns based on the kind of design problem the design patterns address. They suggest that just as architectural patterns have the focus of creating quality living environments, HCI patterns need to have a focus, and it should be on usability. They also argue that design patterns should focus on problems of the end users, not necessarily problems of the designers. For example, within education, the student participating in the learning experience would be considered the end user. They state that, “each pattern that focuses on the user’s perspective is also usable for designers but not vice versa” (van Welie & Traetterberg, 2000). As shown in the user interface design pattern presented in Figure

Table 1. Software engineering design pattern template (Gamma et al., 1995)

Name and Classification	The name conveys the essence of the pattern and the classification is based on the pattern’s purpose in the design process.
Intent	Explains what the pattern does, its rationale, and the design problem addressed.
Also known as	Gives other names for the pattern if any exist.
Motivation	Illustrates the design problem and shows how the pattern solves the problem.
Applicability	Gives the situations in which the pattern can be applied and gives examples of poor designs that the pattern can address.
Structure	Gives a graphical representation of the classes in the pattern.
Participants	Lists the classes and/or objects participating in the design pattern.
Collaborations	Shows the way the objects and classes collaborate.
Consequences	Addresses how the pattern supports its objectives along with the trade-offs and results of using the pattern.
Implementation	Gives the pitfalls and techniques needed when implementing the pattern.
Sample Code	Code fragments on how the pattern might be implemented in C++ or Smalltalk.
Known Uses	Examples of the pattern found in real systems.
Related Patterns	Addresses how the patterns are related and identifies other patterns to be used.

Figure 1. User interface design pattern: Warning (van Welie et al., 2000)

HCI Design Pattern Example

Design Pattern: Warning

Problem: The user may unintentionally cause a problem situation, which needs to be resolved.
Principle: Error Prevention (Safety)
Context: Situations where the user performs an action that may unintentionally lead to a problem.
Forces:

- Work may be lost if the action if fully completed.
- The system can or should not automatically resolve this situation so the user needs to be consulted.
- Frequency of occurrence.
- The number of ways in which the problem can be resolved.
- The likeliness that the user intentionally does the task, e.g. the user wants to dot it.
- Some actions are difficult or impossible to recover from.
- Users may not understand why an action could be damaging.
- Users may not understand the consequences or options.
- The severity of the problem if it occurs i.e. how bad is it?

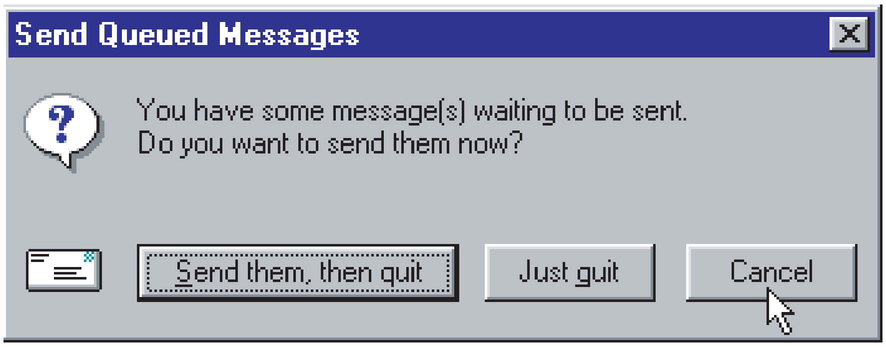
Solution:
Warn the user before continuing the task and give the user the chance to abort the tasks.
The warning should contain the following elements:

- A summary of the problem
- The condition that has triggered the warning
- A question asking the users if continue the action or take on other actions.
- Two main choices for the user, an affirmative choice and a choice to abort.

The warning might also include a more detailed description of the situation to help the user make the appropriate decision. The choices should be stated including a verb that refers to the action wanted. Do not use Yes/No as choices. The choices are answers to the question that is asked. In some cases, there may be more than two choices. Increasing the number of choice may be acceptable in some cases but strive to minimize the number of choices.

Rationale:
By stating the triggering condition, the user can understand why the warning appears. Once that is understood the question leaves the user with only two options. By providing only two options, the choice is made simple for the user: continue or abort. More options make it increasingly difficult for the user to make a decision. By using a verb in the option the user immediately knows what the user is choosing for whereas Yes/No choices require the user remember exactly what the question was. The solution decreases errors and increases satisfaction.

Examples:



This screenshot comes from Eudora 4, if you try to exit the program. It shows that even three choices can be acceptable.

Known Uses: Eudora, Installshield installers (when exiting)

1, they include the design principle in the design pattern and a rationale for how and why the design pattern works. They state that without the rationale section, it is impossible to see whether or why the solution given is good.

Borchers (2001) suggests that the concept of design patterns can be applied to not only architecture, software engineering, and HCI, but can be used to capture design knowledge in any application domain where software is being created. In this research, design patterns were used to capture software and user interface design issues as well as the knowledge from the music domain in the design of interactive musical systems.

There has been no clear consensus on the structure or focus of HCI design patterns. A taxonomy for HCI design patterns has been proposed by Borchers (2000b) along three main dimensions, including:

- *level of abstraction* - Interaction design patterns can address very large-scale issues that comprise a user's complete task or they can address smaller scale, slightly more concrete topics that describe the style of a certain part of the interaction. They can also deal with low-level questions of user interface design that look at individual user interface objects.
- *function* - Patterns can be classified into those that address mainly questions of (visual, auditory, etc.) *perception* (interface output), and those that deal with interface input, or, more specifically, *manipulation* of some kind of application data, or *navigation* through the system.
- *physical dimension* - Some patterns will address questions of *spatial* layout, while others deal with issues of *sequence* (discrete series of events, e.g., a sequence of dialogs), or with continuous *time* (such as a design pattern about good animation techniques in the user interface).

Pedagogical Design Patterns

The goals of design pattern research in education have been twofold. One objective has been to use design patterns as a teaching tool to assist students in gaining design skills as in the computer science education research of Borchers (2002) where designs patterns were used to teach user interface design skills to undergraduate students and in similar research where design patterns have been used as a teaching tool for computer programming related courses (Gelfand, Goodrich, & Tammasia, 1998; Nguyen & Wong, 1999; Preiss, 1999). The second and most prevailing objective is in using design patterns to capture knowledge in teaching and student learning to assist in the design of successful learning opportunities for students. This knowledge may be captured from instructional design and learning theories and expert best practices and experiences. Such design patterns are often referred to in the literature as pedagogical design patterns, learning design patterns, or e-learning design patterns when developed for online course design.

The Pedagogical Patterns Project (PPP), which began in 1996 evolved out of this latter objective to use design patterns to capture the knowledge of experienced educators in learning and teaching object-oriented technology (Sharp, Manns, & Eckstein, 2003). The project began by collecting design patterns from various pattern authors, which varied in focus from curriculum issues to teaching and learning specific object-oriented concepts. The example design pattern presented in Figure 2 is from the earlier work of the project and addresses the problem of exposing students to complex programming problems. These earlier design patterns are referred to as proto-patterns because they had not gone through a rigorous review process and were not a part of a pattern language (Sharp et al., 2003).

In the most recent work of the PPP, the effort has changed in scope moving from the collection of proto-patterns that were largely focused on

Figure 2. Pedagogical design pattern: Fixer Upper (abridged) (PPP, n.d.) ©2000 Joseph Bergin. Used with permission

Examples of Pedagogical Design Patterns

Design Pattern: Fixer Upper **Contributed by Joseph Bergin**
Giving a student or group of students a large artifact that is generally sound but with carefully introduced flaws can both introduce a complex topic early and serve as a way to introduce error analysis and correction. Students are asked to repair and discuss the artifact.

Problem/ Issue
Too often students work on only "toy" problems because they may not have the experience or skill to build large artifacts from scratch and there is only just so much time. But all realistic problems are large and the day in which small problems were interesting is about past. We want to get students to work on large artifacts without overwhelming them. On another front, students also have difficulty when unexpected errors arise in their own work. Compiler and run time error messages, for example, often leave them lost.

Audience/Context
The pattern can be used in several courses and at several levels. It can be used very early in programming courses and in teaching analysis and design. It can also be used to show the overall structure of a solution methodology.

Forces
We often need to introduce students to a new field requiring mastery of several topics. Students often fail to see how the topics fit together when introduced sequentially. They also often fail to have a grasp of the means of locating and correcting errors.
Fixing a larger artifact than can be created by students is generally within their grasp. It gives them a better sense of scale of interesting problems and permits them to integrate a number of issues into the solution of a single problem.
Students can benefit from seeing larger problems than they can solve at their current state of development. They also need critical analysis skills and the ability to evaluate programs, designs, etc. (See Lay of the Land and Larger Than Life).

Solution
Give students an artifact, such as a program or design. The artifact proposes to be the solution to a problem, but while generally correct, the instructor has purposely introduced flaws into the program, design, or whatever. The artifact should be fairly large and should contain a number of flaws. Most of the flaws should be simple and obvious to most readers. There should be one or two deeper flaws.
Ask the students to find and correct the flaws. Ask them to discuss the nature of the flaws found and the reasons for their changes. Finally, ask them to discuss the overall structure of the artifact and draw inferences from it.

Discussion/ Consequences/ Implementation
This pattern allows students to actively work with larger artifacts than they can develop completely themselves. They benefit since finding flaws in their own work is a valuable skill. In programming, students see lexical, syntactic, and semantic errors. In design, they can see the effect of incorrect partitioning of responsibility.
It is important that the overall structure of the artifact be sound. If it is a program it should be well designed and written, with good choice of identifiers. If it is an analysis or design document, its overall structure should be sound with a clear map to the problem statement.
The best way to develop such an artifact is to start with an excellent solution to a problem and then doctor it by introducing flaws. There must be different kinds of flaws, but probably not structural flaws if you are dealing with novices. This latter rule can be broken if the artifact is introduced later in the course rather than at the beginning, at a point at which structure is the main issue.
………

Example Instances
This pattern has been used to teach
1. Beginning programming. Here the artifact is a program illustrating a number of syntactical constructs that have not yet been introduced in class. (It has been used as the first assignment.) The program can be large enough that its structure is not obvious. Two or three classes with several short methods each is about right. One part of the program might be more complex. Together with the driver, there should be three or so pages of code. The errors can be mostly syntactical and lexical, so that the compiler can find them. One or two semantic errors should also be introduced, so that the program does not perform as expected. More serious and perhaps for more advanced students is the failure to fulfill a precondition contract. Ten to fifteen errors is about right if most are easily caught.
Even a single class can be introduced that has a flawed public interface. Students can be asked to analyze the consequences of this in relation to the likely current and future use of the class.
2. Introduction to design. Here a problem is presented and a design for the solution. Six to ten major elements in the design is about the right scale. The design should have a few simple flaws, such as missing message paths or missing functionality within a class.

continued on following page

Figure 2. continued

……..
Contradictions
This must be carefully used if student honesty is an issue. It is easy for one student to point to the locations of errors in C++ programs, for example. One way to address this is to use large artifacts that require teamwork. Another is to ask questions concerning the structure as well as the errors. Finally, the students can be asked to examine the artifact before they are given the full set of questions that will be asked about it.
Some students are frustrated by such large artifacts. The instructor must be prepared to provide support and encouragement that the real world really is like that and that it is ok to initially (a) be frustrated and (b) lack knowledge.

Figure 3. Pedagogical design pattern from the patterns for experiential learning language: one concept, several implementations (PPP, n.d.)

ONE CONCEPT – SEVERAL IMPLEMENTATIONS

You want to provide more than one SOLUTION BEFORE ABSTRACTION.

*** * ***

An abstract concept is hard to understand without a concrete implementation or realization. However, teaching a theory using a concrete implementation might blur the concept itself, because the concrete implementation might not follow exactly the abstract model.

* * *

Therefore, use several different implementations of the concept as examples while teaching the abstract concept. Compare the different implementations afterwards, to re-discover the essence, the abstract concept. You can use this pattern in the form of examples, exercises, group work, etc.

As a consequence, the students learn the abstract concept *and* see several concrete implementations. This allows them to distill the concept itself from the realizations. It is an advantage if the students are already familiar with one of the concrete realizations. If the pattern is used in the form of exercises or group work, immediate feedback is critical to make sure the students don't implement the concept wrong several times.

* * *

For example, it is hard to teach object-oriented programming concepts without binding them to a specific programming language. To change this problem, let the participants implement a small problem in several languages, and afterwards, let them compare the solutions using a table with several comparison criteria, such as encapsulation, polymorphism, inheritance, memory management, syntax, etc.

object-oriented teaching to the development of four pattern languages to address various issues of teaching and student learning (PPP, n.d.; Sharp et al., 2003). The four pattern languages include:

1. Patterns for Active Learning – A pattern language that focuses on pedagogy to promote active learning.
2. Patterns for Experiential Learning – A pattern language that focuses on pedagogy that promotes experiential learning.
3. Teaching from Different Perspectives – A pattern language provides some successful strategies to assist teachers in helping learners examine course material from different perspectives.
4. Feedback Patterns – A pattern language provides some successful strategies to assist teachers in providing feedback to students.

A detailed discussion of how the pattern languages evolved from the original collection of proto-patterns is also provided in Sharp et al. (2003). The design patterns have also changed in presentation (see Figure 3) to the format originally used in architecture because they felt it was more informative and provided better support for connecting the design patterns into a pattern language. In this updated form, each design pattern is divided into four sections separated by "***"; the first section establishes the context for the problem, the second section describes the forces and the design problem addressed, the third section presents the solution with consequences and limitations to the solution, and the last section provides examples and additional information concerning the solution (PPP, n.d.). The work of the PPP has not been without criticism regarding the scale, scope, and method for the development of design patterns (Fincher & Utting, 2002). However, there is no consensus in the literature on the format, content, or level of detail of pedagogical design patterns.

HOW EFFECTIVE ARE DESIGN PATTERNS?

An examination of the literature reveals limited empirical data on the effectiveness of design patterns in supporting novice designers and the quality of the designs produced by pattern users. Mostly from within the software engineering community, descriptions of positive experiences with design patterns have been reported (Beck & Cunningham, 1987; Beck et al., 1996; Cline, 1996; Schmidt, 1995). Prechelt, Unger-Lamprecht, Phillippsen, and Tichy (2002) describe the first controlled experiments with design patterns in the area of software maintenance. They report that design patterns aided users in completing software maintenance tasks faster and with fewer errors.

Borchers (2002) describes his experience with using patterns to teach interaction design to undergraduate students. Design patterns were covered as part of the course content and given to students to use during their first design assignment. He reports that most students were able to relate several design patterns to problems they were facing with their designs and that the patterns helped the students to retain the design knowledge. Dearden, Finley, Allgar, and McManus (2002) describe a study to evaluate design patterns as a tool for participatory design. They claim novice Web designers were able to produce feasible design sketches of a travel Web site using design patterns and that using the patterns enabled participants without experience in Web design to participate in the design of a Web site. However, no claims were made to the quality of the designs produced by the users due to the limited amount of time participants worked on them and because they were only paper-based sketches. Also from the HCI community, Chung et al. (2004) describe two studies to evaluate the usefulness of design patterns in supporting the design tasks of novice designers in ubiquitous computing. They also evaluated the usefulness of the design patterns in improving communication between designers and supporting the creation of higher-quality designs. Again not statistically significant, they report the designs created by participants who used design patterns were generally rated higher by judges and that the design patterns helped novice and experienced designers, assisted in communication between designers, and aided designers in avoiding some design problems early in the process.

We believe that data from control studies on design pattern effectiveness is limited due to experimental design difficulties. Spector and Song (1995) discuss the difficulties of measuring the effectiveness of design support methods due to the fact that design-based tasks can be very individualized and quite time consuming to develop. Prechelt et al. (2002) also discuss these challenges and note that difficulty often arises in experiments that attempt to evaluate a specific form of an information source. Because of these challenges, the design of such studies is a nontrivial task. We have encountered this difficulty within our research (Frizell, 2003, 2006), an issue we discuss in a subsequent section.

DESIGN PATTERNS USAGE IN E-LEARNING

Much of the current research with pedagogical patterns has been in the area of Web-based instructional design or e-learning design. E-learning design can be defined as "the application of learning design knowledge when developing a concrete unit of learning [via an electronic medium], e.g. a course, a lesson, a curriculum, a learning event" (Koper, 2005). Learning design knowledge in this context encompasses beliefs about teaching and student learning derived from a number of sources including educator experiences, best practices, and educational theories. Design patterns have been proposed to capture and disseminate design knowledge from all the aforementioned sources to support both e-learning design and development (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003; E-LEN, n.d.; Goodyear, 2005; Jegan & Eswaran, 2004; Retalis, Georgiakakis, & Dimitriadis, 2006). Our research lies within this realm and is discussed in the following section.

TOWARDS A PATTERN LANGUAGE FOR E-LEARNING DESIGN

In this section, we describe our research towards the development of a pattern language for e-learning design. We have currently developed 26 design patterns that cover various issues in e-learning design (Frizell, 2003). The focus is to support novices in the design of collaborative and active e-learning environments, which incorporate the support and guidance a student may need to be successful in such an environment. Our research is based on the view that principles from learning theory and instructional design research can be used to support effective e-learning design, but that this knowledge needs to be captured and presented in a way that supports instructors in its use (Frizell & Hübscher, 2002a). We also advocate that e-learning design patterns should be based on an underlying design framework or philosophy, an issue first discussed by Mahemoff and Johnston (1998a) regarding the development of HCI design patterns. This approach towards the development of design patterns is considered a value-laden approach where the values inform the development of the patterns (E-LEN, n.d.; Fincher & Utting, 2002). The E-LEN consortium notes that e-learning patterns should be used to express educational values and that it is better to be explicit about the educational values than claiming the development of value-free patterns.

PROPOSED E-LEARNING DESIGN PATTERNS

In developing the design patterns, we examined the literature on learning theories and instructional design to identify pedagogical best practices and

Table 2. Design framework for e-learning patterns

1.	Design for interactivity
2.	Provide problem-solving activities
3.	Encourage student participation
4.	Encourage student expression
5.	Provide multiple perspectives on content
6.	Provide multiple representations of data
7.	Include authentic content and activities
8.	Provide structure to the learning process
9.	Give feedback and guidance
10.	Provide support aides

design principles that support effective learning design. Through this process, we identified 10 design principles that provide a framework for the development of e-learning patterns. The framework presented in Table 2 contains principles that advocate the design of collaborative and active Web learning environments (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Brown, Collins, & Duguid, 1989; Jonassen, 1999; Kearsley, 1999; Kearsley & Schneiderman, 1999; Oliver & Herrington, 2000). There is also a focus

Table 3. E-learning design patterns (Frizell, 2003)

Content Patterns	**Design Goal**
• Course Goals	Provide students with course objectives
• Course Layout	Organize course design decisions
• Course Path	Organize and link course content
• Foundation	Help students recall previously learned information
• Information Bridge	Help students make connections between lessons
• Information Chunks	Provide structure to course content
• Information Representation	Provide content in multiple representational forms
• Points of View	Provide students with multiple perspectives on course content
• Syllabus	Inform students of course content and expectations
Learning Activity Patterns	
• Active Student	Encourage student expression and increase student participation by getting them involved in course activities
• Course Interactions	Increase course interactions
• Group Work	Increase course interactions through group activities
• Learning Community	Encourage students to communicate
• Peer Evaluation	Encourage student expression
• Post Requirement	Encourage student participation in group discussions
• Problem Practice	Provide problem-solving activities
• Real World	Provide problem-solving activities in the context of real world usage
Learning Support Patterns	
• Communication Tools	Support student communication
• Discovery Orientation	Support student exploration
• Facilitated Discussion	Support student communication
• FAQ	Provide students with immediate feedback
• Feedback	Give students feedback on course activities and assignments
• Learner Guidance	Provide support to students in understanding and completing course activities
• Moderated Discussion	Support student communication
• Question Time	Provide students with immediate feedback
• Student Input	Gather student feedback on the course

on providing rich and diverse course content to students (Merrill, 2002; Spiro & Jehng, 1990). Pedagogical principles that emphasize the importance of incorporating structure, support, and guidance into a course's design are also included in the framework (Gagné, 1985; Kearsley, 1999; Merrill, 2002). In developing the framework, we considered the information content, learning activities, and support structures that can be included in a course to enhance student-learning outcomes.

Figure 4. E-learning design pattern example

E-learning Design Pattern Examples

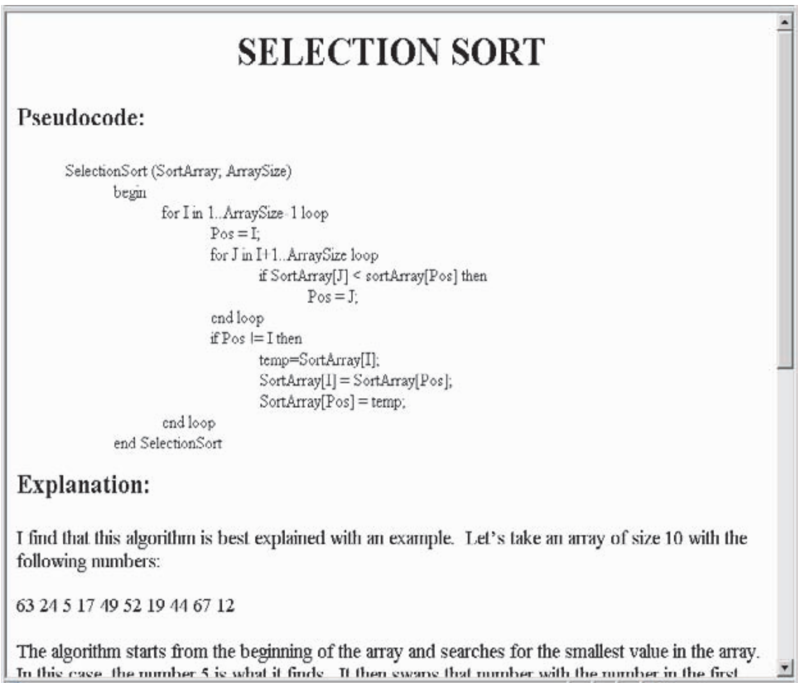
Design Pattern: Information Representation

Context: Use when you are presenting complex material to students and you want to maximize their understanding.

Problem: Presenting complex information in only one form (e.g. a textual description) may hinder some student's ability to effectively understand the material.

Solution: Therefore, provide students with opportunities to study complex information in a variety of representational forms. Depending on the type of information, it may be best represented textually through descriptions, analogies, and examples, and/or visually through diagrams, illustrations, or animations. See also the pattern *Points of View*, which also address presenting diverse instructional content to students.

Examples: The following examples illustrate how course concepts can be represented in different ways. The examples are from a research project that examined the effects multiple representations of computer algorithms had on student learning (Hübscher-Younger, 2002).



SELECTION SORT

Pseudocode:

```
SelectionSort (SortArray, ArraySize)
    begin
        for I in 1..ArraySize-1 loop
            Pos = I;
            for J in I+1..ArraySize loop
                if SortArray[J] < sortArray[Pos] then
                    Pos = J;
            end loop
            if Pos != I then
                temp=SortArray[I];
                SortArray[I] = SortArray[Pos];
                SortArray[Pos] = temp;
        end loop
    end SelectionSort
```

Explanation:

I find that this algorithm is best explained with an example. Let's take an array of size 10 with the following numbers:

63 24 5 17 49 52 19 44 67 12

The algorithm starts from the beginning of the array and searches for the smallest value in the array. In this case, the number 5 is what it finds. It then swaps that number with the number in the first

Representation of the Selection Sort algorithm using text and pseudocode to explain how the algorithm sorts an array (from Hübscher-Younger, 2002).

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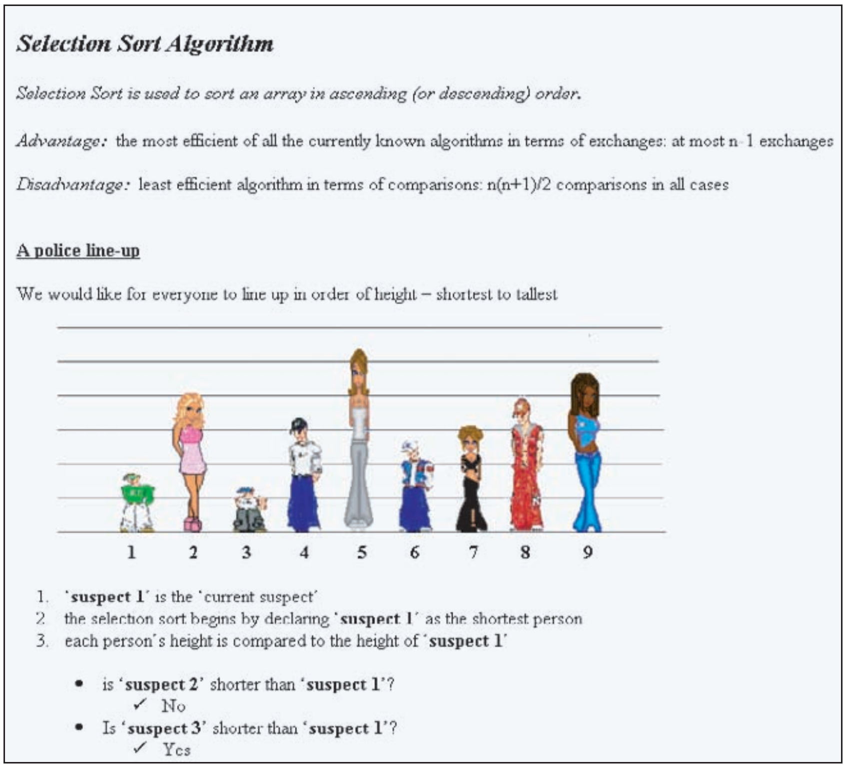
Figure 4. E-learning design pattern example (continued)



Representation of the Selection Sort algorithm using text and colorful graphics of people's heights to explain how the algorithm performs a sort (from Hübscher-Younger, 2002).

References:

Hübscher-Younger, T. (2002). Understanding algorithms through shared representations. Unpublished doctoral dissertation, Auburn University.
Merrill, M. (2002). First Principles of Instruction. *Educational Technology Research and Development*, 50(3), 43-59.
Oliver, R. & Herrington, J. (2000). Using Situated Learning as a Design Strategy for Web-based Learning. In B. Abbey (Ed.), *Instructional and Cognitive Impacts of Web-Based Education* (pp. 178-191).

Table 3 provides an overview of the e-learning design patterns that have been developed based on this design framework. The name and a statement of the design intent of each pattern are listed. The design patterns embody the design philosophy represented by the 10 principles listed above and provide novice course designers with a useful way of looking at this often difficult to understand pedagogical information. We do not suggest that this collection of design patterns cover all possible design problems that may arise in course design and while an initial study with users has been conducted (Frizell, 2006), the design patterns can benefit from continued critiquing or shepherding to refine the patterns and to identify additional patterns.

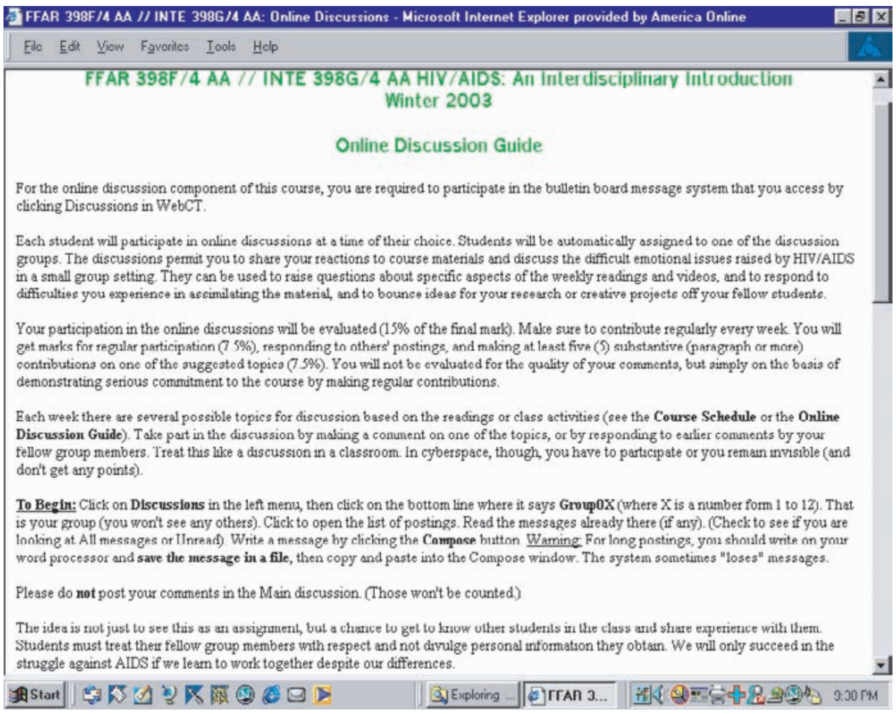
We categorized the e-learning design space based upon the model presented by Oliver and

Herrington (2000) for the design of Web-based learning environments based on principles from situated learning theories. Using this model, the design patterns are structured into three distinct but congruent design categories: (1) design patterns that focus on design problems related to course *content*, (2) design patterns that focus on student *learning activities*, and (3) design

Figure 5. E-learning design pattern example

Design Pattern: Post Requirement

Context: Use when you want to encourage student participation in course bulletin board discussions.
Problem: Bulletin boards (i.e. threaded discussions) can be used for course communication. However, some students will have a tendency to lurk and read the comments of others, but never contribute to the discussions. Students will still need encouragement to get involved. Such encouragement is especially needed for students who are new to online learning or professionals with busy work schedules (Kearsley, 1999).
Solution: Therefore, make participation in online discussions a requirement of the course. This can be done by giving bonus points as an incentive or making participation a component of the course grade. For many, this will provide the motivation to contribute. Making posting a requirement requires involvement from the instructor as well to facilitate and moderate discussion (Kearsley, 1999). See the Learner Support patterns, *Facilitated Discussion* and *Moderated Discussion*.
Examples: In the following example, students are required to contribute weekly to course discussions. Motivation to participate is provided by making it a component (15%) of the final grade for students.



FFAR 398F/4 AA // INTE 398G/4 AA: Online Discussions - Microsoft Internet Explorer provided by America Online

File Edit View Favorites Tools Help

FFAR 398F/4 AA // INTE 398G/4 AA HIV/AIDS: An Interdisciplinary Introduction
Winter 2003

Online Discussion Guide

For the online discussion component of this course, you are required to participate in the bulletin board message system that you access by clicking Discussions in WebCT.

Each student will participate in online discussions at a time of their choice. Students will be automatically assigned to one of the discussion groups. The discussions permit you to share your reactions to course materials and discuss the difficult emotional issues raised by HIV/AIDS in a small group setting. They can be used to raise questions about specific aspects of the weekly readings and videos, and to respond to difficulties you experience in assimilating the material, and to bounce ideas for your research or creative projects off your fellow students.

Your participation in the online discussions will be evaluated (15% of the final mark). Make sure to contribute regularly every week. You will get marks for regular participation (7.5%), responding to others' postings, and making at least five (5) substantive (paragraph or more) contributions on one of the suggested topics (7.5%). You will not be evaluated for the quality of your comments, but simply on the basis of demonstrating serious commitment to the course by making regular contributions.

Each week there are several possible topics for discussion based on the readings or class activities (see the **Course Schedule** or the **Online Discussion Guide**). Take part in the discussion by making a comment on one of the topics, or by responding to earlier comments by your fellow group members. Treat this like a discussion in a classroom. In cyberspace, though, you have to participate or you remain invisible (and don't get any points).

To Begin: Click on **Discussions** in the left menu, then click on the bottom line where it says **Group0X** (where X is a number form 1 to 12). That is your group (you won't see any others). Click to open the list of postings. Read the messages already there (if any). (Check to see if you are looking at All messages or Unread). Write a message by clicking the **Compose** button. Warning: For long postings, you should write on your word processor and **save the message in a file**, then copy and paste into the Compose window. The system sometimes "loses" messages.

Please do **not** post your comments in the Main discussion. (Those won't be counted.)

The idea is not just to see this as an assignment, but a chance to get to know other students in the class and share experience with them. Students must treat their fellow group members with respect and not divulge personal information they obtain. We will only succeed in the struggle against AIDS if we learn to work together despite our differences.

Start Exploring ... FFAR 3... 9:30 PM

References:
Kearsley, G. (1999). *Online Education: Learning and Teaching in Cyberspace.*
Kearsley, G. (1998). A Guide to Online Education. Available from http://home.sprynet.com/~gkearsley/online.htm

patterns that focus on providing a *learning support* structure. This categorization allows for the development of e-learning patterns that focus on both the problems students face in being successful in online environments and the problems instructors face in designing effective online environments. *Content* design patterns assist with design problems related to the presentation and structure of course materials. In developing the design patterns to be included in this category, the focus was on providing rich and diverse course content and on providing structure and guidance in the presentation of course materials. Currently, nine design patterns have been developed to address design problems pertaining to these design goals. *Learning Activity* design patterns provide solutions to problems concerning the creation of collaborative and active e-learning environments. Currently, eight design patterns have been developed that address building learning communities, encouraging student participation, encouraging student expression, and problem solving. *Learning Support* design patterns address problems with proving support to students. The focus was on the creation of design patterns concerned with providing guidance and feedback to students.

Due to space limitations, we present only two of the design patterns in detail. A complete description is available in Frizell (2003). The design pattern shown in Figure 4 named *Information Representation* provides a strategy for providing diverse course content. The design pattern named *Post Requirement* (see Figure 5) provides a strategy for involving students in course activities and addresses the problem of getting all students to participate. A format consisting of six elements—*name*, *context*, *problem*, *solution*, *examples*, and *references*—was chosen to describe each design pattern. We believe this format provides designers with those key features needed to fully understand a design pattern without including too much information so that the pattern becomes difficult to read and follow. The reference section is used to validate the pattern and provides additional resources for those users who are interested in the theory behind the pattern. Borchers (2000a) speaks to the need for patterns to give empirical evidence of their validity without making the pattern unreadable with lots of statistical information. The examples included in the design patterns are obtained from the literature or from existing courses.

FIRST EVALUATION OF THE DESIGN PATTERNS

We conducted a study to investigate the effectiveness of our e-learning patterns in supporting novices and to gain insight on problems and limitations that may exist in end user's abilities to use design patterns. Our research questions included: Are design patterns effective in supporting the design tasks of novices? Can end users apply the knowledge represented in design patterns more effectively than guideline representation? In this section, we summarize the design and results of the study.

Methodology

Participants. Twenty-nine computer science graduate students participated in the study. Based on data from the preliminary questionnaire, 45% has some familiarity with software engineering design patterns, while only 17% had some teaching experience mostly as graduate teaching assistants. None of the students indicated having taken any type of education class that focused on teaching and student learning. This suggests the participants were knowledgeable on the subject matter used in the design task (i.e., design of online C++ programming course), but novices to instructional design.

Procedure. The experimental design was between-groups with the participants being given the same design task to complete. The difference was in the method of design support that was provided to them. One group had access to a Web site containing a subset of the developed e-learning design patterns and the other group had design guidelines. The guidelines were primarily represented as two to three line paragraphs with no accompanying examples. To minimize the effects of having the information not only in different form but also contain different content, we looked for guideline information that provided content as similar as possible to the information represented in the design patterns. However, there was no optimal way to reproduce the exact same information contained in all the sections of the patterns into a guideline without trying to rewrite the guideline as a design pattern.

The design task for the study consisted of the *selection* and *justification* of useful and applicable design patterns or design guidelines by participants for the design of an online C++ programming course. Participants were asked to provide both *why* they considered the guideline or design pattern useful and applicable to the course's design, and *how* they would use this knowledge to affect the course's design. We chose this design task instead of the design of a course module for evaluation because we wanted to observe the participants while they interacted with the design patterns. We did not consider the 10–20 hours reported in the literature needed to design a course lesson for evaluation feasible for our study (Thomas, 2000). Spector and Song (1995) also report on the significant amount of time ranging from weeks to months it can take users to produce a course module that warrants evaluation. Based on the design task, the factors considered in evaluating design pattern effectiveness include:

- **Design task results:** An analysis of participant's task results, which includes the number of patterns or guidelines selected, the appropriateness of the selections, the reasoning given by users for the selection, and the time taken to complete the task.
- **Problems encountered:** Any difficulties observed or reported by users in completing the task.
- **User satisfaction:** A measure of participant's opinions of the design support method after completing the design task. Participants were given a questionnaire after completing the task and asked to rank the method on usefulness, applicability, understandability, learnability, and effectiveness.

The study occurred over a 2-week period with subjects participating one at a time. Participants signed up for 75-minute sessions, but were allowed as much time as needed to complete the design task.

Results summary. Participant's data were studied for any noticeable differences between pattern users and guideline users in the level of understanding or applicability in the information provided when answering the questions of why an item was selected and on how it would be used. There was no consistency in the data provided that would suggest that one group had a higher level of understanding when compared to the other group. However, several participants from the design guidelines group asked for more clarification on the guidelines and asked the evaluator to provide example usages of the guidelines. One participant from this group commented that more details were needed to help fully understand many of the guidelines. Results from the user satisfaction questionnaire yielded no significant differences between groups regarding the usefulness, applicability, understandability, learnability, and effectiveness of the design patterns or design guidelines.

While data analysis of the results was inconclusive in measuring design pattern effectiveness, and no significant differences were found between design pattern and design guideline usage, users rated the design patterns favorably, reported few problems in understanding the design knowledge presented in them, and indicated the design patterns exposed them to design issues not previously considered. An experimental design that focused on the selection and justification of design patterns by users proved to be insufficient for measuring effectiveness. In future research activities, we intend to explore extensions and possible alternatives to the experimental design used in this first study.

FUTURE TRENDS

Design patterns have emerged as a powerful approach for capturing design knowledge to promote reuse of designs and provide design support to novices. To support wide spread adoption and use of design patterns within education, we highlight three main areas of future research: (1) standardization of the design pattern form in education, (2) the integration of design pattern research with current research efforts in learning objects, learning design, and learning management systems, and (3) the development of software tools to facilitate the creation, sharing, and use of design patterns. The structure of design patterns and pattern languages and their use within education is still in the exploratory stage. A number of formats and techniques for the development of pedagogical design patterns have been proposed. The design patterns that are currently available also vary significantly in level of detail and focus. Fincher and Utting (2002) have characterized what they term the functional and nonfunctional requirements for pattern languages. However, given the array of what currently exists, further research is warranted on the development of frameworks or models for the development and use of pedagogical patterns. This research must address standards for the structure of pedagogical patterns and criterion for the characteristics that must be present.

Within the education literature, there is a shift towards reuse of design solutions and in addition to design patterns, research into learning objects (Wiley, 2002) and learning designs (Koper & Tattersall, 2005) exists. While there have been some attempts to analyze the relationship among these approaches, further analysis is needed. Several research efforts have also discussed ways software tools may prove beneficial for developing and using design patterns (Budinsky, Finnie, Vlissides, & Yu, 1996; Chambers, Harrison, & Vlissides, 2000; Dearden et al., 2000; Greene, Matchen, & Jones, 2002). Although no formal studies have evaluated the effects of software tools on design pattern usage, tool support may greatly harness the benefits of design patterns. Chambers et al. (2002) found that the problem that may exist in pattern application is in the designer understanding his problem and deciding which design patterns help solve it best. We have explored the combination of e-learning design patterns within a design environment that supports the process of selecting and applying design patterns and have investigated techniques for integrating design pattern into learning management systems (Frizell & Hübscher, 2002b; Mondle, 2005). Further research is needed to gain more insight on user experiences with design patterns and to evaluate the designs created with design patterns. This data can benefit the development of pattern support tools and design environments as we gain more insight into the process users follow when using design patterns and how those activities can be effectively supported

CONCLUSION

This chapter has described the concept of design patterns and provided a historical overview of their use in a number of different disciplines to capture and disseminate design knowledge. The use of design patterns has moved from architecture, most notably into software engineering, and also to the HCI and education communities. Software engineering design patterns differ from the original architectural design patterns in that they provide specific implementation details and are best understood by designers with some background in the field. Design pattern research within HCI and education are more closely related to architectural design patterns in that there is a focus on the end user's experience with the product being designed and also specific implementation details are left to the designer. The potential of design patterns and pattern languages within e-learning design is great. Continued research is needed to ensure that design patterns live up to their press, have wide spread adoption and use, and make effective and lasting contributions to the practice and understanding of educational design.

REFERENCES

Alexander, C. (1979). *The timeless way of building*. New York: Oxford University Press.

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdhl-King, I., & Angel, S. (1977). *A pattern language: Towns, building, construction*. New York: Oxford University Press.

Alexander, C., Silverstein, M., Angel, S., Ishikawa, S., & Abrams, D. (1975). *The Oregon experiment*. New York: Oxford University Press.

Alur, D., Crupi, J., & Malks, D. (2001). *Core J2EE patterns: Best practices and design strategies*. Prentice Hall.

Appleton, B. (2000, February 14). *Patterns & software: Essential concepts & terminology*. Retrieved March 29, 2008, from http://www.enteract.com/~bradapp/docs/patterns-intro.html

Avgeriou, P., Papasalouros, A., Retalis, S., & Skordalakis, M. (2003). Towards a pattern language for learning management systems [Electronic version]. *Educational Technology & Society, 6*(2), 11-24.

Beck, K., Coplien, J.O., Crocker, R., Dominick, L., Meszaros, G., Paulissch, F., & Vlissides, J. (1996). Industrial experience with design patterns. In *Proceedings of the 18th International Conference on Software Engineering (ICSE)*(pp. 103-114). IEEE Press.

Beck, K. & Cunningham, W. (1987). *Using patterns languages for object-oriented programs*. Paper presented at the OOPSLA 87 Workshop on Specification and Design for Object-Oriented Programming, Orlando, FL.

Borchers, J. (2000a). A pattern approach to interaction design. In *Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (pp. 369-378). New York: ACM Press.

Borchers, J. (2000b). CHI meets PLoP: An interaction patterns workshop. *SIGCHI Bulletin, 32*(1), 9-12.

Borchers, J. (2001). *A pattern approach to interaction design*. New York: John Wiley & Sons.

Borchers, J. (2002). *Teaching HCI design patterns: Experience from two university courses*. Paper presented at the CHI 2002 Conference on Human Factors in Computing Systems, Minneapolis, MN.

Bransford, J., Sherwood, R., Hasselbring, T., Kinzer, C., & Williams, S. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. Sprio (Eds.), *Cognition, education and multimedia: Exploring ideas in high technology*. Lawrence Erlbaum.

Braxton, S. (2000). *Empirical comparison of technical and non-technical distance education courses to derive a refined transactional distance theory as the framework for a utilization-focused evaluation tool*. Unpublished doctoral dissertation, The George Washington University.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Budinsky, F.J., Finnie, M.A. Vlissides, J.M., & Yu, P.S. (1996). Automatic code generation from design patterns. *IBM Systems Journal, 35*(2).

Chambers, C., Harrison, B., & Vlissides, J. (2000). A debate on language and tool support for design patterns. In *Proceedings of Pattern Languages of Program Conference*.

Chung, E., Hong, J., Lin, J., Prabaker, M., Landay, J., & Liu, A. (2004). Development and evaluation of emerging design patterns for ubiquitous computing. In *Proceedings of the 2004 Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques,* Cambridge, MA (pp. 233-242).

Clark, R.E. (1994). Media will never influence learning. *Educational Technology Research and Development, 42*(2), 21-30.

Cline, M.P. (1996). The pros and cons of adopting and applying design patterns in the real world. *Communications of the ACM, 39*(10), 47-49.

Dearden, A., Finlay, J., Allgar, L., & McManus, B. (2002). *Evaluating pattern languages in participatory design*. Interactive poster at CHI 2002 Conference on Human Factors in Computing Systems, Minneapolis, MN.

Derntl, M. & Botturi, L. (2006). Essential use cases for pedagogical patterns. *Computer Science Education*, *16*(2), 137-156.

E-LEN Project (n.d.). *Design expertise for e-learning centres: Design patterns and how to produce them*. Retrieved March 29, 2008, from http://www2.tisip.no/E-LEN

Erickson, T. (2000). Lingua francas for design: Sacred places and pattern languages. In *Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (pp. 357-368). New York: ACM Press.

Fincher, S., & Utting, I. (2002). Pedagogical patterns: Their place in the genre. *ACM SIGCSE Bulletin, 34*(3), 199-202.

Frizell, S. (2003). *A pattern-based approach to supporting Web-based instructional design*. Unpublished doctoral dissertation, Auburn University.

Frizell, S. (2006). Evaluating the usefulness of design patterns in supporting novice course designers: First experiences. In T. Reeves & S. Yamashita (Eds.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 1193-1197). Chesapeake, VA: AACE.

Frizell, S. & Hübscher, R. (2002a). Aligning theory and Web-based instructional design practice with design patterns. In G. Richards (Ed.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 298-304). Chesapeake, VA: AACE.

Frizell, S. & Hübscher, R. (2002b). Supporting the application of design patterns in Web-course design. In P. Barker & S. Rebelsky (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 544-549). Chesapeake, VA: AACE.

Gagné, R. (1985). *The conditions of learning.* New York: Holt, Rinehart & Winston.

Gamma, E., Helm, R., Johnson, R. & Vlissides, J. (1995). *Design patterns: Elements of reusable object-oriented software.* Addison-Wesley.

Gelfand, N., Goodrich, M., & Tamassia, R. (1998). Teaching data structure design patterns. In *Proceedings of the 29th SIGCSE Technical Symposium on Computer Science Education* (pp. 331-335). New York: ACM Press.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice [Electronic Version]. *Australasian Journal of Educational Technology, 21*(1), 82-101.

Graham, I. (2003). *A pattern language for Web usability*. Boston: Addison-Wesley.

Greene, S., Matchen, P., & Jones, L. (2002). *Tools for pattern use*. Paper presented at the CHI 2002 Conference on Human Factors in Computing Systems, Minneapolis, MN.

Hirumi, A. (2002). The design and sequencing of e-learning interactions: A grounded approach. *International Journal on E-Learning, 1*(1), 19-27.

Jegan, T. & Eswaran, C. (2004). *Patterns for e-learning content development*. *Journal of Interactive Learning Research, 15*(2), 117-133. Norfolk, VA: AACE.

Jonassen, D. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory*. Lawrence Erlbaum.

Kearsley, G. (1999). *Online education: Learning and teaching in cyberspace*. Wadsworth Publishing.

Kearsley, G. & Shneiderman, B. (1999). *Engagement theory: A framework for technology-based teaching and learning*. Retrieved March 29, 2008, from http://home.sprynet.com/~gkearsley/engage.htm

Koper (2005). An introduction to learning design. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 3-19). Springer.

Koper, R., & Tattersall, C. (Eds.). (2005). *Learning design: A handbook on modelling and delivering networked education and training*. Springer.

Mahemoff, M. & Johnston, L. (1998a). Pattern languages for usability: An investigation of alternative approaches. In J. Tanaka (Ed.), *Asia-Pacific Conference on Human Computer Interaction* (pp. 25-31). Los Alamitos, CA: IEEE Computer Society.

Mahemoff, M., & Johnston, L. (1998b). Principles for a usability-oriented pattern language. In P. Calder & B. Thomas (Eds.), *Proceedings of Australasian Computer Human Interaction Conference (OZCHI'98)* (pp. 132-139). Los Alamitos, CA: IEEE Computer Society.

Merrill, M. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43-59. Springer.

Metsker, S., & Wake, W. (2006). *Design patterns in Java* (Software Pattern Series). Addison-Wesley Professional.

Mondle, M. (2005). *CourseIDC: A course authoring tool with instructional design content*. Unpublished thesis, Prairie View A&M University.

Nguyen, D., & Wong, S. (1999). Patterns for decoupling data structures and algorithms. *SIGCSE Bulletin, 31*(1), 87-91.

Oliver, R., & Herrington, J. (2000). Using situated learning as a design strategy for Web-based learning. In B. Abbey (Ed.), *Instructional and cognitive impacts of Web-based education* (pp. 178-191). Hershey, PA: Idea Group Publishing.

Pedagogical Patterns Project. (n.d.). Retrieved March 29, 2008, from http://www.pedagogical-patterns.org/

Prechelt, L., Unger-Lamprecht, B., Phillippsen, M., & Tichy, W. (2002). Two controlled experiments assessing the usefulness of design pattern documentation in program maintenance. *IEEE Transactions on Software Engineering, 28*(6), 595-606.

Preiss, B. (1999). Design patterns for the data structures and algorithms course. A*CM SigCSE Bulletin, 31*(1), 95-99.

Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. *Computer Science Education, 16*(2), 105-118.

Schmidt, D.C. (1995). Experience using design patterns to develop reusable object-oriented communication software [Special issue on object-oriented experiences]. *Communications of the ACM, 38*(10), 65-74.

Schmidt, D.C., Johnson, R.E., & Fayad, M. (1996). Software patterns [Guest editorial, Special issue on patterns and pattern languages]. *Communications of the ACM, 39*(10).

Sharp, H., Manns, M., & Eckstein, J. (2003). Evolving pedagogical patterns: The work of the Pedagogical Patterns Project. *Computer Science Education, 13*(4), 315-330.

Spector, J.M., & Song, D. (1995). Automated instructional design advising. In R.D. Tennyson & A.E. Barron (Eds.), *Automating instructional design: Computer-based development and delivery tools* (pp. 377-402). Springer-Verlag.

Spiro, R.J., & Jehng, J. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In D. Nix & R. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology*. Lawrence Erlbaum.

Tennyson, R., & Elmore, R. (1995). Integrated courseware engineering system. In R.D. Tennyson & A.E. Barron (Eds.), *Automating instructional design: Computer-based development and delivery tools* (pp. 303-316). Springer-Verlag.

Thomas, J. (2000). *Applying patterns to hypermedia instructional design (APHID).* Unpublished doctoral dissertation, University of Saskatchewan, Saskatoon, UK.

Thomas, J., Danis, C., & Lee, A. (2002). *Socio-technical pattern language proposal*. Paper presented at the CHI 2002 Conference on Human Factors in Computing Systems, Minneapolis, MN.

Tidwell, J. (2005). *Designing interfaces.* O'Reilly Media, Inc.

van Welie, M., & Traetterberg, H. (2000). Interaction patterns in user interfaces. In *Proceedings of the 7th Annual Pattern Languages of Programs Conference*, Monticello, IL (pp. 13-16).

van Welie, M., van der Veer, G., & Eliens, A. (2000). Patterns as tools for user interface design. In *Proceedings of the International Workshop on Tools for Working with Guidelines*, Biarrite, France (pp. 313-324).

Viljamaa, J. (1997). *Tools supporting the use of design patterns in frameworks* (Technical report). University of Helsinki, Department of Computer Science.

Wiley, D. (Ed). (2002). *Instructional use of learning objects* [Electronic Version]. Bloomington, IN: Agency for Instructional Technology.

Wilson, B. (1997). Reflections on constructivism and instructional design. In C. Dills & A. Romiszowski (Eds.), *Instructional development paradigms*. Englewood Cliffs, NJ: Educational Technology Publications.

Wilson, B. (1999, January). The dangers of theory-based design. *ITForum*. Retrieved March 29, 2008, from http://it.coe.uga.edu/itforum/paper31/paper31.html

KEY TERMS

Design Pattern: An approach for capturing, representing, and sharing design knowledge that promotes the reuse of design solutions.

E-Learning: The delivery of educational content through computer and communication technology.

Instructional Design: A process for the design and development of instructional materials and learning activities based on learning theory research.

Learning Design: The use of learning design knowledge to design education.

Learning Management System: A software application that supports the management and delivery of instructional materials and learning activities.

Learning Theory: Philosophies describing the learning process.

Pattern Catalog: A collection of related design patterns.

Pattern Language: A structured collection of design patterns within a particular domain.

Pattern System: A pattern language and tools to support use of the language.

Pedagogical Design Pattern: An approach for capturing, sharing, and disseminating design knowledge concerning teaching and learning.

Chapter VII
Patterns and Pattern Languages in Educational Design

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ABSTRACT

This chapter provides an overview of recent research and development (R&D) activity in the area of educational design patterns and pattern languages. It provides a context for evaluating this line of R&D by sketching an account of the practice of educational design, highlighting some of its difficulties and the ways in which design patterns and other aids to design might play a role. It foregrounds a tension between optimising design performance and supporting the evolution of design expertise. The chapter provides examples of recent research by the authors on design patterns for networked learning, as well as pointers to complementary research by others. Connections are made with R&D work on learning design and other approaches to supporting design activity.

INTRODUCTION

Slowly but steadily, the core concerns of teaching are moving from the exposition of content to the design of worthwhile learning tasks. The nature and causes of this shift are contested, but one strong driving force is the changing nature of employment: the replacement of unskilled and semiskilled routine work with work that demands flexibility, creativity, and specialist knowledge. The volatility of employment and of the labour market combined with the strengthening of ideologies locate responsibility for learning and skills development firmly with the individual, to create a climate in which capacities for lifelong learning become crucial. Constructivist pedagogies, which centre on learners' involvement in actively constructing their own knowledge, are coming into alignment with capitalism's paradoxical need for more autonomous learners (Longworth, 1995; Stewart, 1998; Urry, 2003). Neither radical constructivism, nor classic instructional design, are much help to the teacher who needs to design tasks that challenge learners to take an active part in knowledge construction (Goodyear, 2000).

Educational design is complex and challenging. Empirical research suggests that teachers at all levels of education find it difficult and that the outcomes are often unsatisfactory (Bennett, Desforges, Cockburn, & Wilkinson, 1984; Hoogveld, Paas, Jochems, & van Merrienboer, 2002; Kirschner, Carr, van Merrienboer, & Sloep, 2002). There have been several lines of response to this problem. One approach has been to provide teachers with computer-based tools that are intended to provide support for their design activity (see, e.g., Elen, 1998; Goodyear, 1997; McAndrew, Goodyear, & Dalziel, 2006; Pirolli, 1991; Spector, Polson, & Muraida, 1993). In general, these tools are meant to carry some of the cognitive load entailed in solving complex design problems. In principle, this allows teacher-users to concentrate on what they know best, while delegating other parts of the design work to the computer. The sharing of load happens in various ways. In some cases, the tool manages the overall structuring of the design task, leading teachers step-by-step down a design path and asking them to fill in details. In other cases, teachers provide an overall logic or general specification for a design, and the computer does the detailed tactical work of sequencing or helps locate relevant units of learning material or learning objects (Barrese, Calabro, Cozza, Gallo, & Tisato, 1992; Goodyear, 1994; Gustafson, 2002; McAndrew et al., 2006). In many cases, the underpinning philosophy (implicit or explicit) is to support performance rather than understanding. That is, the primary goal of most of these approaches is to improve the outcome of the teacher-user's current educational design task. If the teachers also learn something that will help them improve as an educational designer that is seen as a useful by-product. When performance improvement is the primary goal, the teachers and the evolution of their understanding of design take second place.

The approach we summarise in this chapter embodies different values. We do not undervalue improving the performance of teachers on educational design tasks. However, we do value the growth of the teacher's personal understanding of educational design. We are looking for ways of supporting both understanding and performance, striking a good balance between the two. The approach we describe here gives a central place to educational design patterns and pattern languages. Our aim is to provide an introduction to this way of framing educational design and to summarise key ideas and achievements in the literature. Space limitations prevent us from giving many examples of educational design patterns, but we will provide some illustrative examples from our own recent work on design patterns for networked (collaborative online) learning in higher education. The reference list provides pointers to much of the literature on educational design patterns, particularly where the work relates closely to learning with the aid of technology. In the next section, we provide an introduction to design patterns, their origins and recent evolution and give some suggestions about useful supplementary literature on their use in education. After that, we summarise some aspects of our own recent work on design patterns for networked learning. The chapter concludes with some thoughts about promising lines of research and development work.

BACKGROUND

Learning Activity and Educational Design

We use the term 'educational design' to mean the set of practices involved in constructing representations of how to support learning in particular cases (Goodyear, 2005). Much of the literature talks about 'instructional design,' but we prefer the word 'educational' because it avoids some of the narrow connotations of 'instruction.' The term 'learning design' has much currency, partly because it foregrounds learning rather than teaching or instruction. But like the cruder talk of 'delivering learning,' it subtly suggests that we can help learners abdicate their responsibilities for learning. We cannot. Therefore, we stick with 'educational design,' even though we mean it to stretch well beyond the normal confines of formal education.

Educational design is largely a matter of thinking about good learning tasks (good things for learners to do) and about the physical and human resources that can help learners succeed with such tasks. In our view, it should focus on the learner's activity rather than on content coverage, selection of technology, or consideration of what the teacher might do. In some learning contexts, such as safety-critical training, some areas of industrial or military training, or areas in which there is a clear consensus about how something should be done, it can make a lot of sense to approach educational design with the hope that the learner will do what you tell them. In most other cases, it is unwise to assume a 'compliant learner.' Indeed, becoming an autonomous learner depends upon repeated opportunities for exercising disciplined creativity in interpreting the requirements of educational tasks. This introduces an extra layer of complexity into educational design; it becomes more *indirect*. To clarify this, we need to distinguish between learning outcomes, learning activities, and learning tasks (cf. Goodyear, 2005). Learning outcomes are the durable, intended, and unintended cognitive, affective, and psychomotor consequences of the learner's activity (mental and physical). Learning outcomes usually entail additional capabilities or understanding, or both. What matters here is *what the learner does* (Biggs, 2003; Shuell, 1992). The quality of the learner's activity is key. Tasks are set by teachers/designers. They are resources for activity, rather than prescriptions of it. The learner, in the legitimate exercise of autonomy and creativity, will take a task specification and *interpret* its requirements, using this as an opportunity to steer the work towards things that seem to them more interesting, valuable or doable.

We acknowledge that this is an unusual view of the relations between task design and learning outcomes, and that it is also underpinned by a traditional, even dated, cognitivist view of learning. It looks more familiar, even up-to-date, when repainted in sociocultural colours. All we are saying is that *activity is key* and that what anyone does to support learners in their activity has to acknowledge the importance of the learner's freedom of action. It may well be best to view what learners do as some kind of legitimate though peripheral participation in the work of a community of practitioners of some kind (Lave & Wenger, 1991; Lockyer, Patterson, Rowland, & Hearne, 2002; Maynard, 2001). Their induction into the working practices of the community still involves action and guidance and access to appropriate tools and helpful people. The *activity* cannot be designed. Tools and helpful people *may* just come to hand, but they may not, especially for students who are disadvantaged in any way. So when teachers in formal education make use of 'community of practice' metaphors, or otherwise invoke the power of situated learning or learning through apprenticeship, they *do* need to ensure access to the technical and human resources the learners will require. This is a nontrivial challenge, one that needs the kind of planning and careful thinking we call design.

DESIGN AS A CONVERSATION WITH MATERIALS

Donald Schon, in an interview with John Bennett, talked about design as a reflective conversation with materials (see, e.g., Schon & Bennett, 1996):

It is rare that the designer has the design all in her head in advance, and then merely translates it. Most of the time, she is in a kind of progressive relationship—as she goes along, she is making judgments. Sometimes, the designer's judgments have the intimacy of a conversational relationship, where she is getting some response back from the medium, she is seeing what is happening—what it is that she has created—and she is making judgments about it at that level. One form of judgment in which I'm particularly interested is the kind that I call backtalk, where you discover something totally unexpected—'Wow, what was that?' or 'I don't understand this,' or 'This is different from what I thought it would be—but how interesting!' Backtalk can happen when the designer is interacting with the design medium. In this kind of conversation, we see judgments like, 'This is clunky; that is not,' or 'That does not look right to me,' or just 'This doesn't work.' The designer's response may be 'This is really puzzling,' or 'This outcome isn't what I expected—maybe there is something interesting going on here.

In their summary of the outcomes of empirical studies of experienced educational designers, Paul Kirschner and colleagues arrive at elements of a similar view: 'instructional designers, in practice, *design highly solution-driven, context-sensitive solutions through an iterative and integrative process*' (Kirschner et al., 2002, p. 93; emphasis in original). This provides the background for the following sketch of educational design in practice:

1. Educational design takes time. It rarely starts with a clear, complete conception of what is desired. Instead, the designer tries out various ideas, inscribing them in the world in some way (e.g., in a notebook, in a prototype). Over time, there is a convergence on a solution which entails both a clearer realisation of what is needed and what should be done to meet that need. Schon's 'backtalk' helps here.
2. This process of iterative clarification of the nature of the problem and its solution involves complex thought; from time to time, it overloads the designer (Frizell & Hubscher, 2002). At such times especially, designers have to share the cognitive effort of design by using resources in their design environment. Such resources include things designers have produced: notes, part-finished designs, prototypes, and so forth. They also include resources produced by others: templates, guidebooks, general principles, and so on. In short, designers can cope with complex problems that would otherwise overwhelm them by distributing the cognitive work (entailed in design) across minds, tools, and texts.
3. Thought is fast. Coordinating and consulting resources external to the mind takes time. The development of expertise as a designer involves, in part, an internalisation of ideas (etc.) found in texts and tools, as well as a restructuring of one's design knowledge, such that lower level design processes can be tackled automatically (without much conscious thought). In this regard, design expertise is just like other forms of expertise (Chi, Glaser, & Farr, 1988; Etelapelto, 2000).

This sketch provides a framework for evaluating the likely usefulness of a design resource for a teacher-designer. In particular, we would prioritise resources that encode design-relevant knowledge such that it is both easy to use and easy to internalise. It should be easy to consult while stuck on part of a problem. It should be vivid, understandable, memorable, and suited to easy recall in times of need. In our view, design patterns meet both needs: their form makes them usable *and* learnable. However, this is still a claim, not a proven fact. One of the purposes of our chapter is to see how this claim might be evaluated in the light of current literature.

DESIGN PATTERNS AND PATTERN LANGUAGES

A design pattern 'describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice' (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1977, p. x). The idea of design patterns comes from the writings of Christopher Alexander and his colleagues, working in the area of architecture and town planning. Design patterns can be combined to form a pattern language, tailored to the requirements of a particular task such as designing an extension to a house or designing a new program of study.

Figure 1 shows the conventional abstract structure of a design pattern. Figure 2 fills this out with content taken from the area of educational design for networked learning.

The words and phrases in capitals at the start and end of the pattern show how it may fit into one or more pattern languages. For example, this pattern references both a higher level pattern (LEARNING THROUGH DISCUSSION), which it can help complete, and also some lower level patterns that help complete or elaborate it (e.g., FACILITATOR).

RECENT WORK IN THE AREA

Current work on design patterns in educational technology has two main roots. One set of origins can be traced back through the interest of software engineers in design patterns (Gamma, Helm, Johnson, & Vlissides, 1995). Some of these software engineers were also university teachers of computer science or industry trainers and began to experiment with 'pedagogical design patterns' as a way of capturing and sharing ideas about teaching (Sharp, Manns, & Eckstein, 2003). Also, some more technically oriented educational technologists began to draw on the work of the

Figure 1. Internal structure of a design pattern (based on information in Alexander et al., 1977)

An introductory paragraph setting the context for the pattern (explaining how it helps to complete some larger patterns)

◆◆◆
(to mark the beginning of the problem)

A headline, in bold type, to give the essence of the problem in one or two sentences

The body of the problem
(its empirical background, evidence for its validity, examples of different ways the pattern can be manifested)

The solution, in bold type. This is the heart of the pattern – the field of physical and social relationships which are required to solve the stated problem in the stated context. Always stated as an instruction, so that you know what to do to build the pattern.

◆◆◆
(to show the main body of the pattern is finished)

A paragraph tying the pattern to the smaller patterns which are needed to complete and embellish it.

Figure 2. Example design pattern (based on information in Goodyear, 2005)

Discussion group

This pattern is mainly concerned with the establishment of appropriate organisational forms for knowledge-sharing, questioning and critique. It is a way of helping implement the patterns LEARNING THROUGH DISCUSSION, COLLABORATIVE LEARNING and NETWORKED LEARNING PROGRAMME.

◆◆◆

Discussion groups are the most common way of organising activity in networked learning environments. The degree to which a discussion is structured, and the choice of structure, are key in determining how successfully the discussion will promote learning for the participants.

Discussions can be relatively structured or relatively unstructured, and they may also change their character over a period of time. It is not uncommon for a teacher to set up a discussion in quite a formal or structured way, and for the structure then to soften as time goes by – for example, as the participants take hold of the conversation, opening up and following new lines of interest.

The structure of a discussion should be such that it increases the likelihood of:

a) an active and substantial discussion, with plenty of on-task contributions

b) the students coming away from the discussion with a good understanding of the contributions made

c) contributions being made by all members of the group and 'listened' to by all other members of the group.

Unstructured discussions run the risks of (for example)

- not getting going properly within the time available
- dissipating into a number of loosely related strands that fail to engage effectively with subject being studied
- dissolving into monologues or two-way conversations that fail to involve the whole group (Wertsch, 2002).

Pilkington & Walker (2003) have demonstrated the value of assigning explicit group roles in online discussion groups. Some writers, for example, McConnell (2000) are not sure about the validity of the teacher setting specific structuring devices, preferring to make the group itself responsible for determining how it wants to discuss things, or carry out its work more generally.

Therefore:

Start any online discussion by establishing its structure. Make the rules and timetable for this structure explicit to all the members of the group. Where there is little time available to the group for the discussion, and/or the members of the group are inexperienced at holding online discussions, the teacher/facilitator should set the structure. Where the students are to set their own structure, the teacher/facilitator should give them support and ideas about how to do this, and encourage them to do so in a fair and timely way.

◆◆◆

Patterns needed to complete this pattern include: DISCUSSION ROLE, FACILITATOR, DISCURSIVE TASK

software engineering patterns community—a line of development described very well by Garzotto and Retalis (this volume) and exemplified in Lyardet, Rossi, and Schwabe (1998) and Avgeriou, Papasalouros, Retalis, and Skordalakis (2003). The other set of origins can be found in work on tools and methods to support educational designers (e.g., Goodyear, 1997; Gustafson, 2002; Spector et al, 1993) and particularly the branch of this work that tries to relate to contemporary conceptions of learning as something which is complex, physically and socially situated, creative, and emergent (Davis & Sumara, 1997; Goodyear, 2002; Jessop, 2004; Rohse & Anderson, 2006). An important theme in this line of work has been the search for conceptions of design, and underpinning knowledge bases, that acknowledge the need for learners to play a strong part in directing their own learning and shaping their own learning environments. Design ceases to be concerned with channelling learner behaviour. It becomes more indirect, proposing challenging learning tasks; seeing that the learning environment is stocked with appropriate tools and resources (that learners can select, customise, and reconfigure); and doing what can be done to help the formation of convivial learning relationships. This can be seen as a shift in design logic from a logic of control to a logic of affordances (Goodyear, 2000; Hall, 2002; Kreijns, Kirschner, & Jochems, 2002). Product design, ergonomics, architecture, and ecology turn out to be very fertile sources for rethinking educational design and the complex relationships between people, activities, and technology (Goodyear, 2005; Hannafin & Hannafin, 1996; Nardi & O'Day, 1999; Norman, 1990).

Sharp et al. (2003) offer a balanced and reasonably up to date summary of the work of the Pedagogical Patterns Project (PPP). The paper mentions the four pattern languages on which members of the team have been working: feedback, active learning, experiential learning and gaining different perspectives. (More information about each of these can be found on the PPP Web site.) The paper also talks about the project team's decision to change the format of its patterns from the style popular in software engineering (e.g., in Gamma et al., 1995) to one more closely resembling Alexander's 'literary' form. Sharp et al. contend that the Alexandrian form improves the readability of the patterns and helps the reader avoid getting bogged down in detail (pp. 322-323). We would say that the shift to an Alexandrian form is a shift in emphasis from usability to learnability, from performance to understanding. We do not want to argue that this is good or bad; rather, it is a question of emphasis and purpose. More formal structuring makes some design (sub)tasks easier—like browsing or searching for relevant patterns—but it can make it harder to understand the rationale or deeper nature of a pattern and its connection to other patterns. Some of the meaning of a pattern derives from these relationships with other patterns.

Fincher and Utting (2002) have been quite critical of the PPP.

Pedagogical patterns still lack widespread acceptance. …they are so abstracted from the domain (of tertiary computer science education), and therefore generic, that they lack insight; or they are so tightly coupled to specific instances of practice that they are not transferable. The chosen form(s) lack some of the elements that provide patterns with their peculiar communicative power; sometimes they capture practice which is obvious, sometimes the lack of a value system [makes] it difficult to generate new designs from the solutions they propose. (p. 201)

The criticism of form predates the PPP's shift to a classic Alexandrian format. But some of their other criticisms remain trenchant. Table 1 is an elaboration of ideas in Fincher and Utting. It is an attempt to diagnose some of the problems with conceptions of pedagogical patterns involved in the PPP approach, and to say something about what pedagogical patterns *should* offer, by specifying some functional and nonfunctional requirements.

Our own doubts about the lack of success of the PPP to date echo those of Fincher and Utting (see also Garzotto and Retalis, this volume) but we have a deeper worry. It connects with the requirements that patterns should not be 'obvious,' and should provide insight. It is impossible to explain this concern without sounding arrogant, because—in essence—we would contend that the work of the PPP is an attempt to distil the experience of inarticulate amateurs. Carl Bereiter (2002) has argued eloquently that discussion of educational policy and practice is trapped in the language and mindset of a 'folk psychology' that (for example) sees the mind as a container to be filled and teaching as the practice of filling that container. This 'folk psychology' entails many other powerful and damaging beliefs that restrict serious discussion of the practical implications of recent discoveries in the learning sciences. Alexander and his team were able to construct convincing patterns because they were skilled in the *analysis* of built form. They were able to combine mathematical, social, moral, and aesthetic approaches to analysis, drawing on years of professional training and practical experience. They began with, and were able to sharpen, language and other representational devices suited to the tasks of deconstructing built form. University teachers do not typically have such tools and sensibilities (in their role as teachers, that is).

Nor is there a community of university teachers with a common pedagogical language or shared set of robust pedagogical constructs to serve as an imagined audience for a pedagogical pattern book. As Tom Erickson might have observed that university teachers do not have a *lingua franca* for pedagogical design (Erickson, 2000). *Serious* progress in the use of pedagogical patterns

Table 1. Requirements for educational design patterns (based on information in Fincher & Utting, 2002, and adapted and extended by the authors)

Functional requirements	**Nonfunctional requirements**
Capture of practice A pattern is not about an idea, or something that might be, or should be. It is about something that exists in the world. The thing exists because it solves a problem. There may be many variations of this thing, but they will share an invariant property that is essential to solving the problem concerned. NB problems of design are usually problems of reconciliation, of finding a balance between forces that are in tension.	*Non-obvious* Patterns help explain *why* things that succeed are successful at solving the problems they solve. Rather than expressing implementational detail, patterns help bring to the surface aspects of the world and the way it works that we often take for granted or fail to notice.
Abstraction Examples which are too concrete do not help people solve problems which are related to the example but appear disconnected from it. Principles which are too general are very difficult to apply to specific problems. Finding the right level of abstraction is key to crafting a good pattern.	*Insight* Good patterns provide insight into the rationale for a solution.
Value Systems Patterns express good ways of doing things, not just any old way. This necessitates being explicit about what is valued.	
Structuring Principle The links between patterns are at least as valuable as the patterns themselves. A structuring principle is what organises a set of patterns into a whole (a language).	*Generative* Patterns do not 'automagically' produce design solutions. Rather, the structuring principle helps the user find an appropriate pattern and the driving force of the value system helps generate a complete design, expressing 'a certain way of doing things.'
Presentational Form The presentation of the pattern is not the pattern. (The map is not the terrain.) But the presentation of a pattern is significant. Presentational forms vary from one set of patterns to another, but there is an irreducible core of problem statement, solution statement, and rationale.	*Communicative Power* The name of a pattern can become key to its success; if the name enters the lingua franca of a design community (as a shorthand for what the pattern expresses), then it may take on a life of its own. Good names for things we previously struggled to describe (or even see) are particularly powerful.

depends upon developing shared language and understanding.

A number of authors have tried to analyse the relationships between work on pedagogical patterns and developments in the learning design area (e.g., De Moura Filho & Derycke, 2005; McAndrew et al., 2006; Turani, Calvo, & Goodyear, 2005). The essence of De Moura Filho and Derycke's (2005) argument is that pedagogical patterns and learning design are complementary. In their view, pedagogical patterns primarily have a communicative function and should always be expressed in a textual form that teachers-as-designers can read and write. It would be a mistake to express them in a form, such as pseudocode, that would be inaccessible to teachers who were not also programmers. It would also be a mistake to automate them (p. 114). De Moura Filho and Derycke explore the connection with learning design by showing how parts of a selected pedagogical pattern can be mapped onto learning design elements (roles, activities, learning objects, etc.). They conclude that the best mapping can be achieved by working from a pedagogical pattern to a learning design *template*, rather than to a fully-fledged learning design *scenario.* This idea of using pedagogical patterns at higher levels of abstraction can also be found in Turani's work on computer-supported collaborative learning (CSCL) with the Beehive system (Turani et al., 2005). Turani's approach involves four levels of abstraction: collaborative pedagogical models, pedagogical techniques, collaboration tasks patterns, and CSCL tools. Pedagogical patterns *could* be written for elements at each of these levels, but they lend themselves to the higher levels of abstraction. Finally, McAndrew et al. (2006) explore convergences and discontinuities between learning design, the LAMS (learning activity management system) and the patterns-based approach. Again, there is a sense of complementarity rather than competition, and a notion that patterns are best suited to sharing of, and reflection on, educational design ideas by teachers, while LAMS and learning design are more supportive of downstream activity—detailed design and development work, supported as appropriate by technical experts.

We think this analysis can be taken further. Going back to Schon's powerful image of design as a conversation with materials, we are struck by the scale of the imaginative leap that teachers-as-designers have to make when tackling educational design work. The leap from pedagogical pattern to actual student activity can be enormous, but is manageable if the activity is familiar and its relations with other activities and resources are few and simple. As soon as the design becomes complex, then imagining the learning activity and learning environment in any detail becomes cognitively demanding. Evaluating one design choice against another becomes very difficult. Opportunities for Schon's 'backtalk' disappear. In fact, one thing that happens is that teachers short-circuit the design work and move too rapidly to development commitments—that is, they make premature commitments to use *this* learning object, or *that* tool, for specifically *that* task. Some tools—LAMS would be one of them—provide more abstract design representations that allow the teacher-as-designer to try out some design commitments, reflect on their appropriateness, and make changes as they see fit. This is closer to the iterative 'tinkering and reflection' kind of process that Schon describes. Crucially, it depends on having appropriate forms of representation at key levels of abstraction. One needs a pattern book, as well as computer-based tools for creating and manipulating graphical and other representations of provisional design ideas. Alternatively, one needs a much tighter coupling than we can currently conceive for educational design between computer-aided design and computer-aided construction of tasks and learning environments. (Bill Mitchell's account of the architect/designer Frank Gehry's pioneering use of tightly-coupled design and manufacturing tools is a useful evocation of what might be done in the field of educational design here—see, for example, Mitchell, 2004).

To summarise, the relationships between educational design/pedagogical patterns (on the one hand) and work on learning design and learning objects (on the other) depend quite strongly on technologies of representation. The current state of play would suggest that patterns sit comfortably in the world of printed text and have a strong communicative and educative function. Learning design is firmly ensconced in the digital world and is better suited to the implementation of design ideas than their formation by technically unsophisticated teacher-designers. Patterns help with understanding; learning design helps with performance. However, we would argue that this balance depends upon the sophistication and ease-of-use of design technologies available to the teacher. It is not set in stone.

DESIGN PATTERNS FOR NETWORKED LEARNING

In this section, we try to give a flavour of some of our own recent work on hatching design patterns for networked learning through empirical research that involves interviews with experienced teacher-designers as well as with students. 'Networked learning' is our preferred term for online collaborative learning (Steeples & Jones, 2002). Some early work in this area is reported in Goodyear, Avgeriou, Baggetun, Bartoluzzi, Retalis, Ronteltap, et al. (2004). We summarise two lines of research: Goodyear's work with Lally and de Laat, based heavily on de Laat's PhD thesis (de Laat, 2006) and Yang's PhD research that is attempting to combine design patterns with insights from systemic functional linguistics (Yang & Goodyear, 2006).

A FRAMEWORK FOR DESIGN PATTERNS FOR NETWORKED LEARNING

Tables 2 to 5 provide an overview of 48 design patterns derived from de Laat's PhD interview and analysis work (Goodyear, de Laat, & Lally, 2006). The patterns are organised into four phases (start up; beginning; middle; end). The left hand column of each table describes key concerns in each phase. The middle and right hand columns summarise the solution part of relevant design patterns aimed at the group of students and the teacher.

The start-up phase focuses on what might be called induction tasks (familiarisation and community building) that have emerged from the literature and from student and teacher interviews as providing vital foundations for collaborative online working.

The beginning phase is the section of a networked learning course where the collaborative group tasks (such as a group project) gets seriously underway. The emphasis shifts from group formation to group production work. As the group develops its own life and momentum, tutors begin to reduce the number of ways in which they intervene, pulling back to a core monitoring role.

The middle phase is where most of the group project work get done. The teacher plays a reactive role, but the person best placed to get a sense of individual and group activity will also intervene with feedback and guidance about group progress.

The ending phase (Table 5) emphasises the importance of learning through reflection on the process and products of group working. Too often, individual students are so relieved to have finished the assigned group project that they hurriedly move on to the next challenge, losing valuable opportunities for learning. For the teacher, the ending phase is also a time to close the design

Table 2. Patterns for the start up phase (based on information in Goodyear et al., 2006)

Phase	**Group activities**	**Teacher activities**
Start-up phase		
Initial networked learning design		Use previous pedagogical framework and share with other teachers on this (or similar) course
Familiarisation with networked learning environment	Organise premeetings and share experiences	Provide an introduction to the open-learning space
	Get to know each other. Provide background information about work, interests, and reason for signing up for this project	Be an active participant and address changing relationship
Familiarisation with pedagogical models	Discuss what collaborative learning means within the group	Explain the approach to collaborative learning and attitudes towards knowledge construction
		Discuss what the role of the teacher is during this process
		Raise awareness of regulating both task and group processes
	Negotiate individual learning preferences with learning goals and group capability to learn	
Community building	Develop rules of engagement and etiquette	Participate in these conversations, set the right tone, and contribute to the development of a sense of community
	Build trust and discuss how to provide support and guidance to each other	Set the stages in the beginning, provide guidance and reassurance to the group
	Discuss intended level of participation and availability during the project	Participate in this and discuss presence and availability during the project
	Build up a collective understanding of each other's desires, commitment, and work (or learning) preferences	

loop—doing what can be done to see that future course design (etc.) is informed by these recent pedagogical experiences.

DESIGN PATTERNS AND SYSTEMIC FUNCTIONAL LINGUISTICS

Yang's PhD research examines text functions in network learning. Her research explores the use of

Table 3. Patterns for the beginning phase (based on information in Goodyear et al., 2006)

Phase	**Group activities**	**Teacher activities**
Beginning phase		
Conceptualise collaborative project	Negotiate what the project could be about and which problems it will address	Provide active guidance and facilitate group processes to make sure everybody has a voice in establishing their project
Task-focused communication	Create personal and professional focus to increase personalisation, identification, and recognition of the issues that need to be addressed in the project	Participate in developing a working method and learning agenda
	Identify and address overlap and gaps between individual and collective learning processes and outcomes	
Socially centred communication	Create a healthy learning climate and think about individual and shared responsibilities	
Develop a learning agenda based on personalising the group structure and task ownership	Based on previously discussed desired ways of working, develop a structure that is true to your own situation and connected with the content of your task	Open up these conversations and use the pedagogical framework to induct students in this process
	Develop an action plan and set up deadlines and milestones to be met throughout the project	
	Develop roles and strategies to structure the collaborative learning	Stimulate the group to make roles and strategies explicit
Develop a group rhythm	Develop a group rhythm based on previously discussed levels of participation and duration of the task	Discuss your presence
Inter-metacognitive knowledge and skill	Gradually develop inter-metacognitive skills	Gradually hand over control to the group and withdraw

Systemic Functional Linguistics (SFL) and pattern languages in educational design. SFL provides a theoretical tool for analysing how teachers and students use (online) texts in networked learning. Through construction of and interaction with texts, teachers and students develop their capacities to share new ideas, concepts, and values in their learning community. The quality of texts being used by teachers and students plays an important role in the quality of teaching and learning. We

Table 4. Patterns for the middle phase (based on information in Goodyear et al., 2006)

Phase	Group activities	Teacher activities
Middle phase		
		Close monitoring (both content and process)
Strong focus on the content of the task and ongoing facilitation of group processes	Actively work on the task	
Ongoing reflection on group functioning and dynamics	Take control of regulating and managing your project	Hand over control to the group and leave it with them as far as possible
	Make necessary adjustments based on emerging roles, levels of participation, and work needed during this phase	Provide access to feedback material on how the group is working
	Monitor and adjust overlap and gaps between individual and collective learning processes and outcomes	Monitor and adjust overlap and gaps between individual and collective learning processes and outcomes
Community spirit and trust building	Facilitate each other and maintain a healthy learning climate in the group	
	Believe in the quality of the work	Provide scaffolding or guidance when needed

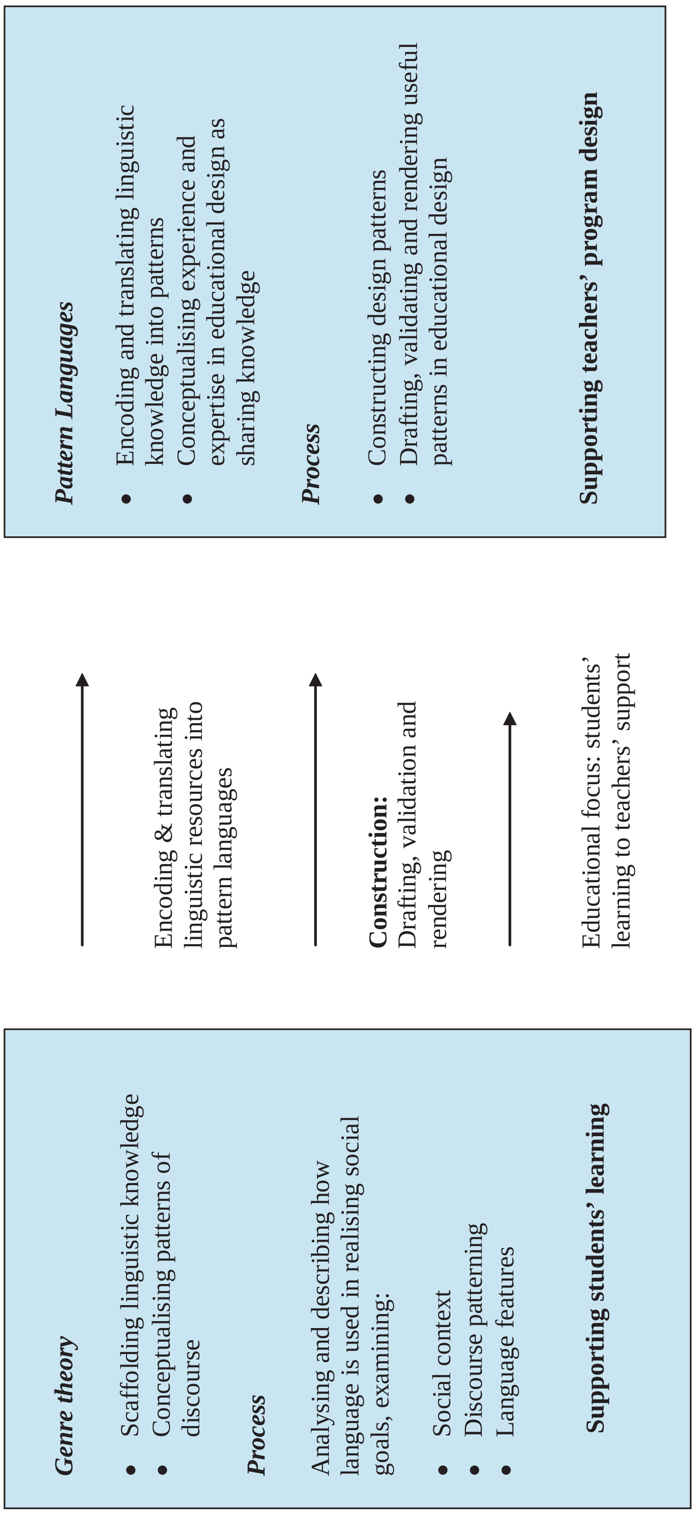
Table 5. Patterns for the ending phase (based on information in Goodyear et al., 2006)

Phase	Group activities	Teacher activities
Ending phase		
Gradual shift towards reflection on the work done	Start wrapping up the project	Provide guidelines, deadlines, and procedures for wrap-up
Reflect on the current group structure to facilitate and design	Revisit original structure to deal with emergent structures	
Reflection on the project	Assess individual and collective learning outcomes, using self and peer assessment reports	
		Update pedagogical framework

need ways of describing and analysing these texts in order to explain how they function.

SFL and genre theory primarily developed through the work of Halliday and Martin (e.g., Halliday, 1974; Martin, 1992). SFL is concerned with explaining language in terms of what people do with it. Halliday identified three different *types of meaning* (or ‘metafunctions’) which can

Figure 3. Genres to pattern languages



be found in all human languages: interpersonal, ideational, and textual. Martin's work on register and genre takes each of these three metafunctions as a variable, which he calls respectively *tenor* (the power and solidarity of relations between speakers; interpersonal meaning); *field* (topic or ideational meaning), and *mode* (the role of language; textual meaning). The idea of genre then allows one to identify and group together the grammatical choices that constitute a recognisable linguistic practice within a culture—to label a typical way of getting something done within that culture.

Yang's research uses SFL and genre theory to analyse some texts selected from networked learning courses. Her study explains and illustrates how different text types are used to fulfill different social functions; how different text types are constructed differently in their schematic structure; and how different text types deploy different linguistic features. The study aims to capture the linguistic resources and knowledge in a repository of educational design patterns. The idea is that these design patterns can be reused and extended through innovative developments in design for networked learning. Also, new teachers can use these patterns as a source of guidance for developing resources and strategies to improve their teaching. The research process falls into three main phases as illustrated in Figure 3.

Some preliminary results from this work can be found in Yang and Goodyear (2004, 2006). Here we focus on one more detailed example of what can be achieved. Students who are new to networked learning do not usually find it easy to adopt appropriate ways of speaking/writing in discussions with their fellow students and the teaching staff. This is apparent from interviews with experienced networked learning teachers as well as from the literature (de Laat, 2006). It is

Figure 4. Hedging design pattern

Hedging

This pattern describes a way of using language in online texts produced by a FACILITATOR and/or a DISCUSSION GROUP. It refers to the use of language which avoids strong commitment to a position in a discussion. It can help avoid premature closure of a discussion, and/or the marginalisation of some members of the discussion group.

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The language used in online discussion needs to serve multiple purposes, including the maintenance of good working relationships and the exploration and clarification of ideas. A sharply-worded analysis of a strongly-held position may be good for conceptual clarity but it may not encourage others to share their views. Conversely, too much time spent on 'group-maintenance' functions can be frustrating for some, and may slow down the collaborative exploration and improvement of ideas.

Hardy et al (1994) provided some very convincing data and arguments about the ways in which online discussions came to a premature end. They associated these with the gender of the speakers/writers. It is clear from their research that people vary in the extent to which they will tolerate, or respond badly to, forcefully-expressed opinions. An underpinning value in networked learning is that all students should feel their opinions will be treated with respect. Therefore the language used should be of a kind that will encourage all participants to engage in the discussion, respecting feelings but also using sufficient precision to allow the collaborative improvement of ideas (Bereiter, 2002).

'Hedging' connotes a way of using language that allows clear expression of key ideas while avoiding the impression that the writer is adopting a position of unassailable authority. It tends to use phrases such as 'it may be the case that…', or 'it's possible that…', or 'I'm not sure about this, but I think that…'. This conditional phrasing undermines the appearance of authority while still allowing the writer to be crystal clear in what they actually want to say about the matter under discussion. Language use is infectious – if some people regularly use hedging, it's likely to spread.

Therefore, in the model texts you provide for students, and in your own contributions to the online discussion, make appropriate use of hedging as a way of maintaining group solidarity, including everyone, and advancing the discussion.

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useful to provide some examples of appropriate kinds of writing. However, the selection and/or crafting of appropriate examples is time-consuming and difficult. The ideas of genre and register prove to be quite powerful tools in selecting and/or crafting, and explaining, appropriate texts.

For example, Yang's research has noted the careful, though not necessarily conscious, use of what she calls 'hedging' in some networked learning texts. Hedging refers to the avoidance of commitment in texts and is marked by phrases such as 'it may be…' or 'it is possible that….' Hedging involves interpersonal meaning (it avoids the inference that the speaker is adopting a position of superiority, authority or power). But it does this in the background, without undermining ideational and textual meaning. It can carry a discussion forward while minimising the risks of premature closure (Hardy, Hodgson, & McConnell, 1994). An implication is that some of the model texts provided for students should make appropriate use of hedging, and that this might also be carried over into the teacher's ongoing use of language during a networked learning course.

FUTURE TRENDS

Producing good patterns is hard, and there are very few success stories to date (Garzotto & Retalis, this volume; Voigt & Swatman, 2006). Fincher and Utting (2002) note that the creation of architectural design patterns by Alexander and his team, and software engineering patterns in the Gamma et al. collection entailed several years of demanding effort by people working closely together. Much of what has been published about patterns in the educational design area is still scratching the surface—at the level of expositions of the approach rather than convincing collections of workable ideas. An exception might be the work of Michael Derntl and colleagues at the University of Vienna (see, e.g., Derntl, 2004) on person-centred e-learning pattern repositories, though it is rather early to be able to tell how widely this work will be taken up.

Another issue of possible concern—sometimes mentioned in the patterns communities—is that Alexander's work has had less influence in architecture than it has had in software engineering. Opinions vary on this matter. For some, Alexander's architectural work is seen as too impractical or romantic. Others point to its hard mathematical edge and its deep philosophical roots, and they also note the extraordinary scope of his more recent writing on the nature of order, touching on fields from biology to poetry (Alexander, 2006). Central to his recent writing is a re-examination of conceptions of life and of the organic: what it means to say something is alive. There are strong parallels with notions of emergence and complexity (Rohse & Anderson, 2006). In short, the challenge is to replace mechanistic ways of seeing and acting in the world with ways that are more organic, to understand process rather than (just) optimise product.

From this broader perspective, we see the following as promising avenues for exploration and development:

1. A shift of emphasis from the individual learning mind to learning in and by communities means that we need more powerful (subtle and insightful) ways of analysing and describing learning processes and their ecologies. We also need to free up our thinking about the role of students as codesigners of their learning environments (Fischer & Giaccardi, 2006; Rohse & Anderson, 2006).
2. In thinking about the interactions between learning activity and the physical/digital environment in which it is set, we need a better understanding of the extent to which that environment reflects and reproduces dehumanised, mechanistic, and alienated ways of learning. A range of analytic paths are available here. We follow Tom Erickson

(2000) in recommending Randolph Hester's work on participatory community design. Hester's careful discovery of what were 'sacred places' for the community with which he worked stands in marked contrast to the romantic and rationalistic tendencies that polarise discussion about technology, place, and human activity.

3. These explorations need to take place at micro *and* macrolevels, uncovering and reanalysing more of the important details of learning as well as building a more robust sense of contexts. Such exploration entails empirical and conceptual work, but also design and development work—testing our understanding through the production and evaluation of new tools and methods (Clancey, 1997). Under this umbrella, further work on and with patterns continues to make sense, as does the articulation of such work with other investigations in the field of educational design.

CONCLUSION

In this chapter, we have tried to give a flavour of recent work on the production and evaluation of educational design patterns and pattern languages, placing this in the wider world of thinking about learning and educational design and complementing the exploration of this topic in Garzotto & Retalis. The sense that one makes of the patterns-based approach depends heavily on where one sees the hard problems of educational design, but also the problems on which some progress might be possible. We reiterate the view that this is a complex and important area, in which progress demands work at micro and macro levels. It makes sense to hatch and reflect on patterns. It also makes sense to worry away at the conceptual and moral foundations on which the prevailing approaches to educational design and its technologies are built. In our view, progress in the field cannot be measured simply by efficiency gains in established kinds of educational design task. Better design performance is only worthwhile if the resulting designs and their underpinning conceptions of learning fit the emerging needs of the autonomous lifelong learner. It may well turn out that approaches to supporting educational design that deal with understanding *and* performance are what we need to help teachers as designers question prevailing practices and transform the nature of educational experience.

REFERENCES

Alexander, C. (2006). *The nature of order* (4 vols.). Berkeley, CA: Center for Environmental Structure.

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A pattern language: Towns, buildings, construction*. New York: Oxford University Press.

Avgeriou, P., Papasalouros, A., Retalis, S., & Skordalakis, E. (2003). Towards a pattern language for learning management systems. *Educational Technology & Society, 6*(2), 11-24.

Barrese, R., Calabro, G., Cozza, S., Gallo, T., & Tisato, F. (1992). CAMCE: An environment to support multimedia courseware projects. *Educational and Training Technology International, 29*(1), 14-25.

Biggs, J. (2003). *Teaching for quality learning at university: What the student does* (2nd ed.). Buckingham: Open University Press.

Bennett, N., Desforges, C., Cockburn, A., & Wilkinson, B. (1984). *The quality of pupil learning experiences*. London: Lawrence Erlbaum.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Chi, M., Glaser, R., & Farr, M. (Eds.). (1988). *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Clancey, W. (1997). The conceptual nature of knowledge, situations, and activity. In P. Feltovich, R. Hoffman, & K. Ford (Eds.), *Human and machine expertise in context* (pp. 247-291). Menlo Park, CA: AAAI Press.

Davis, B., & Sumara, D. (1997). Cognition, complexity, and teacher education. *Harvard Educational Review, 67*(1), 105-125.

de Laat, M. (2006). *Networked learning*. Unpublished doctoral dissertation, University of Utrecht, Utrecht.

de Moura Filho, C., & Derycke, A. (2005). *Pedagogical patterns and learning design: When two worlds cooperate*. Paper presented at the UNFOLD-PROLEARN Joint Workshop, Valkenburg, The Netherlands.

Derntl, M. (2004). *The person-centered e-learning pattern repository: Design for reuse and extensibility*. Paper presented at ED-MEDIA '04, Lugano, Switzerland.

Elen, J. (1998). Automating ID: The impact of theoretical knowledge bases and referent systems. *Instructional Science, 26*(3-4), 281-297.

Erickson, T. (2000). *Lingua francas for design: Sacred places and pattern languages*. Paper presented at the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, New York.

Etelapelto, A. (2000). Contextual and strategic knowledge in the acquisition of design expertise. *Learning and Instruction, 10*(2), 113-136.

Fincher, S., & Utting, I. (2002). *Pedagogical patterns: Their place in the genre*. Paper presented at ITiCSE'02, Aarhus, Denmark.

Fischer, G., & Giaccardi, E. (2006). Meta-design: A framework for the future of end-user development. In H. Lieberman, F. Paterno, & V. Wulf (Eds.), *End user development: Empowering people to flexibly employ advanced information and communication technology*. New York: Springer.

Frizell, S., & Hubscher, R. (2002). *Supporting the application of design patterns in Web-course design*. Paper presented at ED-MEDIA 2002, Denver, CO.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995). *Design patterns: Elements of reusable object-oriented software*. New York: Addison-Wesley.

Goodyear, P. (1994). Infrastructure for courseware engineering. In R. Tennyson & A. Barron (Eds.), *Automating instructional design: Computer-based development and delivery tools* (pp. 11-31). Berlin: Springer Verlag.

Goodyear, P. (1997). Instructional design environments: Methods and tools for the design of complex instructional systems. In S. Dijkstra, N. Seel, F. Schott, & R. Tennyson (Eds.), *Instructional design: International perspectives* (pp. 83-111). Mahwah, NJ: Lawrence Erlbaum Associates.

Goodyear, P. (2000). Environments for lifelong learning: Ergonomics, architecture and educational design. In J.M. Spector & T. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction & technology: Understanding complexity* (pp. 1-18). Dordrecht: Kluwer Academic Publishers.

Goodyear, P. (2002). Psychological foundations for networked learning. In C. Steeples & C. Jones (Eds.), *Networked learning: Perspectives and issues* (pp. 49-75). London: Springer Verlag.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology, 21*(1), 82-101.

Goodyear, P., Avgeriou, P., Baggetun, R., Bartoluzzi, S., Retalis, S., Ronteltap, F., et al. (2004). Towards a pattern language for networked learning. In S. Banks, P. Goodyear, V. Hodgson, C. Jones, V. Lally, D. McConnell, & C. Steeples (Eds.), *Networked learning 2004* (pp. 449-455). Lancaster: Lancaster University.

Goodyear, P., de Laat, M., & Lally, V. (2006). Using pattern languages to mediate theory-praxis conversations in design for networked learning. *Journal of the Association for Learning Technology, 14*(3), 211-223.

Gustafson, K. (2002). Instructional design tools: A critique and projections for the future. *Educational Technology Research and Development, 50*(4), 59-66.

Hall, R. (2002). Collaboration and learning as contingent responses to designed environments. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL2: Carrying forward the conversation* (pp. 185-196). Mahwah, NJ: Lawrence Erlbaum Associates.

Halliday, M.A.K. (1974). *An introduction to functional grammar* (1st ed.). London: Edward Arnold.

Hannafin, K., & Hannafin, M. (1996). The ecology of distance learning environments. *Training Research Journal, 1*, 49-70.

Hardy, V., Hodgson, V., & McConnell, D. (1994). Computer conferencing: A new vehicle for investigating issues in gender and learning. *Higher Education, 28*, 403-418.

Hoogveld, A., Paas, F., Jochems, W., & van Merrienboer, J. (2002). Exploring teachers' instructional design practices from a systems design perspective. *Instructional Science, 30*, 291-305.

Jessop, A. (2004). Pattern language: A framework for learning. *European Journal of Operational Research, 153*, 457-465.

Kirschner, P., Carr, C., van Merrienboer, J., & Sloep, P. (2002). How expert designers design. *Performance Improvement Quarterly, 15*(4), 86-104.

Kreijns, K., Kirschner, P., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society, 5*(1).

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lockyer, L., Patterson, J., Rowland, G., & Hearne, D. (2002). Online mentoring and peer support: Using learning technologies to facilitate entry into a community of practice. *Association for Learning Technology Journal, 10*(1), 24-31.

Longworth, N. (1995). Lifelong learning: The challenge and potential for industry and higher education. *Industry and Higher Education, 9*(4), 205-216.

Lyardet, F., Rossi, G., & Schwabe, D. (1998). *Using design patterns in educational multimedia applications.* Paper presented at the ED-MEDIA '98 Conference.

Martin, J. R. (1992). *English text: System and structure*. Amsterdam: Benjamins.

Maynard, T. (2001). The student teacher and the school community of practice: A consideration of 'learning as participation.' *Cambridge Journal of Education, 31*(1), 39-52.

McAndrew, P., Goodyear, P., & Dalziel, J. (2006). Patterns, designs and activities: Unifying descriptions of learning structures. *International Journal of Learning Technology, 2*(2), 216-242.

McConnell, D. (2000). *Implementing computer supported cooperative learning* (2nd ed.). London: Kogan Page.

Mitchell, W. (2004). Beyond the ivory tower: Constructing complexity in the digital age. *Science, 303*(5663), 1472-1473.

Nardi, B., & O'Day, V. (1999). *Information ecologies: Using technology with heart*. Cambridge Mass: MIT Press.

Norman, D. (1990). *The psychology of everyday things*. New York: Basic Books.

Pilkington, R., & Walker, S. (2003). Facilitating debate in networked learning: Reflecting on online synchronous discussion in higher education. *Instructional Science, 31*(1-2), 41-63.

Pirolli, P. (1991). Computer-aided instructional design systems. In H. Burns, J. Parlett, & C. Redfield (Eds.), *Intelligent tutoring systems: Evolution in design* (pp. 105-125). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rohse, S., & Anderson, T. (2006). Design patterns for complex learning. *Journal of Learning Design, 1*(3), 82-91.

Schon, D., & Bennett, J. (1996). Reflective conversation with materials. In T. Winograd (Ed.), *Bringing design to software* (pp. 171-184). New York: Addison Wesley.

Sharp, H., Manns, M., & Eckstein, J. (2003). Evolving pedagogical patterns: The work of the Pedagogical Patterns Project. *Computer Science Education, 13*(4), 315-330.

Shuell, T. (1992). Designing instructional computing systems for meaningful learning. In M. Jones & P. Winne (Eds.), *Adaptive learning environments*. New York: Springer-Verlag.

Spector, M., Polson, M., & Muraida, D. (Eds.). (1993). *Automating instructional design: Concepts and issues*. Englewood Cliffs, NJ: Educational Technology Publications.

Steeples, C., & Jones, C. (Eds.). (2002). *Networked learning: Perspectives and issues*. London: Springer.

Stewart, T. (1998). *Intellectual capital: The new wealth of organizations*. London: Nicholas Brealy Publishing.

Turani, A., Calvo, R., & Goodyear, P. (2005). An application framework for collaborative learning. In D. Lowe & M. Gaedke (Eds.), *Proceedings of ICWE 2005*, Sydney (LNCS 3579, pp. 243-251). New York: Springer.

Urry, J. (2003). *Global complexity*. Cambridge: Polity.

Voigt, C., & Swatman, P. (2006). Describing a design pattern: Why is it not enough to identify patterns in educational design? In *Proceedings of the 23rd Ascilite Conference*, Sydney.

Wertsch, J. (2002). Computer mediation, PBL and dialogicality. *Distance Education, 23*(1), 105-108.

Yang, D., & Goodyear, P. (2004). Pattern languages and genres for writing computer science discourse. In *Proceedings of the 21st Ascilite Conference*, Perth.

Yang, D., & Goodyear, P. (2006). Learning through online discussions: A focus on discourse analysis and language functions. In *Proceedings of the 23rd Ascilite Conference*, Sydney.

KEY TERMS

Design Pattern: A way of representing a contextualized solution to a design problem with sufficient precision and explanation that it is an effective guide to action, but allowing scope for creative adaptation to specific needs.

Educational Design: A representation of how to support learning in a particular case; educational design is the process of constructing such representations.

Networked Learning: A form of collaborative online learning where technology is used to help learners connect (with each other, with their teachers, with valued learning resources).

Pattern Language: A network of design patterns, where each pattern helps solve a part of the overall design problem addressed by the pattern language.

Systemic Functional Linguistics (SFL): An approach to understanding language that emphasizes its social function: focusing on the exchange of meanings within a social context.

Chapter VIII
The Role of Mediating Artefacts in Learning Design

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ABSTRACT

The chapter provides a theoretical framework for understanding learning activities, centering on two key aspects: (1) the capture and representation of activities and (2) mechanisms for scaffolding the design process. The chapter begins by describing how information can be abstracted from learning activities via different forms of representation (models, iconic diagrams, textual case studies, etc.), which are defined here as 'mediating artefacts.' It discusses how different artefacts can be used to inform the process of designing a new learning activity. It provides an illustration of the theoretical arguments developed in the chapter by summarizing some of the findings from relevant research on learning design and uses the DialogPlus toolkit as a case study and example of a mediating artefact that can be used to support the design of a learning activity. The toolkit includes examples of learning activities (i.e., representations of activities as outlined in 1 above) as well as guidelines and support (i.e., mechanisms for scaffolding the design process as outline in 2 above). The chapter argues that this approach to learning design, which centres on the concept of mediating artefacts and their role in the design process, can be used as a descriptive framework for describing the dynamics, processes, and different aspects involved in learning design.

INTRODUCTION

Technological innovations and new tools continue to develop at a phenomenal rate. Some argue that we may be entering a new phase in the use of technologies; particularly with the emergences of new forms of social software and what is being referred to as Web 2.0 (O'Reilly, 2005;

Weller, 2007), which has become synonymous with this more interactive, peer-generated, and collaborative Internet. Many argue that the new possibilities of these social networking tools are resulting in a fundamental shift in the way we work and learn.

Therefore, technologies have the potential to be used in a rich range of ways to support learning. We are seeing the emergence of technology-enabled spaces and adaptive technologies which offer new and exciting opportunities in terms of contextual, ambient, augmented, distributed, and social networked learning. Rich, immersive virtual environments such as Second Life (http://secondlife.com/) are exciting educators in terms of the possibilities they offer for learning. Second Life, as an interactive, real-time, 3D world enables participants to move around the space and interact with objects and people (Stevens, 2007). Over 100 educational 'islands' have been created to date to explore the potential of this environment in an educational context. Recent research on students' experience of using technologies shows that many are very comfortable in this technology-enriched fast moving environment (Conole, de Laat, Darby, & Dillon, 2006; Conole, de Laat, Darby, & Dillon, 2008; Creanor, Trinder, Gowan, & Howells, 2006; Kennedy, Krause, Judd, Churchward, & Gray, 2006). Google, Wikipedia, e-mail, and MSN chat are listed as core tools to support students' learning; although it is still unclear to what extent students are using these in the most effective ways for learning purposes. Today's students are sophisticated users who appropriate the technologies to their own needs. The implications for educational institutions both in terms of the technological infrastructure we provide and the way in which we support learners are profound. Now more then ever course designers need guidance in producing learning activities which take account of these changes and maximise the potential technologies offer.

Despite these exciting possibilities, examples of truly innovative forms of learning that harnesses the affordances new technologies offer are still rare (Conole & Dyke, 2004; Gaver, 2006; Gibson, 1979). A disappointing aspect of current practice when using new technologies is that it often seems to offer more of the same, replicating or mirroring existing practice in the new medium rather than exploiting the opportunities of creating a truly new learning environment and associated experience.

This problem of the mismatch between the potential of new technologies and their actual use is well known. Conole, Oliver, Falconer, Littlejohn, and Harvey (2007) have argued that there is a gap between the potential of technologies to support learning and the reality of how they are actually used and that this is due to a lack of understanding about how technologies can be used to afford specific learning advantages and to a lack of appropriate guidance at the design stage:

> *Practitioners have a multitude of learning theories that guide the development of learning activities. …In addition, …there is a rich variety of ICT tools that can be used to support the implementation of these. Despite this, the actual range of learning activities that demonstrate specific pedagogic approaches (such as constructivism, dialogic learning, case- or problem-based scenarios, or socially situated learning) and innovative use of ICT tools is limited; suggesting that practitioners are overwhelmed by the plethora of choices and may lack the necessary skills to make informed choices about how to use these theories.* (Conole et al., 2007, p. 101)

Its cause is due to a range of interconnected issues including technological (immature tools, lack of interoperability, etc.), organisational (barriers and enablers to uptake, cultural barriers), and pedagogical (lack of understanding of how to apply esoteric educational models or frameworks). More often than not, designers do not have the appropriate expertise in advanced design methods or a deep enough understanding of the potential affordances of technologies and hence tend to primarily adapt existing practice. Case studies and other forms of guidance often do not provide much help, as they are often not presented in a format suited to the designer's particular needs at that moment in time. This chapter argues that learning design may provide a means of addressing these issues by providing a structured methodology for guiding the design process. It will reflect on some of the current developments and issues around learning design focusing in particular on two central questions.

1. How can we gather and represent practice (and in particular innovative practice) (capture and represent practice)?
2. How can we provide 'scaffolds' or support for staff in creating learning activities, which draw on good practice, making effective use of tools and pedagogies (support learning design)?

Knight, Gašević, and Richards (2006) stress the importance of these issues as a focus, arguing that "specifying reusable chunks of learning content and defining an abstract way of describing designs for different units of learning (e.g., courses, lessons, etc.) are two of the most current issues in the e-learning community" (p. 23). Underneath the deceptive simplicity of the questions outlined above lurks a multitude of issues and complexities such as: What methodologies are appropriate to describe learning activities? Which are representative, consistent, and useful? What methodologies can we use to identify and represent the most significant features of a learning activity? How can we ensure that practitioners will easily understand any abstracted representations of learning activities? What types of guides and support are useful for supporting the design process, which are appropriate for the skill level of the user? How can we reconcile the tension between providing simple representations or guidance that *oversimplify* and more rich, detailed descriptions that are difficult to understand and time consuming to apply? What is the appropriate balance of providing real examples (how many, degree of detail, format, etc.) and abstractions that can be adapted? Which aspects of context are significant and therefore tie an activity to a particular context? Furthermore, although we can record practice, this record does not necessarily indicate whether and why this particular activity is effective or not, and often the tacit aspects of the activity are those which are most important in terms of determining the degree of success.

This chapter attempts to provide both a theoretical approach to describing and framing these issues and suggested solutions for use in practice. The chapter concludes with the latter through the description of a case study of a toolkit, DialogPlus, which attempted to address these issues and an analysis of its strengths and weaknesses, followed by a pointer to current work we are doing in this area through the creation of a learning design tool using a mind mapping package, Compendium.

LEARNING ACTIVITIES AND LEARNING DESIGN

Before we begin to address the questions posed above, it is worth defining two key concepts central to these issues: 'learning activities' and 'learning design'. Learning activities are those tasks that students undertake to achieve a set of intended outcomes. Examples might include finding and synthesising a series of resources from the Web, contributing to a 'for and against debate' in a discussion forum, manipulating data in a spreadsheet, constructing a group report in a wiki or summarising the salient points of a podcast. Beetham (in Beetham & Sharpe, 2007) views learning activities in relation to the design process "as a specific interaction of learner(s) with other(s) using specific tools and resources, orientated towards specific outcomes" (p. 28).

Learning design refers to the range of activities associated with creating a learning activity and crucially provides a means of describing learning activities. Agostinho (2006) describes it as 'a representation of teaching and learning practice documented in some notational format so that it can serve as a model or template adaptable by a teacher to suit his/her context.' Learning design provides a means of representing learning activities so that they can be shared between tutors and designers. For example, this might consist of illustrating learning activities in an easy to understand way (as a diagram and/or text) so that they can (a) shared between a teacher and a designer, (b) be repurposed from one teacher to another, (c) serve as a means of scaffolding the process of creating new learning activities, or (d) provide the tools for practitioners to capture their innovative practice in a form that is easy to share. Such a scaffold might be in the form of an online tool to provide support and guidance to a teacher in the steps involved in creating a new learning activity, including tips and hints on how they might use particular tools.

The term 'learning design' came into common usage with the development of the IMS Learning Design specification (http://www.imsglobal.org/learningdesign/index.html) which sought to provide a means of formally representing (and thus reusing) learning sequences. Since then, the term has gained a broader usage and is often synonymous with 'course design.' Learning design has seen increased activity in the past few years, as researchers and developers have moved beyond a focus on creation and presentation of content ('learning objects') to a focus on learning activities. Beetham and Sharpe (2007) provide a valuable overview of current work in learning design and provide a 'critical discussion of the issues surrounding the design, sharing and reuse of learning activities, and tools that practitioners can apply to their own concerns and contexts' (p. 1).

The approach advocated here is a holistic one, in which learning design is used to describe the set of methods associated with creating and representing practice. There are several reasons why adopting such a learning design approach is beneficial (Conole, Thorpe, Weller, Wilson, Nixon, & Grace, 2007):

1. It can act as a means of eliciting designs from academics in a format that can be tested and reviewed with developers, or a common vocabulary and understanding of learning activities.
2. It provides a means by which designs can be reused, as opposed to just sharing content.
3. It can guide individuals through the process of creating new learning activities.
4. It creates an audit trail of academic design decisions.
5. It can highlight policy implications for staff development, resource allocation, quality, and so forth.
6. It aids learners in complex activities by guiding them through the activity sequence.

CAPTURING AND REPRESENTING PRACTICE: MEDIATING ARTEFACTS

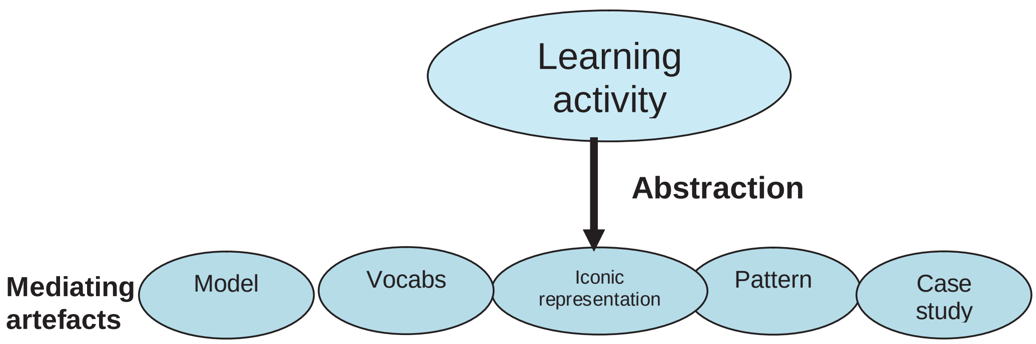
An important aspect of learning design, as outlined above, is the process of eliciting a design describing the essence of a learning activity that can then be reused in the development of a new learning activity. This addresses the first question posed: how can we capture and represent practice? This is a key facet in being able to adapt and reuse existing learning activities. Central to this is the fact that we want to abstract the essential and transferable properties of learning activities; that is, we want to abstract and describe those properties that are effective but can also be applied to other contexts, those properties that are not context bound to a particular instance of activity.

Learning activities can be 'codified' into a number of different *forms of representation*, which each foreground different aspects of the learning activity and which provide a means of illustrating the inherent design. These forms of representation are defined here as *mediating artefacts* because this emphasises their mediating role in terms of how they are used to mediate subsequent design activities. Course designers use a range of these mediating artefacts (MAs) to support and guide decision making, ranging from rich contextually located examples of good practice (case studies, guidelines, etc.) to more abstract forms of representation which distil out the 'essences' of good practice (models or patterns). I am using the term mediating artefacts to align with a cultural historical activity theory (CHAT) perspective (see Cole & Engeström, 1993; Engeström, Miettinen, & Punamäki-Gitai, 1999; Kaptelinin & Nardi, 2006, for an overview of activity theory and its origins). A key idea in CHAT is the notion of *mediation by artifacts* (Kuutti, 1991), which are broadly defined 'to include instruments, signs, language, and machines' (Nardi, 1995). In the context discussed here, I argue that mediating artefacts can be derived from existing learning activities by a process of abstraction (Figure 1). The same learning activity (LA) can result in a range of abstractions:

- A textually based narrative case study describing key features of the LA and perhaps barriers and enablers to its implementation;
- A more formal narrative against a specified formal methodology such as a pattern (see, e.g., Goodyear, 2005);
- A visual representation such as a mind map or formalized unified modeling language (UML) use case diagram;
- A vocabulary such as a taxonomy, ontology, or an evolving folksonomy;
- A model foregrounding a particular pedagogical approach (such as instructivism, problem-based learning, or an emphasis on a dialogic or reflective approach)

Figure 1 concentrates on how one learning activity can be represented through a range of mediating artefacts. Figure 3 later in the chapter goes on to illustrate how these mediating artefacts can then be considered within an activity theory framework as part of the design process. Mediating artefacts help practitioners to make informed decisions and choices in order to undertake specific teaching and learning activities. They differ in a number of respects:

Figure 1. Examples of different mediating artefacts which can be derived from a learning activity



- Their format of presentation (textual, visual, auditory, or multimedia);
- Their degree of contextualization (from abstract to contexualised);
- The level of granularity (i.e., the amount of details available within the MA about the learning activity);
- The degree of structure (flat vocabularies vs. typologies).

EXAMPLES OF MEDIATING ARTEFACTS

Narratives or case studies provide rich contextually located MAs, which are valuable in that they describe the details of a particular pedagogical intervention. The drawback is that precisely because they are so contextually located, they may be difficult to adapt or repurpose. Pedagogical patterns provide a specifically structured means of describing practice building on the work of the Architect Alexander (1979) by presenting the LA in terms of a problem to be solved; see, for example, Goodyear (2005) and the Pedagogical Patterns Project (http://www.pedagogicalpatterns.org/).

Vocabularies represent a more 'atomistic,' text-based form of representation by describing the components involved in learning activities. Currier, Campbell, and Beetham (2006) provide a review of educational vocabularies to describe practice and curriculum design which goes beyond the description of resources, focusing at the level of learning activities. They consider the range of vocabularies that have been developed in recent years to describe practice, including an inventory of existing pedagogical vocabularies, such as flat lists, taxonomies, thesauri, ontologies, and classification schemes. Table 1 illustrates a learning activity vocabulary that lists the key components involved in a learning activity. These include the *context* within which the activity occurs (subject, level, etc.), intended *learning outcomes* (mapped to Bloom's taxonomy) associated with the activity, *pedagogical approaches*, the *tasks* the students are required to do in order to achieve the learning outcomes, and any associated *assets and outputs* (tools, resources, support, or outputs). This has been adapted from a taxonomy developed in previous work (Conole, 2007). This can be used as a checklist in the design process helping to identify and consider each of the components involved in a learning activity and serves to illustrate the variety of factors which constitute a learning activity, further demonstrating the complexities involved in the design process.

Diagrammatic or iconic presentations are important as they provide a means of providing a quick overview of the key features of an activity. They are valuable in that they can emphasise different connections between aspects of the activity and give an indication of structure and a sense of flow or movement. Learning activities can be represented visually adopting a particular iconic representation (Botturi, Derntl, Boot, & Figl, 2006). Examples of this include the formal visual presentations used for UML use cases (see, e.g., Van Es & Koper, 2006) or the approach adopted by the AUTC Learning Design Project (Agostinho, 2006; Agostinho, Oliver, Harper, Hedberg, & Wills, 2002). In the AUTC Learning Design Project, representative learning activities are broken down into a series of *tasks* which students undertake; alongside these, associated *resources* and *support* are illustrated. In addition to these visual 'temporal sequences,' for each learning activity, there is a rich range of additional information about the design process. We have recently developed a particular iconic representation that adopts a similar approach to these (Conole, 2007; Conole, Thorpe et al., 2007; Conole & Weller, 2007), focusing on a set of tasks adopted by each 'role' in the learning activity and an associated set of resources and tools (Figure 2). Two roles are shown (tutor and student), along with the respective tasks (See Minocha et al., 2007, for a more detailed description of the

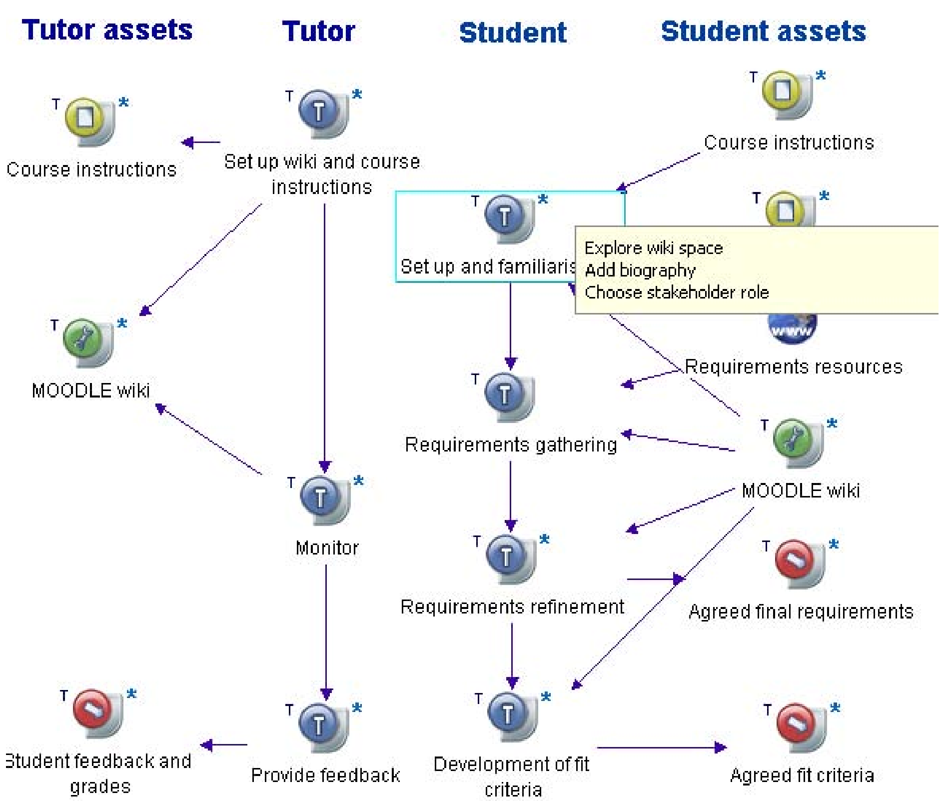
Table 1. Components of a learning activity

Context	Learning outcome, subject, discipline, level, learner characteristics, prerequisites, time to complete							
Pedagogy		**Tasks and supporting assets and outputs**						
Approaches	**Techniques**	**Tasks**		**Tools**		**Resources**	**Support**	**Outputs**
Action research Active learning Case study Collaborative Conceptual Constructivist Dialogic Enquiry-led Experiment Field trip Goal-based scenario Problem-based Procedural Project-based Reflective practitioner Resource-based Role play Vicarious learning	Buzz words Crosswords Drill and practice Exercise Experiment Fishbowl Game Ice breaker Journaling Pair dialogues Panel discussion Peer exchange Puzzles Question/answer Rounds Scavenger hunt Snowball Structured debate Tutorial Web search	Analyse Apply Argue Brainstorm Calculate Classify Compare Construct Create Criticise Critique Debate Decide Define Demonstrate Describe Design Differentiate Discover Discuss Draw Evaluate Experience Explain Explore Gather Generalise Hypothesize Identify Illustrate Infer Interpret Interview Investigate Judge Justify	List Listen Manipulate Model Negotiate Observe Order Organise Practice Predict Prepare Present Produce Question React Read Recite Refine Reflect Report Research Resolve Review Search Select Simulate Solve Specify State Summarise Synthesise Test Translate View Vote Write	Bibliographic software Blogs CAA tools CD/DVD Chat Concordancer Database Digital audio Digital video Discussion board Electronic library E-mail Graphic package Instant messaging iPOD/MP3 player Image software Memory stick Mind map Modeling NVIVO Online assessment Podcast	PowerPoint Project manager Search engine Simulation software Spreadsheet Statistical software Text image audio or video viewer Video conferencing VLE/LMS Virtual worlds Voice over IP Voting system Wikis Word processor	Annotated bibliography Content in blogs Content in wikis Course information Course reading materials Discussion forum content FAQs Interactive CD ROM MCQ Previous cohort resources Schedule/course calendar Peer-generated resource Peer-recommended sites Subject-based Web sites Template Research journal articles Grey literature	Buddying Coach Diagnostic test Explanation Facilitation Formative Feedback Induction Instructions Intervention Monitoring Orientation session Peer collaboration Peer reflection Scaffolding Set up Surgery	Artefact Assignment Book report Concept map Dissertation Essay Paper Performance Portfolio Presentation Product Report Review

development of the activity). Tools, resources, and outputs associated with each task are shown alongside with arrows indicating connections. The diagram was built using a mind mapping tool Compendium (http://www.compendiuminstitute.org/) that enables you to provide hyperlinks between different parts of the diagram. We have adapted Compendium to include a set of learning design specific icons. These can be tagged with appropriate metadata (such as roles, tools, tasks, resources, etc.), and additional information about each element can be layered behind the diagram so that when the user hovers over an icon, additional information appears. For example, in Figure 2, the subtasks ('Explore wikis space,' 'Add biography,' and 'Choose stakeholder role') associated with the task 'Set up and familiarisation' are shown. By clicking on an icon, the user can either be linked to a specific URL, resource, or tool, or to a sequence of layered additional information. Further aspects of this work are touched on in the concluding section of the chapter.

Models provide more abstract forms of representation. Simplistically, a model is an abstract representation which helps us understand something we cannot see or experience directly. Beetham (2004) considers a model to be 'a representation with a purpose' with an intended user and distinguishes five usages of the word: 'practice models or approach,' 'theoretical models,' 'techni-

Figure 2. Visual representation of a collaborative activity using a wiki



cal models,' 'models for organisational change,' and 'students' models'. Models are more than just iconic representations and are usually aligned to a particular pedagogical approach. Examples of learning models in common usage include Kolb's learning cycle (Kolb, 1984), Laurillard's conversational framework (Laurillard, 2002), Salmon's e-moderating framework (Salmon, 2000), and Wenger's community of practice model (Wenger, 1998). Each emphasises different aspects of learning. Kolb presents an action-based or 'learning by doing' model through a four-stage cycle (experience, reflection, abstraction, and experimentation). Laurillard describes the stages involved in the dialogic interaction between a teacher and student, demonstrating the way in which concepts are internalised and adapted by each in the process. Salmon's five-stage framework supports effective e-moderating in discussion forums, emphasising the dialogic aspects of socially situated theoretical perspectives. Finally, although not specifically developed for a learning context, Wenger's theory of communities of practice is valuable as it considers the ways in which communities of practice are formed and developed. He sees four main aspects: learning as community; learning as identity; learning as meaning; and learning as practice. Therefore, each is valuable in that it helps to foreground particular aspects of learning, which can then be used to provide guidance.

MEDIATING ARTEFACTS AS A MEANS OF UNDERSTANDING LEARNING ACTIVITIES

Using the concept of mediating artefacts enables us to foreground the different aspects of a learning activity that a particular representation highlights. MAs have different strengths, weaknesses, and purposes, depending on the context of use and the configurations of their affordances and their constraints. For example, narratives and case studies provide rich contextually located mediating artefacts which are valuable in that they describe the details of a particular pedagogical intervention. The drawback is that precisely because they are so contextually located, they may be difficult to adapt or repurpose. Models and patterns provide more abstract forms of representation. However, because by their nature they are abstractions, practitioners may misunderstand how to effectively apply a model or pattern and, hence, as a result, adopt a surface application of the model to their practice. Patterns are narratives but are grounded in a particular way of thinking which emphasizes a problem-based approach to design.

Agostinho (2006) rightly notes that there is currently no consistent notation system for learning design. The Mod4L Project (http://www.academy.gcal.ac.uk/mod4l/) identified a range of representations that practitioners use to present practice (Falconer & Littlejohn, 2006). These included taxonomies and matrices, visual presentations (flow diagrams, mind maps), and case studies or lesson plans. The project used these with practitioners in a series of workshops to identify their usage and perceived value. They concluded that use is complex and contextualised and that no one presentation is adequate. This aligns with the arguments being made here; by identifying and labeling mediating artefacts, we are able to better understand how learning activities are being represented and how these artefacts might be then used in a mediation role to guide new design.

SUPPORTING PRACTICE: METAMEDIATING ARTEFACTS

Inherent in the rhetoric of current research on learning design is the notion of sharing of good practice and the repurposing of one learning activity into a new learning activity. This addresses the second of the questions posed in this chapter: how can we support practice? Figure 3 shows how existing learning activities can be repurposed to create a new learning activity. First, the essence of a LA is abstracted into a MA. Different MAs highlight or foreground different aspects of the LA. Mediating artefacts can also be aggregated to provide more structured or scaffolded support, for example, in the form of interactive toolkits, planners, or repositories (for example, a library of cases studies). So, for example, a model, case study, or pattern can become part of a repository, which may consist of similar examples or might be a mixture of models, case studies, and patterns. Case studies and models might be combined with some supporting text to form a pedagogical planner or an interactive toolkit. Video clips, case studies, models, and patterns might be reviewed and key points synthesised and put into a set of tips and hints, guidelines, or FAQs (frequently asked questions).

Therefore, mediating artefacts can be aggregated into metamediating artefacts of three main kinds:

- **Aggregates.** The first type consists of aggregates of example MAs, for example, repositories of case studies, patterns, or models or a combined repository containing a mixture of all three.
- **Scaffolds.** The second type consists of scaffolds of some kind (such as FAQs, tips, and hints or guidelines) that synthesise key points and issues.
- **Mixed.** The third type consists of a mixture of example MAs and scaffolds or supporting text, such as toolkits and pedagogical planners.

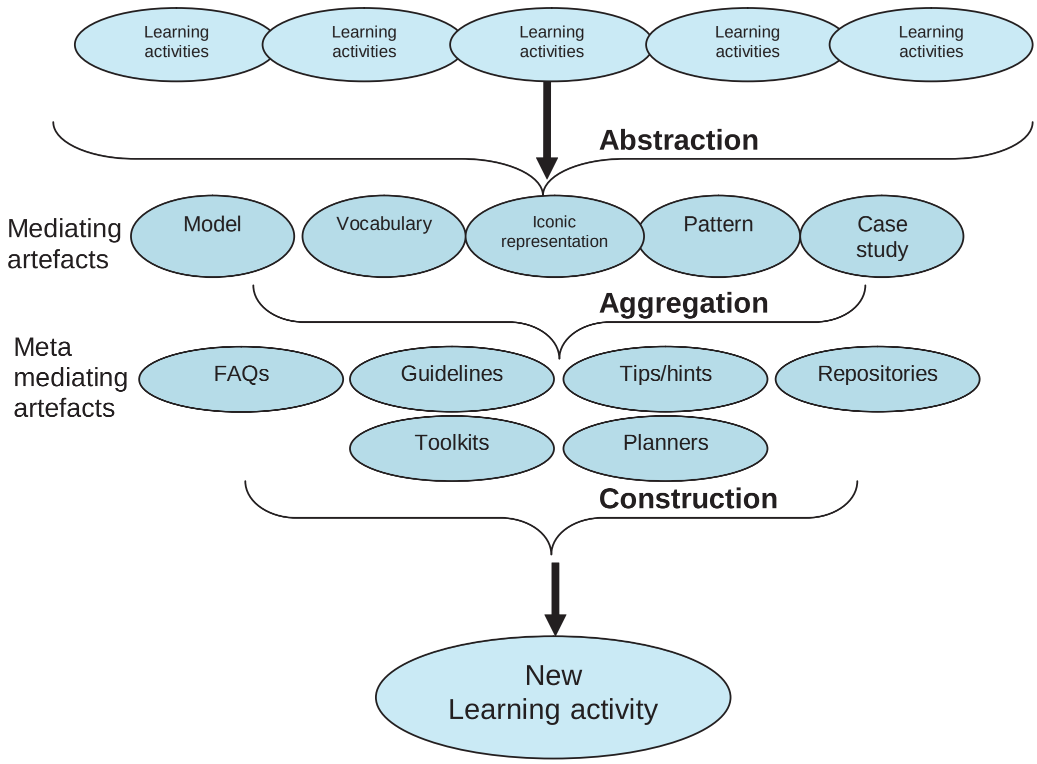
Examples of metamediating artefacts associated with learning activities and learning design include:

- The OTIS repository of case studies (http://otis.scotcit.ac.uk/),
- The e-learning centre library of case studies (http://www.e-learningcentre.co.uk/eclipse/Resources/casestudies.htm),
- The series of effective practice guides and case studies produced by JISC which synthesise key features across their development programmes (http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_practice.aspx),
- The AUTC learning design Web site (http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_practice.aspx),
- The MERLOT database of resources and associated support (http://www.merlot.org), and
- The World Bank Institute Web site which includes a set of tools for learning design; these include tips and hints, a FAQ list, and a series of associated resources (http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_practice.aspx).

Lever (2006) discusses a range of different metamediating artefacts and compares seven examples, which he terms 'educational galleries.' Toolkits and planners represent more structured artefacts that guide users through the process of creating learning activities; examples include the DialogPlus (http://www.nettle.soton.ac.uk/toolkit/Default.aspx), and KEEP (http://www.nettle.soton.ac.uk/toolkit/Default.aspx) toolkits, and the Pedagogic (http://www.wle.org.uk/d4l/) and Phoebe (http://www.wle.org.uk/d4l/) planners.

Figure 3 illustrates the role of mediating artefacts and metamediating artefacts in the design of a new learning activity. It shows how a new LA can be constructed either from individual mediating artefacts (such as a case study, model, or iconic representation) or from a metamediating artefact (such as a toolkit). The figure illustrates the process of *abstracting* learning activities into mediating artefacts that can then be used in the *construction* of a new learning activity. This section has

Figure 3. The role of mediating artefacts in terms of abstracting from existing learning activities and constructing new learning activities

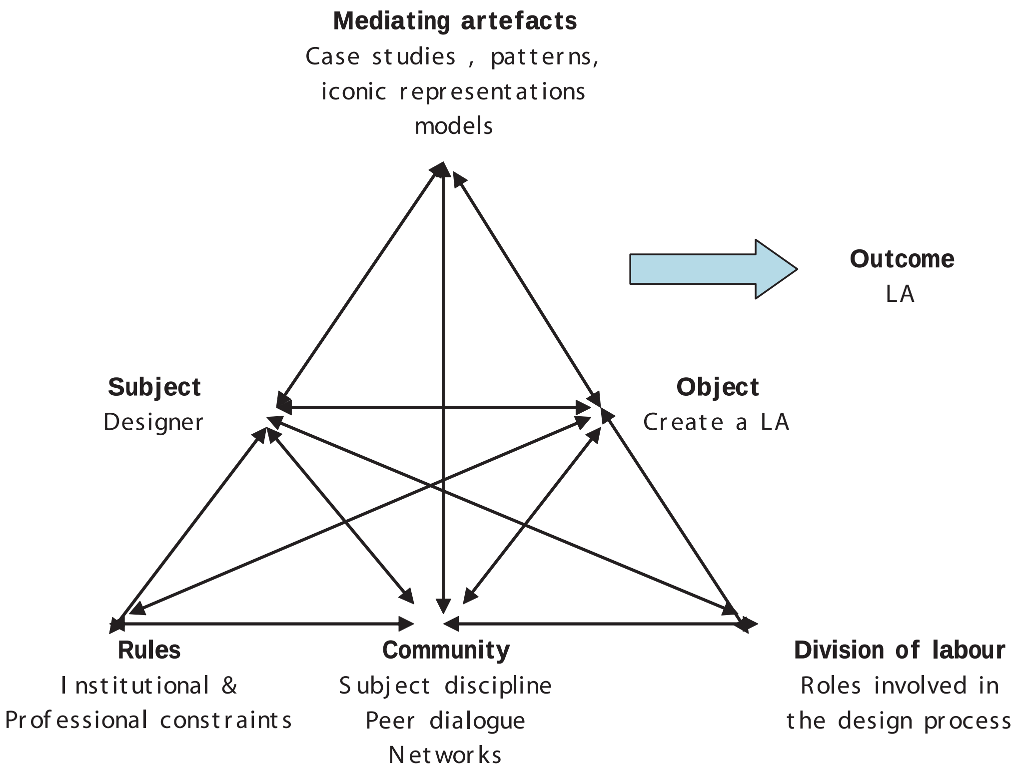


argued that use of the term ‘mediating artefacts’ to describe the different forms of representation, which are associated with a learning activity, helps to make more explicit the value of each MA in the design process. A socio-cultural perspective is used to emphasise both the mediational role of such artefacts and the need to recognise the contextual nature of the design process. This approach is useful because it illustrates the full cycle of abstraction and construction of learning activities and how mediating artefacts are used in the process.

THE THEORETICAL BASIS OF MEDIATING ARTEFACTS

The concept of mediating artefacts as described in this chapter derives from a sociocultural perspective. This perspective recognises that learning activities are contextually bound. Use of an activity theory lens is valuable as it helps to highlight the relationship between the different actors involved in the design process. Figure 4 locates a mediating artefact within a CHAT framework (Cole & Engeström, 1993; Engeström et al., 1999). The subject is the designer involved in creating a learning activity. The object therefore is the motivation to design a learning activity, and the outcome is the designed learning activity. The process can be mediated by a range of mediating artefacts as described earlier. The use of CHAT enables us to more richly describe the context within which this process occurs. First, the design process will involve a number of roles (division of labour). At the simplest level, this may consist of an individual teacher working alone to create a learning activity. However, the design process may be team-based, in which case different individuals might adopt different roles (e-learning advisor, facilitator, evaluator, etc.) or it might be a teacher working in conjunction with an educational developer or an instructional designer. The rules help to contextualise the creation of the learning activity. They include rules and constraints that bound the design process, for example, the institutional context, professional constraints and requirements, local practices, and processes. Finally, the community node helps to identify the range of dialogic mechanisms that are used in the design process. These are important because they provide the designer with flexibility as they provide an opportunity to clarify and discuss issues around the creation of a learning activity in further detail. In a series of interviews with course designers, this dialogic process was cited as one of the most important mechanisms for guiding practice (see Conole et al., 2007, for a description of these case studies). Dialogic mechanisms cited included peer dialogue (e.g., as part of a course team meeting or by asking

Figure 4. CHAT representation of the learning design process



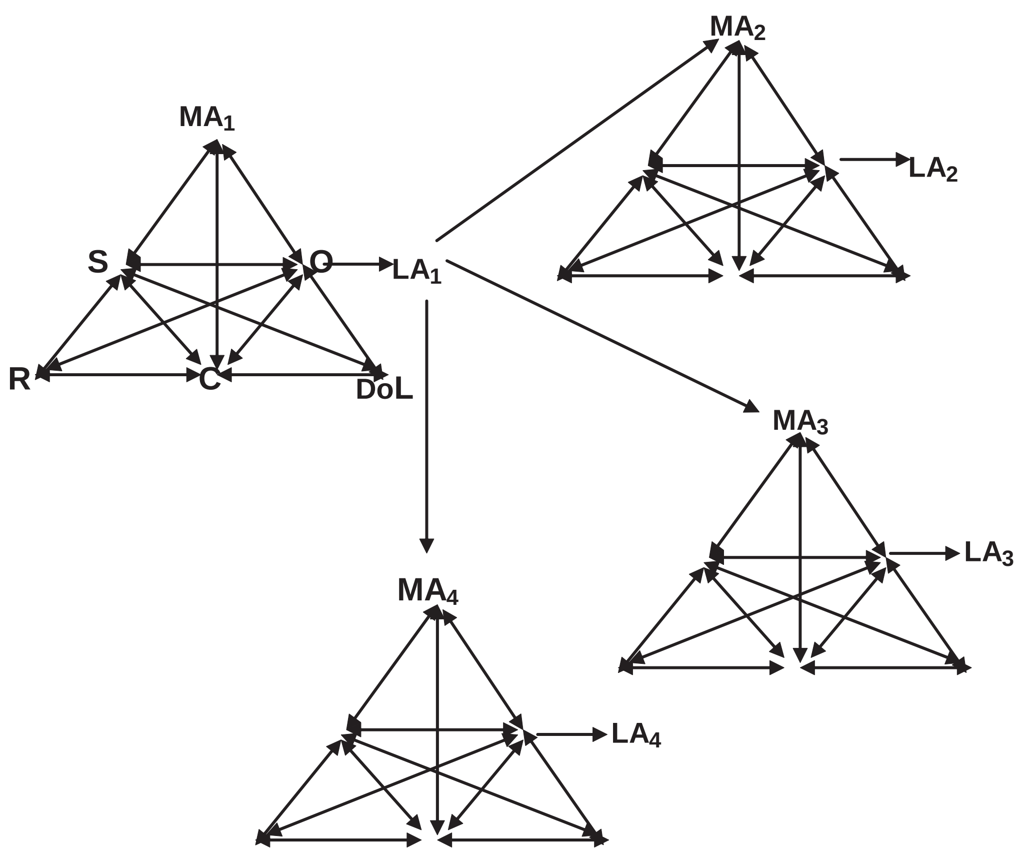
advice from a fellow teacher or e-learning expert about how they designed a learning activity), as well as interactions at conferences, workshops, and staff development events. Surprisingly, online networks and mailing lists were less frequently cited as a form of support.

The learning activity produced as a result of this process can then be represented in a number of different forms of representations which can in turn act as mediating artefacts in the creation of new learning activities (Figure 5). The CHAT triangle on the left illustrates the creation of a learning activity LA_1 using a mediating artefact MA_1. The learning activity, LA_1, can then be represented in a number of forms of representation (MA_2, MA_3, and MA_4, which might be narrative cases studies, iconic representations, video clips, or schematic models) which are in turn used as starting points in the creation of new learning activities (LA_2, LA_3, and LA_4).

CASE STUDY: THE DIALOGPLUS TOOLKIT

The previous section has provided a theoretical basis for the arguments being presented in this chapter. The remainder will illustrate how these concepts can be applied in a practical context. This section describes an example of a metamediating

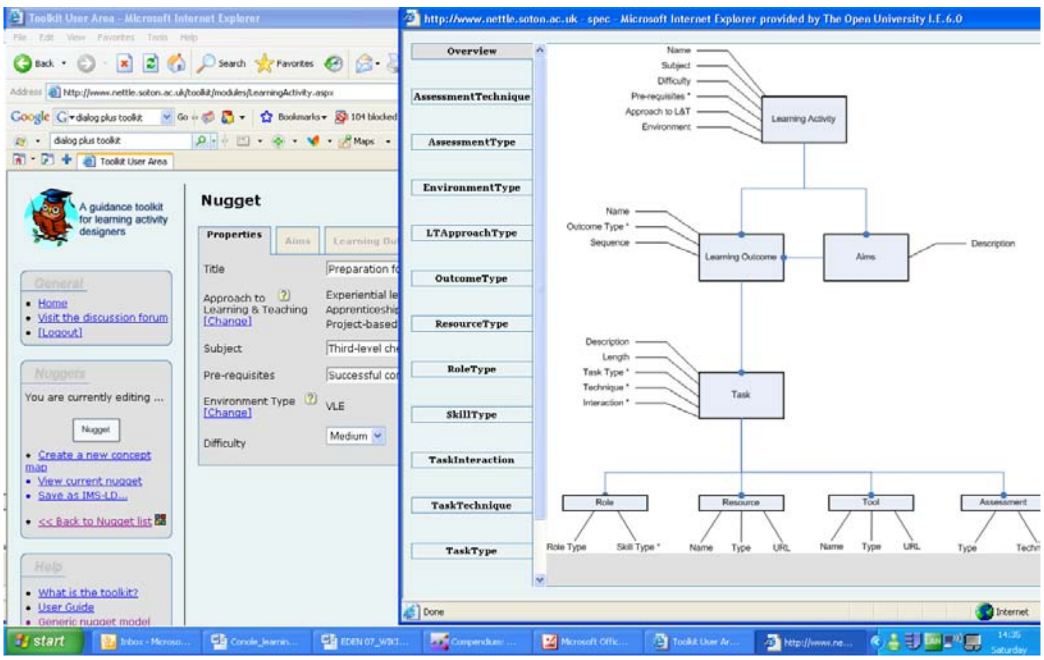
Figure 5. Repurposing of a learning activity via a range of mediating artefacts



artefact, the DialogPlus toolkit, which guides practitioners through the process of developing learning activities (Bailey et al., 2006; Conole & Fill, 2005; Fill, Bailey, & Conole, in press). It is designed to provide the user with support and guidance so that they adopt a more reflective approach to design and hence produce more pedagogically informed learning activities. The toolkit is underpinned by a taxonomy (Conole, 2007) that attempts to consider all aspects and factors involved in developing a learning activity from the pedagogical context in which the activity occurs through to the nature and types of tasks undertaken by the learner. Table 1, which was discussed as an illustration of a *vocabulary* mediating artefact, provides an adapted, revised version of this taxonomy. The taxonomy is based on the premise that learning activities are achieved through completion of a series of tasks in order to achieve intended learning outcomes. Figure 6 shows how the information in the toolkit is layered and contextualised. Tabs are used to guide the user through aspects of design; in the example shown, the user can switch between information relating to the general properties of the learning activity (title, approach to learning and teaching, subject, etc.), and the associated aims, learning outcomes, and tasks. A question mark indicates that additional information and support is available on a particular topic. As illustrated in the righthand side of the figure, a user can also bring up a generic learning activity which demonstrates the relationship between the components of the underlying taxonomy.

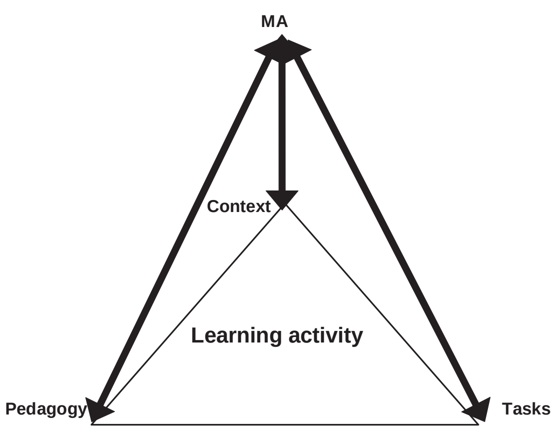
The taxonomy was derived by working with practitioners to elicit the stages involved in the design process and consists of three main components:

Figure 6. Screenshot of the DialogPlus toolkit showing the support and guidance for creating a learning activity



- The *context* within which the activity occurs; this includes the subject, level of difficulty, the intended learning outcomes, and the environment within which the activity takes place.
- The *pedagogy* (learning and teaching approaches) adopted. These are grouped into three categories: associative (acquisition of skills through sequences of concepts/tasks and feedback), cognitive (construction of meaning based on prior experience and context), and situative (learning in social and/or authentic settings).
- The *tasks* undertaken, which specify the type of task, the (teaching) techniques used to support the task, any associated tools and resources, the interaction and roles of those involved, and the assessments associated with the learning activity. In particular, the *types of tasks* a student might do as part of the learning activity are described in detail and grouped into six categories: *assimilative* (attending and understanding content), *information handling* (e.g., gathering and classifying resources or manipulating data), *adaptive* (use of modeling or simulation software), *communicative* (dialogic activities, e.g., pair dialogues or group-based discussions), *productive* (construction of an artefact such as a written essay, new chemical compound, or a sculpture) and *experiential* (practising skills in a particular context or undertaking an investigation).

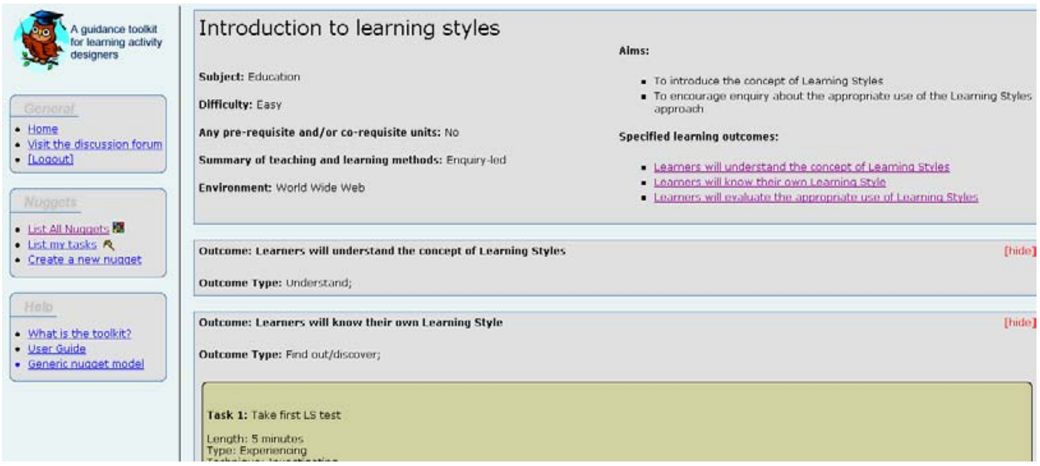
Figure 7. The relationship between mediating artefacts and learning activities



Once the taxonomy had been developed and validated (with practitioners and a community of expert e-learning practitioners), it was used as the basis for developing the architecture for the toolkit. Figure 7 shows the relationship between the toolkit as a mediating artefact and the three components (context, pedagogy, and tasks) involved in designing a learning activity identified in the taxonomy. The DialogPlus toolkit (http://www.nettle.soton.ac.uk/toolkit/) then guides users through the process of developing pedagogically informed learning activities, providing supporting text on each of these components and links to examples and additional resources (Conole & Fill, 2005). Completed learning activities can be uploaded into the toolkit so that they can then be subsequently searched and repurposed by others (Figure 8).

Other examples of metamediating artefacts for learning design include the Phoebe and Pedagogic Planner tools listed earlier. Phoebe adopts a similar approach to DialogPlus by attempting to provide a comprehensive online resource of tips and hints to support decision making. The pedagogic planner instead adopts more of a modeling perspective through mapping tasks to resources and attempting to align the design with specific pedagogical approaches. It is attempting to adopt a user-orientated approach and plans to integrate the tool with LAMS (http://www.lamsfoundation.org/), a tool for managing and delivering learning activities. Both these pedagogic planners and the DialogPlus toolkit consist of a combination of examples and supporting text to guide practice. However, they differ not only in the specific

Figure 8. Screenshot of the DialogPlus toolkit showing a learning activity on "learning styles"



content and examples but also in their underpinning approach.

Fill et al. (in press) argue that:

A key challenge in today's technology-enhanced educational environment is providing course designers with appropriate support and guidance on creating learning activities which are pedagogically informed and which make effective use of technologies. 'Learning design,' where the use of the term is in its broadest sense, is seen by many as a key means of trying to address this issue.

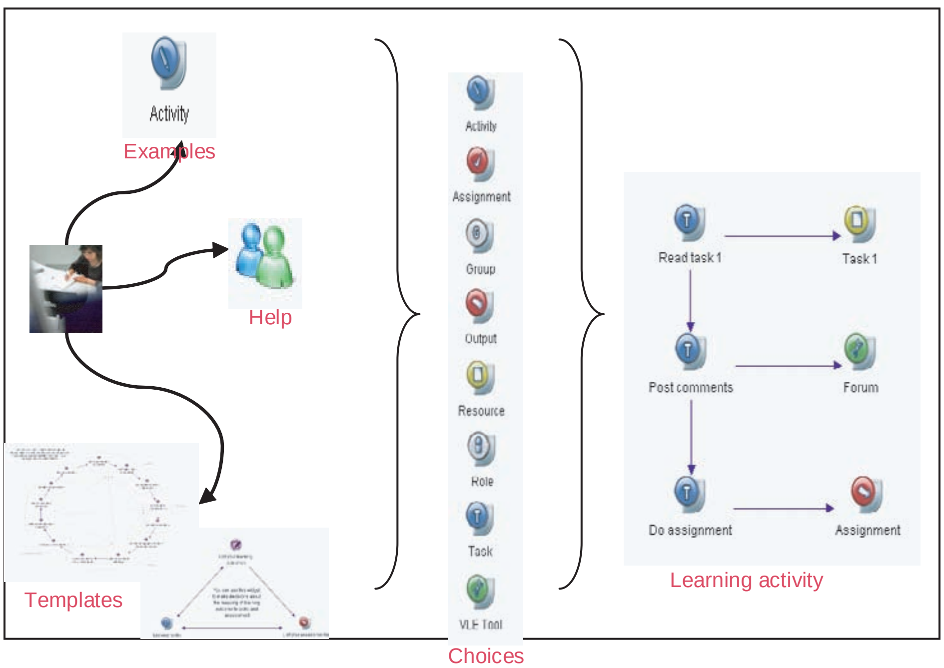
Fill et al. used the notion of guidance and support as the underlying philosophy for the development of the DialogPlus toolkit. However, it is important not to underestimate the complexity and subtlety of the design process. As described in this chapter and articulated in the learning activity taxonomy which underpinned DialogPlus, pedagogy is contingent on many different factors, which means that assuming that a relatively linear and simple decision making design tool will suffice to scaffold design may be over optimistic. On the other hand, it *is* evident that the tool does provide valuable support for reflection and exploration, and in this way to scaffold the design of learning activities. Feedback through evaluation of the tool was positive overall; however, the key issue is whether the tool will *continue* to be used and whether it has an ultimate impact on practice. I would argue now (with hindsight) that it is questionable to what degree such a pedagogically driven (and relatively hierarchically ordered and structured) support tool actually works in practice (albeit very laudable). Reflecting on this work now it seems that a crucial issue is whether users are prepared to commit the time and investment needed to use these types of tools and whether imposing a relatively structured approach is appropriate given the inherently creative and messy nature of the design process.

CURRENT RESEARCH AND FUTURE WORK

A recent series of case studies with practitioners from across a range of subject disciplines (Conole et al., 2007) suggests that course designers are driven more by pragmatic needs than pedagogical theories such as: How can I use a particular set of resources? How can I design an activity which will engage this particular group of students? How can I get these key concepts across? The design process is informed by the subject expertise, peer support, and a lot of trial and error. Furthermore, in related work on the creation of a series of use cases for learning design as part of the LADIE project (http://www.elframework.org/refmodels/ladie), most of the learning activities created fell within a narrow range of pedagogical approaches (Falconer & Conole, 2006). It appears that course designers in both instances seemed unable to 'think outside of the box.' This more recent work has informed our thinking in the development of a new, more flexible learning design tool (see Conole & Weller, 2007; Conole, Thorpe et al., 2007, for a description of this work).

This tool starts from a more pragmatic perspective, namely that the design process is inherently creative and that designers want both examples of good practice (i.e., the capture and representation of practice in question 1) and support/guidance through the design process (i.e., the scaffolding in question 2). Figure 9 provides a vision for the tool we are developing, which attempts to address both questions, enabling the user to work through the design process in creative and iterative ways. In a typical scenario of use, the user would approach the tool and could query an existing set of example learning activities, or use a guiding template (e.g., a step-by-step guide through the design process, as illustrated on the lefthand side of the figure). The user would also be able to access a set of context-sensitive, adaptive help providing them with guidance and further information on different aspects of the design process. The user

Figure 9.



would then work with a set of learning design icons (representing the different factors involved in the design process (such as tasks, tools, resources, assignments, etc.), using these to make informed choices about the creation of the learning activity. A simple example is illustrated on the righthand side of the figure.

An initial prototype of the tool has been developed in the mind mapping tool, Compendium. Eight faculty-based workshops have been run using the tool; initial feedback has been positive; users found the tool easy to use and stated that it both helped them to articulate and share their design processing and thoughts. Work is currently underway to incorporate a range of case studies and adaptive support features.

CONCLUSION

This chapter has argued that there is a gap between the potential of new technologies and their actual use and describes how learning design has emerged in recent years as a possible means of bridging this gap. It has discussed some of the key issues involved in designing learning activities and argues that this is an important area of research because there is now, more than ever, a critical need to provide mechanisms for helping designers make more effective (and pedagogically informed) use of technologies in the creation of learning activities. It applies the concept of mediating artefacts, derived from CHAT, to a learning design context and uses this as a theoretical framework to understand the different ways in which learning activities can be represented and the ways in which different mediating artefacts can be used to support the design process. The chapter argues that articulating the nature of different mediating artefacts clarifies the ways in which each represents different aspects of any one learning activity. The chapter has described the range of mediating artefacts that are commonly used by practitioners, highlighting their different uses. The difficulty of accurately capturing and rarefying practice in this way was discussed. A number of practical tools and approaches for supporting learning design have been described. Recent work on the development of toolkits and planners was described, including our own work on the development of a learning design toolkit, DialogPlus, and our more recent work using the Compendium software as a learning design visualization tool. Overall, the chapter has attempted to demonstrate the complexity behind the deceptively simple questions posed at the start of the chapter: how to capture/represent practice and how to scaffold the design process. It offers a theoretical framework for addresses these questions using the concept of mediating artefacts as the conduit for both abstracting practice from existing learning activities and constructing new learning activities.

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REFERENCES

Agostinho, S. (2006). The use of visual learning design representation to document and communicate teaching ideas. In *Proceedings of ASCILTE 2006*, Sydney. Retrieved March 30, 2008, from http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p173.pdf

Agostinho, S., Oliver, R., Harper, B., Hedberg, H., & Wills, S. (2002). A tool to evaluate the potential for an ICT-based learning design to foster 'higher-quality learning.' In *Proceeedings of ASCILITE 2002*, Auckland, New Zealand. UNITEC Institute of Technology.

Alexander, C. (1979). *The timeless way of building.* New York: Oxford University Press.

Bailey, C., Fill, K., Zalfan. M.T., Davis, H.C., Conole, G., & Olivier, B. (2006). Panning for gold: Designing pedagogically-inspired learning nuggets. *Educational Technology and Society (Special Issue), Theme: Learning Design, 9*(1), 113-122. Retrieved April 24, 2008, from http://www.ifets.info/journals/9_1/10.pdf

Beetham, H. (2004). *Review: Developing e-learning models for the JISC practitioner communities* (Report for the JISC E-Pedagogy Programme). Bristol: JISC.

Beetham, H., & Sharpe, R. (Eds.). (2007). *Rethinking pedagogy for a digital* age. Oxford: RoutledgeFalmer.

Botturi, L., Derntl, M., Boot, E., & Figl, K. (n.d.). A classification framework for educational modelling language in instructional design. In *Proceedings of the 6th IEEE Conference on Advanced Learning Technologies*. Retrieved March 30, 2008, from http://www.ask4research.info/icalt/2006/

Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognition: Psychological and educational considerations* (pp. 1-46). Cambridge: Cambridge University Press.

Conole, G. (2007). Describing learning activities: Tools and resources to guide practice. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age.* Oxford: RoutledgeFalmer.

Conole, G., de Laat, M., Darby, J., & Dillon, T. (2006). *An in-depth case study of students' experiences of e-learning: How is learning changing?* (Final report of the JISC-funded LXP Learning Experiences Study Project). Milton Keynes: Open University.

Conole, G., de Laat, M., Darby, J., & Dillon, T. (2008). 'Disruptive technologies,' 'pedagogical innovation': What's new? (Findings from an in-depth study of students' use and perception of technology). *Computers and Education, 50*(2), 511-524.

Conole, G., & Dyke, M. (2004). What are the affordances of information and communication technologies? *ALT-J, 12*(2), 113-124.

Conole, G., & Fill, K. (2005). A learning design toolkit to create pedagogically effective learning activities. *Journal of Interactive Multimedia Education, 8*. Retrieved March 30, 2008, from http://www-jime.open.ac.uk/2005/08/

Conole, G., Oliver, M., Falconer, I., Littlejohn, A., & Harvey, J. (2007). Designing for learning. In G. Conole & M. Oliver (Ed.), *Contemporary perspectives in e-learning research: Themes, methods and impact on practice* (Open and Distance Learning Series). Oxford: RoutledgeFalmer.

Conole, G., Thorpe, M., Weller, M., Wilson, P., Nixon, S., & Grace, P. (2007). Capturing practice and scaffolding learning design. In *Proceedings of the EDEN 2007 Conference*, Naples.

Conole, G., & Weller, M. (2007). *The OU learning design project.* Paper presented at the 2nd LAMS International Conference, Greenwich. Retrieved April 24, 2008, from http://lams2007.lamsfoundation.org/pdfs/Conole_Weller_LAMS2007.pdf

Creanor, L., Trinder, K., Gowan, D., & Howells, C. (2006). *LEX: The Learning Experience Project* (Final report of the JISC-funded LEX project). Glasgow: Glasgow Caledonian University.

Currier, S., Campbell, L., & Beetham, H. (2006). JISC Pedagogical Vocabularies Project Report 1: Pedagogical vocabularies review. Bristol: JISC. Retrieved March 30, 2008, from http://www.jisc.ac.uk/elp_vocabularies.html

Engeström, Y., Miettinen, R., & Punamäki-Gitai, R.-L. (1999). Perspectives on activity theory. Cambridge: Cambridge University Press.

Falconer, I., & Littlejohn, A. (2006). *Mod4L report: Case studies, exemplars and learning designs*. Glasgow: Glasgow Caledonian University. Retrieved March 30, 2008, from http://mod4l.com/tiki-download_file.php?fileId=2

Fill, K., Bailey, C., & Conole, G. (2008). A toolkit to guide the design of effective learning activities. In P. Rees, L Mackay, H. Durham & D. Martin (Eds.) (forthcominmg), *E-learning for geographers*. IGI Global: Hershey, PA.

Gaver, W. (2006). *Technology affordances*. Retrieved March 30, 2008, from https://www.cs.umd.edu/class/spring2001/cmsc434-0201/p79-gaver.pdf

Gibson, J.J. (1979). *The ecological approach to visual perception*. Houghton Mifflin: New York.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australian Journal of Educational Technology*, *21*(1), 82-101. Retrieved March 30, 2008, from http://www.ascilite.org.au/ajet/ajet21/goodyear.html

Kaptelinin, V., & Nardi, B.A. (2006). Activity theory in a nutshell, acting with technology. In *Activity theory and interaction design* (pp. 29-72). Cambridge, MA: MIT Press.

Kennedy, G., Krause, K.L., Judd, T., Churchward, A., & Gray, K. (2006). First year students' experiences with technology: Are they really digital natives? Retrieved March 30, 2008, from http://www.bmu.unimelb.edu.au/research/munatives/natives_report2006.pdf

Knight, C., Gašević, D., & Richards, G. (2006). An ontology-based framework for bridging learning design and learning content. *Education, Technology and Society*, *9*(1), 23-37. Retrieved March 30, 2008, from http://www.ifets.info/journals/9_1/4.pdf

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Kuutti, K. (1991). Activity theory and its application to information systems development and research. In H.E. Nissen (Ed.), *Information systems research* (pp. 529-549). Amsterdam: Elsevier Science Publications.

Laurillard, D. (2002). *Rethinking university education* (2nd ed.). London: Routledge.

Lever, T. (2006). Who's designing for whom? Comparing taxonomies in Web-based educational design galleries. In *Proceedings of ASCILITE 2006*, Sydney. Retrieved March 30, 2008, from http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p144.pdf

Minocha, S., Schencks, M., Sclater, N., Thomas, P., & Hause, M. (2007). Collaborative learning in a wiki environment: Case study of a requirements engineering course. In *Proceedings of the EDEN Conference*, Naples.

Nardi, B. (1995). Studying context: A comparison of activity theory, situated action models and distributed cognition. In B. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 69-101). Cambridge.

O'Reilly, T. (2005). *What is Web 2.0?: Design patterns and business models for the next generation of software*. Retrieved March 30, 2008, from http://oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-Web-20.html

Salmon, G. (2000). *E-moderating: The key to teaching and learning online*. London: Kogan Page.

Stevens, V. (2007). Second life and online collaboration through peer to peer distributed learning networks. In *Proceedings of the METSMaC Conference*, Abu Dhabi. Retrieved March 30, 2008, from http://www.homestead.com/prosites-vstevens/files/efi/papers/metsmac/metsmac_secondlife.htm

Van Es, R., & Koper, R. (2006). Testing the pedagogical expressiveness of IMS LD. *Education, Technology and Society, 9*(1), 229-249. Retrieved March 30, 2008, from http://www.ifets.info/journals/9_1/19.pdf

Weller, M. (2007). The distance from isolation: Why communities are the logical conclusion in e-learning? *Computers and Education, 49*(2), 148-159.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge: Cambridge University Press.

KEY TERMS

Compendium: An argumentation, or mind mapping tool.

Learning Activities: Those tasks that students undertake to achieve a set of intended outcomes. Examples might include: finding and synthesizing a series of resources from the Web, contributing to a Œfor and against debate¹ in a discussion forum, manipulating data in a spreadsheet, constructing a group report in a wiki, or summarizing the salient points of a podcast. Beetham (in Beetham & Sharpe, 2007) views learning activities in relation to the design process: "as a specific interaction of learner(s) with other(s) using specific tools and resources, orientated towards specific outcomes" (Beetham & Sharpe, 2007, p. 28).

Learning Design: Refers to the range of activities associated with creating a learning activity and crucially provides a means of describing learning activities.

Mediating Artefacts: represent different forms of representation of learning activities. Learning activities can be Œcodified¹ into a number of different forms of representation, which each foreground different aspects of the learning activity and which provide a means of illustrating the inherent design. This emphasises their mediating role in terms of how they are used to mediate subsequent design activities.

Chapter IX
Activity Theory and the Design of Pedagogic Planning Tools

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ABSTRACT

This chapter uses activity theory to construct a framework for the design and deployment of pedagogic planning tools. It starts by noting the impact of digital technology on teachers' practice, particularly the role of planning in the creation of effective technology-mediated learning. It espouses the reconceptualization of planning as design for learning and identifies a key role for the emergent genre of pedagogic planning tools in stimulating practitioners' engagement in this reconceptualized practice. Drawing on activity theory, the chapter then characterizes the principal elements and relationships in design for learning. From the insights gained, it analyzes research data from two projects to pinpoint the enabling factors and tensions in current practice that might be conducive to (or, conversely, impede) the effective design and deployment of pedagogic planning tools. It then synthesizes these into a framework in which software developers and policy makers can explore their own contexts for implementing such tools.

INTRODUCTION

It fundamentally made me think about what I actually do in the class. …The VLE [virtual learning environment] really made me think about "how am I going to project what it is that I give to a lesson when I'm face to face on this screen?"…Usually I don't have to plan my lessons, I just go in and do it. …What it brought me back to was the actual lesson plan, you know, like when you first started off. …it was like that all over again (Masterman, 2006a, p. 31).

E-learning is often talked about as a "trojan mouse", which teachers let into their practice without realizing that it will require them to re-think not just how they use particular hardware or software, but all of what they do (Sharpe & Oliver, 2007a, p. 49).

These observations come from, respectively, a teacher who had recently encountered a virtual learning environment (VLE) for the first time and two researchers with considerable experience in staff development issues. Both express the now commonplace truth that, for many teachers, introducing digital technology into their pedagogy can have ramifications for the whole of their practice—even forcing them to replan from scratch classes which they have taught successfully for years. Many teachers embrace this disruption willingly and with enthusiasm; others, however, remain reluctant to engage with technology, even in institutions where its use is already embedded in the overall teaching and learning strategy.

The reasons for this reticence may lie with the individual practitioners themselves. Data from recent research by Masterman and Manton (2007) point to factors that include a lack of awareness or curiosity regarding the possibilities afforded by technology, "technophobia," lack of time to explore technology, aversion to the risks inherent in experimentation, and—even today—a fear of being supplanted by the computer. Alternatively, the problem may lie in the workplace: for example, other teachers may be using technology to enhance their students' experience, but there are no mechanisms for spreading the message or sharing learning designs. Nevertheless, these individuals find themselves under pressure to adopt technology in their teaching, whether from above (e.g., through making technology use a criterion in performance assessment) or from below, as more and more students arrive at college or university already expert in the use of digital technologies and expecting their tutors to be likewise.

To address this state of affairs, institutions within UK post-compulsory education have begun to assume responsibility at the corporate level for promoting the uptake of technology-mediated learning (e-learning) among teaching staff (Oliver, 2004; Sharpe, Benfield, & Francis, 2006). The concern of this chapter is to drill down directly to the bottom of such institutional initiatives and examine how the uptake can be optimally supported: that is, how to bring institutional change to the individual university or college tutor in such a way that the encounter with novel concepts, forms, practices, and tools will be productive at both levels. This entails studying the individual's practice within the institutional system, keeping the interests of both in balance.

This chapter focuses on planning as the locus of this encounter: that is, where individual practitioners start to get to grips with technology and explore its implications both for their pedagogical (i.e. theoretical) approach and the practicalities of their teaching. More specifically, it is concerned with the mediation of this activity by the emergent genre of pedagogic planning tools (e.g., Earp & Pozzi, 2006; Masterman & Manton, 2007; Walker, Laurillard, Boyle, Bradley, Neumann, & Pearce, 2007). These tools are purpose-built to guide teachers through the construction of plans for learning sessions that make appropriate, and effective, use of technology.

The principal objective of this chapter is to propose a framework for analyzing the planning process in order to uncover the affordances and constraints within current practice that may be conducive to or, conversely, impede the effective design and deployment of pedagogic planning tools and their acceptance by practitioners. This framework is derived primarily from two projects funded by the Joint Information Systems Committee (JISC) and conducted at the University of Oxford between 2005 and 2007. Its ultimate aim is twofold: (a) to provide a means for developers of such tools to contextualize the requirements for their functions and features, and (b) to enable policy makers to explore their own settings and arrive at their own recommendations regarding the deployment of pedagogic planning tools and the policies and processes to support them. In pursuing this aim, the chapter adopts two key positions. The first is a variant perspective on learning design called *design for learning.* The second is the use of activity theory to underpin the analysis of the empirical work.

The chapter will now define the concepts of design for learning and pedagogic planning before characterizing design for learning according to the principles of activity theory. It will then move on to elaborate the framework that lies at the heart of the chapter and conclude with a discussion of the relevance of the framework to other practitioners and of the strengths and weaknesses of using activity theory for this purpose.

FROM PLANNING TO DESIGNING FOR LEARNING: THE PERSPECTIVE OF ACTIVITY THEORY

Defining Design for Learning: A Duality Held in Balance?

The concept of design for learning overlaps with learning design in that it has the same focus on activity-centered learning, activity sequences, and shareability as learning design. However, it additionally embraces the design of sequences of learning activities that involve the use of any technology at all (or even none), regardless of whether the technology is compliant with the IMS learning design specification. Moreover, in terms of process, design for learning restricts itself to "the process by which teachers—and others involved in the support of learning—arrive at a plan or structure or design for a learning situation" (Beetham & Sharpe, 2007, p. 7) that strikes "an appropriate balance between e-learning and other modes of delivery" (JISC, 2004, p. 11).

The advantage of dissociating "design" from a specific form of technology is that it frees researchers to focus on exactly what they wish to support practitioners in doing (design-as-process) and what they want those practitioners to produce (design-as-product). However, analyzing design-as-process is far from straightforward, since even a cursory review of the literature on design yields as many definitions as there are authors on the subject. To paraphrase some characterizations from Winograd's (1996) introduction to a collection of essays on software design, design bridges the gap between technology and the human world; it can involve the application of "systematic principles and methods"; yet simultaneously it is "pervaded by intuition [and] tacit knowledge" and is "a creative activity that cannot be fully reduced to standard steps" (pp. xx, xxii).

Beetham and Sharpe (2007) also recognize the duality inherent in design, and the "for" in "design for learning" is no mere sleight of words, since "learning can never be wholly designed, only designed *for* (i.e. planned in advance) with an awareness of the contingent nature of learning as it actually takes place" (2007, p. 8). It is this foregrounding of the creative and contingent on the one hand, and the rational and systematic on the other, that represents the primary distinction between design for learning and the practice traditionally known as course or lesson planning.

From Lesson Plans to Pedagogic Plans and Learning Designs

The reconceptualization of "traditional" planning as "design for learning" has prompted a new perspective on its outputs, "traditional" lesson plans. These appear to have taken on two forms: *pedagogic plans* and *learning designs*. Pedagogic plans are the direct equivalent of lesson plans, characterized as:

[descriptions of] how learners can achieve a set of learning objectives…how a series of lessons or a single lesson should take place … which activities learners and teachers must carry out, the order in which the activities should be carried out, the circumstances under which the activities will be carried out, how learners will be grouped and what materials or technology may be used (Van Es & Koper, 2006, quoted in Earp & Pozzi, 2006, p. 35).

The quasi-neologism "pedagogic plan" serves two functions. First, it is intended to appeal to university teachers, who usually denote learning sessions by their formal structures (e.g., lecture, seminar, tutorial) and find the concept of a "lesson" both alien and alienating. Second, the adjective "pedagogic" acts as a mnemonic: a reminder that the consideration of one's approach to teaching and learning is an integral part of structuring a sequence of learning activities. Indeed, the contemporary concept of pedagogy "embraces an essential dialogue between teaching and leaning" (Beetham & Sharpe, 2007, p. 2), which is lent urgency by the capacity of digital technologies to bring to the surface hitherto tacit aspects of pedagogic practice.

A learning design embraces not only the pedagogic plan and the supporting resources themselves (e.g., handouts and digital presentations), but also information relating to the outcomes of the learning session that was taught using the plan. This information may include assessment scores, student feedback, and reflections by the teacher, together with other artifacts that other practitioners have identified as helpful for making sense of the design and, hence, determining its adaptability to their circumstances (cf. Falconer & Littlejohn, this volume).

DESIGN FOR LEARNING AS AN ACTIVITY SYSTEM

Activity theory (Center for Activity Theory, 2004a, 2004b; Kuutti, 1996; Leont'ev, 1981) has been chosen to underpin the analysis of design for learning for two reasons. First, given the concern of this chapter to hold in view both the individual practitioner and the institution, activity theory is a particularly suitable analytic tool through its function as "a philosophical and cross-disciplinary framework for studying different forms of human practice as development processes, with both individual and social levels linked at the same time." Indeed, it is argued that the individual's actions are impossible to understand without knowledge of the social context in which they take place (Kuutti, 1996, p. 25). Second, the notion of historicity inherent in activity theory—namely, that "problems and potentials [of activity systems] can only be understood against their own history" (Engeström, 2005, p. 315)—resonates with the premise of this chapter that innovation must be built upon an understanding of present practice.

Activity theory has played a role in the design and evaluation of e-learning environments for well over a decade (see, e.g., Bellamy, 1996; Ravenscroft, 2001; Scanlon & Issroff, 2005), but instances of its application to the domain of design for learning remain few. However, Oliver (2004) has used it to analyze the production of digital resources to support academics, and Beetham (2007) acknowledges its influence on her model of a learning activity.

Delineating an Activity

An activity is distinguished from other practical undertakings by its *motive*: that is, the need to work on some form of *object*, or "problem space" (Center for Activity Theory, 2004b), and transform it into an *outcome*. The object may be a material artifact (as in a manufacturing activity) or an abstract entity, as with design for learning. Here, the object is the learning session that is being "designed for," and the outcome is the pedagogic plan and other components of the learning design that can be created or specified in advance of the session itself.

The scope of an activity is open to interpretation and can range from "systemic formations which gain durability by becoming institutionalized" (Engeström, 2005, p. 312), such as an entire university, to small-scale short-lived structures, such as a series of classes on a particular topic. Moreover, an activity system does not necessarily consciously recognize itself as such, and in reality may exist more as an analytical construct for the researcher than as a formally delineated entity. What counts, however, is that for analytical purposes the activity should have a motive giving it "directionality, purpose, and meaning" (Engeström, 2005, p. 312).

The Structure of an Activity

As a system, an activity is composed of a number of interacting elements in addition to the object and outcome. It is always carried out by one or more human *subjects*: in design for learning, typically (but not exclusively) teaching staff. However, even where an activity has multiple subjects, it is essential to capture the perspectives of individuals, whether they fulfill similar roles (e.g., views of different teachers) or different ones (e.g., teaching staff and learning technologists).

The activity is mediated by two types of tools: *technical tools*, which mediate physical actions, and *psychological tools*, which mediate cognitive actions (Vygotsky, 1981). Language is the primary psychological tool, but Vygotsky's definition also includes algebraic symbol systems, writing, and diagrams. The concepts and representations coined by design for learning—learning designs, pedagogic plans, learning activity sequences, and so forth—are thus psychological tools for helping teachers to think about their practice in new ways. Of course, for psychological tools such as pedagogical plans to be accessible to others, they must exist as artifacts in the real world constructed with the aid of technical tools (e.g., pencil and paper or computer).

The social dimension of an activity means that it is always considered to be carried out within a *community*, even if the subject is working in physical isolation. A community can be formally constituted (e.g., a college, university, or special interest group), or it can be an informal grouping of people who share a common interest. Communities can overlap (in that someone may belong to both a university department and a society for subject-specialists), or be nested within each other (e.g., a department within a university).

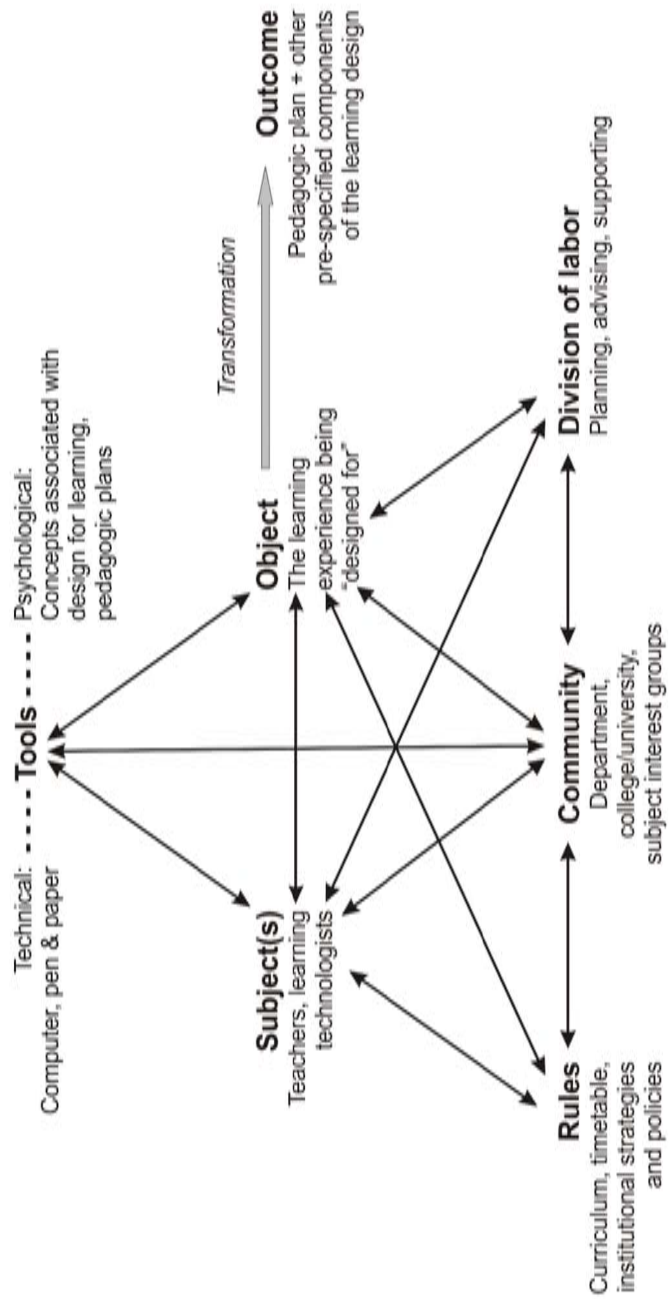
Rooting the activity in its social context throws into relief two additional mediational elements: a set of *rules* and the *division of labor*. Rules are "explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system" (Center for Activity Theory, 2004b). In design for learning, they are recognizable as, *inter alia*, curriculum, time tabling, and procedures for booking IT facilities. The division of labor determines how the task is segmented among the subject(s) and other members of the community since, "in order for a community to achieve a common objective, the activities of the individuals in it must be organized, and the paths of communication coordinated" (Bellamy, 1996, p. 125). Thus, for example, senior lecturers may plan a course curriculum, junior lecturers may take responsibility for a subset of study units within that curriculum, learning technologists advise on the effective use of technology, and IT support staff maintain the hardware and software (i.e., the technical tools).

Engeström (1987) developed the now ubiquitous triangular representation of an activity systems as a set of reciprocal paired relationships among the elements of the system. In Figure 1, it has been applied to the activity of design for learning.

Change and Development within the Activity System

Despite the appearance of stability suggested by the triangular representation, an activity never stands still. Instead, it is continually changing and developing in expansive cycles (Engeström, 1987) that are driven by *contradictions*: "structural tensions" (Engeström, 2005, p. 313) or misfits (Kuutti, 1996) occurring both within the activity system and between the activity and other activities with which it interacts. The first type of contradiction within an activity system lies within an individual element: specifically, in the disparity between its "use value" and its "exchange

Figure 1. Visualizing the activity system as a triangle throws into relief the relationships among elements. Note, however, that despite the absence of arrows direct relationships may exist between tools and rules, tools and division of labor, and rules and division of labor.



value" (Engeström, 1987). In design for learning, this may be manifested in the usefulness of, say, a concept-mapping tool to an individual teacher vs. the cost to his college of acquiring the tool and supporting its use. However, if the teacher then decides to make use of a similar, free-of-charge Web-based tool instead, then the teacher may find a conflict with college regulations that do not allow staff to run externally hosted software. A second type of contradiction would be thus created, this time between two elements in the activity system: here, an innovative tool and the rules barring its use.

An activity system can interact with other activity systems in the sense that its elements may be the products of those other activities. A straightforward example is a software development activity that has produced the word processor in which a teacher in the design-for-learning activity constructs pedagogic plans. Another, with the potential for contradiction, is the activity that has resulted in a teacher adopting a particular pedagogical approach. If the teacher has not undergone formal teacher training, but instead bases the approach on the knowledge-transmission model encountered during university studies, then the teacher may have difficulty espousing the constructivism inherent in design for learning. There will thus be a contradiction between the teacher's previous learning activity, one of the outcomes of which was a didactic conception of teaching, and the activity of designing for learning.

When a contradiction of any kind irrupts into an activity system in the form of a more culturally advanced (i.e., innovative) practice or tool, the system seeks to resolve that contradiction by investigating how the new practice or tool might be appropriated and a new model for the activity generated. The expansive cycle will then restart as contradictions begin to surface once the new model has been implemented. In this way, design for learning can be viewed as a creative response to the contradictions generated by new digital technologies, but one which remains developmentally linked to—that is, rooted in—"traditional" planning. Identifying the contradictions in the planning activity as currently practiced by teachers, and exploring their implications for pedagogic planning tools, constitute the main thrust of the remainder of this chapter.

TOWARDS A FRAMEWORK FOR IMPLEMENTING PEDAGOGIC PLANNING TOOLS

Keeping in mind the foregoing characterization of design for learning as an activity system, this chapter now turns to its principal focus. Drawing on data from the two projects outlined below, it uses activity theory to analyze current practice in order to put forward the framework of questions to inform the development and deployment of pedagogic planning tools.

Methodological Aspects

Most of the data contributing to the framework were collected in the Learning Design Tools Project (or the LD Tools Project) (Masterman, 2006b; Masterman & Vogel, 2007), funded by JISC. This project gathered research-based information on the use of generic tools in planning: word processing, spreadsheets, presentation tools, and mind-mapping and concept-mapping software, as well as pencil and paper. Quantitative, and limited qualitative, data were collected through an initial online questionnaire, while extensive qualitative data were elicited later from semi-structured interviews and lesson plans collected at specially convened workshops. During these workshops, practitioners created a lesson plan using tools in the two categories listed above. Participants who were unfamiliar with mind-mapping and concept-mapping software had the opportunity to familiarize themselves with MindManager® (Mindjet Corporation) and VUE (Tufts University) before embarking on this task. In all, 70 lecturers, tutors, and learning technologists completed the questionnaire, 39 of whom also participated in the workshops. They represented the full spectrum of subject domains and types of institution in postcompulsory education. The data reported here are largely qualitative, in order to illustrate the various contradictions and enabling factors in the activity of planning. The quantitative data are reported at length in the project report (Masterman, 2006b), from which substantial portions of the present chapter have been adapted.

A requirement of the project was to compile recommendations to practitioners and policy makers on the effective deployment of tools in designing for learning. However, implicit in the concept of "effective deployment" is an assumption that there exists an objectively defined set of criteria against which any tool or process may be measured absolutely. In practice, of course, it is possible to assess effectiveness only in relation to the use of a particular tool by a specific practitioners or functional group of practitioners within a particular setting. Therefore, rather than offer "one-size-fits-all" recommendations, the research team decided to put forward a framework in which the respective stakeholders—in this case, primarily practitioners and organizations—could evaluate the potential for different tools within their own contexts and derive their own recommendations.

A small proportion of the data used to illustrate the construction of the framework were drawn from the JISC-funded "Phoebe" Project (Masterman & Manton, 2007), which developed and evaluated a prototype online pedagogic planning tool. The design requirements for Phoebe were derived substantially from the LD Tools Project and from scenarios constructed from semi-structured interviews with nine practitioners in different sectors of post-compulsory education. They also represented a number of institutional stances *vis-à-vis* e-learning, ranging from enthusiastic promotion to near-disinterest. To generate these scenarios, data were analyzed using a grounded-style approach rather than activity theory; however, individual items are included here for their interest and relevance to present purposes. They are reported for the first time here.

Constructing the Framework Using Activity Theory

Activity theory was chosen to provide the theoretical underpinning for the framework for the reasons explained in "Design for Learning as an Activity System" section above. In addition to the contradictions reported by project participants, the researchers looked for "enabling" phenomena: that is, those which, if the proposed tools are deployed, should promote successful execution of the activity. These were interpreted as indications of design-for-learning practice, even though the activity systems in which they occurred did not (yet) explicitly align themselves with this new perspective. From the contradictions and enabling factors, the researchers extrapolated a series of questions they felt policy makers and developers would need to address, regardless of the number of occurrences of that factor in the actual data.

In the first version of the framework (Masterman, 2006b), the evidence, and hence the questions, were categorized according to the six elements within the activity triangle. However, this resulted in a number of overlaps and confusions: for example, if a contradiction involved both subject and tools, under which element should it be categorized? On review, it proved more productive to categorize the data according to the relationships between elements, since it is in these that the dynamism and forward trajectory of the activity lie. However, when constructing the actual framework, the researchers regrouped questions again, this time under four headings with which they envisaged its audience might identify: the problem-space or task (i.e., object), community and users (i.e., subjects), and technology (i.e., tools). The revised framework is presented in Table 1, and the next few sections show how the questions were elicited from the data, using the notation *(→ Q#)*, where *Q#* corresponds to the question number.

Subject–Object Relationship

A key aim of design for learning as an emergent activity is to expand the object as currently perceived by the subject, or subjects, and to open up them to new ways of working. In the words of one college tutor, "each time we introduce a new technology it opens up ways of doing things that may have always been done, but which can now be done more effectively." A key driver in this process is a disposition towards critical reflection: according to a university staff-develop-

Table 1. Framework of issues for consideration in the design and deployment of pedagogic planning tools

Working in the problem-space: supporting individual and collaborative planning tasks

Will the tool

P1. Provide a representation (or representations) of the pedagogic plan that
- Contains all the required components?
- Supports the way in which users think about the problem space?
- Is appropriate to the different subtasks involved in planning?
- Can be used to realize the plan as a learning session (face-to-face, online, or blended)?
- Is meaningful to the practitioners with whom it is shared?

P2. Accommodate a multiplicity of paths through the design activity? For example, will it allow users to
- Work on different stages concurrently?
- Revisit earlier stages in the process?

P3. Unify the plan with the other components of the learning design (e.g., handouts, assessment scores) either by storing them in the same location, or by enabling links to the locations where the other components are kept)?

P4. Enable pedagogic plans to be edited by multiple users for the purpose of
- Collaborative planning?
- Mentoring?

P5. Enable communication among collaborating practitioners in order to orchestrate the different roles they take?

Community aspects of fostering and sustaining design for learning

D1. What role might the tool play in the institution's staff-development program for e-learning?

D2. Will the tool incorporate guidance on effective practice in design for learning relevant to practitioners in the institution?

D3. Will the tool support the sharing of learning designs by allowing users to
- See and adapt the learning designs of colleagues?
- Access relevant learning designs created by practitioners elsewhere?

D4. How might communities be formed and fostered within the institution in order to
- Encourage and support practitioners as they engage in design for learning; for example, through peer-mentoring?
- Promote the sharing and reuse of learning designs among colleagues?

D5. What are the communities outside the institution into which practitioners might tap?

D6. What institutional strategies, policies, models, and procedures need to be modified in order to promote creativity in design for learning; for example, in terms of
- Pedagogic approaches and models of learning?
- Policies governing the use of technology?

What might be the implications of such modifications?

continued on following page

Table 1. Framework of issues for consideration in the design and deployment of pedagogic planning tools (continued)

Users' needs and preferences
U1. What efforts are being made to consult practitioners directly about their needs and preferences in relation to pedagogic planning tools, and to synthesize these individual requirements into a general specification for the tool?
U2. Where an existing tool is being evaluated for potential adoption, to what extent do its interface and functionality facilitate or impede the user's task?
Technology issues
T1. Where a new tool is being developed, will it be distributed free of charge, and if so, will the source code be openly available?
T2. Where an institution is considering acquiring an existing tool but is restricted to purchasing only a limited range of existing software applications, what suitable free or open-source tools are available? • What efforts need to be made to establish a community of users of these applications within the institution, and what resources are there to support and sustain such a community? • Are restrictions currently placed on access to free-of-charge online tools? Can they be overcome?
T3. What level of technical expertise is required on the part of individual users in order to work productively with the tool? • What steps need to be taken, or are being taken, to raise that level of expertise where necessary, and to provide ongoing support to individual users?
T4. Will practitioners be able to access the tool away from the workplace? • If the tool is sold as proprietary software, is there a scheme under which practitioners can have licenses for their home computers? • If the tool is Web-based, can it be run off-line?
T5. Can the tool(s) run on mobile devices (e.g., PDAs)?

ment officer, the practitioners most receptive to change are those who are "happy to talk about their teaching … [and] interested in moving their teaching forward." This suggests a staff development context for the introduction of pedagogic planning tools *(→ D1, D2)*.

Data from the LD Tools Project suggested that the transformation of object into outcome involves a limited number of steps: brainstorming, organizing ideas, creating the plan, and sourcing the associated learning materials. However, the data also showed that practitioners' paths through these steps are by no means uniform or even linear: they may have different starting points (e.g., learning outcomes or activities), iterate between planning and resource creation, or carry out actions in parallel. Thus, where possible, it is important that the design of a tool should recognize and support this diversity in task execution *(→ P2, P4)*.

Subject–Community Relationship

As already stated, even a subject who works alone is indivisible from the community or communities of which he or she is a part. Although a number of practitioner-informants in the Phoebe Project testified to instances of lone innovators, the role of explicitly delineated supportive design-for-learning communities is paramount. As one of the Phoebe practitioner-informants put it, "It comes out of networks of people who are interested in teaching." The community can also be recruited to support the technology-reticent, by creating "teams of people, where the strong carry the weak along with them" (learning technologist in a university). These supportive communities may be formed in the "home" workplace (Sharpe et al., 2006), they may be online groupings (Earp & Pozzi, 2006), or they may follow a peripatetic model (Ferrell & Kelly, 2006) *(→ P4, D4, D5).*

Community–Object Relationship

Together, communities constitute the sociocultural context in which the transformation of the object takes place: for example, how it is prescribed (curriculum planning bodies), carried out (practitioners), and enabled (IT support staff). Yet the object has the power to develop and strengthen communities of practitioners, in particular, through the sharing and reuse of learning designs. True, sharing and reuse have hitherto had a limited impact in the UK, especially in the university sector and across institutions (Lucas, Masterman, Lee, & Gulc, 2006). However, they are increasingly recognized as essential to effective practice and can grow from such modest internal initiatives as informal peer-observation, posters on notice boards, articles in staff magazines, and departmental discussion groups *(→ D3).*

Subject–Tools Relationship

The relationship between practitioners and the psychological and technical tools with which they construct their pedagogic plans was explored extensively in the LD Tools Project. The psychological tools are primarily the successive representations through which practitioners capture and organize their ideas during the planning process: outputs from brainstorms laid out on adhesive slips of paper ("sticky notes") or as mind maps; rough notes; and even Microsoft PowerPoint® presentations which fulfill the dual role of planning tool and learning resource. They also include predefined "templates" for pedagogical plans, as well as the finished plans themselves, an example of which is shown in Figure 2.

The project used a cognitive framework, the five "dimensions of fit" (Peterson, 1996), to illuminate the relationship between practitioners and the tools which they use—or would like to use—in design for learning. This framework was designed for application to different forms of representation; here, it is extended to technical tools. The key dimensions relevant to the subject–tool relationship are *user-fit, process-fit,* and *circumstance-fit*.

A tool with good user-fit supports the user's own cognitive characteristics, such as the capacity for different types of reasoning, powers of memory and processing, and level of expertise in the domain (Peterson, 1996). The first of these characteristics is well illustrated by this quotation from a university teacher: "I prefer the mixtures of both diagrams and verbal thinking. …Sometimes I doodle—it's the shapes—I need to visualise first, then formalise it" (Masterman, 2006b, p. 35).

Process-fit applies to the properties of the actual representations which practitioners construct and manipulate during the course of their planning. These must be suited to the kinds of mental operations they are performing; hence, for example, "thinking about a linear process does not go well with [a mind-mapping tool's] non-linear and multi-directional approach" (unidentified practitioner quoted in Masterman, 2006b, p. 33) *(→ U1).*

As applied to the user-tool relationship, circumstance-fit roughly equates to usability: the extent to which the tool feels natural to use or, conversely, interferes with the user's performance: "It didn't come naturally to do [mind-]mapping. Pen and paper is very natural. I was so focused on the [mind-mapping] tool that it got in the way of my flow" (university teacher, quoted in Masterman, 2006b, p. 36) *(→ U2, T3).*

The above examples show how the user's characteristics and needs influence the nature

Figure 2. Pedagogic plan produced by the author and a colleague for a master's program in e-learning

MSc E-LEARNING SESSION PLAN: SESSION 16

TITLE OF SESSION: Learning Design and Design for Learning
DATE OF SESSION: Tuesday 14th November
LEAD TUTORS: Liz Masterman, Howard Noble
LOCATION: OUCS Windrush Room
TIME: 9-12.30

SESSION CONTENT SUMMARY
Students will be introduced to the concepts of Learning Design and design for learning. They will then have hands-on experience of a learning design tool, LAMS, as both learners and authors, as well as such other tools as the available technology permits. Finally, students will explore, through discussion, the issues associate of practitioners and the establi:

LEARNING OBJECTIVES
The aim of this session is for s
1. Gain an understanding of t and design for learning, in
2. Use, and critically apprais
3. Consider the cultural, soci objects.

READING LIST
Britain, S. (2004). *A Review of the JISC E-learning Pedagogy* www.jisc.ac.uk/uploaded_doc
Conole, G. and Fill (2005). A activities. *Journal of Interacti*
Dalziel, J. (2003). Implementi (LAMS). Available at www.m
Malcolm. M. (2005). The exer *British Journal of Educational* http://tdnet.bodley.ox.ac.uk/.

DETAILED SESSION PLAN

Timing	*Activity*	*Tutor*	*Materials for students*	*Materials for tutors*
Before	**PREPARATION**			
	• Reading • Thinking about the processes involved in planning a learning session		• Email & briefing document	
9.00-9.30	**INTRODUCTION TO LEARNING DESIGN**			
9.00-9.20	Welcome Presentation: definitions; concept and practice of learning design incl. reuse of learning objects	LM		PowerPoint presentation
9.20-9.35	Overview of LD: IMS LD etc.	HN		
9.35-9.45	Questions and discussion of material covered so far	LM, HN		
9.45-10.40	**LEARNING DESIGN ACTIVITY 1** *Purpose: Get a feel for the process of design for learning as people do it currently: multiplicity of paths through the process, differences in terms used to describe the same/similar things.*			
9.45-10.20	*Divide into pairs or threes. NB ensure that at least one group member has teaching experience.* Walk through the process of planning	LM	Activity 1 Briefing doc (x10) Cue cards (x5) Flipchart paper, coloured pens, glue sticks, scissors	
10.20-10.40	Tutor-initiated feedback: groups present their "flowcharts."	LM	Finished representations of the D4L process	

of the tool chosen. However, in keeping with the transactional nature of relationships within the activity system, the tool also has the potential to change the way in which the user thinks, as shown in this extended extract from an interview with a teacher in adult and community learning. Normally, she used a template plan provided by her college, but in the LD Tools Project workshop she experimented with a mind-mapping tool:

Normally, I'd tend to do it linearly. You know: 9.00 o'clock we start doing this, then 9.30 we start doing this. …I think that doing it in a free style like this is making me think about the different types of things you can do—the different activities you can do. …I'm hoping that maybe it helps me think about things in more creative ways (Masterman, 2006b, p. 26).

The tool has not merely facilitated a different perspective on the object; it appears also to be expanding the user's cognitive capabilities. This suggests that providing teachers with alternative tools, in addition to the ones with which they are currently comfortable, opens up possibilities for individual expansion.

Tools–Object Relationship

The relationship between tools and object can also be analyzed using the "dimensions of fit" framework, this time under the categories of *ontology-fit*, *task-fit*, and an additional interpretation of circumstance-fit. Peterson defines ontology as "a conceptual framework, or set of features of the world which are relevant to the performance of [a particular] task" (1996, p. 9). In the context of a learning design, this means that it must be possible to represent not only all the required elements of the design (as listed earlier in the chapter), but also the relationships among those elements where relevant. Poor ontology-fit accounts for this contradiction encountered by a learning technologist who struggled to represent her plan as a mind map: "I…had content in one space and activities in the other and I had them all together as the same thing, but I couldn't go any further because I couldn't separate out process from content" (Masterman, 2006b, p. 31) *(→ P1, P3)*.

The dimension of task-fit relates to how useful and appropriate the tool is to the purpose of the task for which it is being used. It helps to explain the continued prevalence of pencil-and-paper tools in the early states of planning, as shown in this quotation from a university lecturer:

1. Pen and paper – broad conceptual overview, key learning activities mapped as a storyboard/concept map. 2. Formalise this map in Word® or PowerPoint®. 3. Detailed matrix of [learning outcomes], activities and assessment in Excel® for detailed analysis etc. (Masterman, 2006b, p. 15).

In relation to psychological tools, task-fit may necessitate switching between different forms of representation according to the task being carried out; for example:

I found mind-mapping software helped sort out the interrelation of issues at strategic level. It helped with overall planning. Course level has been more difficult. The staff who do that detail tend to work in a linear fashion—i.e. planning over course weeks to meet set criteria. They liked the idea [of mind-mapping] but soon fell back into using Word®/table grid (head of adult and community learning college quoted in Masterman, 2006b, p. 31).

Within the tools-object relationship, circumstance-fit applies to the suitability of the tool to the physical environment. In addition to the workplace, this may be the home or even the pub: locations that have implications for Web-based tools in particular *(→ T4, T5)*.

Community–Tools Relationship

The transactional nature of the community–tools relationship is manifested in a number of ways. At the institutional level, the community may determine what tools can, or must, be used: for example, dictating what software can be used in pedagogic planning *(→ T1, T2)*. At the level of the practitioners themselves, the community may actually be dependent on tools to build and sustain it, especially where far-flung members have to use e-mail or discussion boards to communicate and to share resources (Masterman, 2006b). Finally, communities can also be influential in shaping new tools to suit their own needs. For example, the workshops conducted by the LD Tools Project brought practitioners together in transient communities to try out different tools and to construct wish-lists of requirements for input into the development of the Phoebe pedagogic planning tool *(→ P5, P3, U1)*.

Relationships Involving Rules

The primary effect of what activity theorists refer to as "rules" is to support or, conversely, constrain how subjects work on the object. For example, a tutor at one college visited during the Phoebe project described how it had developed its own framework for teaching and learning specifically designed to support students in the transition from teacher-led to independent learning, and e-learning is firmly embedded in it: "Where students ask 'when's the deadline?' or 'what are the criteria for this assignment?' [we] tell them to look on [the VLE]—and even this shifts their perspective." Even so, in other settings creative design for learning may struggle to assert itself in the face of a curriculum that prescribes what must be taught, as opposed to what the practitioner and learners might like to cover in order to satisfy learners' curiosity for knowledge *(→ D6).*

A contradiction in the rules–tools relationship, already alluded to, was reported by a participant in the Phoebe project. He recounted how a school teacher wanted to use a Web-based message board (i.e., a novel tool) for an online discussion, but found its use was blocked on school computers by the regulations (rules) which did not allow staff to run externally hosted software.

Relationships Involving the Division of Labor

In mediating the relationship between the subject(s) and object, the division of labor can operate at the macro level, by determining subjects' overall function—curriculum designer, tutor, learning technologist, or the like—and at the micro level, determining the roles taken by subjects as they work in the problem space; for example:

I meet with colleagues (telephone/F2F, email), establish the bottom-line objective, brainstorm a pathway to it, sketching on pencil and paper, or in Word®/email as we go, agree who's doing what, then break to prepare materials etc. Often we share out the work on the basis of known strengths, but sometimes I delegate to help my colleagues to develop new skills (Learning technologist in university, quoted in Masterman, 2006b, p. 21) (→ P5) .

The informal division of labor can also exercise a substantial impact on the efficacy of mentoring, or initiatives designed to inspire through example: "I think it probably makes a lot of difference if it comes from a colleague, and [from] a colleague who's…also a Law lecturer" (IT support officer, university law department) *(→ P4)* .

Relationship with Other Activities

As noted earlier, each element in the activity system may itself be the outcome of an activity that produced it; for example, the activity that shaped the practitioner's pedagogical approach or the institutional activities that determine the rules, division of labor, and psychological tools such as templates for pedagogic plans. These may set up contradictions with the design for learning activity. There is also a major potential contradiction between the outcome of the design for learning activity—the pedagogic plan and associated materials—and its function as a tool mediating two activities directly related to it: (a) the activity which realizes the plan as a learning session with students, and (b) the activity of sharing learning designs among practitioners as a means to promote effective practice. Where the learning session is realized in a face-to-face session, the same form of representation may suffice for both these neighboring activities. However, where the learning session is to be realized within a technological environment such as LAMS (LAMS International) or Reload, which require input in XML format, an additional form of representation will be needed *(→ P1)* .

Intended Use of the Framework

The questions in the framework are intended to be relevant both to developers of new planning tools and to policy makers with responsibility for evaluating, selecting, and deploying tools in their workplace (i.e., in the activity system), whether these are dedicated pedagogic planning tools, generic software tools that can be appropriated as planning tools, or checklists and sets of guidelines distributed in either electronic or printed form.

In its focus on the enabling aspects of elements and their relationships, the framework is intended to offer creative solutions to the contradictions within the given situation, and to alert designers and policy makers to aspects of practice which might be missing in their particular settings and which, if introduced, could promote successful execution of the activity. It is therefore designed with the presupposition that a full analysis of the contradictions in existing practice is carried out prior to its application, and with the caveat that the deployment of new tools can also exacerbate existing conflicts or give rise to new ones.

Through focusing on relationships, the framework disregards within-element contradictions: principally, the usefulness of a tool as a planning aid vs. its cost to the institution. However, underlying the framework is the assumption that it will be applied in the search for a resolution to that conflict: viz. to acquire or develop a tool that will be both useful to teaching staff and cost-effective at the institutional level.

APPLICABILITY OF THE FRAMEWORK AND CONCEPTUAL IMPLICATIONS OF DESIGN FOR LEARNING

The immediate application of the framework was to the development of a specific pedagogic planning tool, Phoebe. Core to the design rationale was the conviction that the tool should propagate the principles of effective practice to as wide an audience as possible by allowing them to develop new pedagogical approaches while still using the planning tools with which they were familiar, if they so chose. By meeting practitioners on their "home ground," the design team planned to introduce them to new, more effective tools and processes (question D2 in Table 1), and thereby lead them to espouse technology where appropriate to their situations. The interviews with representative practitioners (U1) had suggested a staff-development or initial teacher-training context for deployment of the tool (D1), and this was confirmed in early evaluations.[1] Developing the tool as an open-source product (T1) was a condition of funding which also chimed with the designers' belief that, if the guidance and exemplar learning designs embedded in the tool were to be relevant to practitioners' own domain and educational sector, then Phoebe should be made available as a community tool, for individual departments or institutions to own and customize according to their contexts (D3, D4).

The design decisions uncovered a number of areas of tension of potential import for pedagogic planning tools in general. For example, allowing users to enter data in unvalidated free-text fields poses and to navigate through the tool at will poses challenges for an adaptive help system, which can only "know" what users are planning by imposing the use of controlled vocabularies that might compromise their spontaneous thinking. Moreover, where practitioners continue to create plans in the tools of their choice (e.g., word processors), the output cannot readily be captured and converted into XML for input into learning activity management systems.

Turning to the applicability of the framework itself within the wider design-for-learning community, two possible uses are envisaged. The first is as a prototype, to be iteratively refined from successive analyses contributed from a range of different settings, in order to arrive at a co-constructed template for use by the community at large. The second is as an exemplar of the sort of framework that can emerge from an in-depth activity-theoretic analysis of current practice in a single setting only, that is, to show the way but to allow policy makers in that setting to construct their own frameworks, choosing whether or not to borrow from the one proposed in Table 1.

Although developed independently of the typology of effective interventions to support practitioners identified by Sharpe and Oliver (2007b), the framework is broadly consonant with four of the five principles in the typology: contextualization, professional learning, communities, and learning design. In particular, Sharpe and Oliver comment on the positive contribution that lesson (i.e., pedagogic) plans and supportive software can play in the effective adoption of technology by practitioners. Further work on the framework, therefore, might investigate how it might be integrated as a tool to mediate the envisaged interventions. Broadening the purview still further, the research community has yet to explore the contribution that activity theory can make to an understanding of learning design, over and above its obvious role in the design and evaluation of learning activity sequences and learning objects through providing a means to understand the different ways in which technology can affect students' learning (cf. Ravenscroft, 2001; Scanlon & Issroff, 2005).

The strength of activity theory is that it provides an *a priori* analytical framework in which researchers can frame, in an open-ended way, their interrogation of the relationships among practitioners, the tools they use when working in a given problem space, and the community with which they share that problem space. True, activity theory has received its fair share of criticisms, including doubts over its value as a predictive paradigm (Ravenscroft, 2001). Yet it was never intended as such: as Nardi makes clear, "Activity Theory is a *powerful and clarifying descriptive tool* rather than a strongly predictive theory" (1996, p. 7: italics added), and its designation as a theory, with connotations of explanatory (if not predictive) capabilities, is perhaps an unfortunate misnomer.

CONCLUDING REFLECTIONS

This chapter has addressed the role of pedagogic planning tools in mediating practitioners' uptake of technology through their espousal, conscious or not, of the activity of design for learning. This activity has been characterized in two ways. The first is as a variant perspective within, but separable from, learning design that focuses on the construction of pedagogic plans which are both comprehensive and rationally designed, yet allow for the creative and contingent irruptions that can take a learning experience in unintended, yet fruitful directions. The second is as an activity which has novel characteristics, yet remains developmentally linked to the practice traditionally referred to as planning.

Using activity theory as a lens through which to capture the contextual features of a multiplicity of settings has thrown into relief the contradictions and enabling aspects of practitioners' relationships with their tools and the communities with which they share the problem-space of pedagogic planning. Both negative and positive aspects can lead to the reshaping of perspectives and, hence, the adoption of design for learning. Further, the chapter has explored how this process can be mediated by furnishing teachers with pedagogic planning tools appropriate to their varying personal needs and preferences, the nature of the task at hand, the supportive role which their communities can play, and the constraints placed on them by their institutions and the physical environment in which they work. The framework of design questions emanating from this analysis can be viewed both as a foundation for further work on interventions to support design for learning and as an exemplar decision-making tool for the design and deployment of pedagogic planning software.

The chapter opened with the observation that introducing digital technology can have a radical impact on the whole of a teacher's practice, but that to speak in terms of a disruption can be alienating to those less ready to embrace innovation. However, activity theory reminds us that, although technology may disrupt the historical trajectory of a particular practice, design for learning and learning design remain rooted in that practice. Acknowledging this connection, and building on it, is essential for the successful recruitment of practitioners to the new model. That is, as well as identifying contradictions in existing practices that might be resolved researchers should pinpoint, and capitalize on, those instances of current practice that are recognizable as emergent design-for-learning behavior, even if the community has yet consciously to acknowledge them as the seeds of creative expansion.

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REFERENCES

Beetham, H. (2007). An approach to learning activity design. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 26–40). London: Routledge.

Beetham, H., & Sharpe, R. (2007). An introduction to rethinking pedagogy for a digital age. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 1–10). London: Routledge.

Bellamy, R. K. E. (1996). Designing educational technology: Computer-mediated change. In B. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 123–146). Cambridge, MA: The MIT Press.

Center for Activity Theory and Developmental Work Research. (2004a). *Cultural-historical activity theory*. Retrieved April 1, 2008, from http://www.edu.helsinki.fi/activity/pages/chatanddwr/chat/

Center for Activity Theory and Developmental Work Research. (2004b). *The activity system*. Retrieved April 1, 2008, from http://www.edu.helsinki.fi/activity/pages/chatanddwr/activitysystem/

Earp, J., & Pozzi, F. (2006). Fostering reflection in ICT-based pedagogical planning. In R. Philip, A. Voerman, & J. Dalziel (Eds.), *Proceedings of the First International LAMS Conference 2006: Designing the Future of Learning* (pp. 35–44). Sydney, Australia: LAMS Foundation.

Engeström, Y. (1987). *Learning by expanding*. Helsinki, Finland: Orienta-konsultit. Retrieved April 1, 2008, from http://communication.ucsd.edu/LCHC/MCA/Paper/Engestrom/expanding/toc.htm

Engeström, Y. (2005). Knotworking to create collaborative intentionality capital in fluid organizational fields. In M. M. Beyerlein, S. T. Beyerlein, & F. A. Kennedy (Eds.), *Collaborative capital: Creating intangible value* (pp. 307–336). Amsterdam: Elsevier.

Ferrell, G., & Kelly, J. (2006). Collaborative approaches to the management of e-learning (CAMEL). In *Proceedings of the 12th International Conference of the European University Information Systems Organisation* (pp. 333–337). Tartu, Estonia: University of Tartu.

JISC. (2004). *Effective practice with e-learning*. Bristol, UK: JISC. Retrieved April 1, 2008, from http://www.jisc.ac.uk/uploaded_documents/jisc%20effective%20practice3.pdf

Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In B. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 17–44). Cambridge, MA: The MIT Press.

Leont'ev, A. N. (1981). The problem of activity in psychology. In J. V. Wertsch (Ed.), *The concept of activity in Soviet psychology* (pp. 37–73). Armonk, NY: M. E. Sharpe.

Lucas, B., Masterman, L., Lee, S., & Gulc, E. (2006). Sharing and reuse of learning designs for English studies: A UK higher education perspective. In R. Philip, A. Voerman, & J. Dalziel (Eds.), *Proceedings of the First International LAMS Conference 2006: Designing the Future of Learning* (pp. 55–64). Sydney, Australia: LAMS Foundation.

Masterman, L. (2006a). *JISC eLISA Independent Lifelong Learning Project: Evaluation report.* Unpublished report, University of Greenwich & University of Oxford, UK.

Masterman, L. (2006b). *The Learning Design Tools Project: An evaluation of generic tools used in design for learning.* Bristol, UK: JISC. Retrieved April 1, 2008, from http://www.jisc.ac.uk/uploaded_documents/LD%20Tools%20Report%20v1.1.pdf

Masterman, L., & Manton, M. (2007, March). *Disrupt or co-opt? The role of a pedagogic planning tool in promoting effective design for learning.* Paper presented at the CAL'07 Conference, Trinity College, Dublin, Ireland.

Masterman, L., & Vogel, M. (2007). Practices and processes of design for learning. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 52–63). London: Routledge.

Nardi, B. (1996). Activity theory and human-computer interaction. In B. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 7–16). Cambridge, MA: The MIT Press.

Oliver, M. (2004). *Effective support for e-learning within institutions.* Bristol, UK: JISC.

Peterson, D. (1996). Introduction. In D. Peterson (Ed.), *Forms of representation: An interdisciplinary theme for cognitive science* (pp. 7–27). Exeter, UK: Intellect.

Ravenscroft, A. (2001). Designing e-learning interactions in the 21st century: Revisiting and rethinking the role of theory. *European Journal of Education, 36*(2), 133–156.

Scanlon, E., & Issroff, K. (2005). Activity theory and higher education: Evaluating learning technologies. *Journal of Computer Assisted Learning, 21*, 430–439.

Sharpe, R., Benfield, G., & Francis, R. (2006). Implementing a university e-learning strategy: Levers for change within academic schools. *ALT-J, 14*(2), 135–151.

Sharpe, R., & Oliver, M. (2007a). Designing courses for e-learning. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 41–51). London: Routledge.

Sharpe, R., & Oliver, M. (2007b). Supporting practitioners' design for learning: Principles of effective resources and interventions. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp. 117–128). London: Routledge.

Vygotsky, L. S. (1981). The instrumental method in psychology. In J. V. Wertsch (Ed.), *The concept of activity in Soviet psychology* (pp. 134–143). Armonk, NY: M. E. Sharpe.

Walker, K., Laurillard, D., Boyle, T., Bradley, C., Neumann, T., & Pearce, D. (2007). *Introducing theory to practice in pedagogical planning.* Paper presented at the CAL'07 Conference, Trinity College, Dublin, Ireland.

Winograd, T. (Ed.). (1996). *Bringing design to software*. New York: ACM Press.

KEY TERMS

Activity Theory: A descriptive framework for studying the contextual aspects of different practices, linking the individual and social dimensions of that practice.

Contradictions: Within activity theory, structural tensions or problems that emerge within and between activity systems. Contradictions form the key drivers for change and development within an activity.

Design for Learning: A perspective closely associated with learning design, that (a) focuses on the process of planning for a learning session which makes appropriate use of technology and (b) recognizes the distinction between the systematic and the creative dimensions of this process.

Learning Design: As an outcome of the activity of design for learning: a pedagogic plan plus (a) the artifacts necessary to realize the plan in a learning session with students and (b) information relating to the outcomes of that session that may aid other practitioners in determining the reusability of the learning design for their purposes.

Learning Session: A stretch of learning broadly equivalent to a lesson, lecture, seminar, tutorial, or practical class.

Pedagogic Plan: In design for learning, the equivalent of a lesson plan, comprising, *inter alia*, a statement of the learning objectives; a description of the learners' characteristics (level of learning, special needs, etc.); the sequence of activities which students and teacher are to carry out to meet the learning objectives; a specification of the environment in which learning will take place; and a list of the technologies and other resources required.

Post-Compulsory Education: In the UK, a generic term for the educational sectors covering students aged 16 and upwards: chiefly further education, higher education (universities), adult and community learning, and work-based learning.

Practitioners: Professionals who participate in the activity of design for learning, including teaching staff, curriculum development teams, instructional designers, learning technologists, and e-learning "champions."

Psychological Tools: Tools that mediate cognitive actions: for example, language, counting systems, algebraic symbol systems, works of art, writing, diagrams, maps, and mechanical drawings.

Technical Tools: Tools that mediate physical actions: for example, pens, pencils, scissors, computers. Technical tools are needed to produce psychological tools such as written texts, diagrams, and maps.

ENDNOTE

1 The Phoebe tool was still in development at the time of writing, and so comprehensive evaluation data were not available.

Chapter X
Developing a Taxonomy for Learning Designs

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ABSTRACT

This chapter describes the development of a taxonomy of learning designs based on a survey of 52 innovative ICT-using projects that formed the basis of a grounded approach to classifying high quality learning designs. The concept of learning designs has the potential to support academics in the process of offering high quality ICT supported learning settings in the higher education sector. The taxonomy is proposed as a mechanism to explore ways in which learning designs can be made accessible to academics and to help with the understanding of the goals of the learning design movement. The development of the taxonomy is described, and user review of the representation of learning designs in a Web context is discussed. Finally, the current gap in the literature about accurate and effective taxonomies describing and distinguishing between various forms of learning design is discussed in relation to future research agendas.

INTRODUCTION

In higher education, an effective educational setting is characterized by high quality teaching based on contemporary views of learning (Boud & Prosser, 2002). Whilst much of the influential research in learning has been school based, higher education has developed a significant history of research interest focused on moving what has traditionally been instructivist practices in teaching to practices based on contemporary theories of learning (Schön, 1995) or the so called "new pedagogy." Governments worldwide are supporting this growing awareness and emphasis on high quality teaching as they implement policies within which "learning has been explicitly identified as the main catalyst for economic competitiveness and growth" (Cullen, Hadjivassiliou, Hamilton, Kelleher, Sommerlad, & Stern, 2002, p. 12). Mechanisms for quality assurance for learning in higher education sectors are being used to drive these policies. Consequently, as funding models for higher education has shifted to user-pay systems, both students and their institutions can no longer afford to tolerate high levels of student attrition or poor learning outcomes related to poor teaching (DEST, 2004).

Some countries have moved toward explicitly supporting academics in improving their teaching process. National bodies, government policies, and forums encouraging innovation in teaching practice have been established across most western countries. For example, in the United States, there is a range of support to foster high quality teaching such as The Carnegie Foundation for the Advancement of Teaching (http://www.carnegiefoundation.org/); the "Improving University Teaching" annual conference (http://www.iutconference.org/); the Teaching, Learning and Technology group (http://www.tltgroup.org/); and The National Teaching and Learning Forum (http://www.ntlf.com/). In the UK, there are a number of initiatives taking on different forms of dissemination, such as journals and magazines to stimulate and encourage the sharing of ideas about current practices in teaching and learning in higher education (e.g., Exchange Magazine—http://www.exchange.ac.uk/)—and Web sites such as the recently formed Higher Education Academy (http://www.heacademy.ac.uk/).

In Australia, the Carrick Institute for Learning and Teaching in Higher Education (http://www.autc.gov.au/institute.htm) and its predecessor, the Australian Universities Teaching Committee (http://www.autc.gov.au), support these processes with government policy moving toward teacher qualifications for new academics. The Carrick Institute was launched in August 2004 to promote and advance learning and teaching in Australian higher education. Its vision is to promote long-term change through a focus on systemic change in the higher education sector in Australia. The initiative represents a significant investment in learning in the higher education sector in Australia.

Of course, even with instructional skills, academics have another set of requirements in research and development and should not be expected to have teaching as their only focus. An effective and efficient way forward would be to improve teaching in higher education and still maintain the other necessary research activities essential in academic tenure. Trends in e-learning may offer opportunities to address this strategy. The current push to reuse existing learning resources via the use of learning objects as well as efforts to describe educational strategies in consistent notational forms (referred to as design patterns and/or learning designs) are strategies that may encourage academics to implement different and innovate teaching practices. This possibility of sharing and modeling expert practice will not eliminate the need for academics to have an understanding of contemporary learning theories and their applications, but this approach would provide academics with a scaffold to help them design high quality learning environments without investment of excessive amounts of time. Additionally, this movement has the potential to be a catalyst to improve the quality of teaching in higher education generally.

Recent projects have explored many different aspects of learning designs, including the development of modeling languages (Koper & Mandeveld, 2004), representation strategies (Falconer, Beetham, Oliver, Lockyer, & Littlejohn, 2007), development strategies (Conole & Fill, 2005), strategies to facilitate the representation of best practice models as reusable, transferable, and generic entities (Hedberg, Harper, Oliver, Wills, & Agostinho, 2002), resources and tools supporting development of learning designs (Britain, 2004; Littlejohn, 2004), e-learning models (Beetham, 2004), and systems supporting sharing and reuse (Dalziel, 2003).

One area of inquiry, however, that remains to be more fully explored relates to the development of descriptions of distinctive types of learning design. There has been little published about exemplar learning designs and ways to describe these designs that will facilitate access to high quality learning implementations. Whilst there are many descriptions of different forms of learning and teaching approaches, the tendency of this work has been to provide broad distinctions based on the various roles of the learner and teacher (e.g., Littlejohn, 2003; Mayes & de Freitas, 2004). There is little documented work that has sought to provide a means to classify and categorise different learning designs. The development of accurate and effective taxonomies describing and distinguishing between various forms of learning design is needed to facilitate the use of a common language and understanding across content domains and teaching cultures. The development of such could conceivably play a large part in supporting their accessibility and reusability. This chapter seeks to address this gap in the literature through describing a project that investigated the development of the explication of a series of learning designs as well as an exploration of several taxonomies by which learning designs might be categorised for accessibility and dissemination (AUTC, 2003).

THE AUSTRALIAN UNIVERSITY TEACHING COMMITTEE PROJECT: INFORMATION AND COMMUNICATION TECHNOLOGIES AND THEIR ROLE IN FLEXIBLE LEARNING

The aim of the AUTC project (AUTC, 2003) was to maximise opportunities for teachers in the higher education sector to create high quality flexible learning experiences for students. This was to be accomplished by developing a range of software tools and templates that drew upon previously successful information and communication technology (ICT) projects which could be generalised beyond the level of the individual project. In the conduct of the project, a number of learning designs that had been demonstrated to contribute to high quality learning experiences in higher education were identified. These were drawn from nominations from "teaching and learning units" in Australian institutions and projects previously supported with Australian government funds. More than 50 examples of best practice were selected as potentially suitable for development as reusable software, templates, exemplars, and/or frameworks. A framework document for evaluation was devised based on the work by Boud and Prosser (2002). The framework described four attributes as essential elements of a quality higher education learning setting:

1. **Learner engagement:** The reasons for the learner wishing to become involved with the learning tasks and the way the tasks require them to reflect or employ their previous interests and understandings.
2. **Acknowledgement of the learning context:** In the case of e-learning, there are unique characteristics. Learners are often in a real context and assessment can be made to employ real world skills. Furthermore, assessment can support the transfer between learning context and professional practice.
3. **Learner challenge:** Novices need supportive structures; experts require information to fill in the missing blanks in an existing knowledge structure; too much ambiguity can turn a novice student away, and too little and they become bored. Students might need support to extend the information provided as part of a problem-solving scenario.

4. **The provision of practice:** As with most effective learning contexts the matches between assessment, learning tasks, and the transfer tasks might align and model performance. To ensure that it occurs, the feedback must support the ongoing development of the learning.

The development and application of the evaluation instrument, referred to as an *evaluation and redevelopment framework* (ERF) was planned to facilitate the identification of learning designs that foster high quality learning experiences and to serve as a mechanism to determine whether such learning designs have the potential for redevelopment in a more generic form (Agostinho, Oliver, Harper, Hedberg, & Wills, 2002).

Two evaluators were contracted to review each of the examples of best practice using the ERF. Descriptive information about each practice model was sought and based on the team's review of this information, a subset of 32 practice models was chosen for use in the project. This subset was based on the following criteria:

- evidence of support for high quality learning experiences;
- the need for a range of learning design exemplars that reflect a diversity of learning outcomes;
- the need for ICT-based learning products/settings that reflect a diversity of ICTs employed;
- the need for ICT-based learning products/settings that reflect a range of discipline areas; and
- learning designs perceived or empirically evaluated to contribute to high quality learning experiences.

After a comprehensive development process, a range of resources was developed to support sharing and reuse of the best practice models. These included descriptions of the learning settings in their original contexts, generic descriptions of the learning designs, and guidelines and exemplars to assist teachers seeking to reuse the learning designs in their own settings. Having created this comprehensive set of resources, the team set about exploring how best to organize and store the resources in a Web-based setting so that they would be visible and accessible to teachers who might wish to use them. To achieve this, the team explored strategies for categorising the learning designs through the use of a taxonomy or typology.

DEVELOPMENT OF A TYPOLOGY

Taxonomies or typologies for ICT use in learning have been developed from a number of perspectives. Most have categorised the parts or components of ICT learning environments. For example, taxonomies have been devised to distinguish the tools used (Bruce, 1997), source of experience (Ip & Naidu, 1999), and resources used (Hill & Hannifin, 2001). Kozma (2000) identifies ICT environments by context, learning outcomes, and materials but does not provide a taxonomy that links these components. The challenge for the AUTC project was to attempt to categorise the whole ICT learning environment, not just the components used.

An analysis of the entire list of learning design models collected for the AUTC project was undertaken by examining each to determine possible emergent clusters. In this grounded categorisation process, the project team identified four distinctive learning approaches or foci within the selected best practice models. These foci were characterised as designs that employed tasks:

- based on the application of rules;
- based on incidents and events;
- that require strategic thinking, planning, and activity; and

- where the learning outcomes are based on learners' performance and personal experiences.

These categorisations were termed rule focused, incident focused, strategy focused, and role focused learning designs. The four broad foci were based upon the expected focus of the learning processes as the learner works toward an outcome for a learning task. Table 1 shows this simple taxonomy including the description of the learning design, expected outcomes, and examples. The term task was chosen as it is more generic than problem; however, it is believed that most high

Table 1. Simple taxonomy of online flexible learning designs

Focus	Description	Outcomes	Examples
Rule focus	Applying learned processes and rules to achieve an outcome. The learning task requires learners to apply standard procedures and rules in the solution.	A capacity to meaningfully and reflectively apply procedures and processes.	Solving a task, which requires the selection and application of a set of principles to achieve the goal. Creating a report within a writing genre with standard structures.
Incident focus	Starting from a critical incident or scenario learner argues a course of action (moving from incident to outcome or resolution). The learning activity is based around learners' exposure and participation in events or incidents of an authentic and real nature. The learning is based around activities requiring learners to reflect and take decisions based on actions and events.	Disambiguate scenario using an understanding of procedures, roles, and the ability to apply knowledge and processes.	Read a scenario and identify what are the key issues, and how these influence what should be done.
Strategy focus	Application of problem solving strategy with multiple options to achieve the outcome (for design problems the criteria might also include innovative application of ideas). Often, the strategy options are generated as part of the solution.	A capacity to apply knowledge in meaningful ways in real-life settings often with time and performance constraints.	Teaching in live class. Arguing points of law before court. Compose a fugue. Design a vehicle that flies.
Role focus	The learning is achieved through learners' participation as a player and participant in a setting that models a real world application. The position and perspective of the learner (the role they take) assists in achieving an outcome for the dilemma (focus on multiple perspectives assists in achieving the outcome). Learners apply judgements and make decisions based on understanding of the setting in real time scenarios based upon the particular perspective of the role they take to the learning task.	Understanding issues, processes, and interactions of multivariable situations with outcomes based on the multiple perspectives of roles taken.	Conduct negotiations for a peace resolution within the Middle East based on each learner researching and taking a first person perspective on the role and negotiating from that perspective.

quality learning tasks will involve some type of problem if the learning task is to be challenging and require students to construct their own interpretations of the world or at least the constrained context in which the task is situated.

Oliver and Herrington (2001) describe a framework that identifies and distinguished three critical elements within any learning design: the content or resources learners interact with; the tasks or activities learners are required to perform; and the support mechanisms provided to assist learners to engage with the tasks and resources. This framework provided another means to seek to distinguish and describe types of learning design in the best practice models identified in the project. As part of the process of exploring features distinguishing different types of learning designs, the framework was applied to identify the characteristics of these various elements. Table 2 demonstrates how these characteristics differ across the four types of learning design.

PROBLEMS VS. TASKS

In exploring different strategies for categorising learning designs, as well as the grounded approach based on the original set of practice models, the project also examined the theoretical typology problem types that support knowledge construction identified by David Jonassen (2000). Jonassen suggests that all learning settings are

Table 2. A framework for learning designs

Focus	Learning Tasks	Learning Resources	Learning Supports
Rule focus processes	Closed tasks and logical and bounded tasks in authentic settings and procedural sequence of manipulations. Projects and inquiry-based forms.	Situation-based materials, authentic resources, multiple sources, algorithmic descriptions and tutorials	Collaborative learning, teacher as coach/ guide, opportunities to articulate and reflect.
Incident focus processes	Story-based tasks, which require learners to disambiguate variables, situational analysis tasks, simple decision-making tasks, and trouble shooting tasks.	Incident /event descriptions and scenarios, case materials, theoretical underpinnings.	Collaborative learning, opportunities to articulate and reflect, teacher as coach/ guide.
Strategy focus processes	Complex and ill-defined tasks, diagnosis solutions, strategic performance, and design tasks.	Authentic resources, multiple perspectives, expert judgements, theoretical underpinnings sample tasks and solutions,	Teacher as coach, collaborative learning, peer assessments, opportunities to articulate, and reflect.
Role focus interactions	Assumption of roles within realistic settings, assuming the role, playing the role in resolution of a complex problem where the perspective is the focus of learning.	Procedural descriptions, role definitions, resources to define and guide role, scenarios, theoretical underpinnings, researched roles, and personalities.	Learners assume individual roles, teacher as moderator, opportunities to articulate and reflect.

characterised by the tasks/problems that learners undertake and describes 11 problem types in the form of a continuum from abstract to context dependent. The continuum includes tasks that range from working with very procedural approaches to others which are modified and reoriented as the students participate within them. The project identified two additional problem types (learning task types) to the original 11 devised by Jonassen (2000) relating to role-type problems. When these ideas were integrated with the project team's grounded categorisation, they provided a simple means to describe a series of learning designs. These learning design foci suggest a structure for identifying the intention of the learning designs based on the form of learning outcome that is being sought. Table 3 provides examples, which illustrate the nature and difference between the various types of rule and incident-focused tasks. The table demonstrates how the nature of the tasks increases in complexity and difficulty from the top of the table to the bottom.

It is possible to show distinctions between the various tasks and the forms of learning activity that each represents. Table 4 maps the task types against a number of characterising features includ-

Table 3. Examples of rule and incident-focused learning problems (adapted from Jonassen problem types, 2000)

Focus	Tasks	Examples
Rule focus	Logical Problems	Tower of Hanoi; Cannibals & Missionaries; how can I divide the water in the first jug and second jug using only three jugs; draw four straight lines on 3x3 array of dots without removing pen from paper; divide triangular cake into four equal pieces.
	Algorithmic Problems	Factor quadratic equation; convert Fahrenheit to Celsius; bisect any given angle.
	Story Problems	How long for car A to overtake car 8 traveling at different speeds; apply Boyle's law to problem statement; calculate reagents needed to form a specific precipitate in a chemical reaction; most back-of-the-chapter textbook problems.
	Rule Using Problems	Search an online catalogue for best resources; expand recipes for 10 guests; how many flight hours are required to pay off a 777; prove angles of isosceles triangle are equal; calculating material needed for addition; change case to subjunctive.
Incident focus	Scenario Problem	Read a scenario and identify what the key issues are; how do these influence what should be done? Argue on the basis of an example.
	Decision-making Tasks	Should I move in order to take another job? Which school should my daughter attend? Which benefits package should I select? Which strategy is appropriate for a chess board configuration? How am I going to pay this bill? What's the best way to get to the interstate during rush hour? How long should my story be?
	Case Analysis Task	Harvard business cases; plan a menu for foreign dignitaries; render judgement in any tort case; develop policy for condominium association; evaluate performance of a stock portfolio; how should Microsoft be split up?

Table 4. A description of rule and incident-focused learning designs and their associated problem types (adapted from Jonassen problem types, 2000)

Focus	Rule focus				Incident focus		
Tasks	Logical Problems	Algorithmic Problems	Story Problems	Rule-Using Problems	Scenario Problem	Decision-making Tasks	Case Analysis Task
Learning Activity	logical control and manipulation of limited variables; solve puzzle	procedural sequence of manipulations; algorithmic process applied to similar sets of variables; Calculating correct answer	disambiguate variables; select and apply algorithm to produce correct answer using prescribed method	procedural process constrained by rules; select and apply rules to produce system-constrained answers or products	presentation of a situation which might have multiple solutions	identifying benefits and limitations; weighting options; selecting alternative and justifying	solution identification, alternative actions argue position
Inputs	puzzle	formula or procedure	story with formula or procedure embedded	situation in constrained system; finite rules	situation with limited alternative outcomes	decision situation with limited alternative outcomes	complex, leisure time system with constraints; ill-defined goals
Success Criteria	efficient manipulation; number of moves or manipulations required	answer or product matches in values and form	answer or product matches in values and form; correct algorithm used	productivity (number of relevant or useful answers or products)	number of relevant or useful answers or products	answer or product matches in values and form	multiple, unclear
Context	abstract task	abstract, formulaic	constrained to predefined elements, shallow context	purposeful academic, real world, constrained	purposeful real world like scenarios	life decisions	real world, constrained
Structure	discovered	procedural predictable	well-defined problem classes; procedural predictable	unpredicted outcome	finite outcomes	finite outcomes	ill-structured
Abstract -ness	abstract, discovery	abstract, procedural	limited simulation	need-based	issue situated	personally situated	case situated
Learner stance	3rd person	3rd person	3rd person	3rd person	3rd person	3rd person	3rd person
Learning Resources	Case-based materials, authentic resources, multiple sources, algorithmic descriptions and tutorials				Incident/event descriptions and scenarios, case materials, theoretical underpinnings		

ing a description of the tasks itself; the content that is worked with in attempting the task (the inputs), the characteristics of success, the context, structure, level of abstraction, learner stance, and learning resources and supports. This taxonomy appeared to be too complex to use for teacher access to learning designs. Expert review and discussions with teachers indicated that the level of pedagogical sophistication necessary to make use of this problem-based categorisation was not common. However, it did provide a conceptual means to link the two views of learning design categorisation.

It is interesting to compare the nature of the various tasks in the forms described in Table 4. From a learning perspective, there are clearly different forms of learning outcomes able to be achieved through use of the different problem/task types. As well, there are a range of differing inputs and demonstrations of learning outcomes. The descriptions of the various tasks provides little indication to teachers as to how they might develop learning activities based on these different forms of tasks. The descriptions serve to provide insights into the nature of problems and teachers would clearly need other forms of information and

Table 5. Examples of strategy and role-focused learning problems (adapted from Jonassen problem types, 2000)

Focus	Tasks	Examples
Strategy focus	Troubleshooting	Troubleshoot inoperative modem; why won't car start? Determine chemicals present in qualitative analysis; determine why newspaper article is poorly written; determine isolate cause of inadequate elasticity in polymer process; why are trusses showing premature stressing? Why is milk production down on dairy farm?
	Diagnosis-Solution Problem	Virtually any kind of medical diagnosis and treatment. How should I study for the final exam? Identifying and treating turf grass problems on a golf course; develop individual plan of instruction for special education students. Why does communication break down in a committee? Why local economy is inflationary despite national trends.
	Strategic Performance Problems	Flying an airplane; driving a car in different conditions; managing investment portfolio; how can I avoid interacting with person X? Moving to next level in Pokemon game; teaching in live class; arguing points of law before court.
	Design Task	Design instructional intervention given situation; write a short story; compose a fugue; design a bridge; make a paper airplane; design a dog house; design a vehicle that flies; developing curriculum for school; plan marketing campaign for new Internet company; develop investment strategy for money
Role focus	Dilemmas	Should abortions be banned? Resolve Kosovo crisis; negotiate peace between Hutus and Tutsis in Rwanda; redistribute wealth through tax policies; develop bipartisan bill for U.S. Congress that will pass with 2/3 majority.
	Social Dilemmas	Role play simulation where participants take on a role and argue from that perspective. Negotiate an outcome while in role using only the information and options available within that role; Conduct negotiations for a peace resolution within the Middle East.

Table 6. A description of strategy and role-focused learning designs and their associated problem types (adapted from Jonassen problem types, 2000)

Focus	Strategy focus				Role focus	
Tasks	Troubleshooting	Diagnosis-Solution Problem	Strategic Performance Problems	Design Task	Dilemmas	Social Dilemmas
Learning Activity	examine system; run tests; evaluate results; hypothesize and confirm fault states using strategies (replace, serial elimination, space split)	troubleshoot system faults; select and evaluate treatment options and monitor; apply problem schemas	applying tactics to meet strategy in real-time, complex performance maintaining situational awareness	acting on goals to produce artifact; problem structuring and articulation	reconciling complex, nonpredictive, vexing decision with no solution; perspectives irreconcilable	reconciling complex, nonpredictive, vexing decision with no solution; perspectives taken from a particular perspective
Inputs	malfunctioning system with one or more faults	complex system with faults and numerous optional solutions	real-time, complex performance with competing multiple needs	vague goal statement with few positions requires structuring	situation with antinomous positions	situation with antinomous positions, persons with personal perspective
Success Criteria	fault(s) identification; efficiency of fault isolation	strategy used; effectiveness and efficiency of treatment; justification of treatment selected	achieving strategic objective	multiple, undefined criteria; no right or wrong; only better or worse	articulated preference with some justification	positional preference with some justification
Context	closed system real world	real world, technical, mostly closed system	real-time performance	complex, real world; degrees of freedom; limited input and feedback	topical, complex, interdisciplinary	topical, complex, interdisciplinary
Structure	finite faults and outcomes	finite faults and outcomes	ill-structured strategies; well-structured tactics	ill-structured	finite outcomes, multiple reasoning	finite outcomes, multiple reasoning
Abstractness	problem situated	problem situated	contextually situated	problem situated	issue situated	personality-person situated
Learner stance	3rd person	3rd person	3rd person or 1st person	3rd person or 1st person	3rd person or 1st person	1st person
Learning Resources	Authentic resources, multiple perspectives, expert judgements, theoretical underpinnings sample tasks and solutions,				Procedural descriptions, role definitions, resources to define and guide role, scenarios, theoretical underpinnings.	
Learning Supports	Collaborative learning, teacher as coach/guide, opportunities to articulate and reflect				Collaborative learning, teacher as coach/guide, opportunities to articulate and reflect	

support in order to be able to develop learning activities that use the problem and tasks types. Table 5 provides examples of strategy and role-focused tasks and problems.

As with Table 4, Table 6 provides a description of the various characteristics and attributes of strategy and role-focused tasks. In these task forms, the inputs tend to become more complex and the indicators of success more open and varied.

The use of the task and problem typology to distinguish various forms of learning activity provided a very strong conceptual basis for comparing and judging the learning potential of the learning activities that were considered. The approach however appeared to provide limited support for teachers seeking to reuse and share learning designs because there is little in the description that can guide and inform teachers about the processes associated with creating their own form of task and implementing this with a cohort of learners. The next stage of the study involved an exploration of ways to categorise learning designs that would facilitate the discovery and accessibility by interested teachers.

DEVELOPMENT OF THE TAXONOMY FOR WEB REPRESENTATION

A Web environment was constructed to represent the comprehensive set of resources that came out of this project. A learning design categorisation of rule, incident, strategy, and role focus was used to represent the learning designs in order to offer uses multiple access mechanisms to the various learning designs represented in the site. A multiphase evaluation of the Web environment was implemented with an emphasis on learning design categorisation and access in the plan. The plan consisted of three phases of review and redesign:

- a review of the individual learning designs by the learning design authors
- a usability and user review of the site
- review by two representative focus groups and an expert synthesis of the reviews with design recommendations

The first phase of the review process ensured the learning design intent was well represented, and the content was accurate. Phase two consisted of a usability review, commissioned by the project steering committee chair and a focus group review. The focus group consisted of six academics across a range of disciplines and with a range of ICT use in learning experience from nil to extensive. The third phase of the evaluation was implemented by an independent reviewer following changes to the site based on phase one and two of the review. This phase consisted of two groups of academics (n=11, 9) at two different institutions experiencing the site and then being interviewed via a common protocol. The academics were volunteers and represented a range of academics across disciplines and experiences. An independent reviewer then synthesised the responses and made a series of recommendations on the design.

Each phase of the evaluation resulted in changes to the design. With respect to categorisation of learning designs, the response from phase two of the evaluation indicated that the categorisations of rule, incident, strategy, and role focus for the learning design exemplars would not strongly support teacher selection of designs as they were too abstract. It was proposed that a categorisation with descriptions that were closer to academic's teaching experience would be more appropriate. Several other categories were explored as ways to distinguish between the learning designs in ways that would make them more accessible to teachers. The other categories included:

- **Title:** each learning design was given a title that identified it in a meaningful way from others. This category was designed to enable designs to be found quickly once they had been previously identified by a teacher;

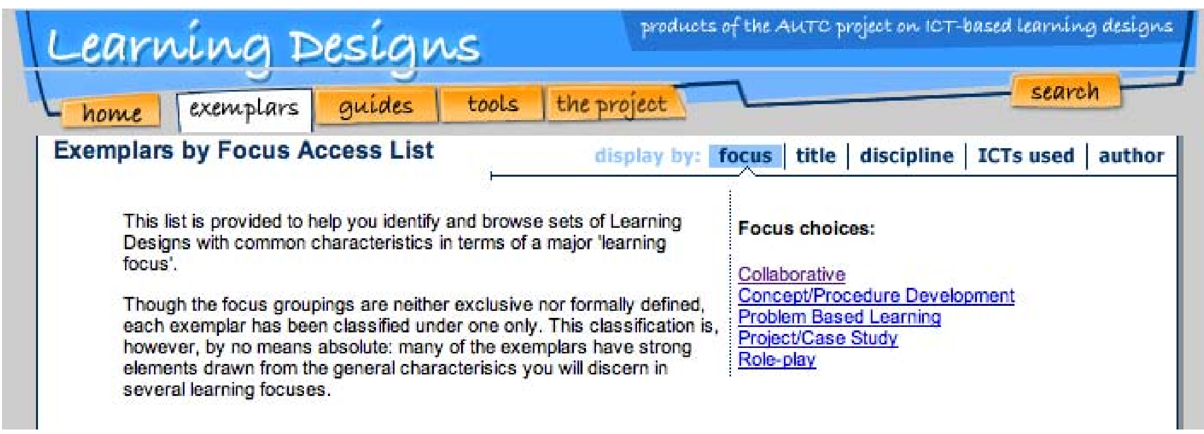
- **Discipline:** this categorisation indicated the discipline area in which the design was originally used.
- **ICTs used:** a description of the technology used to facilitate the delivery of the learning design
- **Author:** the name of the designer(s) and developers of the learning design. This enabled teachers looking for learning designs to explore those developed by known teachers.

Response from the users indicated that they could make use of all categorisations offered, with individual preferences broadly spread. Some academics suggested that "discipline" be used as the primary field to display the list of exemplars, others suggested "author" as an appropriate strategy because it helped to identify the learning designs of academics they knew to be leaders in their field, and some chose "ICTs used" because of the limitations of the tools available to them (see Figure 1). The users did not specifically comment on the foci but tended not to use this display mode. It was apparent that while the four foci provided a very sound theoretical basis for distinguishing between learning designs, this aspect was not what teachers would or could use as a means to select learning designs for reuse. Following this feedback, the focus categorisation was redesigned to attempt to give teachers a less abstract representation of the focus of the learning design. What was needed was a categorisation that more closely aligned to teachers' expectations of different teaching and learning approaches.

What was proposed was to maintain multiple modes of access with a less formal framework for the foci categorisation to enable users to better explore similar kinds of exemplars. The modified foci were:

- **Collaborative Focus:** the emphasis of the learning design is interacting and collaborating with peers to facilitate construction of knowledge.
- **Concept/Procedure Development Focus:** the emphasis of the learning design is to understand and/or consolidate student learning about concepts and/or procedures.
- **Problem Based Learning Focus:** the emphasis of the learning design is on the process of students solving a real world problem.
- **Project/Case Study Focus:** the emphasis of the learning design is to create a product for

Figure 1. The AUTC Web site showing the modes of display of the exemplars with focus chosen



artefact. The "learning by doing" process may be supported by case materials from which the learner can distil/abstract lessons learnt to apply in a new project situation.

- **Role Play Focus:** the emphasis of the learning design is subrogation: "walking in the shoes of others."

The project team believed that these learning design foci might suggest, for higher education teachers, a better structure for identifying the intention of the learning designs based on the form of learning outcome that was being sought. Phase three of the review process included questions in the protocol that asked academics about access to learning designs and to comment on the focus categorisation. There was a greater acceptance and use of the new representation of the foci by the two teams of teachers involved in this site review. This was taken as a positive response and the final Web site incorporates this display mode (see Figure 1).

SUMMARY

There is considerable activity currently being undertaken in the realm of learning designs in relation to discovering effective representation strategies. This research is seeking to develop forms of representation that provide the information teachers need to be able to find learning designs they might use, to be able to make the changes needed to adapt learning designs for their own purposes, and to be able to successfully implement the learning design with students. The outcomes from the research suggest that different forms of representations are needed for these different functions. The form of representation needed to make learning designs accessible and understandable would appear to need to be able to distinguish between different types of learning design, and it was this need that underpinned aspects of our project where we sought to develop a typology or framework for distinguishing between generic forms.

The AUTC project attempted to explore the concept of learning design through review of a large number of well-tested learning settings and to generalise these designs for use in other contexts. The project was a first attempt at identifying and describing a range of successful pedagogies, supported by ICTs, used in higher education. The outcomes of this work suggest the need still remains for appropriate representation models for learning designs to be developed and the current models to be tested in the field with teachers. The challenge now is to put in place research agendas to investigate setting this work into the wider context of the different approaches to describing pedagogical processes such as standards for representation (e.g., IMS-LD, 2003) and terminology that may win favour as a common language for discussion. The current work of he Mod4L project in seeking to identify representation strategies appears timely and responsive to this need (Falconer et al., 2007).

CONCLUSION

Considerable research still remains to be undertaken in this domain if current best practice in ICT-facilitated learning is to be reused and shared. With emerging strategies being developed that provide the means to represent and describe learning designs, the extent of reuse and sharing that will be achieved would appear to depend to a large part on the processes used to organise and store the representations. The use of appropriate taxonomies will be of critical importance to facilitating the intended outcomes. Future research that is needed to support sharing and reuse of effective learning designs will need to identify the information that influences teacher' choices in recognising and choosing alternatives to their current teaching practices. It will be important to develop and use a vocabulary that is unambiguous and useable by teachers across the different sectors of education. And if the process is to promote the uptake of models of best practice, research is also needed to identify classification schemes that recognise teachers' existing practice models in ways that promote and support their movements to more effective and more desirable alternatives.

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REFERENCES

Agostinho, S., Oliver, R., Harper, B., Hedberg, H., & Wills, S. (2002). A tool to evaluate the potential for an ICT-based learning design to foster "high-quality learning." In A. Williamson, C. Gunn, A. Young, & T. Clear (Eds.), *Winds of change in the sea of learning: Proceedings of the 19th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 29-38). Auckland, New Zealand: UNITEC Institute of Technology.

AUTC. (2003). *The Australian University Teaching Committee Project: Information and communication technologies and their role in flexible learning.* Retrieved April 1, 2008, from http://www.learningdesigns.uow.edu.au

Beetham, H. (2004). *Review: Developing e-learning models for the JISC practitioner communities.* Retrieved April 1, 2008, from http://www.jisc.ac.uk/uploaded_documents/Review_emodels_draft.doc

Boud, D., & Prosser, M. (2002), Appraising new technologies for learning: A framework for development. *Educational Media International, 39*(3/4).

Britain, S. (2004). *A review of learning design: Concept, specification and tools.* Retrieved April 1, 2008, from http://www.jisc.ac.uk/index.cfm?name=project_elearn_ped_learning_design_tools

Bruce, B. C. (1997). Educational technology: Tools for inquiry, communication, construction and expression. *Journal of Educational Computing and Research, 17*(1), 79-102

Conole, G., & Fill, K. (2005). *A learning design toolkit to create pedagogically effective learning activities.* Retrieved April 1, 2008, from http://www-jime.open.ac.uk/2005/08/

Cullen, J., Hadjivassiliou, K., Hamilton, E., Kelleher, J., Sommerlad, E., & Stern, E. (2002). *Review of current pedagogic research and practice in the fields of post-compulsory education and lifelong learning.* The Tavistock Institute.

Dalziel, J. (2003). *Implementing learning design: The learning activity management system.* Paper presented at the ASCILITE 2003, Melbourne.

DEST. (2004). *Higher education attrition rates 1994-2002: A brief overview.* Retrieved April 1, 2008, from http://www.dest.gov.au/research/publications/research_notes/1.htm

Falconer, I., Beetham, H., Oliver, R., Lockyer, L., & Littlejohn, A. (2007). *Mod4L final report: Representing learning designs.* Retrieved April 1, 2008, from http://www.mod4l.com/tiki-download_file.php?fileId=7

Hedberg, J., Harper, B., Oliver, R., Wills, S., & Agostinho, S. (2002, December). Implementing generic learning designs based upon quality ICT exemplars. In *Proceedings International Conference on Computers in Education (ICCE)*, New Zealand (pp. 1011-1016).

Hill, J., & Hannifin, M. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology, Research and Development*, *49*(3), 37-50.

IMS Learning Design Best Practice and Implementation Guide Version 1.0 Final Specification. (2003). IMS Global Learning Consortium Inc. Retrieved April 1, 2008, from http://www.imsglobal.org

Ip, A., & Naidu, S. (1999). Experienced-based pedagogical designs for elearning. *Educational Technology, 41*(5), 53-58.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development, 48*(4), 63-85.

Koper, R., & Mandevald, J. (2004). Educational modelling language: Modelling reusable, interoperable, rich and personalised units of learning. *British Journal of Educational Technology, 35*(5), 537-551.

Kozma, R. (2000). Reflections on the state of educational technology research and development. *Educational Technology, Research and Development, 48*(1), 5-20.

Littlejohn, A., & Pegler, C. (2007). *Preparing for blended e-learning.* Oxon: Routledge.

Mayes, T., & de Freitas, S. (2004). Stage 2: Review of e-learning theories, frameworks and models. Retrieved April 1, 2008, from http://www.jisc.ac.uk/uploaded_documents/Stage%202%20Learning%20Models%20(Version%201).pdf

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Edith Cowan University: Western Australia.

Schön, D. A. (1995, November/December). The new scholarship requires a new epistemology. *Change*, pp. 27-34.

Transcript of the launch of the Carrick Institute for Teaching and Learning in Higher Education (2004). Retrieved April 1, 2008, from http://www.dest.gov.au/Ministers/Media/Nelson/2004/08/n853110804.asp

KEY TERMS

Exemplars: Learning design description that are know for quality learning taxonomy—the practice and science of classification.

Learning Designs: Refers to a variety of ways of designing student learning experiences, that is, the sequence of activities and interactions. The scope of a learning design may be at the level of a subject/unit or subject/unit components.

Learning Objects: A digitized entity which can be used, reused, or referenced during technology supported learning.

Chapter XI
Using Expert Reviews to Enhance Learning Designs

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ABSTRACT

The chapter will describe an expert review process used at The Chinese University of Hong Kong. The mechanism used involves a carefully developed evaluation matrix which is used with individual teachers. This matrix records: (1) the Web functions and their use as e-learning strategies in the course Web site; (2) how completely these functions are utilized; and (3) the learning design implied by the way the functions selected are used by the course documentation and gauged from conversations with the teacher. A study of 20 course Web sites in the academic years 2005–06 and 2006–07 shows that the mechanism is practical, beneficial to individual teachers, and provides data of relevance to institutional planning for e-learning.

CLARIFYING THE FOCUS OF EXPERT REVIEWS IN E-LEARNING EVALUATION

This chapter rests on several well-known evaluation principles which fit together coherently:

- Evaluation of e-learning is best conducted with a *naturalistic approach* (Guba & Lincoln, 1981). It is difficult, if not impossible, to track the actual learning outcomes of new strategies under controlled evaluation designs because of the complicated and contextual nature of educational settings. For example, it is unethical to split the class into two groups and provide different treatment to the two groups of students. As educational settings are highly multivariate, it is really impossible to control all the factors. Other evaluation strategies are needed. The expert reviews described in this chapter provide a strategy whereby informed views can be obtained on a complex artifact—a course Web site.

- *Authenticity*, that is, evaluation in real teaching and learning contexts, is important (Oliver, 2000). Controlled experiments are often criticised as not being representative of actual classroom situations, and conclusions made from such studies are "problematic" in "generalisability" (Kember, 2003, p. 97). Our expert reviews are of 'working' course Web sites and not of isolated pieces of courseware.
- *Triangulation* is essential in complex, authentic environments, and multiple sources of data are needed (Lam & McNaught, 2004). The model of evaluation that our team has developed has been used with approximately 100 educational projects in the past five years. We use data from teachers, students, and third-party reviewers in order to make judgments about educational efficiency and effectiveness. Our expert reviews are just one of a number of evaluation strategies used in the cases described.
- Both *qualitative and quantitative methods* should be considered (Jones, Scanlon, Tosunoglu, Ross, Butcher, Murphy, & Greenberg, 1996). It is important to avoid an over-reliance on qualitative opinion data garnered from surveys and focus groups. Quantitative data, for example, from assessment results or log data, can provide useful evaluation evidence. Our expert reviews are semi-quantitative in that numbers are assigned in a matrix. As we describe, this can be a trigger to discuss other qualitative feedback and design options.
- Results from *multiple studies* provide better explanatory power (Kember, 2003). The results of a number of small studies can provide information on overall preferences and trends. One example in Hong Kong is an examination of 58 e-learning projects that indicated that glossaries, notes and PowerPoints, assessment tasks associated with grades, and exhibition of student-generated multimedia projects are considered by teachers and students in Hong Kong to be the most beneficial aspects of e-learning (McNaught & Lam, 2005). We discuss 20 Web sites in this chapter, each of which is the focus of a small-scale evaluation study.

However, it is important not to treat evaluation as a research exercise only. Another principle that underpins this chapter is that evaluation efforts should provide feedback for improvement into teaching and learning. This pragmatic focus echoes Patton's (1997) model that evaluation should have a 'utilization focus,' that all stakeholders should be included in the evaluation design. Useful feedback can be provided through reports to individual teachers and also by meta-analyses across cases (Lam & McNaught, 2008; McNaught & Lam, 2005). In the work reported in this chapter both approaches are taken. In our context, therefore, the work supports individual teachers teaching their own courses and feeds into policy decision making at an institutional level.

Expert reviews are one source of evaluation data. They have the advantage of providing focused and authoritative comments on learning issues. Tory and Möller (2005) acknowledged that expert reviews are efficient in eliciting quick feedback on interface usability. They remarked that expert reviews are a very useful strategy, especially in formative evaluation, while other strategies such as peer review and user sessions can be used to collect more detailed user feedback:

"few usability experts can find a large percentage of a system's usability problems. Compare this with up to 50 participants for a formal laboratory user study" (p. 8). Moreover, the comments can allow teachers across multiple disciplines to see how they are appraised on a common set of criteria by a common group of 'experts.' Tessmer (1993) also reviewed a number of common strategies for formative evaluation of instructional designs: expert review, one-to-one evaluation, small group evaluation, and field test evaluation. He commented that expert reviews have certain advantages over the other approaches; for example, the reviews "furnish information that complements the learner-based evaluations" (p. 67). Also, expert reviews tend to be comparatively inexpensive.

The type of expert review we have instituted moves beyond usability reviews—what Nielsen and Mack (1994) called a 'heuristic evaluation,' "the most informal method and involves having usability specialists judge whether each dialogue element conforms to established usability principles" (p. 5). Reeves, Benson, Elliott, Grant, Holshuh, Kim et al. (2002) explained 'heuristic evaluation' as a form of expert review where a "small set of evaluators examine the interface and judge its compliance with recognized usability principles" (p. 1615). Usability is important but the focus of the reviews to be described here is more explicitly on learning designs. We have also taken a view that expert reviews can usefully extend beyond the, again useful but contained, reviews of isolated materials in repositories of sharable learning objects, for example, as described by Nesbit and Li (2004).

This chapter examines a strategy to provide third-party expert review evaluation data on real cases of e-learning strategies with an emphasis on providing feedback on the learning designs used in the cases. The service, called 'e+,' was introduced to The Chinese University of Hong Kong (CUHK) in 2005. The chapter explains the design of our instrument, the procedures used in the service, the experience with 20 reviews, and the observed benefits from such a service.

THE CONTEXT OF THE CHINESE UNIVERSITY OF HONG KONG

CUHK is a comprehensive, research-intensive university with a student population of 10,000 undergraduate and 9,000 postgraduate students, and 1,200 full-time academic teachers. CUHK started the provision of a central e-learning platform in the year 2000. Since then, e-learning has developed significantly. During the 2003–04 academic year, a study (called eL@CU) was carried out to assess the extent and nature of e-learning at the university. The eL@CU study also examined barriers to uptake of e-learning and outlined a strategy for more appropriate and comprehensive e-learning support (McNaught, Lam, Keing, & Cheng, 2006).

Hong Kong is a content-oriented and examination-focused educational environment, and this rigidity extends to a rather restricted use of the Web in teaching and learning. In 2003–04, WebCT and CUForum (an in-house platform) attained an average annual growth rate of 30% and 23% respectively in the number of courses and forums hosted. However, of the 4,637 (undergraduate and postgraduate) courses offered at CUHK in the 2003–04 year with enrolments of 10 or more students, 45% had a supplementary online course site (though this may be an underestimate as there may have been 'undiscovered' locally hosted Web sites). At CUHK, the Web is mostly seen as a convenient storage house for easy distribution of course materials to students. Most communications are done through online forums with simple designs—mostly teacher–student communication about course and course content. In general, most of the forums are not very active; students, on average, post only one to three messages. While there are some very keen and active e-teachers (we interviewed 26 during this study), the Web is seen as an adjunct to face-to-face teaching and is rarely integral to the overall learning design. This study made it clear to us that evaluation feedback to teachers needed to support a range of uses of the Web and their potential value in supporting student learning.

ARTICULATING LEARNING DESIGN

In framing our work, we have tried to focus on the overall learning design of a course. To that extent, we work with teachers to see what technical functions they are using in their course Web sites, what content 'objects' or activities they place there, and how this all works together with their desired student learning outcomes. We therefore see learning designs as being an amalgamation of Web functionality, learning materials/objects and/or activities, all arranged with specific learning intentions. Evaluation should provide explicit feedback to teachers in a form which enables them to reflect on their current designs and make decisions about possible changes.

A brief exploration of the tension between the relative focus on 'learning' and 'object' in the 'learning objects' literature is useful in order to understand some of the decisions we made about our own evaluation instruments and strategies. The initial focus of the learning objects literature was overwhelmingly on delineating the concept of learning objects, their technical specifications, and their metadata—a focus on 'objects' rather than 'learning' (Agostinho, Bennett, Lockyer, & Harper, 2004; Boyle, Bradley, Chalk, Jones, Haynes, & Pickard, 2003). Similarly, Mohan and Greer (2003) remarked that "development efforts seem to be driven by available technology" but not the "pedagogical design used in conjunction with the features of the medium" (p. 263). This imbalance has led to a call for greater consideration of pedagogical purpose (Jonassen & Churchill, 2004; Wiley, 2003), and reflective practice and evaluation (Laurillard & McAndrew, 2003).

We have adapted the four-category classification of learning designs framed by Oliver, Harper, Hedberg, Wills, and Agostinho (2002) and Agostinho, Oliver, Harper, Hedberg, and Wills (2002): rule focus, incident focus, strategy focus, and role focus. Our use of these terms is simpler than the apparent intention of the researchers in the AUTC-funded Project 'Information and Communication Technologies and Their Role in Flexible Learning' (http://www.learningdesigns.uow.edu.au/). As noted earlier, CUHK teachers do not use technology widely, and we needed a classification that fit the types of teaching and learning practices used in our context. An additional category of 'management' was added; this is rather stretching the meaning of learning design, but it is a common use of the Web in Hong Kong courses and needed to be accommodated in some way.

This model suits the purpose neatly as the categories are simple and easy for teachers to understand, and yet they are capable of interpreting a wide range of teaching and learning strategies according to their probable learning outcomes. Because of its higher level of generalisation, it seems to be more helpful to teachers, particularly in our context, than the multifaceted IMS learning design information model which looks at dimensions such as environment, activity, role, and method, which in turn have numerous parameters. The IMS (2003) system is able to record "a countless number of possible design solutions" and would be rather overwhelming in the Hong Kong context, and we suspect elsewhere as well. The project 'Sharing the LOAD: Learning Objectives, Activities and Designs' (University of Cambridge, 2006–07) describes learning designs with ratings on a five-point scale in 12 key attributes which are interactivity, objective, integration, context, richness, prerequisites, support, feedback, self-direction, navigation, assessment, and alignment. Spider maps can be drawn to effectively visualise the learning designs according to their strengths and weaknesses on

Table 1. Learning design definitions used in this study

Management	The Web is intended to facilitate class management such as online distribution of handouts and announcement of venues and special events, etc.
Rule focus	The Web is intended to enhance the teaching and explanation of knowledge and concepts.
Incident focus	The Web is intended to display well-defined real cases and scenarios. Discussion is on the incident and understanding its context.
Strategy focus	The Web is intended to support students in learning how to handle ill-defined realistic problems, cases, and scenarios in the field of study. Discussion is on appropriateness of treatment and/or alternative treatments. Here, the focus is on the development of useful learning processes.
Role focus	The Web is intended to support students in playing the role of a professional in the field of study. Discussion relates to ill-defined real cases and scenarios in the field and the different strategies used in different professional roles. A strong focus on immersion in authentic real-life situations.
Non-interactive	The materials on the Web are for viewing or downloading only. The computer provides no feedback or very simple (e.g., yes/no) feedback to students' input.
Interactive	Students receive quite comprehensive pre-installed feedback from the computer system. This can be adaptive to students' input. Alternatively, students may receive feedback from their peers and/or teachers.

these 12 dimensions. While the visual aspect of Sharing the LOAD is appealing, the learning design categorisation method adopted in this study, however, tends to be simpler. Nevertheless, our matrix has the key strength of explicitly mapping a relationship between pedagogical intention and desired learning outcomes of the designs and the actual Web functions used for the purpose. Some working definitions are in Table 1.

THE DEVELOPMENT OF AN EVALUATION MATRIX FOR EXPERT REVIEW

The matrix we have developed to support feedback to teachers has three aspects: (1) the Web functions and their use as e-learning strategies in the course Web site; (2) how completely these functions are utilised; and (3) the learning design implied by the way the functions selected are used by the course documentation and gauged from conversations with the teacher.

1. Concerning the nature of the Web functions/e-learning strategies, initial versions of the matrix were based on the four functions of the Web in learning listed by McNaught (2002): communicative interaction, feedback on learning progress, study program management, and content resources for students to engage with. A preliminary list of 22 Web functions for teaching and learning was documented (see Appendix for the list). The Web matrix was revised several times. The final list of common e-learning strategies was strongly influenced by the eL@CU study and by the e3Learning (enrich, extend, evaluate learning) Project (http://e3learning.edc.polyu.edu.hk/) which provided design, development, and evaluation services to teachers and teams in 139

Web site subprojects across three Hong Kong universities during the period 2003–05. The final Web matrix contains a list of 15 Web functions/strategies (Table 2). The list was restricted to the strategies most commonly used in Hong Kong. The final set of four categories was described as 'communication,' 'assessment,' 'simple resources,' and 'enriched resources.'

Table 2. The e+ evaluation matrix

Design ***Web functions/ strategies***	On the RHS of the matrix, there are five columns (**Management, Rule-based, Incident-based, Strategy-based, Role-based**), each subdivided into 'non-interactive' and 'interactive.' These 10 columns are used for rating. In the matrix, ●s indicate the usual way in which the Web function/strategy is implemented	
	non-interactive	interactive
Communication		
Asynchronous forums. Discussion topics can range from course arrangements to discussion of cases and professional tactics.		
Synchronous such as chat-room, virtual lecturing, video-conferencing, etc. Focus on knowledge, cases, or strategies.		
Assessment		
Interactive exercises such as quizzes and tutorials. Focuses on knowledge or strategies. Various forms of feedback possible.		
Past papers and assignments. Degree of detail in answer key can vary.		
Online submission of assignments. Variation includes the use of peer review and the nature of teacher online feedback.		
Resources (simple)		
Announcements, course information, and teacher information. May be linked to follow-up online discussion.		
Lecture/laboratory notes and/or PPTs.		
Frequently Asked Questions (FAQs).		
Tools and templates.		
Resources (enriched)		
Extended self-study content/Web links.		
Glossary of terms. Can be multimedia-enhanced.		
Cases and scenarios. May be linked to follow-up online discussion.		
Role-related and problem-solving games and simulations.		
Exhibition of student work. Variation includes the use of peer review and the nature of teacher online feedback.		
Materials on learning skills. May be linked to follow-up online discussion.		

We are quite open to changing this set of Web functions and strategies. Others (such as e-portfolio) can be added as necessary. In this way, this matrix can be seen as an evolving and responsive descriptive tool.

2. We use three levels of implementation:
   0 – the strategy is by and large absent;
   1 – the strategy is implemented in a limited fashion; and
   2 – the strategy is well-implemented.

The judgments on the degree of implementation are necessarily qualitative. In the earlier eL@CU study, 30 'active' sites at CUHK were studied. The degree of agreement between educational designers and technical staff about the degree of implementation was high (McNaught et al., 2006).

3. Decision about the learning design. All judgments about the degree of implementation and the nature of the learning design are checked in conversation with the course teacher. These conversations are in themselves valuable staff development explorations. The matrix acts as a tool for conversation about the existing design and the possibilities for modification.

THE E+ SERVICE IN OPERATION

The service we have developed using this matrix is called 'e+' (originally ePLUS Web, evaluating the Potential for Learning: Use and Structure of the Web). e+ was introduced to CUHK in 2005. During the second half of the 2005–06 and the first term of the 2006–07 academic years, we worked with the teachers in 20 courses.

At the end of an e+ review, the course teacher receives a report with two components: the completed matrix, about which there would have already been some discussion; and the results of a questionnaire given to students on their perception of their learning outcomes in the course and how the Web environment might have supported this learning. We have also collected data on students' achievements on an open-ended authentic task in the discipline area. The eventual aim is to produce a model that shows relationships between the value students place on the specific features of the educational course Web sites, students' discipline-based learning, their approaches to learning, and their development of capabilities such as critical thinking and communication skills. However, this chapter is intended to focus, not on the whole e+ project, but rather on the value of the e+ matrix as an evaluation tool to assist teachers to articulate their current learning designs and explore other possibilities. In passing, it should be noted that the e+ matrix is just one component in the evaluation support we provide for teachers.

A total of 20 course Web sites was used as the first batch of Web sites to undergo the e+ expert reviewing service. The sites came from a relatively widespread range of disciplines. Seven of the 20 cases were from language courses, three cases from engineering courses, three from science courses, three from arts courses, two from education courses, one from a business course, and one from a social science course. As noted earlier, the final matrix decisions were discussed with the teacher. The e+ service is entirely voluntary; initially most of the teachers who used the service were approached by us as we know who the more active e-teachers on campus are. Our cases are not at all representative of CUHK as a whole. Our intention is to provide feedback to enthusiastic colleagues and also to obtain information on what learning designs work well in the Hong Kong context.

A team of five members of staff in the Centre for Learning Enhancement And Research (CLEAR) were involved in the Web function judgment—the three authors and two other educational design staff. A brief description of the review team will illustrate the need to have reviewers with a wide range of appropriate experience. There is no clear definition of an 'expert'; it is the synergy across the review team that can bring useful insights. Carmel McNaught is a professor of learning enhancement in CLEAR. She has over 30 years of research experience in teaching and learning. Paul Lam is an assistant professor in CLEAR and has many years of teaching experience, followed by six years of extensive research and development experience in e-learning projects. Alex Wong has seven years experience in learning, teaching, and assessment, both online and off-line; he is now an educational designer in CLEAR. Kin-Fai Cheng and Poon Wai Kei are research assistants in CLEAR who are relatively recent graduates and bring a student perspective to the review process. These professionals reviewed all the participating course Web sites and made judgments about the degree of implementation of the learning designs.

The judgment was carried out in two phases. In the first stage, four reviewers visited the course Web sites individually and jotted notes about the Web functions. Then, these four reviewers held a meeting. They looked at the course Web site together again and discussed each item on the Web matrix until reaching a consensus. There were, as expected, disagreements among the reviewers. The reviewers discussed until consensus was reached, and they had a final set of judgments.

In the second phase of the judgment, the set of judgments made by the four reviewers was passed to the first author for cross-checking and validation. Judgments of this nature are necessarily qualitative. The final rating was based upon overall Web site reviews. The profiles are intended to be summaries of qualitative data.

Throughout the two phases, the working team discussed many issues that assisted in further clarifying the boundaries of the individual categories in the matrix. The discussions were well recorded in the form of a supplementary document for the matrix. The discussions explained and elaborated the matrix. The document further improves the practicability of the instrument as a tool to accurately measure Web designs in different contexts. Table 3 illustrates the discussions with an extract from the supplementary document.

Table 3. Extract of the supplementary document of the matrix

Functions	**Issues met when considering this function**	**Decisions reached**
Asynchronous forums	In one course, only one-way 'discussion' occurred: the teacher asked questions, but no one replied. How to judge the interactivity and degree of implementation.	We still treat it as interactive, because we focus on the 'intention' of the teacher; but we gave it a 1 for degree of implementation.
Extended self-study content/ Web links	Many links go to big sites (such as Google and sites of big organizations and projects). It's hard to go through them all to see what learning materials they contain.	We stick to the principle of 'directness.' If the learning materials are not easily found by following the links, we do not count the learning materials.

FINDINGS

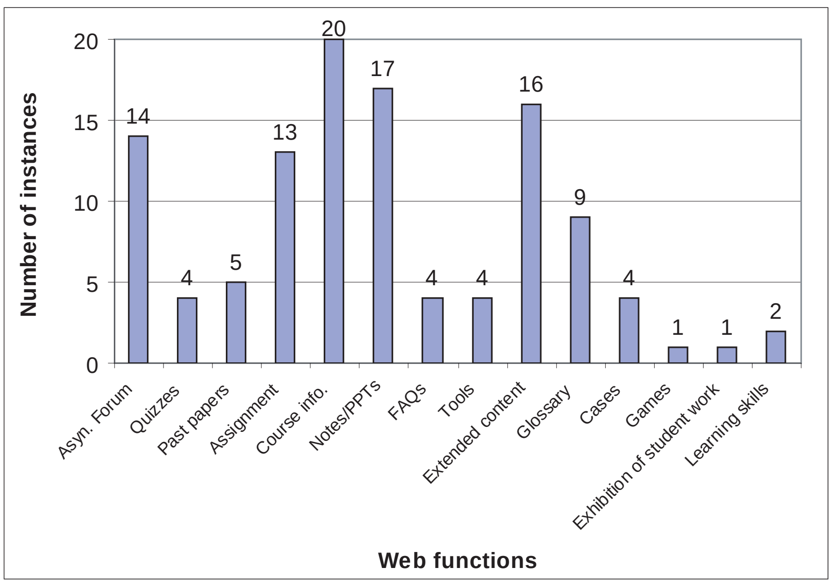
Across all the cases, we noticed that the e-learning designs of these 20 Web sites were quite diverse. Teachers, in general, provided high quality and rich resources on the Web. The feedback given back to individual teachers was found to be very well received and appreciated. They appreciated that the purpose of the evaluation strategies was not to put pressure on them to 'do well—get 2s' in all items of the matrix. We stressed that it is completely legitimate for different teachers to value some features and functions more highly than some others, based on their teaching beliefs, teaching styles, students' learning styles, learning objectives of the course, and characteristics of the subject content. However, all teachers noted that this was an interesting and worthwhile process. They felt they had received practical data that could be used in making changes to their Web sites and other aspects of their courses.

Most teachers used a number of strategies and the number of total strategies used across the 20 Web sites (courses) was 114. Among the 114 instances of strategies, we found there was a limited set of strategies commonly used. Only one of the 15 functions was not present at all among the cases. This was the synchronous communication function such as chat-room, virtual lecturing, video-conferencing, and so forth. In our relatively small face-to-face university, this is not surprising.

As can be seen in Figure 1, six out of the remaining 14 strategies could be considered as being the more common e-learning strategies used. They were:

- Announcements, course information, and teacher information;
- Lecture/laboratory notes and/or PowerPoints;
- Extended self-study content/Web links;
- The asynchronous communication function, always as forums;
- Online submission of assignments; and
- Glossary of terms.

Figure 1. Strategies used by functions



Apart from the use of forums, this list is quite consistent with the study mentioned earlier of 58 course Web sites in Hong Kong (McNaught & Lam, 2005). The content-oriented and examination-focused nature of the Hong Kong educational environment is apparent.

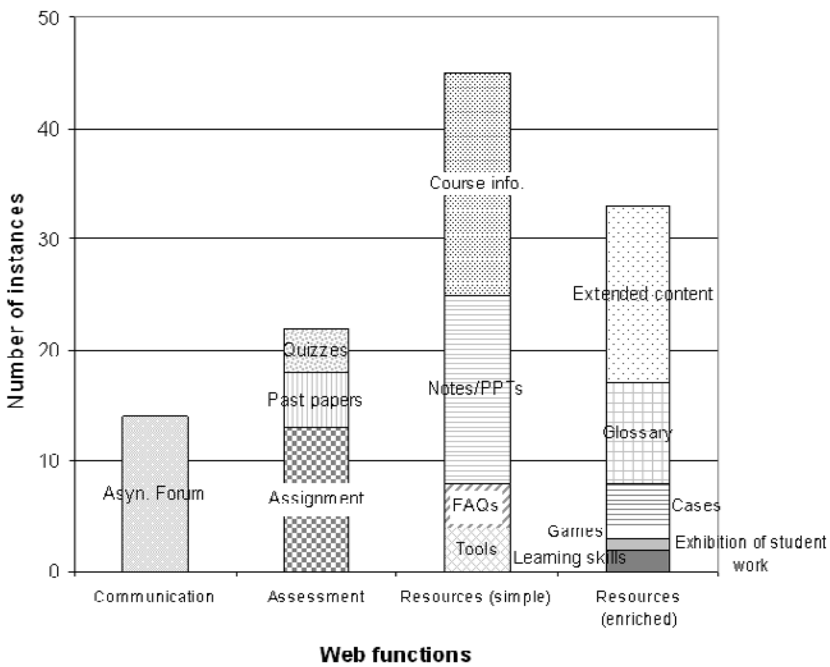
Figure 2 illustrates how the 114 strategies have employed the four main functions that the Web can assist teaching and learning: communication, assessment, simple, and enriched resources. Our 20 teachers largely focused on the resources functions. They most commonly used the Web as a storage place for learning materials. Some of them put up simple text-based documents such as course information, notes, and PowerPoints. Also, many of the teachers put extended materials such as links to extra readings, notes, and cases, some of which were multimedia-rich.

Figure 2 also illustrates that teachers viewed the Web as an assessment tool (for both formative and summative assessments). There were 22 instances where the online activities were related to self-assessments (e.g., quizzes) or course assessments (e.g., putting up past papers for examination revision, assignment submission, and online tests). The most common strategy among these was the assignment submission function.

As shown in Figure 3, the learning resources were generally non-interactive. Whether they were simple or enriched, they tended to be materials for students to view and read only. Few interactive exercises or activities were included with the materials. Eighty-four of the 114 strategies were classified as non-interactive, while the remaining 30 were interactive.

Though most forums were quite active, an example of a non-interactive instance in the communication function was a very quiet forum without student participation. In these cases, the communication tools were mainly used as places

Figure 2. Strategies used by their major functions



for teachers to disseminate ideas, while students took the role of readers. The non-interactive instances in the assessment category were cases where the quizzes did not give any feedback. The teachers in these cases did not want to disclose the correct answers to the students immediately, but by doing so, the activities were deprived of much of their learning value. Butler and Winne (1995) suggested that provision of feedback is important as it contributes to the construction of knowledge in the learning process. Hara and Kling (2000) pointed out that the lack of prompt feedback was "a major source of anxiety and frustration for students because they were concerned about their performance" (p. 567).

Figure 4 represents the reviewers' judgments on the learning designs in each of these 20 cases. This was a somewhat complicated exercise because teachers used different parts of their Web sites in somewhat different ways. So, there could be a strong organizational (management) focus on a site that also included some good case material. Indeed, conversations with teachers showed that many of them felt that they were somewhat restricted in their designs by what they perceived to be the demands of the programmes or the expectations of the students. As a result, Figure 4 focuses on categorisation at the level of the 114 strategies used. The strategies appeared to be mainly used with management and rule-based intentions. In other words, the focus of attention was either about achieving convenience in managing the class or improving students' understanding of the rules of the discipline. Seldom did we find strategies used that focused on situations and cases in the discipline (incident-based), learn the skills in solving problems in the discipline (strategy-based), or acquire the attitude and capabilities to be real professionals in the discipline (role-based).

Last, we looked at the degree of implementation. Most of the strategies were regarded by the reviewers as highly implemented (86 out of the 114). The rest, 28 out of 114, were regarded as having medium-level implementation. In the communication function, for example, most teachers we studied were able to facilitate meaningful and abundant online discussions on their forums. In the assessment function, either there were rich collections of quizzes or past papers (with answers), or there were recorded activities in which students participated in the online assessment activities. In the resources functions, there were on the

Figure 3. Interactive and non-interactive strategies

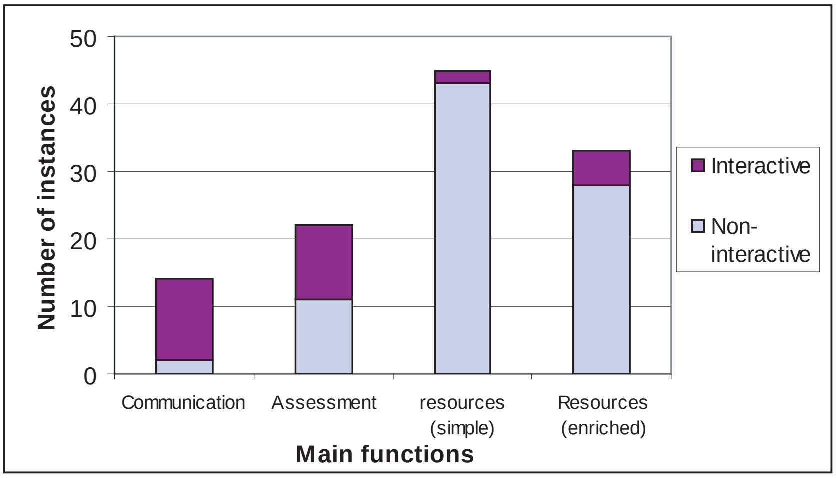
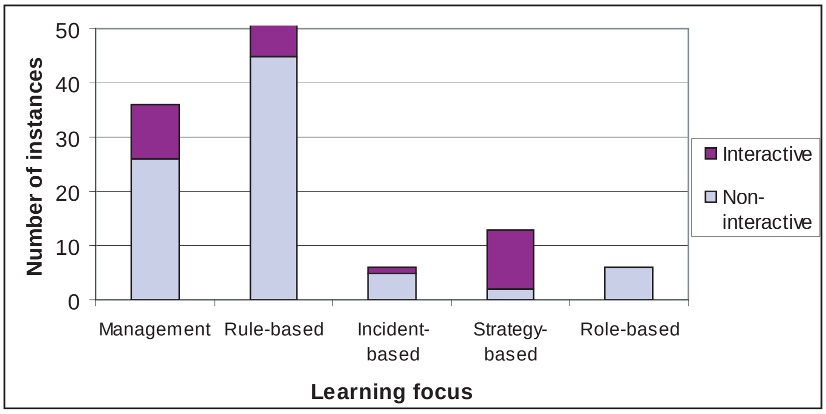


Figure 4. Strategies used by their learning focuses



whole good coverage of learning materials that generally touched upon most of the key areas of the course and could explain the course concepts well. The extended resources such as links of the other online sites were also rich.

DISCUSSION

There are many potential benefits of this expert reviewing method. We have found it to be a good tool for doing in-depth 'spot checks' on e-learning instances at a university. It is a good strategy for providing support to individual teachers as it supplies succinct and authoritative feedback to teachers on their e-learning designs.

Value to the Institution

Across the 20 cases described above, we noticed that the e-learning designs of these selected Web sites were quite diverse. Teachers were also in general able to put up high quality and rich resources onto the Web as the reviewers rated most of the strategies as highly implemented. However, these teacher cases were not randomly picked among all e-learning cases at the university but were invited cases from teachers we knew were pioneers in employing e-learning strategies. We will have a clearer picture of the university-wide situation when more expert reviews are conducted.

Despite the limited scope of this study, a number of preliminary ideas on improvements can still be identified from the experiences of these teachers. First of all, teachers can be encouraged to have learning focuses that aim at more than just explaining the rules to students. Second, teachers can be introduced to some strategies which are less commonly used at the moment. Third, teachers can explore ways to make their online activities more interactive. As an education development group, we have used this information in framing some of our recent activities. Our e-learning service Web site at http://www.cuhk.edu.hk/eLearning/ provides some information on our activities and resources.

Value to the Individual Teachers

Reports were sent to the individual teachers, together with survey results about students' perceptions of how valuable the course Web site was for their learning. These reports served as triggers for discussions about the learning design of the Web site. The purpose of the report is to help teachers understand the teaching and learning potentials of their strategies.

The first part of the report was the reviewers' scores '0, 1, or 2' on the matrix, indicating what activities were found, the learning focus of the activities and their level of implementation. The second part of the feedback was the reviewers' further comments on the activities and the reasons behind their judgments. Table 4 is an extract of one such piece of extra information. The extract here, for example, explains why the rating '1' was assigned to the 'asynchronous function' and why the 'past paper and assignments' function was assigned a '2.' These entries were designed to give teachers some ideas about possible enhancements.

Teachers were also given detailed guidelines to assist them in interpreting the report data and consider what changes (if any) they wanted to make. For example, concerning the Web strategies, the teachers were reminded that the purpose of listing 15 strategies on the report is *not* to encourage them to employ all, or anywhere near totality, of these 15 Web strategies. However, this list of strategies and functions should certainly be helpful in leading them to rethink their present e-learning design. Having a fairly complete list of the common Web strategies and functions might assist teachers in finding new Web strategies or functions that could be useful in their courses. Detailed guidelines were included in the reports to assist teachers in interpreting the reviewers' comments.

For example, the pedagogical potential of the e-learning strategies was explained:

- In general, online communicative strategies are very good strategies for teachers to build teacher–student or student–student relationships. They also offer opportunities for teachers to listen to students, to let shy

Table 4. Extract of detailed comments from reviewers to teachers

Functions available	**Reviewers' judgment**	**Remarks**
Function 1: Asynchronous forums	Management (Interactive) Level 1	• A channel for communication is available o under the 'communication' part, there is a discussion board for students to communicate o under the 'communication' part, there is an announcement session for students to discuss the new arrangement of the course • Limited usage of the function o in the discussion board section, only the group list is posted on the Web o in the announcements, only the news from teacher is posted in the Web
Function 4: Past paper and assignments	Rule-based (Non-interactive) Level 2	• Examination samples are available for students' revision o the past paper in 03 and 04 academic years are available on the Web o but no answer is provided • Good to have enough samples for revision o two years' samples are provided for students to familiarise themselves with the format of the examination

students 'speak' up, and to have problematic concepts identified and clarified. Many of these activities are missing in traditional classrooms because of time and space restrictions.

- Assessment strategies can be used as self-assessment tools or as mark-giving exercises for students. In general, they tend to engage students in learning. Also, quizzes that are multimedia-enabled are often better alternatives than traditional paper-and-pen exercises.
- The various strategies to provide learning resources such as text-based readings or multimedia-enriched materials can also serve to engage students in prelecture preparations or postlecture revisions. Well-written and designed resources sometimes can explain facts and concepts really well as students are given the opportunity to unlimited access of these materials in the online space.

Learning designs were also explained. The 'management,' 'rule-based,' 'incident-based,' 'strategy-based,' and 'role-based' dimensions can assist teachers to rethink what they want the technology to do for them.

- Do they want the Web to facilitate class management (management)? This can be achieved by strategies such as online distribution of handouts and announcement of venues and special events.
- Do they want the Web to assist the explanation of knowledge and concepts (rule-based)? If yes, putting well-designed explanatory notes, exercises, or links to good Web resources or further readings may be what they want.
- Do they want students to see how concepts and theories can be applied (incident-based)? Perhaps they can think of displaying well-defined real cases and scenarios. Discussions of these stories may further enhance students' understanding.
- Or, do teachers wish to support students in learning how to handle ill-defined realistic problems and use knowledge in real situations (strategy-based)? They may then consider putting up more cases and scenarios in the field of study, followed by discussions on the appropriateness of treatment and/or alternative treatments.
- Finally, if they want to support students in playing the role of a professional in the field of study (role-based), they may need online activities that have a strong focus on immersion in authentic real-life situations. Students can then experience the feelings and decision-making processes of actual professional situations.

There were also explanations of the judgments on the degree of implementation, that is, the ratings 0 (blank row) – absent, 1 – implemented in a limited fashion, and 2 – well-implemented. Teachers had the chance to reflect on the practice and plan for improvements.

- In general, online resources can be enriched through linkage to good external sources of information, appropriate uses of multimedia, and a wider coverage so that the resources cover the most important or difficult, if not all, the topics in the course.
- The assessment strategies can be enhanced through well-designed questions which are designed not only for assessing students but also for assisting students to master the knowledge through errors. Online quizzes that provide feedback such as common misconceptions or learning tips on students' mistakes, for example, are better than questions that just inform students that their answers are wrong.
- Finally, higher quality communication strategies can be achieved through higher level of engagement of both teachers and students. These can be achieved, for example,

> through effectively motivating students to discuss online (giving marks for online participation can be a good ice-breaking strategy here). Heated online discussions can also be a result of well-planned discussion procedures. In general, provision of clear discussion topics and clear indications about when the discussion periods begin and end are needed. Splitting the class into groups with or without prespecified positions on the topics may also help to engage students in the discussions.

Teachers were reminded that the feedback from the 'experts' is at best only indicative rather than conclusive, as we admit that there are obvious limitations. It is completely legitimate for different teachers to use only some features and functions. We are hopeful that our feedback will encourage teachers to be reflective about the learning designs they are using and consider how they might continuously enhance the work they do.

Although we have not obtained concrete evidence that the expert reviews changed our teachers' actual teaching and learning practice as the project is still ongoing, the initial perception is promising. We received positive comments from teachers who were sent the reports and below are some quotes:

"I'll study it and look for ways to improve my Web-based course delivery in future."

"Thanks for the effort. I shall read the report and see how to further improvement the website."

"The report is excellent, and I have learnt from its structure and organisation."

"The report is both affirming and informative."

There were challenges, however, in following up these teacher cases and in supporting the teachers in reworking their e-learning strategies. The reviews pointed out ideas for improvement but perhaps did not provide practical advice on how to implement changes. Nor did the project team have resources to assist teachers in changing their Web sites (though recent funding improvements have changed this situation).

Also, as the teaching and learning culture in the Hong Kong context is largely content-oriented and examination-focused, teachers in general are not able to immediately comprehend the importance and benefits of the strategy-based and role-based learning designs. Ongoing efforts are need on the part of the project team to explain and demonstrate new e-learning options to teachers. Follow-up meetings, seminars, and showcases (e.g., see http://www.cuhk.edu.hk/eLearning/resources/showcases.htm) occur, but this type of professional development is a long-term process and requires sustained enthusiasm. In a context where the pedagogy is less content-focused, the 'higher level' strategy-based and role-based learning designs may be more common. Having a matrix with a range of learning designs provides a flexibility that should make it useful in a range of contexts.

As mentioned earlier, the e+ matrix is one component of the e+ service project. The overall objectives of this project are to characterise the ways in which educational Web sites used in courses in higher education can support student learning, to develop guidelines for how the use of the Web can support student learning, and to understand whether the design features of the Web that are now widely advocated are perceived by students as having a positive impact. In order to achieve this, extensive survey and assessment data have been collected. The matrices will be used as illustrative material (vignettes) to describe the relationships between the value students place on the specific features of the educational course Web sites, students' discipline-based learning, their approaches to learning, and their development of capabilities such as critical thinking and communication skills.

Having a model based on local evidence has been very persuasive in other work at CUHK. For example, a set of principles of excellent teaching derived from interviews with 18 award-winning teachers at CUHK is used to frame professional development for all new teachers and teaching assistants (Kember, Ma, McNaught, & 18 exemplary teachers, 2006), and a model of the relationship between the development of capabilities and factors in the teaching and learning environment is used to explain students' feedback on programme-level questionnaires (Kember & Leung, 2005; McNaught, 2005). These grounded models have resulted in greater take-up of services. We are hopeful that our research will do the same for e-learning.

CONCLUSION

This chapter describes a project on providing expert reviews on e-learning strategies in active courses. The mechanism used involves a carefully established evaluation matrix. The matrix allows reviewers to judge e-learning practices on aspects regarding their level of implementation, the nature of the strategies used, and their learning focuses through engaging student in these online activities. The first study of looking at 20 course Web sites at The Chinese University of Hong Kong in the academic years 2005–06 and 2006–07 shows that the mechanism is both practical and beneficial. Despite the limited scope of this initial study, a number of preliminary ideas on improvements can still be identified from the experiences of these teachers. The feedback given back to individual teachers was well received.

As in most staff development work, teachers who have found an activity valuable are our best advertisement. It will be valuable to see whether the pattern of use shown by this first set of 20 cases remains the same or shifts over time. The Hong Kong government is requiring evidence of student learning outcomes at an institutional level. The e+ matrix provides snapshot data of individual courses but it could be used to exemplify and correspond with overall claims that programmes make about the student-centred nature of their designs. The data from the eL@CU study resulted in funding for an expanded e-learning support service. The data from the e+ matrix will be part of the data used in the production of the next institutional report at the end of 2007.

We are hopeful that the matrix is flexible enough to be able to support teachers in other contexts. Presentations in other countries (Singapore, Malaysia, and South Africa) have been well received with follow-up discussions taking place. As in much academic work, disseminating ones's own ideas enables new strategies to be developed.

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REFERENCES

Agostinho, S., Bennett, S., Lockyer, L., & Harper, B. (2004). Developing a learning object metadata application profile based on LOM suitable for the Australian higher education context. *Australasian Journal of Educational Technology, 20*(2), 191–208. Retrieved April 1, 2008, from http://www.ascilite.org.au/ajet/ajet20/agostinho.html

Agostinho, S., Oliver, R., Harper, B., Hedberg, J., & Wills, S. (2002). A tool to evaluate the potential for an ICT-based learning design to foster 'high-quality learning.' In A. Williamson, C. Gunn,

A. Young, & T. Clear (Eds.), *Winds of change in the sea of learning*: *Proceedings of the 19th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 29–38). Auckland, New Zealand: UNITEC Institute of Technology. Retrieved April 1, 2008, from http://www.ascilite.org.au/conferences/auckland02/proceedings/papers/164.pdf

Boyle, T., Bradley, C., Chalk, P., Jones, R., Haynes, R., & Pickard, P. (2003, April). *Can learning objects contribute to pedagogical improvement in higher education: Lessons from a case study?* Paper based on presentation given at CAL 2003, April 2003. Retrieved April 1, 2008, from http://www.londonmet.ac.uk/ltri/learningobjects/papers_pres/CAL_Objects_paper.doc

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research*, *65*(3), 245–281.

Guba, E., & Lincoln, Y. (1981). *Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches.* London: Jossey-Bass.

Hara, N., & Kling, R. (2000). Student distress in a Web-based distance education course. *Information, Communication & Society*, *3*(4), 557–579.

IMS Global Learning Consortium, Inc. (2003). IMS learning design information model, version 1.0 final specification. Retrieved April 1, 2008, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_infov1p0.html

Jonassen, D., & Churchill, D. (2004). Is there a learning orientation in learning objects? *International Journal on E-Learning, 3*(2), 32–41.

Jones, A., Scanlon, E., Tosunoglu, C., Ross, S., Butcher, P., Murphy, P., & Greenberg, J. (1996). Evaluating CAL at the Open University: 15 years on. *Computers in Education*, *26*(1:3), 5–15.

Kember, D. (2003). To control or not to control: The question of whether experimental designs are appropriate for evaluating teaching innovations in higher education. *Assessment & Evaluation in Higher Education*, *28*(1), 89–101.

Kember, D., & Leung, D. Y. P. (2005). The impact of the teaching and learning environment on the development of generic capabilities needed for a knowledge-based society. *Learning Environments Research*, *8*, 245–266.

Kember, D., Ma, R., McNaught, C., & 18 exemplary teachers. (2006). *Excellent university teaching.* Hong Kong: Chinese University Press.

Lam, P., & McNaught, C. (2004, June 21–26). Evaluating educational Websites: A system for multiple Websites at multiple universities. In L. Cantoni & C. McLoughlin (Eds.), *ED-MEDIA 2004: Proceedings of the 16th annual World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Lugano, Switzerland (pp. 1066–1073). Norfolk VA: Association for the Advancement of Computers in Education.

Lam, P., & McNaught, C. (2008). A three-layered cyclic model of eLearning development and evaluation. *Journal of Interactive Learning Research*, *19*(2), 313-329.

Laurillard, D., & McAndrew, P. (2003). Reuseable educational software: A basis for generic learning activities. In A. Littlejohn (Ed.). *Reusing online resources: A sustainable approach to e-learning* (pp. 81–93). London: Kogan Page.

McNaught, C. (2002). Adopting technology should mean adapting it to meet learning needs. *On The Horizon*, *10*(4), 14–18.

McNaught, C. (2005, November 24–25). From diagnostic feedback to university policy: Programme-level evaluation at a Hong Kong university. In C. S. Nair (Ed.), *Communicating evaluation outcomes: Issues and approaches: Proceedings of the 2004 Evaluation Forum*, Melbourne (pp. 96–106).

McNaught, C., & Lam, P. (2005). Building an evaluation culture and evidence base for e-learning in three Hong Kong universities. *British Journal of Educational Technology, 36*(4), 599–614.

McNaught, C., Lam, P., Keing, C., & Cheng, K. F. (2006). Improving eLearning support and infrastructure: An evidence-based approach. In J. O'Donoghue (Ed.), *Technology supported learning and teaching: A staff perspective* (pp. 70–89). Hershey, PA: Information Science Publishing.

Mohan, P., & Greer, J. (2003, June 23–28). Reusable learning objects: Current status and future directions. In D. Lassner & C. McNaught (Eds.), *ED-MEDIA 2003: Proceedings of the 15th Annual World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Honolulu, Hawaii (pp. 257–264). Norfolk VA: Association for the Advancement of Computers in Education.

Nesbit, J. C., & Li, J. (2004, July 21–25). *Web-based tools for learning object evaluation*. Paper presented at the International Conference on Education and Information Systems: Technologies and Applications, Orlando, Florida. Retrieved April 1, 2008, from http://www.sfu.ca/~jzli/publications/Nesbit_Li_2004.pdf

Nielsen, J., & Mack, R. L. (1994). *Usability inspection methods.* New York: John Wiley & Sons.

Oliver, M. (2000). An introduction to the evaluation of learning technology. *Educational Technology & Society, 3*(4), 20–30.

Oliver, R., Harper, B., Hedberg, J., Wills, S., & Agostinho, S. (2002). Formalising the description of learning designs. In A. Goody, J. Herrington, & M. Northcote (Eds.), Quality conversations: Research and development in higher education. *Proceedings of the Annual International Conference of the Higher Education Research and Development Society of Australasia, 25,* 496–504. Jamison, ACT: HERDSA. Retrieved April 1, 2008, from http://www.ecu.edu.au/conferences/herdsa/main/papers/ref/pdf/Oliver.pdf

Patton M. (1997). *Utilization-focused evaluation: The new century text.* (3rd ed.). Thousand Oaks, CA: Sage.

Reeves, T. C., Benson, L., Elliott, D., Grant, M., Holshuh, D., Kim, B., Kim, H., Lauber, E., & Loh, S. (2002, June 24–29). Usability and instructional design heuristics for e-learning evaluation. In P. Barker & S. Rebelsky (Eds.), *ED-MEDIA 2002: Proceedings of the 14th annual World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Denver (pp. 1615–1622). Norfolk, VA: Association for the Advancement of Computers in Education (AACE).

Tessmer, M. (1993). *Planning and conducting formative evaluations: Improving the quality of education and training.* London: Kogan Page.

Tory, M., & Möller, T. (2005). Evaluating visualizations: Do expert reviews work? *IEEE Computer Graphics and Applications, 25*(5), 8–11.

University of Cambridge. (2006–07). *Sharing the LOAD: Learning design taxonomies.* Retrieved **April 1, 2008,** from http://www.ucel.ac.uk/load/taxonomies.html

Wiley, D. A. (2003). *Learning objects: Difficulties and opportunities* (Academic ADL Co-Lab News Rep. No. 152- 030406). Retrieved April 1, 2008, from http://opencontent.org//docs/lo_do.pdf

KEY TERMS

Incident Focus: The Web is intended to display well-defined real cases and scenarios. Discussion is on the incident and understanding its context.

Interactive: Students receive quite comprehensive pre-installed feedback from the computer system. This can be adaptive to students' input. Alternatively, students may receive feedback from their peers and/or teachers.

Learning Designs: Learning designs are an amalgamation of Web functionality, learning materials/objects and/or activities, all arranged with specific learning intentions.

Management: The Web is intended to facilitate class management such as online distribution of handouts and announcement of venues, special events, and so on.

Non-interactive: The materials on the Web are for viewing or downloading only. The computer provides no feedback or very simple (e.g., yes/no) feedback to students' input.

Role Focus: The Web is intended to support students in playing the role of a professional in the field of study. Discussion relates to ill-defined real cases and scenarios in the field and the different strategies used in different professional roles. A strong focus on immersion in authentic real-life situations.

Rule Focus: The Web is intended to enhance the teaching and explanation of knowledge and concepts.

Strategy Focus: The Web is intended to support students in learning how to handle ill-defined realistic problems, cases, and scenarios in the field of study. Discussion is on appropriateness of treatment and/or alternative treatments. Here, the focus is on the development of useful learning processes.

APPENDIX

Original List of 22 Web Functions with Descriptions

A. Communication

Asynchronous

1. *Forum.* A virtual space for displaying of the written message exchanges for the whole class or selected groups of students in the class. **Online forums** and **newsgroups** are the two most common ways to realize this function.

Synchronous (can be reviewed when the exchanges are archived)

2. *Chat-room.* **Real-time text-based** message exchanges usually between more than two parties over the Web. Messages are viewable by all members participating the chat-room session.
3. *Graphic-enabled Chat.* Extended chat-room that enables exchanges of messages that **contain graphics** as well as text.
4. *E-lecturing.* **Virtual lectures** in which the students listen to and often also view teachers instructing online real-time. In some advanced system, the e-lecturers may also show PowerPoints while they teach and/or accept questions from the floor raised by the learners.
5. *Video-conferencing.* **Virtual conferences** in which the participants (two or more) view and chat with each other real-time in front of their video-enabled and broadband-connected computers.

Time-independent

6. *Role-play.* Students play certain **roles** relevant to their areas of study and do online activities using the forum or other Web communication tools.

B. Assessment and Feedback to Learners

7. *Quizzes.* Online exercises that give immediate feedback to learners. Questions may take many different formats: for example, **true/false (T/F) questions**, **multiple choice (MC) questions**, **open-ended questions, or even exploratory-type simulations**. Feedback may take the form of giving some

hints, giving the suggested answers, or giving both the answers and the explanations to learners.

8. *Online feedback on assignments.* **Uploading** of assignments to the Web site by students as an official way of work submission. The functions usually go with an **online marking system** in which the students can view their teachers' comments and the grades given to their work online.
9. *Peer review.* Students **view** their peers' work online and then give their **comments** on each other's work. The comments can be viewed on the Web site.

C. Study Management and Skills Support

10. *Course information.* Description of the course, its **objectives**, **schedule**, **mark allocations**, and/or **assignment** and **examination** specifications.
11. *Teacher's information.* Information about the teachers and tutors. It may include teachers' and/or tutors' **background**, **research interests**, **office hours**, **e-mail addresses,** and/or links to **personal homepages**.
12. *Lecture notes and/or PPTs.* **Storage** of lecture notes and/or ppts the students may need before or after the lectures. Some teachers may add a time-release function to these **downloadable materials** so that the students do not get the things earlier than teachers think they should.
13. *Lab notes/Lab handbooks/Tutorial questions.* **Storage** of laboratory notes and/or tutorial question sheets that students may need before or after laboratory or tutorial sessions.
14. *Learning skills (tips, links, inventories).* **Self-learning materials** on improving learning skills which the teachers think are important to the course. The skills may include reading skills, information-searching skills, and presentation skills.

D. Enrichment

15. *Online learning resources.* **Learning materials** that can be **text-based**, **graphically-rich**, or even **multimedia-enabled** built by the teachers to enhance the students' learning of the course.
16. *Past papers and assignments.* **Archived** past assessments (exam papers and/or selected work of the students) to give students a better understanding of the course and the subject matter.
17. *Glossary.* **Explanations of terms** commonly used in the course (prepared by the teachers or linked to external sites).
18. *FAQ on content.* Collections of **answers to commonly-asked questions** concerning the course content.
19. *Cases and scenarios.* **Stories of real cases** in the field of study to give students greater understanding about the professional life of the discipline and the application of the knowledge in real situations.
20. *Students' work/ presentations as resources.* **Online exhibition** of selected work or presentations of students.
21. *Role-related games.* **Game-like activities** designed to enable students to learn while they play certain roles in their field of study.
22. *Tools.* Provision of **practical tools** essential to the subject. For example, a teacher may put up software for typing formulae for students to download so that they can type in formulae in their assignments more easily.

Chapter XII
Investigating Prospective Teachers as Learning Design Authors

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ABSTRACT

This chapter reports on findings from a recent project situated in the area of preservice teacher education. The project investigated prospective teachers authoring and using their own contextualised learning designs. The chapter describes how 17 secondary and primary preservice teachers adapted existing, well-researched learning strategies to inform the design of their own specific online learning tasks and how they implemented these tasks in the context of their teaching practicum. The prospective teachers used an online learning design authoring system as a tool and flexible 'test-bed' for their learning designs and implementation. An account of the ways in which the prospective teachers developed sophisticated understandings of their chosen learning strategy and developed fresh insights into online and face-to-face teaching issues is presented.

INTRODUCTION

A problem facing teacher education today is the resilient nature of teachers' beliefs that shape their (face-to-face and online) classroom practices and the need to provide them with opportunities to discuss and reflect critically on these beliefs. For example, preservice teachers study a variety of learning principles and strategies in theory classes at university, and are exposed to an increasing range of online learning designs in their studies. (The term *learning design* (LD) in this study is informed by Oliver and Herrington (2003) and refers to a sequence of coordinated online learning experiences underpinned by a learning strategy, learning resources, and support mechanisms to provide guidance and feedback to learners.) However, preservice teachers often struggle to implement theory into practice (Fang, 1996), and there is good evidence that when faced with the hectic pace and demands of every day teaching duties, they revert to more traditional didactic teaching methods (Goodrum, Hackling, & Rennie, 2001). Furthermore, design of online activities tends to be pedagogically shallow and content-driven (Odlyzko, 2001).

This study investigated these problems by situating preservice teachers as learning design authors and examining how the process of authoring and implementing a contextualised learning design might help 'build bridges' between theory and practice in their university course. It explored the efficacy of teachers creating their own Web-based learning task using a learning design authoring system and how they can use, and reflect upon, these contextualised designs on their school teaching practicum. In this study, the scope of these learning tasks was at the level of 'lesson component' and typically comprised a 20–30 minute online learning activity. The main research question for this study is: *How does preservice teachers' authoring and use of contextualised online LDs enhance their development as teachers?* Subsidiary questions for this chapter include: *To what extent do preservice teachers develop knowledge of (online and face to face) teaching and learning?* and *To what extent is their understanding of specific learning strategies enhanced?* Although findings are mostly generalisable to all domains, the study was confined to math and science education contexts due to budget and time constraints.

BACKGROUND

This study aims to build on the current interest in LDs to investigate pertinent issues involved in preservice teacher education. It highlights prospective secondary and primary teachers as important stakeholders and introduces school-based classroom contexts to the LD research agenda. Research into teachers' use of LD authoring systems is a crucial but underdeveloped area of the LD research agenda.

Teachers, Learning Designs, and Learning Design Authoring Systems

Researchers have recently identified and explored the underpinning support structures and learning strategies incorporated in exemplary online learning designs, particularly from tertiary education contexts (Agostinho, Oliver, Harper, Hedberg, & Wills, 2002; Laurillard & McAndrew, 2003). For example, multimedia-supported predict–observe–explain (POE) tasks use the well-researched POE learning strategy (White & Gunstone, 1992) to effectively scaffold students' learning in an e-learning environment, presenting digital demonstrations set in real-life contexts as stimuli for their learning (Kearney, 2002). However, research into how teachers might adapt and use LDs is in its infancy (e.g., see Bennett, Lockyer, & Agostinho, 2004; Cameron, 2007; Kearney, 2006) and has mainly been confined to tertiary teachers. This study builds on the Kearney (2006) study by focusing on three exemplary learning strategies across two disciplines, and also involves participants' use of a LD authoring system—in this case, the *learner activity management system* (LAMS) (Dalziel, 2003)—as a 'test-bed' for teachers to contextualise and implement their specific LDs. LAMS (version 1.0 at the time of the study) was chosen primarily because its intuitive drag and drop authoring environment was considered user-friendly for novice (student teacher) participants; it was freely available as open source software, provided local support, and has shown positive signs for engaging the teaching community (Masterman & Lee, 2005; Russell, Varga-Atkins, & Roberts, 2005).

Many studies have focused on technical aspects of LDs and associated authoring tools in great depth but only recently, an important new focus has emerged on pedagogical and procedural issues associated with teachers designing—and occasionally 'enacting' (Earp & Pozzi, 2006)—their own online learning tasks. Hernandez-Leo, Villasclaras-Fernandez, Asensio-Perez, Dimitriadis, Jorrin-Abellan, Ruiz-Requies, and Rubia-Avi (2006) investigated three tertiary teachers using a LD authoring tool to design collaborative learning experiences for their students, while Griffiths and Blat (2005) investigated issues relating to enabling teachers to participate in the LD process and also ways of representing LDs to teachers. Earp and Pozzi (2006) discussed two European projects (*Netform2* and *Remath*), including initiatives with novice teachers authoring and reusing LDs to support pedagogical reflection. Finally, Gibbs and Philip (2005) investigated a range of 10 teachers across both tertiary and school sectors using LAMS as an authoring tool and found positive teacher perspectives about opportunities for teacher reflection on pedagogy, as well as student collaboration, motivation, and engagement. Our study builds on this Gibbs and Philip study by focusing on preservice teacher learning and issues emerging from participants' design and implementation of their specific contextualised LDs on their practicum.

Learning Strategies Used by Participants in This Study

The education literature details a range of effective strategies to support student learning. For example, *learning strategies* informed by a constructivist perspective (Tobin & Tippins, 1993) have been extensively reported in the math and science education literature, particularly strategies that support students' understanding of difficult concepts that are often encountered in these domains (e.g., Baird & Northfield, 1995; Skamp, 2004; Treagust, Duit, & Fraser, 1996). As these strategies were aligned with the constructivist philosophy underpinning the students' math and science education subjects, the preservice teachers in this study were encouraged to create specific online learning tasks underpinned by their choice of one of the following three well-researched learning strategies from this literature base:

- The *analogical reasoning* (AR) strategy (Harrison & Treagust, 2006; Treagust, 1995). This strategy supports learners' use of a familiar analogue to explore a 'target' concept;
- The *predict–observe–explain* (POE) strategy (White & Gunstone, 1992). This strategy scaffolds students' engagement with key demonstrations as stimuli for their learning;
- The (broader) 'interactive teaching' model (Biddulph, 1990; Faire & Cosgrove, 1993), subsequently referred to as the *learners' questions* (LQ) approach (e.g., see Baird & Northfield, 1995, p.240). This approach elicits learner questions as a basis for further investigations.

There was ample literature available to the students on these three strategies, including research authored by lecturers within the participants' programs (e.g., Aubusson, Harrison, & Ritchie, 2006).

STUDY METHODOLOGY

A qualitative methodology was employed to uncover preservice teachers' professional learning experiences during authoring and implementation of their own contextualised LD. This approach enabled a comprehensive and descriptive account of the participants' experiences to emerge (Merriam, 1998). An interpretive approach to data analysis was employed and this provided insight into how participants made sense of their learning experiences (Mason, 1996). This methodology is supported by educational technology theorists such as Neuman (1989) and Salomon, Perkins, and Globerson (1991) who have advocated more naturalistic studies that provide appropriate data about relevant social and cognitive processes in order to explore the affordances of innovative technologies.

Participants

Participants in this study were 10 volunteer teacher education students from the fourth year of the Bachelor of Education (Primary) program and seven students from the Graduate Diploma in Education (Secondary) program in the Faculty of Education, University of Technology, Sydney (UTS), Australia. They were advised that participation in the study would not influence their grades in their course, and there was no background technical skill requirement. An initial survey of research participants revealed they had minimal background knowledge of designing or implementing an online learning task for school students and no participant had used LAMS. This survey also revealed that the preservice teachers had minimal background knowledge of the three learning strategies: predict–observe–explain, analogical reasoning, and learners' questions approach. The K–6 preservice teachers had more experience with the broad notion of using 'constructivist learning strategies' to elicit school students' conceptual understanding in math and science contexts, having already completed three years of their education studies and related professional experiences.

Procedures

The study took place during semesters one and two in 2006 and comprised four phases: Phase 1: Familiarisation (with LAMS and the learning strategies); Phase 2: Design of specific, contextualised LDs for school students; Phase 3: Implementation; and Phase 4: Reflection. The project utilised an online learning management system to support students with links to relevant articles and resources and provision of online discussion and communication tools.

As preservice teachers were not due to implement their final learning task until their second semester practicum, they spent the first semester engaged in several preliminary learning opportunities to become familiar with their chosen learning strategy as well as becoming acquainted with the LD authoring software (LAMS). These experiences included:

- *Introductory university lectures and background reading.* At the start of the project, preservice teachers attended two 90-minute lectures led by academic staff from UTS Faculty of Education who had conducted research on learning strategies. These sessions initially involved students participating (as learners) in sample, face-to-face tasks underpinned by relevant learning strategies. These tasks were completed using a range of individual, small group, and whole class structures and also included the lecturers modeling, explaining. and deconstructing exemplary teaching practices. The sessions culminated with further questions, critique, and analysis. Preservice teachers also were issued with several key articles from the science and math education literature (e.g., *AR strategy*: Harrison and Treagust (2006); *POE strategy*: White and Gunstone (1992); *LQ approach*: Biddulph (1990)) to give them a foundational understanding of their chosen learning strategy, consistent with information from the lectures. These readings were the subject of further participant-initiated verbal and online discussions (mediated by academic staff members) during and after other preliminary learning experiences mentioned below. The lectures and readings informed the use and 'testing' of their chosen strategy in a whole-class, face-to-face setting on their semester one practicum.

- *Trial of strategies in their semester one practicum classes.* Their semester one practicum served as a pivotal opportunity for research participants to test their newly chosen strategy in typically whole class, traditional classroom environments. Many preservice teachers tried at least one of the strategies on this practicum as a face-to-face task. School staff and school students gave the participants valuable feedback.
- *Engagement with sample LAMS tasks.* After the semester one practicum, four contextualised learning designs were created for student teachers to engage with as learners: one underpinned by a POE strategy using a physics context; one using a LQ strategy in biology; and two using an AR strategy in physics and mathematics contexts. Informed by the science and math education literature surrounding the three learning strategies, these model tasks were created by the research team in conjunction with subject and pedagogical experts in the Faculty of Education, UTS, including critical friends of the project. They were placed on the 'public' section of our project's LAMS account (viewable only to project participants), so the preservice teachers could also access them in author mode and analyse their structure at a 'LAMS tool' level. This experience allowed the participants to engage in existing sequences from a student's point of view (i.e., learner mode); deconstruct the sequences from a design perspective (in author mode); and also learn about the particular learning strategies informing each online design. This approach is consistent with the principle of teachers needing to experience novel learning environments as learners themselves to consider changes in their teaching (Loughran, 1997).
- *Two Introductory LAMS workshops.* These sessions introduced participants to range of tools in the teacher 'authoring mode' of the LAMS environment and other LAMS tutorials and resources. At the time of the project, only version 1 of LAMS was available.

The participants then designed their own specific contextualised LDs before implementing them in a primary or secondary classroom during their second semester practicum. Participants shared their draft and final designs with their peers in the 'public' section of our LAMS project space. After implementation, the participants were provided with opportunities to reflect on the design and implementation process and changes for the future. Ethics approval was obtained early in the year from the university's research office to carry out this project. All names in this chapter are pseudonyms.

Data Collection and Analysis

Data were collected throughout the four phases using ongoing participant journals, two surveys, individual and focus group interviews, observation, and collected documents and artefacts. Participants kept an online journal for both semesters, documenting their development as teachers and their reflections on their professional learning. Two open-ended questionnaires probed preservice teachers' views about their pedagogical knowledge development. These were administered at the start and end of the project with responses to final surveys informing final focus group interviews. Sample participants also were interviewed immediately after the implementation of their LD during practicum. Preservice teachers were observed both during their practicum lesson and during final university class presentations. Written rationales for their designs and reflections on their practicum experiences were also collected for examination at the end of the project, as were their (LAMS-based) specific LDs.

This data were analysed according to emerging themes across all data sources and across the collective case. In the first instance, each researcher individually examined all of the data from either the primary or secondary teachers. Themes were independently established from the perspective of each researcher. The research team then came together and, through a process of negotiation and critical collaborative reflection (Bullough & Gitlin, 1991), identified common themes that were capable of capturing the experiences of the participants.

TEACHERS DEVELOPING UNDERSTANDING OF ONLINE AND FACE-TO-FACE TEACHING ISSUES

Exploration of the first subsidiary research question—'*To what extent do preservice teachers develop their knowledge of (online and face to face) teaching and learning?*'—drew mainly on data from interviews, surveys, and journals. Four key themes emerged relating to the participants' developing professional knowledge of online and face-to-face teaching: unit planning and programming insights; promoting independent learning in an e-learning environment; classroom strategies to facilitate online learning; and strategic use of digital media and Web-based resources.

Unit Planning and Programming Insights

The process of developing an online learning task for their practicum class encouraged participants to consider, in significant depth, the appropriate sequence of learning activities and the most suitable blend of online and face-to-face components to facilitate their students' learning. Recognising the value in having their online task integrated into a relevant unit of work, participants aimed to 'blend' their online task with other face-to-face lessons. However, this raised a new and challenging issue for many participants: 'I want to include so much [in the LAMS task] because I keep forgetting that this is only one tool to teach and that I can add to the lesson outside the program.' (Yasmine, journal). Indeed, many participants developed an appreciation for the complexities of unit planning involving a 'blend' of online and face-to-face strategies. For example, early in the project Hope mentioned in her journal:

I really need to get a unit plan laid out and decide what part could be online. But firstly need to know exactly what topic, content and online resources, syllabus requirements, teaching approaches and how to teach Earth and its Surroundings in order to get this unit plan—a lot of work beforehand!

Often the decision to locate the online task at the beginning, middle, or end of a lesson sequence depended on how the participant viewed the online task as a tool to uncover student learning and understanding. One participant, who designed an analogical reasoning task, thought it was important to use the LAMS tasks at the end of her unit of work 'so that the [school] students will have more knowledge to contribute' (Eleanor, journal). This was in contrast to many participants who used their LD task as an introductory, diagnostic activity and had to think about follow-up lessons.

In her final survey, Elizabeth stressed that she could better tailor follow-up discussion because of the variety of responses she received via her online POE task. The systematic nature of the online tasks to automatically record and collate individual school student's progress was highly valued: 'the ability to review every student's feedback since in class most of the views would not have been exposed' (Elizabeth, final survey). Mike concurred: 'one of the strengths…was being able to collect and store students' responses for further scrutiny at a later date' (Mike, final survey).

Promoting Independent Learning in an E-Learning Environment

Many participants became conscious of designing an online task that enabled their school students to work independent of the classroom teacher. They consequently developed insights into issues relating to scaffolding and self-pacing, and also into their new authoring and teaching roles. Each participant went to great lengths to consider the appropriate language, visuals, and sequence of tasks they believed necessary to enable their students to successfully navigate and complete the online activity with minimal teacher assistance.

It was noticeable that many preservice teachers discussed the affordances of self-pacing in their rationales, interviews, and surveys. For example, Natalie valued this aspect of her online design: 'they can go back and look at parts again (potentially) as a point of revision to start again. …Then continue on to new work at their own pace' (Natalie, final survey). Others thought the self-pacing aspect encouraged more school student ownership of task responses, and also supported less didactic teaching methods: 'The fact the kids were able to work at their own pace on the computer meant there wasn't a teacher at the front doing all the teacher talk' (Eleanor, final focus group).

However, one problematic issue to emerge towards the end of the project was the participants perceived level of 'teacher control' and the extent to which the online tasks supported students' control over their own learning. Most perceived the teacher control over the design phase as a positive aspect: 'The program gives teachers the ability to put exactly the information desired and makes students follow the path that teachers want, making learning very specific and efficient' (Yasmine, journal). However, others perceived the level of scaffolding to be problematic. For example, Lucy and Eleanor critiqued the level of student flexibility:

It's hard for students to have input in the direction the task takes.…There is not as much room for lateral movement in the task. (Lucy, final survey)

They [the students] get no choice in the sequence of events, nor a chance to investigate any misunderstood concept any further than the information presented to them. The program seems to speak to them, but cannot read their answers/responses and adapt the following sequence accordingly like a teacher could. (Eleanor, focus group)

Preservice teachers questioned the potentially constraining nature of their structured online tasks and the limited opportunities for school students to influence the direction of their task. Natasha emphasised the key role of the teacher here: 'you can't have it so the kids are in total control. …you need teacher input to give them stimulus and direction' (Natasha, focus group); while Anna advocated a balanced approach: 'I have found that such [online] activities need to … be designed to guide, but not excessively constrain, the students' exploration… promoting lines of inquiry that help students develop their understanding of the important concepts' (Anna, Rationale/Reflection).

While still acknowledging that the level of participation could vary between individual learners, all participants agreed that their online tasks gave their students an opportunity to actively participate in their learning compared to a general class discussion where only three or four school students might participate. Nick's comments were typical: 'it is no different from other "analogue" tasks in the classroom. We just have to guard against the passive use of the computer screen' (Nick, survey). Also, some preservice teachers felt that participation was promoted because online tasks provide a safety valve or a more 'risk-free' environment, which was less confronting, especially when anonymous postings were allowed. This enabled their school students to express their personal science and math beliefs more openly and freely 'give answers without the fear of being ridiculed if they are incorrect' (Laura, survey).

Classroom Strategies to Facilitate Online Learning

Although participants focused on creating an online learning task which facilitated learner independence, they all chose to design a task that was completed by the school students under their guidance, in a face-to-face school-based learning environment. They emphasised the importance of this face-to-face role: 'students feel more secure in the sense that the teacher is available to answer questions and guide them in the right direction' (Natalie, final survey) and 'from an educational view, to discuss ideas, clarify and focus, recap, etc' (Lucy, final focus group). They also highlighted the spontaneous nature of learning and the crucial presence of the teacher: 'although very accommodating, computer technology is not able to deal with spontaneous learning that happens in the classroom, it can only aid it' (Laura, final survey).

The face-to-face environment was seen as particularly important for younger learners and practical considerations such as typing skills were a consideration for this age group: ' Since the students are not likely to be able to type their responses, I may ask them to orally respond their answers and opinions and have it more as a discussion' (Alice, journal). Indeed, the participants who had younger learners tended to adopt more authoritative roles in their classrooms: 'I will involve all students, have them working in pairs, and use a modelled and guided version of talking the students through each stage of the software to use the analogy and enter their findings' (Amy, journal).

With a teacher present in the room, school students appeared to have a reliance on them and this was a surprise to many preservice teachers, given the emphasis they had placed on independent learning in their designs. Participants also experienced the dilemma of how much (face-to-face) guidance to give their students—a common problem with trainee teachers in their practicum classrooms. They again seemed surprised that they would experience this dilemma after consciously incorporating adequate scaffolding and prompting in their designs. Nick and Mike tried to keep a facilitatory role: 'it was hard not to prompt and keep out of the way' (Nick, final survey), and similarly, 'I tried to lean over their shoulder and ask them to work through the LAMS task …I'd give them some hints there' (Mike, postlesson interview). Lucy developed an awareness of this issue: 'I've come to realise how fine a line there is between giving students the answer and helping them find it—they can need a lot of guidance sometimes.' (Lucy, final survey).

Participant reflections indicated they revised and developed their views on face-to-face strategies in these e-learning environments. A significant number of participants reported that next time they would further integrate more (face-to-face) questioning and discussions during the online task and 'chunk' or reduce the length of their design accordingly. Natalie designed her task with the notion of complete learner independence but upon review of her students' evaluations began to see the importance of her face-to-face role:

The task was designed so that the teacher was not required to provide feedback to students during the task on their ideas and answers, allowing them to work independently. However, from a number of the student's comments, they may have benefited from more teacher feedback either directly in the classroom or indirectly or by having the teacher involved in an online 'group' chat at the same time. (Natalie, reflections)

Participants' emerging understanding that online and face-to-face activities are able to be more readily integrated than they had initially thought was evident. For example, Elizabeth came to realise that she didn't have to think of her online task as an isolated e-learning episode with distinct face-to-face lessons before and after it: 'I think that online and face-to-face teaching could be effectively sandwiched throughout a lesson rather than devoting lessons to one or the other' (Elizabeth, final survey).

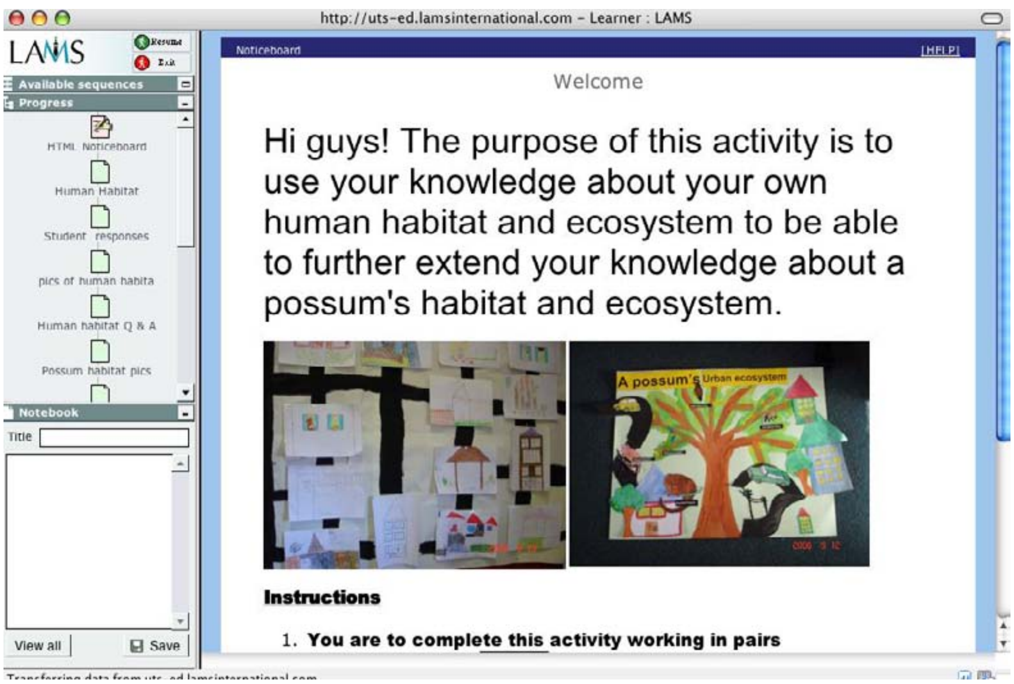
Strategic Use of Digital Media and Web-Based Resources

Participants also developed sophisticated skills in selecting appropriate media and Web-based resources for their LDs. Many participants became mindful of utilising these resources to create rich contexts and enhance their students' interactivity. Some participants used appropriate media to enhance learners' observation of phenomena, and subsequently, the level of school students' visual literacy skills was raised by participants as a key issue.

Naomi recognised that inclusion of appropriate media (in her case, videos of recent cyclones), allowed her students to view rich, out-of-class, and possibly very current contexts that would not be possible to observe in traditional resources such as textbooks:

LAMS allows children to access … class contexts, such as cyclones, that they otherwise would not be able to access in real life circumstances and also allows kids to have the opportunity to view or learn about very recent occurrences or concepts (that textbooks would not yet include). (Naomi, survey)

Figure 1. First page of Eleanor's task (LAMS learner mode) containing her children's work samples



Hope made similar comments:

Multimedia content serves to motivate students into engaging into science learning because resources are fun, novel, can be controlled by students (e.g., when watching videos and simulations), multisensory (e.g., watching, listening, playing, and directing materials), and reflect real world materials used by scientists themselves. Additionally, without ICT such diverse resources are not easily accessible in textbooks at school or within children's lives for them to examine. (Hope, Rationale)

Although many participants used external sources of media, some created their own. Virginia, for example, created a car racing video-based demonstration to provide rich stimulus material for the boys engaging in her Year 9 Mathematics POE task on 'rates.' Similarly, Eleanor used photos of her students' work in her analogical reasoning task designed to help her Year 2 children learn about animal habitats (see Figure 1). She reasoned that this would not only help her students to visualise the analogy but also create learner ownership of the task.

An interesting point raised by the prospective primary teachers in the project concerned school students' background visual literacy skills, especially young children's ability to interpret key photographs and videos in their online tasks. This was a particularly pertinent point in the context of the crucial observation stage of the POE strategy; and also in the AR strategy where media can help learners make connections between the analogue and target concept. For example, Laura was concerned about her children's interpretation of a time-lapse photography video that condensed the life cycle of a butterfly. She explained the problem in her interview: 'Due to the student's lack of experience with time lapse movies, they had difficulty ascertaining whether their initial prediction was correct or if they correctly observed the phenomenon.' Amy also was concerned about her Year 1 children's interpretation of a satellite image. Various solutions were discussed. Laura suggested inclusion of an 'extra page' in her LD, after the time-lapse video, containing key still images extracted from the movie to enhance observation of the phenomena. Lucy made a similar suggestion, discovering that a focus question or statement was necessary immediately after her video-based demonstration to help people understand the analogy in her task. Amy suggested the possibility of preliminary lessons devoted to interpreting media and also minor editions to photos such as labels on key photos in her task.

Ten participants carefully selected and embedded external Web-based resources such as applets, wikis, and online drawing tools to provide extra interactivity. This was of prime concern for Mike who embedded a Maths applet that helped his students develop their knowledge of angles: 'The relevance of the relationship between angles is seen clearer and easier than drawing many forms of the relationship by hand to get the same effect' (Mike, Rationale). Similarly, Natalie included an interactive graphing tool from an external Web site to help her students manipulate changing slopes on a graph. She also included a range of other resources and recognised the efficiency benefits in being able to 'wrap' these experiences into one task for learners: 'This task makes use of Web links, applets and video in one package, …enabling [students] to be involved in discoveries through the technology that wouldn't be achieved as quickly in a paper environment' (Natalie, Rationale).

In summary, the participants demonstrated increased awareness of planning and sequencing activities along with design issues relevant to promoting independent learning. This subsequently raised their awareness of issues surrounding the integration of online and face-to-face activities and the role of the classroom teacher during such learning experiences. They also showed understanding of the use of appropriate media to support student learning.

TEACHERS DEVELOPING AN UNDERSTANDING AND VALUE OF SPECIFIC LEARNING STRATEGIES

Exploration of the second subsidiary research question—'*To what extent are preservice teachers' understanding of specific learning strategies enhanced?*'—drew mainly on journal entries, final survey and interview data. Pre-service teachers developed deeper understandings of their chosen learning strategy, how it can be used to inform an online learning task and other relevant classroom issues.

Participants Choosing the Predict–Observe–Explain (POE) Strategy

Participants who chose this strategy developed new insights into all stages of the POE procedure. They generally used the survey and question and answer (Q&A) LAMS tools for the prediction and reasoning stages of the POE procedure (e.g., see screenshot of Laura's authoring mode in Figure 2).

Although some, like Elizabeth, preferred the Vote and Journal tool. Indeed, Elizabeth experimented a little with the observation and explanation phases of the POE procedure, before giving a verdict on the best combination of (LAMS) tools in her final survey:

I tested using the 'Share Resources' [LAMS tool] followed by a 'Q&A' tool as well as the combined 'Resources and Forum' tool. The first worked much better. [My] Students found the step by step sequence easier to navigate. I would change the next time to have a 'Q&A' [LAMS tool] following.

Laura, who developed a task on 'life cycles' for her Year 2 children, developed new understandings of the 'reasoning' and 'explain' stages of the POE procedure: 'Using this teaching strategy gave me an insight into the importance of asking children to explain their answers and how many children actually have great difficulties answering why they think a certain way.' Troy commented on the value of the observation stage: 'The observations give students a real world connection between what they are learning and how it can affect them.' (His task incorporated a video-based demonstration of lightning.) Elizabeth also valued the prediction and reasoning stages and, like many teachers who chose this strategy, appreciated the potential use of students' elicited views as stimulus for follow-up class discussions: 'I think the questioning (predict and explain) of learners was very valuable in truly understanding my students' (Elizabeth, final survey). She thought the whole procedure helped her students to appreciate their own personal beliefs: 'Students need to be coached in the fact that they can learn from identifying wrong perceptions as much or even more than confirming right ones.'

Alice emphasised in her rationale the importance of choosing familiar and interesting contexts for POE tasks (in her case, she chose ice cream for her Year K children's task on melting). She stressed the importance of children being 'comfortable' with the details of these rich scenarios to allow them to make confident predictions. She thought the designing process helped her to become more sensitive to her children's science views: 'In doing this [design process] you need to place yourself in the children's shoes and really think about what they think.' Indeed, both Alice and Tom chose to create follow-up POE tasks, with one crucial variable changed in each subsequent task (e.g., in Alice's case, the colour of the ice cream)—a technique advocated by White and Gunstone (1992). Tom's three consecutive POE tasks (see Figure 3) helped probe his Year 9 students' understanding of sound waves.

Figure 2. Screenshot of Laura's POE task (LAMS author mode)

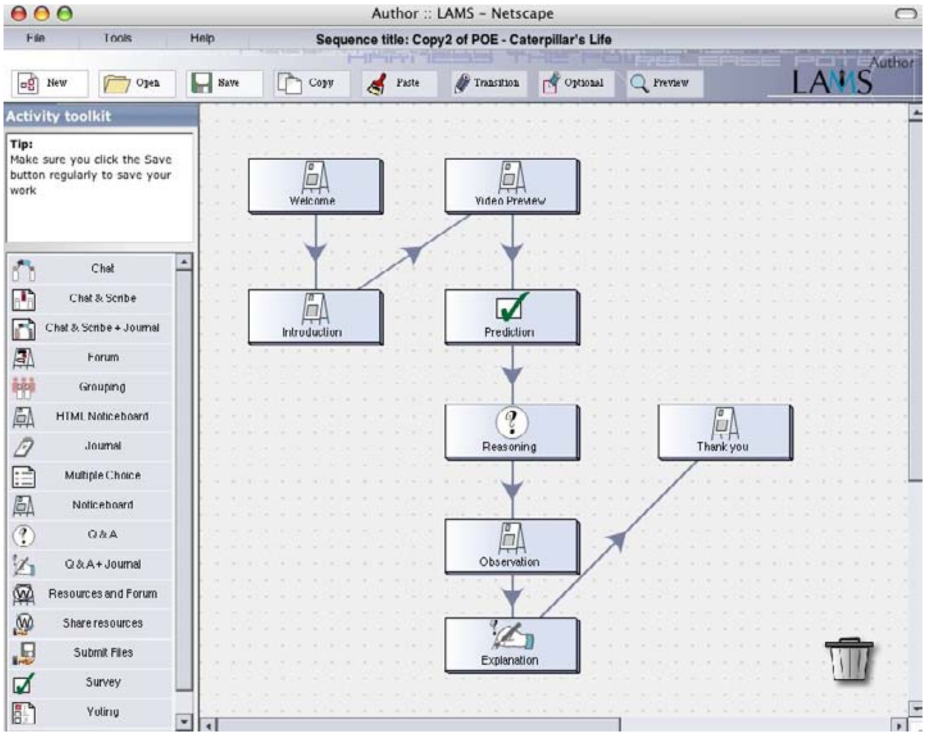
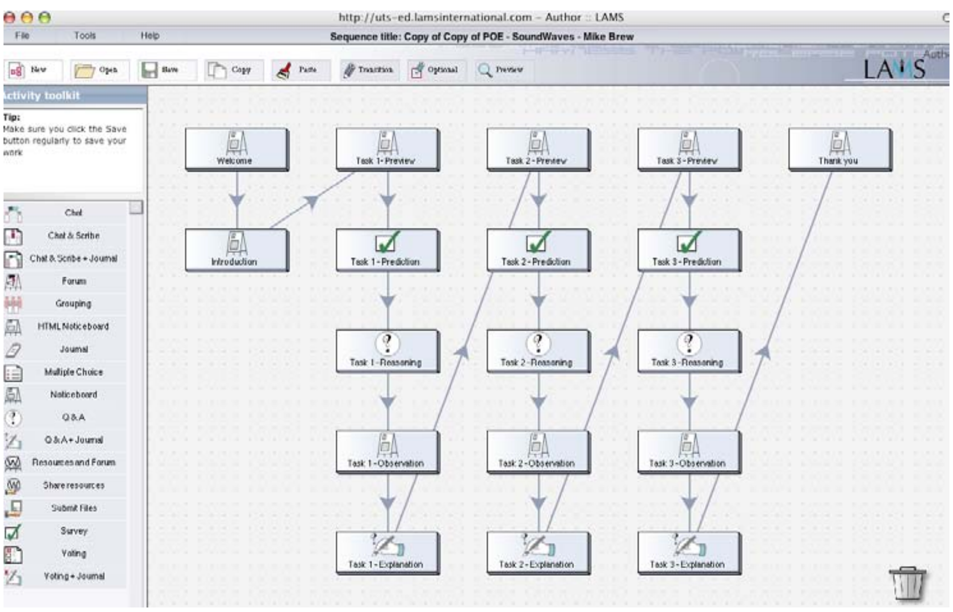


Figure 3. Screenshot of Tom's multiple POE tasks (LAMS author mode)



Participants Choosing the Learners' Questions (LQ) Approach

These participants used their online task to scaffold the 'exploration' and 'children's questions' stages (see Background section) of the interactive teaching model (Hand & Prain, 1995, p. 200) to elicit meaningful questions from their students. There was some interesting discussion about grouping and the best way to elicit questions from learners and how to conduct the subsequent 'investigation' stages. These preservice teachers developed an awareness of the strong locus of control afforded to the learner engaged in these LQ tasks. Naomi appreciated this factor but also recognised the difficulty of eliciting appropriate questions from her students for later investigation:

Its strengths lie in the fact that children are in control of their own learning which is motivating for them. Weaknesses include the actual questions the children may pose in that they may not be 'investigative' type of questions and may need to be rephrased.

Nick's rationale showed that he valued this strategy in helping his students take control of their learning. His task was used to elicit investigative questions for children to address in their upcoming excursion to a pond. He wanted them to 'construct their own ideas on how to investigate the pond, rather than [use] my ideas as a teacher on where the activities should lead' (Nick's journal).

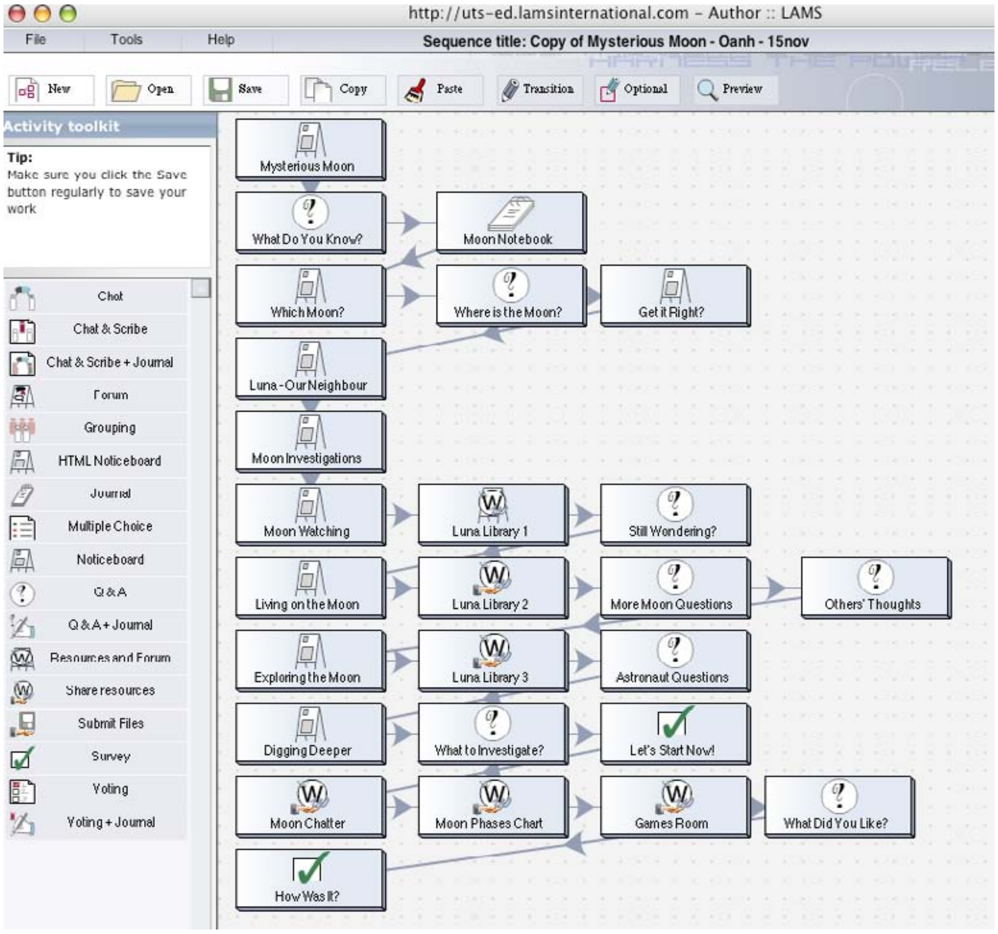
Naomi emphasised (in her rationale) the importance of collaborative (face-to-face) peer discussion at the computer as a crucial factor in eliciting questions. Indeed, in the feedback session after her lesson, school students said they enjoyed working in their small groups as they felt this helped them to generate more questions and ideas (researcher observation notes).

One issue raised by the participants was how best to approach the crucial phase (after learners' questions have been elicited) where learners negotiate an appropriate investigative question and suitable method to investigate this question. Naomi and Nick thought this was best done verbally in a whole-class discussion. For example, Naomi mentioned: 'better to print out the questions and then talk about them face-to-face and create an investigation from those questions' (final focus group). However, Hope chose to scaffold this (later) part of the model in her online LD designed to support her Year 6 children's learning about the moon. She did this by using the LAMS survey tool (see icon 'Let's Start Now' towards bottom of Figure 4) to ask children for their commitment level to questions they had chosen to investigate. In her rationale/reflection, she suggested further discussion forums or journals would be added to future versions of her task to mediate these later research phases of the interactive teaching model (Faire & Cosgrove, 1993). Like other participants who chose this strategy, Hope valued the authentic nature of this approach: 'It would demonstrate to students what it is like to answer real-life problems by themselves, through thinking through what they know, what gaps in their knowledge are…and thinking of how they would carry it out' (Hope, survey).

Participants Choosing the Analogical Reasoning (AR) Strategy

Preservice teachers who chose this strategy stressed the importance of using images to help their students' visualisation processes, especially in the initial 'focus' stage (Treagust, 1995) of the analogical reasoning procedure. Amy highlighted in her rationale that her use of images helped her students become familiar with the analogy, while Lucy explained the role of pictures and a video in her design to help kids visualise the comparison of positive and negative integers with fairies and monsters. Like many preservice teachers using this strategy, Eleanor wanted her students to have the confidence to explore similarities and differ-

Figure 4. Screenshot of Hope's LQ task (LAMS author mode)



ences between the analogue and target concepts and did so by incorporating her students' work samples into the design, as discussed previously. She also critiqued the strategy, showing concern for the possibility that an analogy may reinforce or even introduce alternative conceptions. She suggested teacher (face-to-face) mediation and follow-up as a possible solution here.

Lucy later explored the difference between teacher-created and learner-generated analogies (Aubusson & Fogwill, 2006): 'It [the project] really made me think about how much we develop the analogies for the kids and how much they should develop it themselves.' However, she thought that math contexts might be more difficult for school students to create their own analogies. She concluded in her survey: 'This project has really made me realise how hard it is to use analogies well in the classroom and how important it is to get students involved in creating them and talking about what the differences are.'

In summary, providing sufficient resources and time to enable preservice teachers to familiarise themselves with a chosen learning strategy was invaluable in fostering participants creative design and use of an online learning task. Having preservice teachers actually implement the design in an authentic context enabled in-depth reflection of the pedagogical issues associated with a particular learning design.

DISCUSSION

The preservice teachers explored appropriate ways to design and use an online task to facilitate their school students' learning. The preservice teachers 'unpacked' and thoughtfully critiqued the chosen learning strategy which informed their design. They evidenced a thoughtful approach to the use of media to ensure that it actually served to facilitate their students' learning. In some instances, where the use of media proved less effective for student learning than expected, participants reflected on appropriate solutions. Opportunities to reflect on the implementation of their LD in a real-life, school context encouraged thoughtful analysis of related pedagogical issues Of particular importance to them was the sequencing and blending of their online tasks with other face-to-face activities. The issues surrounding the creation of independent learning tasks but still wanting to be present to assist their students, created some conflict for the beginning teachers in understanding and managing their teaching roles.

The study has implications for support structures needed in this type of e-learning design exercise to promote preservice teacher reflection on pedagogy. If possible, the design of an online learning task should not be treated as an isolated exercise in teacher education courses and needs to be embedded in the authentic context of school practicum. The process of implementing their design gave the preservice teachers greater opportunities for reflection and evaluation of their role as a designer and a learning facilitator in a blended learning environment. Furthermore, preservice teachers need time to read about and 'test' their new understandings of strategies informing their designs, time to learn how to use LD authoring tools, and opportunities to reflect on their school-based implementations. This 'purposeful' design and implementation process gives preservice teachers further opportunities to form 'bridges' between theory and practice (Richards, 2005).

To build on this study, larger longitudinal studies should follow preservice teachers as they enter the profession and observe how they represent, document, and reuse their LDs in their own classrooms, with their colleagues, and across the school. Also important are ways in which they share and discuss their LDs with larger audiences such as the LAMS and Education Network Australia (EDNA) online professional communities. The practice of creating, implementing, and sharing LDs has enormous potential to reduce the traditional isolation of teachers, and it would be useful to explore how, when, and why teachers use their LDs to remove some of the barriers to professional collaborations across disciplines. One outcome of this project, after further analysis of the students' contextualised LDs, will be the drafting of visual representations and text-based formal descriptions (Agostinho, 2006) of generic LDs associated with the AR and LQ strategies used in this study. These representations will inform the creation of (LAMS-based) content and context independent 'e-templates' for other teachers to use in a similar fashion to the 'e-templates' created by Kearney and Wright (2002) for the multimedia-based POE design. Indeed, this study also raises the question of how other established, well-researched classroom learning procedures, especially from school-based contexts (e.g., see Baird & Northfield, 1995) might inform useful generic online LDs for teachers to adapt to their specific contexts.

The importance of LD research in naturalistic settings such as schools has been highlighted in this study. It emphasises the realities of school-based e-learning environments, where online

LDs are typically enacted in a face-to-face school computer laboratory. LD research needs to have stronger emphasis on these types of classroom environments to be relevant to school practitioners. Indeed, there is a need for further research into how prospective teachers might learn how to 'orchestrate' a mixture of online and face-to-face strategies in a lesson. Related to this issue is the need for further research into the nature of physical learning spaces provided for these types of lessons (Dillenbourg, 2006), including suitable furniture and mobile technologies conducive to quality learner interactions and collaborations. However, just as noticeable in this study was participants' minimal discussion (for example, in their rationales) of temporal and location affordances of the online medium. Further work is needed in teacher education courses to help future teachers reconsider the traditional 'same time, same place' framework of the typical school-based learning environment.

Finally, this study promotes teachers as important stakeholders in research on LD. It is important for the LD research agenda to further explore this area and continue a strong focus on practical and pedagogical issues. Participants in this study raised the issue of 'flexibility' and the danger of LDs being viewed by inexperienced preservice teachers as self-contained entities encouraging scripted, 'plug and play' teaching, too easily ignoring the diverse range of students' background knowledge and learning styles. Teaching is a complex 'business,' and good teachers take advantage of serendipitous pedagogical opportunities arising from learners' unanticipated 'ah-ha' moments (Fuller, 1992). At the very least, LD descriptions and representations need to acknowledge the flexible and dynamic nature of learning in school classrooms and fully detail a range of pedagogical issues in order to be useful for educators, especially novice teachers.

CONCLUSION

The study promotes good practice for teacher educators (and professional development programs) aiming to improve teachers' understanding of issues associated with new e-learning approaches. It also speaks to schools about problems facing teachers in trying to embrace online learning in environments that may not be ideal for flexible, integrated learning approaches.

The findings highlight the efficacy of preservice teachers authoring and implementing their own specific, contextualised LD to facilitate in-depth thinking and reviewing of a range of important teaching issues. In creating these tasks for use in their own practicum classes, preservice teachers started to think about blended learning issues and how to utilise the affordances of an online environment to promote independent learning. They developed skills and insights into the strategic use of media and Web-based resources in their designs to create context and interactivity, and developed an understanding of integrating appropriate face-to-face classroom strategies with their online task.

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REFERENCES

Agostinho, S. (2006). The use of a visual learning representation to document and communicate teaching ideas. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds.), *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who's Learning? Whose Technology?* (pp. 3-7). Sydney: Sydney University Press.

Agostinho, S., Oliver, R., Harper, B., Hedberg, H., & Wills, S. (2002). A tool to evaluate the potential for an ICT-based learning design to foster ‘high-quality learning. In A. Williamson, C. Gunn, A. Young., & T. Clear (Eds.), *Winds of change in the sea of learning: Proceedings of the 19th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 29-38). Auckland, New Zealand: UNITEC Institute of Technology.

Aubusson, P. J., & Fogwill, S. (2006). *Roleplay as analogical modelling in science*. In P. Aubusson, A. Harrison, & S. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. 91-102). Dordrecht: Springer.

Aubusson, P. J., Harrison, A. G., & Ritchie, S M. (Eds.). (2006). *Metaphor and analogy in science education*. Dordrecht: Springer.

Baird, J., & Northfield, J. (1995). *Learning from the PEEL experience*. Melbourne: Monash Print Services.

Bennett, S., Lockyer, L., & Agostinho, S. (2004, December 5-8). Investigating how learning designs can be used as a framework to incorporate learning objects. In R. Atkinson, C. McBeath, & R. Philips (Eds.), *Proceedings of the 21st ASCILITE Conference*, Perth (pp. 116-122).

Biddulph, F. (1990). Pupil questioning as a teaching/learning strategy in primary science education. In *SAME Papers Centre for Science and Mathematics Education Research* (pp. 60-63). University of Waikato, Hamilton, NZ.

Bullough, R., & Gitlin, A. (1991). Educative communities and the development of the reflective practitioner. In R. Tabachnich & K. Zeichner (Dir.), *Issues and practices in inquiry-oriented teacher education* (pp. 35-56). London: The Falmer Press.

Cameron, L. (2007). Scaffolding effective learning design with pre-service teachers. In *Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 195-202). Chesapeake, VA: AACE.

Dalziel, J. (2003). Implementing learning design: The learning activity management system (LAMS). In G. Crisp, D. Thiele, I. Scholten, S. Barker, & J. Baron (Eds.), *Interact, Integrate, Impact: Proceedings of the 20th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education*, Adelaide.

Dillenbourg, P. (2006). Orchestrating integrated learning scenarios. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds.), *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who’s Learning? Whose Technology?* (p. 955). Sydney: Sydney University Press.

Earp, J., & Pozzi, F. (2006). Fostering reflection in ICT-based pedagogical planning. In R. Philip, A. Voerman, & J. Dalziel (Eds.), *Proceedings of the First International LAMS Conference 2006: Designing the Future of Learning* (pp. 35-44). Sydney: LAMS Foundation.

Faire, J., & Cosgrove, M. (1993). *Teaching primary science*. Hamilton: Waikato Education Centre.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research*, *38*(1), 47-65.

Fuller, R. (1992). Millikan lecture 1992: Hypermedia and the knowing of physics: Standing on the shoulders of giants. *American Journal of Physics*, *61*(4), 300-303.

Gibbs, D., & Philip, R. (2005, June 27-July 2). Engaging with e-learning: Trialling a new learning activity management system (LAMS) in Australia. In *Ed-Media Conference, World Conference on Educational Media, Hypermedia & Telecommunications*, Montreal, Canada.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning of* *science in Australian schools: A research report*. Canberra: DETYA.

Griffiths, D., & Blat, J. (2005). The role of teachers in editing and authoring units of learning using IMS learning design. *International Journal on Advanced Technology for Learning, 2*(4), 1-9.

Hand, B. & Prain, V. (1995). *Teaching and learning in science: The constructivist classroom*. Sydney: Harcourt Brace.

Harrison, A., & Treagust, D. (2006). Teaching and learning with analogies. In P. Aubusson, A. Harrison, & S. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. 11-25). Dordrecht: Springer.

Hernandez-Leo, D., Villasclaras-Fernandez, E. D., Asensio-Perez, J. I., Dimitriadis, Y., Jorrin-Abellan, I. M., Ruiz-Requies, I., & Rubia-Avi, B. (2006). Collage: A collaborative learning design editor based on patterns. *Educational Technology & Society, 9*(1), 58-71.

Kearney, M. (2002). *Description of predict–observe–explain strategy supported by the use of multimedia*. Retrieved April 3, 2008, from Learning Designs Web site, http://www.learningdesigns.uow.edu.au/exemplars/info/LD44/index.html

Kearney, M. (2006). Prospective science teachers as e-learning designers. *Australian Journal of Educational Technology, 22*(2), 229-250.

Kearney, M. & Wright, R. (2002). Pr*edict–observe–explain eShell*. Retrieved April 3, 2008, from Learning Designs Web site, http://www.learningdesigns.uow.edu.au/tools/info/T3/index.html

Laurillard, D., & McAndrew, P. (2003). Reusable educational software: A basis for generic learning activities. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 81-93). London: Kogan-Page.

Loughran, J. (1997). Teaching about teaching: Principles and practice. In J. Loughran & T. Russell (Eds.), *Teaching about teaching: Purpose, passion and pedagogy in teacher education* (pp. 57-69). London: Falmer Press.

Masterman, L., & Lee, S. (2005). *Evaluation of the practitioner trial of LAMS: Final report*. JISC. Oxford University Computing Services, UK.

Mason, J. (1996). *Qualitative researching*. London: Sage Publications.

Merriam, M. B. (1998). *Qualitative research and case study applications in education*. San Franscisco: Jossey-Bass Publishers.

Neuman, D. (1989). Naturalistic inquiry and computer-based instruction: Rationale, procedures and potential. *Educational Technology, Research and Development, 37*(3), 39-51.

Odlyzko, A. (2001). Content is not king. *First Monday, 6*(2). Retrieved April 3, 2008, from http://firstmonday.org/issues/issue6_2/odlyzko/index.html

Oliver, R., & Herrington, J. (2003). Exploring technology-mediated learning from a pedagogical perspective. *Journal of Interactive Learning Environments, 11*(2), 111-126.

Richards, C. (2005). The design of effective ICT-supported learning activities: Exemplary models, changing requirements, and new possibilities. *Language, Learning & Technology, 9*(1), 60-79.

Russell, T., Varga-Atkins, T., & Roberts, D. (2005). *Interim report of the BECTA LAMS review* (Specialist Schools Trust Trial). University of Liverpool.

Salomon, G., Perkins, D., & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher*, *20*(3), 2-9.

Skamp, K. (2004). *Teaching primary science constructively*. South Melbourne: Thomson Learning.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 3-21). Hilldale, NJ: Lawrence Erlbaum.

Treagust, D. (1995). Enhancing students' understanding of science using analogies. In B. Hand & V. Prain (Eds.), *Teaching and learning in science: The constructivist classroom* (pp. 44-62). Sydney: Harcourt Brace.

Treagust, D., Duit, R., & Fraser, B. (Eds) (1996). *Improving teaching and learning in science and mathematics*. New York: Teachers College Press.

White, R., & Gunstone, R. (1992). *Probing understanding*. London: The Falmer Press.

KEY TERMS

Edna Community: Education Network Australia's free online network for educators (see http://www.edna.edu.au/).

LAMS Author Mode: Refers to the *learning activity management system* interface used by designers to author their task.

LAMS Community: The global online community for all teachers, administrators, and developers that use LAMS (see http://www.lamscommunity.org).

LAMS Learner Mode: Refers to the *learning activity management system* interface used by learners.

Learning Design: Refers to a coordinated set of online tasks designed to support conceptual change among learners (Oliver, 2001). The framework of these online designs consists of a learning strategy, learning resources, and support mechanisms to provide guidance and feedback to learners (Oliver & Herrington, 2003).

Learning Design Authoring System: Refers to software used to support the creation and delivery of online learning tasks.

Learning Strategy: Refers to conceptual change procedures and techniques that help learners develop their ideas (Skamp, 1998).

Chapter XIII
Using IMS Learning Design in Educational Situations

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ABSTRACT

IMS Learning Design (IMS LD) is a specification for describing a range of pedagogic approaches. It allows the linking of pedagogical structure, content, and services, whilst keeping the three separate, thus providing the potential for reuse as well as forming the basis for interoperability between learning activities and services. As such, this specification promises unprecedented opportunities to build effective tutor support and presence into e-learning systems. The tools that implement the specification have primarily been used for research purposes and have not been targeted at teaching practitioners or learners working in teaching and learning situations. There is a perception amongst practitioners and tool developers that the specification and tools are too technical or difficult for practitioner use. This chapter examines practitioner use of current tools for creating IMS LD and the use of IMS LD units of learning (UoLs) with learners through projects being undertaken at Liverpool Hope University (LHU). It presents some of the experiences and findings gained from these projects. The chapter also examines current technologies and tools for creating and running IMS LD UoLs, and finally discusses the potential and future for IMS LD.

INTRODUCTION

The IMS Learning Design (IMS LD) specification (IMS, 2003) is an evolution of the Educational Modeling Language (EML) developed by the Open University of the Netherlands (OUNL). EML was designed for online distance learning but was not considered a standard. The IMS LD specification was developed as a standard to encompass a wider range of teaching and learning situations. The specification claims to capture a wide range of pedagogies in electronic form, and as such, promises unprecedented opportunities to build effective tutor support and presence into e-learning systems.

IMS LD is a specification that can:

1. Describe learning situations which use a wide range of pedagogic approaches; the learning situations can be at any level of granularity, for example, activity, lesson, themed block, module, or course.
2. Link the learning with a range of content and services, potentially allowing for the reuse of learning designs.

IMS LD is well suited to offer the flexibility of implementing any pedagogical approach, allowing students to collaborate or progress through units of learning entirely at their own pace. It offers adaptability for students' abilities by allowing a practitioner to set up a unit of learning (UoL) that allows students to take different paths through it or through different UoLs based on their experience or learning styles.

Although the IMS LD specification has been available for around four years and much research and development has built up around it, for example, the UNFOLD project (UNFOLD, 2004) and TENCompetence (TENCompetence, 2005) project, few practitioners have had practical experience of it. Currently, the understanding of the utility of the specification and its uptake is low. Factors contributing to this include lack of "practitioner friendly" tools and the inaccessibility of the specification to people who do not have a technical background.

The aim of this chapter is to discuss the current status of IMS LD and, in particular, its uptake by teaching practitioners. This will be achieved through a discussion of findings and experiences from Joint Information Systems Committee (JISC) and Higher Education Academy (HEA) funded research projects carried out at LHU that are based on the use of IMS LD by teaching practitioners and learners.

The core objectives of the chapter are to discuss:

- The current technologies,
- The production of IMS LD UoLs,
- The experiences of practitioners and students,
- The potential for reuse.

The chapter will appeal both to practitioners wishing to use IMS LD in teaching and learning situations (for example, supporting the delivery of blended learning or fully online courses) and researchers interested in the technologies and current research surrounding IMS LD.

BACKGROUND

IMS LD was released in 2003 and is based on the Educational Modeling Language which was created by the OUNL. The OUNL no longer supports EML; instead it contributes to the ongoing development of IMS LD (Jeffery & Currier, 2003). IMS LD does not define a development methodology (Koper, 2005); rather it allows learning scenarios to be described and presented to learners online as well as enabling them to be shared between systems. It can describe a wide variety of pedagogical models, or approaches to learning, including group work and collaborative learning. It does not define individual pedagogical models; instead it provides a high level language, or metamodel, that can describe many different models. Like EML, the language describes how people perform activities, using resources (including materials and services) and how these are coordinated into a learning flow. Simply put, IMS LD is designed to represent many pedagogical models and to be a standard that offers interoperability and reuse (Kew, 2004; Koper, 2001).

This dual, but interrelated, definition, on the one hand describing pedagogy, but on the other, describing a standard for interoperability brings about a tension. Educators without a technical background may look at the specification (since this is currently what defines learning design), attracted by its claims that it will describe any pedagogy, but will be exposed to technical details such as the XML required to create a UoL. It is understandable then, that on first sight, educators might form the opinion that IMS LD is too difficult to use. As software developers will tend to focus on system level issues and are therefore working with the specification at this level, it is similarly understandable that they may see IMS LD as too difficult for educators to use. Whilst this view prevails, it is unlikely that the tools will be used, perhaps fueling the problem as developers see the tools not being used, and so continue to develop them for a more technical community.

Although the specification has been available since 2003, the use of IMS LD is still in its infancy. There has not been a very wide uptake as it is perceived to be too technical. To an extent this could be exacerbated by the availability, of research tools (i.e., tools that are not "practitioner friendly") or tools that do not fully exploit the specification (and hence are unlikely to meet the real needs of educators). This view is supported by Griffiths (2006) and De Vries, Tattersall, and Koper (2006) who suggest that more suitable tools for users are required. The uptake of IMS LD is also low due to there being few examples of UoLs or data from their use in actual teaching and learning contexts. The examples that are available, such as those at http://imsld.learningnetworks.org/course/, are helpful but offer little guidance to a practitioner who may want to put his/her course online. Research is being carried out in a wide range of areas, for example, interoperability, reuse, connectivity, services, tools, and pedagogy (e.g., Milligan et al., 2005; Navarro, Díaz, Such, Martín, & Peco, 2005; Pacurar, Trigano, & Alupoaie, 2005; Tattersall, 2004). Much of this research is technical and not aimed at the use of learning design in real educational settings. There is a need now to move the focus of research towards practitioners and learners and investigate how learning design can be used effectively and how usable tools can be developed to support this. More needs to be done, for example, to make the features of IMS LD more accessible for educators, provide access to services, choice of players, and so on.

A number of research projects have been undertaken or are underway which investigate aspects of IMS LD. A significant amount of work was undertaken by UNFOLD which has now come to an end. This included the development of tools such as CopperAuthor (no longer being developed) and research into the technical aspects of implementing and using IMS LD. This community also produced exemplar units of learning to demonstrate the utility of IMS LD (Learning Networks for Learning Design, 2004-05). However, these exemplars have, in general, been created from a technical perspective focusing on the best practice guide for their creation rather than having been developed within an actual educational context from a pedagogical perspective. The UNFOLD site also makes reference to projects that relate to IMS LD, and the majority of these focus on the tools and technologies. The UNFOLD community also proposed an architecture to support the use of an IMS LD system, known as the Valkenburg model (Wilson, 2005). Other projects in this area include the Learning Network for IMS Learning Design (LN4LD, 2006) and European Unified Approach for Accessible Life Long

Learning (EU4ALL, 2007). The LN4LD project was established to set up a learning network for the discussion and dissemination of projects and information involving IMS LD. The EU4ALL project focuses on accessible lifelong learning using an "Open, Standards-based, Reusable and Extensible Architecture of Services" (Boticario, Cooper, Montandon, & van Dorp, 2006). One of its objectives is to provide personalised and standards-based services which will involve the use of IMS LD.

A number of tools have been developed that could fit within this framework. Notably, a number of editors have been developed, along with a smaller number of players and repositories. Some editors have been produced that attempt to present a more usable interface to users or guide the user through steps to creating a UoL. Collage (Hernández-Leo, Villasclaras-Fernández, Asensio-Pérez, Dimitriadis, Jorrín-Abellán, Ruiz-Requies, & Rubia-Avi, 2006) is an example of a user interface that has been connected to the Reload editor. It presents the user with a visual representation of preset educational patterns. It produces a level A UoL, which could be further enhanced to level B or C by anyone who is more familiar with the specification. The lack of flexibility that is intrinsic to this approach means that teaching practitioners are likely to find it difficult to produce UoLs that are relevant to their particular teaching contexts. The approach does, however, show the utility of the Reload software in that different interfaces can be linked to it or that a user interface to Reload could be configured to present a different perspective to different users.

The NOCE Team, at the Université des Sciences et Technologies de Lille (Caron, 2006) is using the ModX tool that defines metamodels using Meta-Object Facility (OMG, n.d.). The tool allows a teaching practitioner to develop a UoL using a graphical interface, which is based on an underlying description of IMS LD as a metamodel. This can then be transformed into a lower level model that is specific to a particular delivery platform. This appears to be a flexible system which can provide different views to cater for various user groups, although a teaching practitioner would still need to have knowledge of the IMS LD specification in order to build a course and, in its current form, appears inaccessible to a nontechnical audience. The MOT+LD editor provides a user interface that is designed to be easy to use, but still requires knowledge of the IMS LD specification and is compliant to level A only.

This is just a small sample of the kinds of editors that are or have been developed. A general criticism of these editors is that they are usually compliant only to level A, and it is the experience of the Hope team that editors that are compliant to levels B and C are essential in order to support actual teaching scenarios. The UNFOLD website provides a good overview of IMS Learning Design architectures, editors, and players (UNFOLD, 2006).

Although the UNFOLD project has now finished, work continues through projects supported by, for example, TENCompetence and the JISC Design for Learning programme. TENCompetence looks at IMS LD in the context of lifelong learning competence. The project is also producing tools for creating UoLs along with runtime systems. The TENCompetence Web site identifies many projects working on IMS LD related themes, including Pro Learn Network of Excellence, which is examining IMS LD in the context of professional learning; the iClass project which has developed a graphical authoring tool for learning design; ASK-LDT; Prolix who have examined the IMS LD specification to plan the learning activities needed when a change in business process occurs; the Calibrate project that provides tools for teachers based on IMS LD for use in the collaborative exchange of learning resources in schools; the Cooper project, which is using IMS LD to support long distance cooperation of teams of students working on complex projects; the OpenDock project which is developing the IMS LD-aware OpenDocument.Net repository to hold educational material for vocational education and training. Other projects listed on the TENCompetence Web site include the learning activity management system (LAMS), which has been adapted to export IMS LD level A and Moodle which is working towards IMS LD import and export.

An interesting aspect of this range of projects is the fair balance between technical and practitioner based research. Also, it is encouraging to see more established learning environments such as LAMS and Moodle incorporating facilities to import and export IMS learning designs. This can only help to encourage awareness, uptake, and use of the specification.

CURRENT TECHNOLOGIES

The focus of this chapter is on the authoring and running of IMS LD in actual teaching and learning situations. This includes the development of UoLs by teaching and support staff and the running of these online with learners, along with the tools to support this. Frameworks and architectures have been developed that define the tools and workflows in an activity management system, notably through the work of the Valkenburg Group (Wilson, 2005). Until recently, there has been little implementation of tools that are IMS LD compliant. Learning design implementations include the LAMS which appears to be the most useable and widely used learning design system currently available (Britain & Liber, 2004; JISC, 2005), although this system does not currently follow the IMS LD specification and does not fully support sharing and reuse or interoperability. A major impetus to IMS LD implementation is the recent availability of a fully compliant IMS LD engine, CopperCore (Open Universiteit Nederland, 2005). Implementations based on this engine include the service-based learning design system, SLeD (Open University, 2005), which forms the basis of much of the work described in this chapter. The SLeD system is designed to fit within a service-oriented architecture and represents the runtime environment component within the Valkenburg architecture. Services specified within a learning design would need to be available as components external to the player. This is an advantage of the SLeD player as compared to, for example, LAMS, whereby these services could be provided by software components that are already used by learners or may form a part of the learners' personal learning environments. On the other hand, this presents a potential barrier to the uptake of such tools, as services suitable for connection to a system such as SLeD are not currently in widespread use, and there is some debate as to whether these should be generic services or tailored to suit the purposes of IMS LD.

Reload (2005) is an open-source tree-based editor that models the full IMS Learning Design specification and presents the user with a graphical interface through which to work with it. The tool is designed such that new user interfaces can be connected to it. The current version, having not been designed for practitioner use but to allow people to experiment with the specification, exposes all the elements of the specification. However, in the authors' opinions, this remains the best tool available for the authoring of UoLs in a real context. Despite its experimental nature, the authors and their user group found it to be reliable when creating level A and B learning designs to use with learners in classroom situations; the software was found to be stable, appeared to implement the specification, and was flexible in its configuration. It is based on the widely used IMS Content Package editor and is reaching maturity as a learning design editor. One of the projects being carried out at LHU concerns working with the Reload team to develop a user interface that is more suitable for practitioners. These practitioners could be teachers, who, in general, ought to be shielded from the specification, or learning technologists who may wish to work more closely with the specification, and so could be presented with a different user interface to the same tool.

These tools have mainly been proof-of-concept, designed to allow researchers and the IMS LD community to investigate and experiment with the specification, and were not intended for use by teaching practitioners or learners. The team at LHU, however, recognized the potential of IMS LD to support pedagogic integrity in the electronic delivery of learning. The existence of these tools made real the possibility of trying the approach in a teaching and learning situation, which gave rise to the projects described below.

SLED INTEGRATION DEMONSTRATOR (SLIDE): PRACTITIONER USE OF SLED

This was a JISC-funded demonstrator project (JISC, 2005a) and was one of the very first times that an IMS LD UoL running on CopperCore and SLeD was used with a live, assessed course. The project involved installing a learning design system (based on LMS LD) and integrating this with the university's existing systems. The project provided valuable experience of carrying out this process in an organisation other than that in which the toolkits were developed. The tools were set up within the normal university network and made available to learners through their normal institutional authentication. This initial project investigated whether the specification could be used for teaching and learning purposes. A tutor volunteered to use IMS LD to design a UoL to support a second year undergraduate course, Media Production and Scripting. This course consisted of 15 students. It is worth noting that this tutor previously was reluctant to use any kind of e-learning or VLE. The tutor's previous experiences had demonstrated that the current institutional VLE could not accommodate the pedagogical structure or the type of content that was required for teaching the module.

The practitioner was given a short training session in using the Reload editor before starting to create her own UoL. This did not require knowledge of the specification but rather an understanding of the Reload editor's interface. The practitioner found that the specification would allow her to replicate the learning and teaching processes that were required for the course. However, the Reload interface made this difficult. It was quickly found that in order to develop more complex activities such as uploading a file, sending notifications, or monitoring timed activities, a knowledge and use of IMS LD properties and conditions as well as XML coding were required. Both the practitioner and project team felt that this would present a barrier to the wider uptake of IMS LD as the majority of practitioners will not want to write code. The IMS LD specification also allows linking to services, such as a forum or chat, but this again would require programming skills. Different approaches were investigated as to how to describe a learning design appropriately. It was initially decided to adopt the approach described in the IMS LD Best Practice Guide as a means of describing the tutor's learning design as it seemed to have been used effectively by the UNFOLD Project to describe their demonstrator UoLs.

Data were collected from both the practitioner and learners via questionnaires. The tutor questionnaire covered the usability of Reload whilst the student questionnaire focused on the learner experience and usability of SLeD. The questionnaires were designed and analysed by a data analyst who was assisting the project team, and the experiences of both the practitioner and learners were recorded. Overall the responses were positive, with a few negative responses to questions relating to reliability and performance. This may be due to the use of proof-of-concept tools, the CopperCore engine, and SLeD player not being appropriate for live use at that time. In addition, the system did not appear to be scalable or robust; for example, the SLeD player's response time tended to degenerate as a user worked through a UoL. There were also usability issues.

As the tutor created UoLs, she reported that it was easier (and more natural) for her to work from her scheme of work and lesson plans, as these already described the teaching and learning process in terms of appropriate pedagogy, activities, sequencing, resources required, and who does what. She also noted that when using the Reload editor, the process required was beneficial to lesson planning. A lesson plan in a traditional sense would describe the activities, their timings, and resources needed. In a blended environment, this can be adapted as it is being delivered. It was felt that the specification encourages a tutor to think more carefully about planning a lesson and that this would be particularly beneficial in planning for a fully online learning session.

A major issue was that a practitioner could not adapt runs of a unit of learning "on the fly"—something that a practitioner might want to do, particularly in a face-to-face or blended situation. Currently, learners will lose any progress achieved when the UoL is modified. This is due to the way that UoLs are published as precompilations. This means that course designers need to plan for every eventuality, which is impractical. The team worked around this issue by building smaller UoLs.

Learners using the system were canvased for their opinions, and mean scores for the Likert-style statements used show that they were generally positive about the guidance offered, ease of navigation, and ease of use and usefulness of the software but negative about the reliability of the software. Statements that focused on aspects of the IMS LD specification itself rather than the usability of the software generally elicited positive responses. It should be noted that the student experience was somewhat influenced by the runtime errors and stability of the CopperCore engine and the usability of the SLeD player.

Findings from this project suggest that whilst the Reload editor was an invaluable tool for producing UoLs, a more usable interface for teachers/course designers would be required if such a tool were to be used in the wider institutional context, and especially by practitioners not possessing technical or programming skills. The team felt that the project, although limited, demonstrated the utility of IMS LD. The system in use was shown to other practitioners at LHU, who were generally enthusiastic about the possibilities. The team sees the barriers to uptake of the specification to be the lack of usable and reliable tools and a lack of a "critical mass" of practical IMS LD UoLs. These findings have provided the basis for further research and have led to the funding of further projects which are outlined below.

Subsequent projects, Learning Designs for Practitioners (LD4P), Developing for Learning Designs (D4LD), and Higher Education Academy (HEA), build upon these findings by focussing on the tools (LD4P); the robustness and usability of the engine and player (D4LD); and practitioner and student experiences (HEA).

LHU leads two of these projects: LD4P, which is evaluating the Reload IMS LD editor and is developing a prototype user interface based on practitioner requirements. The HEA project involves practitioners creating learning designs for an MSc computing programme, and the practitioner and student experiences, whilst the UK Open University leads the D4LD which focuses on the SleD player and improving the performance of the CopperCore engine.

IMS LD FOR PRACTITIONERS (LD4P): AUTHORING

This is a JISC-funded project (JISC, 2007a) which focuses on improving the user interface for the Reload learning design editor so that it is more appropriate and usable for practitioners. The Reload editor has been designed as a research tool, and as such, its user interface is not suitable for mainstream educators and practitioners. Workshops on the use of Reload have been run with practitioners from both the further education and higher education sectors at St. Helens College and LHU. The practitioners came from a range of disciplines including computing, psychology, and English from HE and beauty, mathematics, English, and science from FE. The workshops introduced the Reload interface and consisted of working through the process of building a predesigned learning design. The practitioners were then encouraged to develop one or more of their own lessons into an IMS Learning Design. Initial requirements have been gathered from the users both at the end of the initial workshop and when they had completed their own learning design. This approach was used as the initial workshop allowed practitioners to become familiar with Reload and provided preliminary feedback on the interface. Allowing users to create a learning design specific to their own subject discipline provided better feedback as it was no longer seen as an artificial setting. The practitioners were able to try out a wide range of different tasks to create their lessons. This has provided invaluable feedback on the different aspects of the Reload interface.

The project is still underway and the feedback from the questionnaires along with observations and interviews are being used to design a prototype interface informed by user requirements. The questionnaires were designed to elicit an unbiased response from the practitioners regarding usability, interface, and workflow. The prototype will be evaluated with the practitioners as part of an iterative process and further feedback, and requirements will be gathered using the prototype. It is hoped that the final interface will offer practitioners the tools they need to be able to create IMS Learning Designs, and in so doing, it will remove one of the barriers to institutional uptake.

Feedback from the workshops has been generally positive and suggests that the majority of users see the educational benefits of using the IMS LD specification and how it can be applied to their subject disciplines. Interestingly, all of the practitioners have experience with different VLEs, and some were firmly committed to the institutional VLE, but many of these tutors could see the advantages of using those features of IMS LD not offered within their institutional VLE.

During the workshops, practitioners were canvased for their opinions on the Reload software. Two questionnaires were used to gather the data. The first questionnaire was completed after the practitioners had created the predesigned learning design during the first workshop. The second was completed after they had completed their own subject specific learning design. These questionnaires were also analysed by a data analyst. Opinion was largely neutral with the largest factor being that respondents were unsure of the software's workflow. The strongest expression of negative feeling (nearly all agreed) was to the statement, 'Sometimes I don't know what I should do.' The most positive reaction was to the statement, 'The different sections of the software make sense.'

There were ostensibly two different groups of participants who might be categorised as 'experts' and 'novices' in the use of software applications: those who attended the workshop at ALT-C, along with computing lecturers from Hope who attended a workshop were designated as 'experts' and the others who attended the workshops from Hope & St Helens as 'novices.' There were no statistically significant differences between the two groups except in responses to the statements 'I find the layout of the screen confusing' and 'The conceptual metaphor of a "play" is confusing.' Experts were less confused by both the layout of the screen and by the use of the conceptual metaphor, 'play' (taken from questionnaires analysed for project).

The findings also suggest that an in-depth knowledge of the specification and a deep understanding of all of the properties is not required to create UoLs. The practitioners could create IMS Learning Designs with little or no knowledge of the specification. The presentation of the myriad properties in the Reload editor can be mislead-ing as it seems to suggest a need for in-depth knowledge. All that the practitioners require are their lessons plans and schemes of work and a means of relating what they do to the editor. This contradicts research from De Vries and Tattersall (2006), which suggests that knowledge of the specification is required. The findings also suggest that different pedagogical approaches can be implemented using the specification. This goes some way to support the specification's claim that IMS LD can model all pedagogical approaches. IMS LD is a useful way of describing lesson planning or for reflecting on lesson planning created using other approaches. Finally, the research indicates that the Reload tool is not currently user friendly and is a barrier to uptake; for example, the metaphor and the workflow are not appropriate for a practitioner.

DEVELOPING FOR LEARNING DESIGN (D4LD): RUNTIME

This project (JISC, 2007b) is being carried out in partnership with the UK Open University (the project leader) and OUNL. It focuses on improving the runtime tools (CopperCore and SLeD) for use in an institutional setting. Building on the findings from the SLiDe project, the aim of the project is to improve the performance of these tools and to improve the usability of SLeD for learners.

The two main problems identified with the CopperCore engine used in the SLiDe project were that the system was unreliable and it suffered from performance issues. Initial improvements have been made to the CopperCore engine to increase its efficiency and stability. This new version is being used with small student numbers on an MSc Developing Multimedia module, and the stability and performance of the system appear to have improved. Further testing involving larger numbers is now required. The usability of the SLeD player interface is being improved on the basis of feedback from the SLiDe project. Issues that were identified include the duplication of property names in the player interface, linking to limited file formats and screen scrolling. The first two of these problems have been addressed. Further improvements to performance and usability issues will be carried out based on feedback from the HEA and LD4P projects. Feedback from this project will be gathered using the same methodology used in the LD4P project.

HEA PROJECT: DEVELOPING UNITS OF LEARNING

This project is funded via the Higher Education Funding Council (HEFCE) capital funding through the HEA and is centred on the creation of UoLs for the online delivery of the MSc computing degree at Liverpool Hope University. Its purpose is to measure practitioner experience in creating LDs and to see if IMS LD can be used to produce lessons using a variety of pedagogical approaches and to measure the student experience in comparison to their existing e-learning experiences. This will involve the creation of 10 learning designs each using different pedagogical approaches, covering different computing subjects.

To date, four modules have been created, one of which has been used to deliver the Developing Multimedia module. Initial findings for this pilot module suggest that students found delivery via IMS Learning Design to be of benefit because it allowed them to track their own progress clearly; they knew where they were in the syllabus, and each activity always had a clear description and associated resources. It gave the students structure and flexibility. They were able to work at their own pace and able to revisit sections of the course. The IMS LD allowed the students to connect to a range of resources of different file types, which had not been possible with the institutional VLE. The students found these resources beneficial as they were practical demonstrations of multimedia techniques. Overall, course results improved in comparison to the previous year. Due to the small number of students involved, no statistical significance to this can be claimed, but the result would warrant further investigation. Modules will be run during the following academic year, and the student learning experience will be measured via questionnaires and observations. Student performance will also be compared to previous years.

Benefits for the tutor included the ability to closely monitor the group and the individual via tutor views of the learning design. An individual student's progress could be tracked; for example, progress, submissions, and communications could be made with each student as required. On a group level, progress could be synchronised and monitored too.

Although only one module has run to date, three other modules have been fully developed with the remainder still in development. Practitioner experiences will be measured using observations and interviews. These will focus on the practitioner experiences of using Reload, the perceived usability of the Reload editor, and of their user requirements. Findings from the creation of the learning designs so far has indicated that the specification is able to cater for the different teaching and learning approaches used on the Master's programme. The findings also indicate that the tutors do not need to have an in depth knowledge of the specification to create IMS Learning Designs, merely an introduction to the Reload interface, a plan of how they want to deliver their courses and the appropriate resources.

FUTURE TRENDS

From the literature review and findings from the research projects described in this chapter, there are a number of gaps that could be seen as barriers to the uptake of IMS LD, including:

- A lack of tools that allow the creation, editing, and linking of presentation, for example, the learner view, teacher view, assessments (QTI), and services.
- No easy means of connecting to services (forums, etc.).
- The lack of a set of "default" services that can be quickly linked to a unit of learning.

In the short term in order for IMS LD to be seen as more acceptable as a means for delivering learning, tools that are more usable are needed. This is currently being addressed in several different ways. For example, the projects discussed in this chapter address improvements in authoring tools (LD4P) and improvements in the runtime engine and player (D4LD). Other research is addressing issues such as methods of exporting learning designs from other learning spaces (for example Moodle and LAMS) or providing a learning environment that allows the use of IMS LD (for example .LRN).

It is clear to the authors and others (De Vries & Tattersall, 2006) that the tools implementing an IMS LD system will play a major role in learning management systems in the future, particularly if issues of usability and the needs of users such as teaching practitioners and learners are addressed. These tools fit within a service-oriented architecture upon which the e-framework is based, backed by the UK JISC, the Australian Department of Education Science and Technology (DEST), and more recently, by New Zealand's Ministry of Education. The spirit of the framework is also supported in Europe by projects such as TENCompetence. This approach therefore has an international backing and is gaining momentum within the e-learning industry. More accessible tools that currently enjoy relative popularity, such as LAMS, are, in the authors' opinion, likely to be replaced by a suite of tools that fit within the e-framework as this matures and becomes more widely adopted by educational institutions and as the benefits of tools that capture a variety of pedagogies become more widely recognised. It is also likely that such a suite of tools will form a part of learners' or educators' personal environment and may be selected by them, rather than the institution.

In the longer term, there is increasing research into the use of *distributed* approaches for learning, including service oriented architectures (SOA), grids, and decomposed (or disaggregated) approaches such as Web 2.0 or simply using a wiki, blog, or e-mail to support learning. In these contexts, it is the authors' opinions that IMS LD could be used as the common "glue" for pedagogic activities during the eventual breaking up of monolithic institutional VLEs and, in light of some of the previously mentioned technologies, such as Web 2.0 and SOA, IMS LD could be the "glue" that provides the pedagogical underpinning that links the teaching approaches with the required services.

IMS LD also offers the flexibility to support the current drive towards a service oriented approach (SOA) to promote better support for lifelong learning. This is achieved through the IMS specifications ability to link out to 'in principle' any Web service. This offers a huge advantage over any VLE where the practitioners are tied in to the services offered by the vendor. This means that IMS LD could take advantage of new Web 2.0 services thus emphasising the importance of standards and interoperability.

There is growing recognition of a synergy between IMS LD and the emerging social software paradigm, or the so-called 'Web 2.0.' This will present a challenge to the learning design community as tools will be needed to discover and configure services required by a learning design. Perhaps a bigger challenge, though, is how a specification such as IMS LD can support the management of learning activities in such an environment, whilst enabling institutions to guarantee effective educational integrity of formal learning. This is a question that is being tackled by the authors within the IMS Learning Design tools for Users project as part of the JISC Users and Innovation: Personalising Technologies Capital Programme.

The future of IMS LD therefore lies in a more widespread uptake, and a result of this should be a maturation of the tools and an evolution of the specification as the education community gains experience in using these. Barriers to uptake may include a lack of accessible tools that implement learning design and a paucity of easily deployed services. In the short term, in order for IMS LD to be seen as a more acceptable approach for delivering learning, tools that are more usable are needed. This is currently being addressed in several different ways. An example of this is the improvement of user interfaces to tools that work directly with the specification such as Reload, which is being tackled by the LD4P project and TENCompetence. The D4LD project is improving the performance of the CopperCore engine and SLeD player and making them more robust so that they can be used in institutional settings. Also, the specification is diffusing from these experimental tools into more widely used tools such as Moodle and LAMS, which are developing methods to import/export IMS LD.

REFERENCES

Boticario, J.G., Cooper, M., Montandon, L., & van Dorp, J.K. (2006). *Towards an open, standard-based, reusable and extensible architecture of services for accessible lifelong learning: An introduction to the EU4ALL project.* Retrieved April 3, 2008, from http://www.ia.uned.es/~jgb/publica/EadtuFull-jgbmclmkd06.pdf

Britain, S. & Liber, O. (2004). *A framework for the pedagogical evaluation of e-learning environments.* Retrieved April 3, 2008, from http://www.cetis.ac.uk/members/pedagogy/files/4thMeet_framework/VLEfullReport

Caron, P. (2006). *Implantation de scénarios pédagogiques selon une approche rientée modèle*. Paper presented at 1ères Rencontres Jeunes Chercheurs en EIAH, RJC-EIAH'2006.

De Vries, F., Tattersall, C., & Koper, R. (2006). Future developments of IMS learning design tooling. *Educational Technology & Society, 9*(1).

EU4ALL. (2007). *EU4ALL home page*. Retrieved April 3, 2008, from http://www.eu4all-project.eu/index.php

Griffiths, D. (2006, November 8). *IMS-LD, progress and prospects*. IMS LD Summit Heerlen. Retrieved April 3, 2008, from http:// www.imsglobal.org/ldsummit/4.%20Dai%20Griffiths_LD-summit_08nov06_post.pdf

Hernández-Leo, D., Villasclaras-Fernández, E., Asensio-Pérez, J., Dimitriadis, Y., Jorrín-Abellán, I., Ruiz-Requies, I., & Rubia-Avi, B. (2006). A collaborative learning design editor based on patterns. *Journal of Educational Technology & Society, 9*(1).

IMS Global Learning Consortium. (2003). *Learning design specification*. Retrieved April 3, 2008, from http://www.imsglobal.org/learningdesign/index.html

Jeffery, A., & Currier, S. (2003). *What is… IMS learning design? CETIS standards briefings series*. Retrieved April 3, 2008, from http://zope.cetis.ac.uk/lib/media/WhatIsLD_web.pdf

JISC (2005). *Evaluation of the practitioner trials of LAMS*. Retrieved April 3, 2008, from http://www.jisc.ac.uk/uploaded_documents/LAMS%20Final%20Report.pdf

JISC. (2005a). *SliDe SLeD Demonstrator: Final report*. Retrieved April 3, 2008, from http://www.jisc.ac.uk/whatwedo/programmes/elearning_framework/elfdemo_livhope.aspx

JISC. (2007a). *Learning design for practitioners*. Retrieved April 3, 2008, from http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_ld4p.aspx

JISC. (2007b). *Developing for learning design*. Retrieved April 3, 2008, from http://www.jisc.ac.uk/whatwedo/programmes/elearning_pedagogy/elp_d4ld.aspx

Kew, C. (2004). *Learning designs presentation*. Retrieved April 3, 2008, from http://www.unfold-project.net/general_resources_folder/introsld/IMSLD-pres/Learning%20Design.ppt

Koper, E.R.J. (2001). *Modelling units of study from a pedagogical perspective: The pedagogical meta model behind EML*. Retrieved April 3, 2008, from http://eml.ou.nl/introduction/docs/ped-metamodel.pdf.

Koper, R. (2005). *Some basic ideas behind IMS learning design*. Retieved April 3, 2008, from http://hdl.handle.net/1820/489

Learning Networks for Learning Design. (2004-05). *How to modify a unit of learning*. Retieved April 3, 2008, from http://imsld.learningnetworks.org/course/view.php?id=10

LN4LD. (2006). *Learning network for IMS learning design (LN4LD)*. Retrieved April 3, 2008, from http://www.learningnetworks.org/

Milligan, C.D., Beauvoir, P., & Sharples, P. (2005). The Reload learning design tools [Special issue on advances in learning design]. *Journal of Interactive Media in Education*. ISSN: 1365-893X. Retrieved April 3, 2008, from jime.open.ac.uk/2005/07

Navarro, L.I., Díaz, A.S., Such, M.M., Martín, D.M., & Peco, P.P. (2005). Learning units design based in grid computing [Special issue on advances in learning design]. *Journal of Interactive Media in Education*. ISSN:1365-893X. Retrieved April 3, 2008, from jime.open.ac.uk/2005/10.

OMG. (n.d.). *OMG's MetaObject Facility*. Retrieved April 3, 2008, from http://www.omg.org/mof/

Open Universiteit Nederland. (2005). *The IMS Learning Design Engine*. Retrieved April 3, 2008, from http://coppercore.org.

Open University. (2005). *Service based learning design player*. Retrieved April 3, 2008, from http://sled.open.ac.uk/web/

Pacurar, E. G., Trigano, P., & Alupoaie, S. (2005). A QTI editor integrated into the netUniversité Web portal using IMS LD [Special issue on advances in learning design]. *Journal of Interactive Media in Education*. ISSN:1365-893X. Retrieved April 3, 2008, from jime.open.ac.uk/2005/09

Reload. (2005). *Learning design editor*. Retrieved April 3, 2008, from http://www.reload.ac.uk/ldeditor.html

Tattersall, C. (2004). *QTI and learning design*. Retrieved April 3, 2008, from http://hdl.handle.net/1820/242

TENCompetence. (2005). Retrieved April 3, 2008, from http://www.tencompetence.org/

UNFOLD. (2004). Retrieved April 3, 2008, from http://www.unfold-project.net:8085/UNFOLD

UNFOLD. (2006). Retrieved April 3, 2008, from http://www.unfold-project.net/general_resources_folder/tools/

Wilson, S. (2005). Architectures to support authoring and content management with learning design. In R. Koper & C. Tattersall (Eds.), *A handbook on modelling and delivering networked education and training* (pp. 45-50). Springer-Verlag.

KEY TERMS

Educational Modeling Language (EML): This is a specification based on XML that allows the modeling of instructional design. This is the precursor of IMS LD and is no longer being developed.

IMS Learning Design (IMS LD): This is a specification allowing the representation of various pedagogical models to describe learning.

Open Source: This normally refers to any program whose source code is made freely available for use or modification by others. This software is commonly developed and maintained by communities of coders.

Repositories: This refers to a place where data, for example, units of learning, can be stored, shared, and maintained.

SOA: This is a collection of services that communicate with each other, for example, coordinating activities and passing data. Services are self contained, well defined, and do not rely on the state of other services, for example, chat room.

Unit of Learning (UoL): This is the representation of a course or module created using the IMS LD specification that can be run through a player such as SLeD for use with students

XML (Extensible Mark-up Language): XML is a W3C standard for creating mark-up languages that describe the structure of data. It is a metalanguage for describing other languages, for example, IMS learning design.

Chapter XIV
Online Role-Based Learning Designs for Teaching Complex Decision Making

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ABSTRACT

Decision-making processes in relation to complex natural resources require recognition and accommodation of diverse and competing perspectives in a decision context that is frequently ill defined and fraught with value judgements. Online environments can be used to develop students' skills and understanding of these issues. The focus of this chapter is the learning design of an online roleplay-simulation (Mekong e-Sim) which was created to develop learning experiences about these types of issues across multiple institutions with students from the disciplines of engineering and the humanities. The key stages of interaction within the e-Sim are described and linked to student tasks, resources, and supports. The evolution and adaptation of the learning design used in the Mekong e-Sim has been described. Eight key challenges in the design and implementation of online roleplay-simulations have been identified. In this chapter, we have tried to address a gap in the online role-based collaborative learning literature about the design of these activities, linkages between pedagogy and information and communication technology, and how to exploit these linkages for effective learning.

INTRODUCTION

University courses seek to develop students' content and disciplinary related knowledge and skills. The professional workplace is characterised by multidisciplinary teams working together to solve increasingly complex issues and problems. Well prepared graduates need more than just knowledge and skills; it is critical they have the capability to generalise from one situation to another, to adapt their behaviour to a range of contexts, and to understand multiple perspectives. To function successfully in the contemporary workplace, graduates also need to understand how to work cooperatively and collaboratively. A recent Australian review of science graduates found little evidence that graduates' training had contributed to an awareness of social implications of developments in their discipline, an understanding of other points of view, the ability to use information technology effectively, the ability to work with others, and a capacity to deal with complexity and ambiguity (McInnis, Hartley, & Anderson, 2001). The challenge facing university teachers is how to incorporate these new dimensions of curriculum into an already full programme. It is acknowledged that the development of students' skills and understanding in these generalisable and transferable skills is a necessary dimension of professional education. Despite this, there is a paucity of descriptions of strategies that teachers can use to develop students' skills in a sustainable way.

University teachers have been challenged to develop effective teaching approaches that will support students in learning the broad range of skills and knowledge now considered essential for the professions. One approach to teaching that appears to offer a solution to this dilemma is that of active learning. Active learning methods attempt 'to develop the cognitive [knowledge, understanding, and thinking] and affective [emotive] dimensions of the learning process in such a way that learners' active involvement in the learning is improved' (Learning and Teaching Support Network, 2003). They involve a more discursive and collaborative approach to problem solving and seek to illustrate and accommodate diversity that provides a means by which students can develop discipline-specific and generalisable skills and knowledge. Active, engaged learning can be achieved through the use of a wide range of strategies, including collaborative learning, problem-based learning, case methods, enquiry-based learning, and combinations of roleplay and simulation. These strategies can be represented through learning designs.

Learning designs provide a way of representing the components of a planned learning activity or experience and the ways in which those components interact. These representations can be applicable to different kinds of learning approaches and be used to enable repeatable, effective, and efficient instances of learning. In addition, learning designs support the reuse and repurposing of component elements and the framework and components of a learning instance (IMS, 2007). A learning design can be repopulated with different contents and resources to be applied in a new learning context (Richards, 2005), and/or a set of learning activities can be included in different courses (McAndrew & Weller, 2005).

In the following sections, we discuss the active learning principles that have underpinned our approach to creating a learning design for an online roleplay-simulation. We then focus on the learning design of the Mekong e-Sim and discuss how the design has been adapted for different teaching contexts. We then address the challenges facing designers of these activities, particularly in regard to designing these types of activities to use the affordances of information and communication media in a way which enhances student learning.

BACKGROUND

Contemporary learning theories are informed by the belief that learning is an active process of constructing knowledge that is supported by teaching or instruction (Duffy & Cunningham, 1996). The types of learning environments that support students in achieving these learning outcomes are those that are designed to foster knowledge construction. Learning contexts based on constructivist principles (Harper & Hedberg, 1997) are considered most likely to encourage active learner engagement and involvement in actively constructing knowledge rather than passively receiving information transmitted by the teacher. In constructivist theories, social interactions among learners are seen to play a critical role in the processes of learning and cognition (Vygotsky, 1978), so it is important that learners are given opportunities to encounter multiple perspectives within meaningful contexts. Active knowledge construction is supported by learning experiences in which the learner is involved in the active and interpretive development of personal understandings and meaning. The design of learning experiences that promote knowledge construction is a complex process, and there is a lack of pedagogic models and explicit frameworks for learning designers (Oliver, Harper, Hedberg, Wills, & Agostinho, 2002). However, there are general concepts and principles that can guide effective e-learning design to support the type of active learner engagement that is necessary for learners to develop understanding and meaningful outcomes.

Cunningham, Duffy, and Knuth (1993) suggest that constructivist learning settings concurrently:

- Provide experience in the knowledge construction process;
- Provide experience in and appreciation for multiple perspectives;
- Embed learning in realistic and relevant contexts;
- Encourage ownership and voice in the learning process;
- embed learning in social experience;
- Encourage the use of multiple modes of representation; and
- Encourage self-awareness in the knowledge construction process.

Learning designs can be used to represent constructivist learning approaches. These designs describe the elements and structure of any unit of learning and frequently include consideration of the following elements:

- Resources
- Instructions for learning activities
- Templates for structured interactions
- Conceptual models (e.g., problem-based learning)
- Learning goals, objectives, and outcomes
- Assessment tools and strategies

Oliver (1999) and Oliver and Herrington (2001) have synthesised the range of learning designs by identifying the critical elements required in a learning design, particularly when they are ICT mediated. The critical elements comprise the content or resources learners interact with, the tasks or activities learners are required to perform, and the support mechanisms provided to assist learners to engage with the tasks and resources (Oliver et al., 2002). The systematic use of learning designs to represent online roleplay-simulation is relatively recent which in part may reflect that only in the last decade has there been a widespread infusion of Internet-based ICT into traditional teaching approaches.

Roleplay-simulation can be an effective approach for facilitating active learning about complex, multidimensional, controversial issues (Oulton, Dillion, & Grace, 2004). Roleplay-simulations involve participants deliberately adopting a role for a specific purpose within a simplified simulated environment. The simulation acts as the context and structure within which the roleplay occurs. Students learn about the adopted role or persona, the setting in which the simulation occurs and the factors that support or hinder interdependence among the personae. Roles are designed to encompass a range of interests, values, and knowledge bases that represent the diversity of positions and opinions present in any complex system. The roleplay-simulation learning environment is authentic and situated, and participants operationalise different perspectives within a simplified but functionally accurate version of a complex decision-making context. The simulated 'system' provides opportunities for participants to engage in extended interactions as they identify and reconcile the diverse values and beliefs represented through the situation while resolving a problem.

Roleplay-simulations have been used for teaching and learning in a number of disciplines in higher education (Applegate & Sarno, 1997; Bos, Shami, & Naab, 2006; Feinman, 1995; Guikema, Ortolano, Ohshita, & Collins, 2001; Lane, Slavin, & Ziv, 2001; Lean, Moizer, Towler, & Abbey, 2006; Livingstone, 1999; Starkey & Blake, 2001; Vincent & Shepherd, 1998). Traditionally, roleplay-simulation has been used in face-to-face teaching environments. Once it was realised that Internet-based roleplay-simulation approaches can deliver rich learning environments there has been an increase in this mode of delivery. The term e-sim, is used to describe a roleplay-simulation which is facilitated and supported through the use of information and communications technology (ICT). The way in which ICT is used within roleplay-simulation will vary. It may range from a blended mode of interaction where online interaction and resource provision are supported by face-to-face student interaction, through to a distance mode where all interactions and resource access are conducted through online activity. The use of ICT enables access to a wide variety of information resources that can be manipulated, analysed, and synthesised more easily than paper-based resources; provide a range of tools for communication between students and teachers independent of place and time; and software can support testing and tracking of student activities and learning during the roleplay-simulation.

Internet mediated roleplay-simulations appear capable of developing:

- An awareness of different perspectives about an issue
- Awareness of different organisations and their roles/responsibilities
- Practice with procedures/protocols
- Appreciation of socio-technical system dynamics
- Integrating skills into action: negotiation, ICT (computer) literacy, problem-solving, teamwork

Attempts to identify the salient characteristics of Internet-mediated roleplay-simulations have only recently appeared in the literature (Asakawa & Gilbert, 2003). They recognised that while the Internet can provide alternate ways to explore issues, it requires careful planning and implementation strategies for successful game experiences. An interpretive summary of the learning design of four Internet mediated roleplay-simulations found that they all "engaged students with experiencing complexity in a context that mirrored professional practice, and where different dimensions and disciplinary perspectives (as well as individual beliefs, interests, and values) were interacting dynamically over time" (Golja, 2003). This combination of a technologically rich learning environment which seeks to incorporate elements of authentic practice, diversity, and complexity provides a challenge for the development of frameworks and methodologies that can be used to understand the nature of learning in these environments. The need for learning designs which can effectively create role-based collaborative learning activities across a range of learning contexts was recognised in 1998. "One is struck by the gaps in our knowledge about the educational simulation/gaming process or about those elements that contribute to its effective or ineffective use" (Woofe & Crookall, 1998). A review of the current literature (Magee, 2006) supports the need for further research in this area. The following section describes the learning design for an online roleplay-simulation which has been widely recognised through teaching awards and citations as an innovative and effective learning design.

MEKONG e-SIM: A ROLEPLAY SIMULATION

In the Mekong e-Sim, students from different disciplines work collaboratively to investigate and resolve issues related to economic development in the Mekong region of South East Asia. The Mekong e-Sim facilitates active student engagement and learning and encourages high levels of distributed student interaction. Through Mekong e-Sim, students learn discipline-specific knowledge in the disciplines of engineering and geography while developing generic skills and understandings relating to the complexities of decision making and collaboration, and the societal impact of development.

We sought to design a learning experience that would:

- Assist geography and engineering students in developing science-based knowledge as well as an understanding of the societal impacts of the work of engineers and geographers;
- Show the complexities of working as a professional in resource development and management;
- Develop students' appreciation of the impact of their actions and decisions;
- Develop learners' understanding of the multiple perspectives associated with issues related to regional and economic development and technology application within the Mekong subregion of South East Asia;
- Facilitate students' awareness of the political, social, economic, and scientific dimensions of decision making in situations requiring the management of conflict associated with resource development;
- Develop student understanding of the responsibilities and actions of key stakeholders in the particular context;
- Encourage students to work collaboratively; and
- Support distributed interaction and engagement across different geographic locations.

The intention was to create a learning experience that would assist students to master fundamental discipline-based knowledge while developing transferable skills such as communication, research, negotiation, decision-making, and ICT skills as well as an understanding of the range of perspectives that could be taken with regard to complex situations.

The e-Sim Teaching Context

The Mekong e-Sim was used concurrently at four different universities with different student cohorts integrated into the activity. Whilst there was commonality in student undertaking the e-sim activity, the way it was contextualised and supported the goals and learning objectives of each subject was different. The three subjects were:

- Technology Assessment, University of Technology, Sydney (UTS)

This subject developed students' understanding of relationships between technology, economics, the environment, politics, and society. This involved approximately 20 third-year engineering students drawn from subdisciplines comprising civil, environmental, telecommunications, computer software, and mechanical engineering. At UTS, the Mekong e-Sim was used to engage students with sustainability principles while more broadly teaching about technology assessment principles and processes (McLaughlan, 2007).

- Environmental Engineering II, Adelaide University and Sepang Institute of Technology, Malaysia

This subject covered fundamental concepts in environmental engineering such as environmental systems, environmental decision making, and sustainable development. The student cohort comprised approximately 60 second-year civil and environmental engineering students. Maier, Baron, and McLaughlan (in press) proposes a framework for sustainability and uses the e-sim to help teach sustainability principles.

- Asia-Pacific Development: Faculty of Science, University of Sydney

This third-year geography unit on Asia-Pacific Development dealt with the processes and consequences of development and its social, environmental, and political ramifications. It involved approximately 60 students drawn from a range of disciplines including geography, media, science, education, and law. Hirsch and Lloyd (2005) describe how the e-sim contributed to cross-cultural communication and understanding, multidisciplinary approaches to environment and development, and regional knowledge of Southeast Asia. This demonstrates the potential of well-designed multifaceted, rich simulations to simultaneously support multiple teaching contexts.

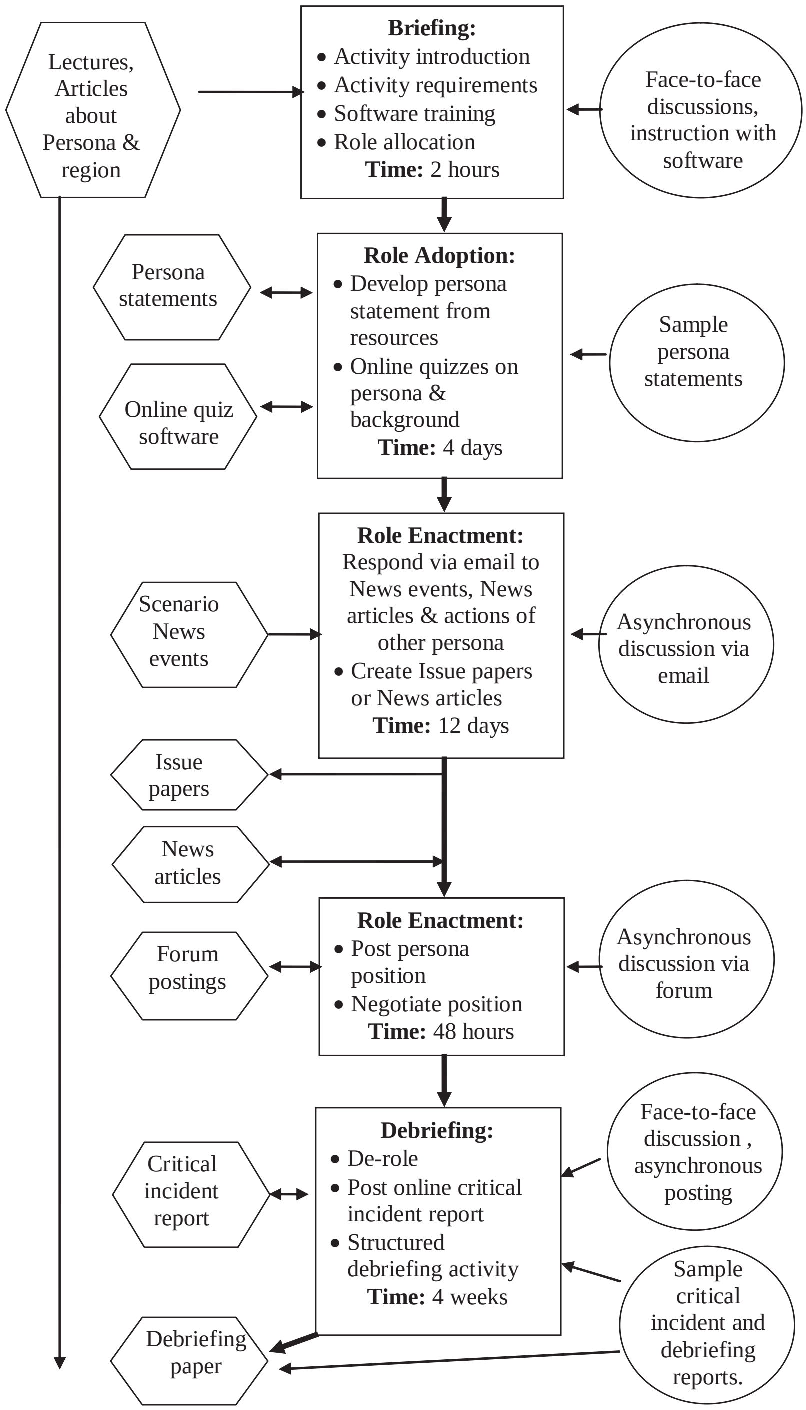
Design of the e-Sim

The five key stages of interaction in Mekong e-Sim are informed by principles of experiential learning and are consistent with the design of other roleplay simulations. The simulated environment of the roleplay simulation provides opportunities for a variation of the "direct experience" that allows a learner to construct knowledge, skill, and value (Luckmann, 1996). In experiential learning, structured experiences are followed by reflection, discussion, analysis, and evaluation of those experiences. Debriefing provides an opportunity for critical reflection that can focus on a variety of issues, including the tacit norms underlying a judgement, the strategies behind an action, the feeling associated with an event, or the specific role a person is trying to fulfil (Caffarella & Barnett, 1994). The Mekong e-Sim was designed to provide students with the opportunity to 'live' in the learning events rather than simply attend them.

Within any roleplay-simulation, participants take on a functional role or persona within a simulated environment constituted by the scenario. Within our e-Sim, the scenario comprised the setting or situation for the roleplay-simulation (i.e., the Mekong region) enhanced by events based on real occurrences. These events are designed to trigger interaction among the interdependent personae. Learning occurs as a consequence of a participant engaging with the scenario as well as their reflection on the interactions between participants.

The representation used to describe the learning design for the Mekong e-Sim (Figure 1) conducted in 2002 follows the structure proposed by Oliver et al. (2002). Within the learning design (Figure 1), the resources learners interact are represented by hexagons, the tasks or activities the learners are required to perform by squares, and the support mechanisms provided to assist learners to engage with the tasks and resources by circles. This representation has been useful for the e-sim designers to help identify the linkages between critical elements within the complex learning activity and to subsequently develop simplified flowcharts to help students appreciate the various components of the e-sim

Figure 1. Learning design of Mekong e–sim



and their interrelationships. The total time for the e-sim activity was nearly eight weeks with indicative times for each of the stages indicated in the activities box.

The e-Sim Tasks and Activities

Stage One: Briefing

The briefing stage fulfils a preparatory role as participants become familiar with the Web site, communications technology, the operation of e-sim and assessment requirements. Personae are allocated and developed in this stage. To encourage students to collaborate and to develop interdependence and accountability among members of each persona, we assigned one persona to a group of students. Students research their allocated role independently before collaborating on the development of their shared persona. They are supported through face to face discussions and required instruction with the software.

Stage Two: Role Adoption

The purpose of this stage is the development of a student knowledge base. Students research the context of the e-sim, in this case, the geopolitical background of the Mekong region. Key resources are provided, and students are encouraged to locate additional resources. During this stage, participants extend their persona, addressing the skill sets, knowledge, values, and political positions that are appropriate to that person. Each persona posts a collective statement about their role for the information of other participants.

Stage Three: Role Enactment: E-mail

As news events are released by the facilitator, personae respond via e-mail. Responses are also generated by the actions of other personae. An issues paper based on a topic specific to each persona is assigned, and students work on this in their persona groups. Students work independently and collaboratively to identify the issue and research it. This research contributes to the development of subject knowledge and the identification of values and positions. Media personae issues papers take the form of newspaper articles that are publicly available on the Web site and in the discussion forum. These articles require and generate interaction between the media personae and other stakeholders in the e-sim. Media personae report on any findings resulting research undertaken for the issues papers and comment on the debate that is taking place in the discussion forums. During this stage, students formulate and operationalise their understanding of their persona and expand their background knowledge about the context and related subject-specific information. It is also during this stage that personae develop alliances and strategic liaisons to assist them in achieving their aims. The e-mail interaction and activities associated with the issues papers prepare students for the forum interaction stage.

Stage Four: Role Enactment: Forum

Four ‘public forums’ with specific terms of reference are conducted online. These events are modeled on real public forums where stakeholders associated with a major development are brought together for several days to debate the issues associated with the development. Personae post submissions and responses to the forum sharing their positions and debating the relative merits. Participants must demonstrate relevant discipline knowledge and apply it to emerging situations. As they observe the behaviour of other stakeholders and the impact of various actions and decisions, students develop an understanding of the perspectives of other personae.

Stage Five: Debriefing

This is an essential activity through which participants identify what they have learned as a consequence of their engagement. It is a structured process using guided recall, reflection, and analysis of the experience and requires students to submit a critical learning incident report and debriefing essay that are published online. This is complemented by an optional fact-to-face debriefing activity of approximately two hours conducted at each site. These model a structured process for reflection that students can apply to the online critical learning incidents.

Resources and Support

The five stages of the e-sim are supported by various learning resources and communication media support both internal and external to the learner management system which hosts the e-sim. Specific resources are provided to students, and they are encouraged to consult a wide range of additional resources. Print resources include handbook describing assessment tasks and timelines as well as a book of readings containing articles on the region and critical issues related to resource management. The Web site contains links to relevant Web sites. Each of the instructors at the participating universities also provided additional resources through specialised lectures and videotapes. The exact nature of this additional resources depended on how the Mekong e-Sim was integrated in to the subject in which it was embedded.

Different tasks within the e-sim require different forms of support. While electronic dialogue can support interactions such as information exchange, opinion, and suggestions which are integral to such simulations, it is less suited for communicating agreement and disagreement and for social-emotional tasks involving conflict and negotiation (Hiltz & Wellman, 1997). Mekong e-Sim relies heavily on asynchronous Web-based communications to minimise inconvenience arising from students living in different time zones and having competing class timetables. However, students used face-to-face, phone, voice mail, and synchronous chat to support different interactions. Exemplars of assessment tasks were also provided to students to support their learning and ability to demonstrate their learning. For example, sample debriefing essays showing examples of interpreting roleplay-simulation interaction in terms of both lower and higher levels of structural complexity (Biggs & Collis, 1982) were available.

Is It Effective?

Evaluation strategies of the Mekong e-Sim (McLaughlan & Kirkpatrick, 2004) and an earlier e-sim (Kirkpatrick & McLaughlan, 2001; McLaughlan & Kirkpatrick, 1999), which has similar design elements, included student learning outcomes, analysis of the subtasks of the roleplay-simulation, and effectiveness of various media to support necessary interaction; student feedback via survey and focus group interview; and measurement of the communication needs of participants. These provide support for the effectiveness of the design in engaging learners, developing generalisable skills, alternate perspectives, and relevant subject knowledge. The online roleplay-simulation or e-sim facilitates a learning experience that would not otherwise be convenient or possible in a traditional university context. Mekong e-Sim was successful in creating a context where learners with diverse knowledge, skills, and values could actively participate in a shared experience followed by reflection. It was well received by students who perceived that the learning activities embedded with the e-sim contributed positively to their learning about their discipline and about the complexities of environmental decision making and its impact. The e-sim was designed to encourage active student engagement in learning, and the results of student assessment and analysis of participation in the e-sim reflect the success of the design. Students demonstrated understanding of complex issues and multiple perspectives and exhibited higher order learning outcomes.

EVOLUTION AND ADAPTATIONS OF THE E-SIM LEARNING DESIGN

All learning designs build to some degree on existing designs. The original design of the Mekong e-Sim (McLaughlan, Kirkpatrick, Maier, & Hirsch, 2002) was influenced by an earlier e-sim (Pollutsim: McLaughlan & Kirkpatrick, 1999: Kirkpatrick & McLaughlan, 2001) and the following online social science simulations: Middle East Simulation (Vincent & Shepherd, 1998), Project IDEELS, and Project ICONS (Starkey & Blake, 2001). A major adaptation to existing e-sims was to restructure the resources, tasks, and support to suit a generic learner management system (Blackboard) rather than the proprietary systems under which most systems ran. A key task in repurposing roleplay-simulations from other disciplines is to create interaction forums and reporting tasks that are professional relevant to the student cohort and desired learning outcomes, since a feature of e-sims is their strong link to relevant professional practices and protocols. For the social science e-sims, this could be simulating UNESCO meetings or collaboration on development of a policy document. In the Mekong e-Sim which simulated natural resource management, we required students to write technical reports and contribute to a forum based on an environmental impact assessment inquiry.

Adapting single institution, single discipline, or centrally run e-sims to a decentralised, multidisciplinary format can require significant adaptation. In the e-sim model, the teaching staff at each of the institutions provides support in face-to-face mode (e.g., running briefing and debriefing sessions, addressing group interaction issues, and providing supplemental resource material). During the development of the e-sim, staff from each of the three teaching institutions and an academic developer/evaluator were involved to ensure the necessary disciplinary knowledges and cultures of the teaching institutions were accommodated. A number of academic and institutional issues were encountered during the planning and implementation of the Mekong e-Sim. This included the need to negotiate and agree on shared teaching and assessment practices as well as sharing institutional resources (McLaughlan, Kirkpatrick, Maier, & Hirsch, 2001). If these practices are not explicitly addressed then different expectations of teaching staff from each course may lead to different student expectations and behaviours (McLaughlan & Kirkpatrick, 2001). As the e-sim design evolved, there was a progressive shift to decentralised and institutionally focused assessment of some tasks. This occurred after teaching staff were familiar with the assessment tasks and it allowed staff at each institution to create levels of student support consistent with their own context. Whilst these aspects of the teaching are not included in learning designs, they underpin the implementation of the design and ultimately the effectiveness of the learning design in that particular teaching environment.

The learning design of the Mekong e-Sim outlined in this chapter has been further adapted since 2004 by one of the designers (Holger Maier) at the University of Adelaide. This has included changes to the interpretive framework, video content, and assessment tasks (Maier et al., in press). The e-sim has helped create a focus on situational learning within that institution.

Philip Hirsch of Sydney University who was involved with this Mekong e-Sim has further adapted it to a new Year 3 geography unit of study on ‘Globalisation and Regions in Transition.’ The essential structure of e-sim remained the same, but it reverted to a single-institution exercise. The change of context to Global e-Sim required relatively little by way of fundamental changes in the philosophy of the program, and the shift to a theme more familiar with students’ everyday media exposure (globalisation) allowed for a more immediate identification with the key personae. On the other hand, the geographical learning that had been part of the Mekong e-Sim was less pronounced in the Global e-Sim, and the same holds true for the cultural learning outcomes (Hirsch & Lloyd, 2005). A second adaptation of Mekong e-Sim led by Phil Hirsch has come with the Mekong Learning Initiative (MLI) program coordinated by the Australian Mekong Resource Centre. MLI is a collaborative effort by eight Mekong universities in five countries to develop innovative approaches to teaching on themes closely related to e-sim. Inspired by the Mekong e-Sim, MLI partners have developed face to face and online role play exercises for Southeast Asian students at several of the MLI partner institutions. In 2007, some of the academic staff at these institutions are participating in the Mekong e-Sim that is now being run in single-institution mode for geography students at University of Sydney.

Kate Lloyd who was also involved with the e-sim at Sydney University has over a period of four years adapted and reused it in a different university and subject (Lloyd, 2004). Lloyd and Butcher (2006) found that the learning design of the e-sim was robust and sustainable but that the migration and reuse of the e-sim was only possible with adequate preparation time and institutional financial assistance and support from designers and experienced users. Changes that were required for their environment were adaptation to a different learner management system, length of the activity, assessment, development of new scenarios, and content as well as the training of a new facilitator.

In 2005, Elizabeth Rosser adapted the Mekong e-Sim learning design to a more blended (b-sim) delivery as part of the University of New South Wales Foundation Year which provides an opportunity for international students to experience study at a university prior to undertaking an undergraduate degree. The b-sim is located in an innovative course called 'International Issues and Perspectives' designed by Elizabeth Rosser and Anne Walsh using a sequenced problem-based learning format. A particular challenge in adapting the e-sim for this context has been to provide support for students who have often come through a Confucian system of learning to develop the self-directed learning and value/perspective taking competencies necessary to be fully engaged with the b-sim learning design.

The learning design for the Mekong e-Sim has also been modified to create a structured controversy (McLaughlan, 2004, 2007) that is similar to a multiparty debate. This activity has integrated aspects of structured academic controversy (Johnson, Johnson, & Smith, 2000) into the selected elements of the e-sim learning design. The structured controversy is a shorter activity with a nominal student time of 25 hours compared with 50 hours for the Mekong e-Sim. Whilst the stages in the Mekong e-Sim and the structured controversy have some similarity, they are different in nature, and different assessment activities reflect different expectations about learning outcomes from the two activities. Within the structured controversy, there is less focus and therefore less student time and support for role (persona) development. This may impact the opportunity for a deep and sustained engagement with the values of the adopted persona. A pervasive comment from many students in the e-sim was the challenge of adopting the values and attitudes that they perceive would be appropriate for their persona; however, this comment was less frequently made by participants in the structured controversy.

FUTURE TRENDS

There is tremendous interest in the role of games and simulation in learning. In particular, online role-based learning holds promise. We have identified eight areas where we see particular challenges in designing effective online role-based learning environments. How we address these challenges will help shape future trends in this area of education.

- Managing online text-based dialogue

Participants within online discussion activities have identified that the threaded structure of the discourse within discussion boards and the large number of postings were not suited to high levels of closure or consensus building within these activities. The limitations of asynchronous computer mediated communication and threaded discussion boards in providing support for convergent process (e.g., synthesising and summarising) have also been recognised in other studies (Hewitt, 2001). Some online-based learning designs explicitly use face to face sessions at critical points where consensus is needed to help address this issue.

- Creating reflective practice online

Reflective practice is central to both knowledge synthesis and self-directed learning and needs to be facilitated within either an experiential or a collaborative learning framework. Reflection can focus on a variety of issues, including the tacit norms underlying a judgement, the strategies behind an action, the feeling associated with an event, or the specific role a person is trying to fulfil (Caffarella & Barnett, 1994). It is therefore a key part of online roleplay-simulations. However, we have found it difficult to create a suitable environment online for the large number of participants (i.e., 100–140 people) in our online roleplay-simulation to share knowledge and attitudes. Strategies we have tried include online debriefing reports integrated with face-to-face sessions. Face-to-face debriefing sessions used a stepwise-facilitated process to model a process for critical reflection that students could apply to the interpretation of experiences from the activities. Then the debriefing reports allowed students to integrate multiple perspectives and incidents and generalise their understanding about decision making. There is little published literature on debriefing large classes online.

- Supporting persona development and participant interaction

During online roleplay-simulations with multiple geographic sites, it is possible to have persona groups made up of participants from one site or several. Having participants from multiple sites and disciplines was found to create a rich learning environment for some participants. It was also found to require significantly increased communication skills and resources to function as an efficient team. In our experience, limiting of persona groups to a single site was found to improve communication within groups but also make explicit support to groups more manageable for facilitators. One effective strategy was to create conditions so that groups could authentically form alliances; this allowed participants to explore the challenges of finding consensus within small diverse groups. Some software environments collect data on participant log-ins and interactions which allow the facilitator of an online roleplay-simulation to detect inactivity by participants and to take action to encourage their participation.

- Knowledge building within online roleplay-simulations

There is little data and few studies on how learning occurs in the rich, ill-structured, and complex environment of an online roleplay-simulation and how this knowledge could be used to better support student learning through improved simulation design. Many proponents of Internet mediated roleplay-simulation claim they are effective educational activities based on student perceptions of the achievement of learning objectives set by the simulation designer. Whilst these studies are useful to develop an understanding of some aspects of the learning that may occur within these environments, they are limited in their ability to contribute to a deeper understanding of the nature of the learning outcomes that the participants believe they have achieved. Existing methodologies used in discourse analysis of computer mediated communication (Gunawardena, Lowe, & Anderson, 1997; Thomas, 2002) have not been critically evaluated and tried for their utility within role-based collaborative learning environments. One of the few published studies into the nature of the learning which occurred within an Internet mediated roleplay-simulation noted that the "types of discourse in question defy easy categorization, and traditional methods of text or conversation analysis do not adequately explain the complex activities that occur in these games" (Kupperman, Weisserman, & Goodman, 2000). There is a clear need to identify appropriate methodologies to understand the nature of the knowledge building process which occurs in these learning environments.

- Adopting and adapting learning designs

Limited time, resources, and support have been recognised as the three principal obstacles to the use of simulations and games amongst UK academics (Lean et al., 2006). That study also found that academics make the decision to use the techniques based upon their professional judgement on the benefit and risk attached to these teaching methods. In order to benefit from using roleplay-simulation a number of changes need to be made to the curricula. In particular these types of activities which explore social/political/contextual information do not suit traditional assessment strategies which focus on discrete knowledge and skills rather than generalisable knowledge and skills (Magee, 2006). Integrating ICT into roleplay-simulations also causes a number of changes to the curricula (Kirkpatrick & McLaughlan, 2005). Even where there already is a learning design for online roleplay-simulation, there can be a need to adapt the design for another context. In discussions with academics who have further adapted the Mekong e-Sim, it was found that most have required extensive technical and educational support from their institutions. The reuse of learning designs for online roleplay-simulation (Alexander, 2005; Wills & McDougall, 2006) is an area of active research interest which may help address some of these barriers to adoption and adaptation.

- Understanding student attributes required for effective participation

Online role-based learning is particularly suited to a constructivist approach where it is believed that individuals construct their conceptions on issues according to the way they focus on, structure, and integrate particular aspects of knowledge, attitudes/values, and behavioural orientation. There is a need for self-directed learning and an ability to engage in an assigned role. To what extent there is a need for students to have a minimum set of skills to be able to effectively participate in these types of learning activities has not been well tested. Developing a better understanding of what the student attributes required for effective participation in an e-sim and how to support the development of those will be a necessity for better understand learning design reuse.

- Developing online socialisation and familiarisation with the learning environment

A particular challenge in a large scale online roleplay-simulation can be the complexity of the learning environment where participants need communication and group work skills that will allow them to establish effective working relationships with their peers very quickly in both traditional face-to-face settings and in an Internet mediated environment. The use of text based messaging as the primary means of communication can also make building relationships more difficult. Our experience suggests the need for face-to-face communication during the initial stages of the collaborative experience (e.g. briefing and role adoption phase) when both group formation and a shared understanding of the problem are being developed. Another effective strategy we have used involves introductory activities that explicitly facilitate the establishment of relationships among group members. Developing activities which use the appropriate communication media to enhance online socialisation and familiarisation with the learning environment is a challenge for e-sim designers.

- Effective facilitation

Facilitation of online role-based learning is a necessary but often poorly recognised aspect of translating learning designs into effective learning. The experiential nature of roleplay-simulations requires facilitators to have particular skills and knowledge (Leigh & Spindler, 2004). This requires the facilitator to be able to understand the constructivist nature of roleplay-simulation learning designs. The types of skills and knowledge needed for the often chaordic nature of roleplay-simulations can differ from that required for traditional teacher centred teaching activities. Within online roleplay-simulations, the facilitators may variously be involved in resolving disputes, briefing and debriefing participants, assessing performances, providing advice to participants about role engagement and enactment as well as modifying game information to improve playability.

CONCLUSION

Online role-based learning activities has emerged as a powerful technique for creating engaging, rich, authentic learning environments. Examples such as the Mekong e-Sim have demonstrated the effectiveness and adaptability of the technique. Whilst there are many cases showing the effective use of these techniques to create the desired learning outcomes, it is still not clear which aspects of the learning designs are critical to the effective use of the technique. Central to achieving the desired learning outcomes from online role-based collaborative learning is the way communication media is used within them. Our understanding of how to effectively use these types of communication media particularly within role-based collaborative learning activities and the extent to which these activities need to be redesigned to exploit their affordances is still emerging. Other key factors which will impact how effective the learning designs are in producing the desired learning outcomes are related to how the activity is facilitated and integrated into the curricula.

REFERENCES

Alexander, S. (2005). Role play simulations for teaching political science. In J. McKenzie, S. Alexander, C. Harper, & Anderson, S. (Eds.), *Dissemination, adoption & adaptation of project innovations in higher education* (Report for the Carrick Institute of Learning & Teaching). AUTC.

Applegate, J. S., & Sarno, D. J. (1997). FUTURESITE: An environmental remediation game-simulation. *Simulation & Gaming*, *28*, 13–27.

Asakawa, T., & Gilbert, N. (2003). Synthesizing experiences: Lessons to be learned from Internet-mediated simulation games. *Simulation & Gaming*, *34*, 10–22.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy*. New York: Academic Press.

Bos, N.D., Shami, N.S., & Naab, S. (2006). A globalization simulation to teach corporate social responsibility: Design features and analysis of student reasoning. *Simulation & Gaming*, *37*(1), 56–72.

Caffarella, R. S., & Barnett, B. G. (1994). Characteristics of adult learners and foundations of experiential learning. In L. Jackson & R. S. Caffarella (Eds.), *Experiential learning: A new* *approach, new directions for adult and continuing education* (No. 62, pp. 29–42). San Francisco: Jossey-Bass

Cunningham, D., Duffy, T. M., & Knuth, R. (1993). Textbook of the future. In C. McKnight (Ed.), *Hypertext: A psychological perspective*. London: Ellis Horwood Pubs.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 170–198). New York: Simon Schuster Macmillan.

Feinman, J. (1995). Simulations: An introduction. *Journal of Legal Education*, *45*, 469–479.

Golja, T. (2003, December 7–10). Generating professional knowledge based on e-learning research and development. In G. Crisp, D. Thiele, I. Scholten, S. Barker, & J. Baron (Eds.), *Proceedings of the 20th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE): Interact, Integrate, Impact*, Adelaide, Australia (pp. 203–214).

Guikema, S. D., Ortolano, L., Ohshita, S. B., & Collins, P. (2001). Using simulation to teach negotiation processes to environmental engineers. *Journal of Engineering Education*, *90*, 631–635.

Gunawardena, C. N., Lowe, M. A., & Anderson, T. (1997). Analysis of global online debate and the development of an interaction model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research*, *17*(4), 397–431.

Harper, B., & Hedberg, J. (1997, December 7–10). *Creating motivating interactive learning environments*. Paper presented at the ASCILITE Conference: Reflections on Learning with Technology, Perth, Australia.

Hewitt, J. (2001). Beyond threaded discussion. *International Journal of Educational Telecommunications*, *7*(3), 207–221

Hiltz, S. R., & Wellman, B. (1997). Asynchronous learning networks as a virtual classroom. *Communications of the ACM*, *40*, 44–49.

Hirsch, P., & Lloyd, K. (2005). Real and virtual experiential learning on the Mekong: Field schools, e-sims and cultural challenge. *Journal of Geography in Higher Education*, *29*(3), 321–337.

IMS (2007). *IMS learning design best practice and implementation guide (Version 1.0): Final specification*. Retrieved April 5, 2008, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html#1503857

Johnson, D. W., Johnson, R., & Smith, K. (2000). Constructive controversy: The educative power of intellectual conflict. *Change*, *32*(1), 28–37.

Kirkpatrick, D., & McLaughlan, R. G. (2001, Winter). Evaluating pollutsim: Computer supported roleplay-simulation. *Academic Exchange Quarterly*, *5*(4), 2076-1w.

Kirkpatrick, D., & McLaughlan, R. G. (2005). Integrating the Web into environmental decision making roleplay-simulations. In M. O. Thirunarayanan & A. Perez Prado (Eds.), *Integrating technology in higher education* (pp. 155–163). Lanham, MD: University Press of America.

Kupperman, J., Weisserman, G., & Goodman, F. (2000, April 10–14). *The secret lives of students and politicians: Online and face to face discourse in two political simulations*. Paper presented at Annual meeting of the American Educational Research Association, Seatle, WA.

Lane, J. L., Slavin, S., & Ziv, A. (2001). Simulation in medical education: A review. *Simulation & Gaming*, *32*(3), 297–314.

Lean, J., Moizer, J., Towler, M., & Abbey, C. (2006). Simulations and games. *Active Learning in Higher Education*, *7*(3), 227–242.

Learning and Teaching Support Network (LTSN). (2003). Glossary of terms in learning and teaching in higher education. Retrieved April 5, 2008, from http://www.heacademy.ac.uk/glossary.htm

Leigh, E., & Spindler, L. (2004). Simulations and games as chaordic learning contexts. *Simulation & Gaming*, *35*(1), 53–69.

Livingstone, I. (1999). Role-playing planning public enquiries. *Journal of Geography in Higher Education*, *23*, 63–77.

Lloyd, K. (2004, November 30–December 3). Playing games with conflict: The Ha Long Bay e-sim. In E. McKay, (Ed.), *International conference on computers in education: Acquiring and constructing knowledge through human–computer interaction: Creating new visions for the future of learning*, Melbourne (pp. 171–178).

Lloyd, K., & Butcher, M. (2006). Reusing learning designs: Role play adaptations of the Mekong and Ha Long Bay e-Sim. In *Proceedings of the 23rd Annual Ascilite Conference: Who's Learning? Whose Technology?* Sydney, Australia.

Luckmann, C. (1996). Defining experiential education. *The Journal of Experiential Education*, *19*, 6–7.

Magee, M. (2006). State of the field review: Simulation in education (Final report). Alberta Online Learning Consortium Calgary AB. Retrieved April 5, 2008, from http://www.ccl-cca.ca/NR/rdonlyres/C8CB4C08-F7D3-4915-BDAA-C41250A43516/0/SFRSimulationinEducationJul06REV.pdf

Maier, H.R., Baron, J., & McLaughlan, R. G. (2007). Using online roleplay simulations for teaching sustainability principles to engineering students. *International Journal of Engineering Education*, *23*(6), 1162-1171.

McAndrew, P., & Weller, M. (2005). Applying learning design to supported open learning. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 281–291). Netherlands: Springer.

McInnis, C., Hartley, R., & Anderson, M. (2001). *What did you do with your science degree?* Australian Council of Deans of Science (ACDS). Retrieved April 5, 2008, from http://www.acds.edu.au/occas.htm

McLaughlan, R. G. (2004). *Creating online structured academic controversies*. Paper presented at American Society Engineering Education, Salt Lake City, Utah (paper 1479, Session 2531).

McLaughlan, R. G. (2007). Instructional strategies to educate for sustainability in technology assessment. *International Journal of Engineering Education*, *23*(2), 201–208.

McLaughlan, R. G., & Kirkpatrick, D. (1999). A decision making simulation using computer mediated communication. *Australian Journal of Educational Technology*, *15*, 242–256.

McLaughlan, R. G., & Kirkpatrick, D. (2001). Peer learning using computer supported roleplay-simulations. In D. Boud, R. Cohen, & J. Sampson (Eds.), *Peer learning in higher education: Learning from and with each other* (pp. 141–155). London: Kogan Page.

McLaughlan, R. G., & Kirkpatrick, D. (2004). Online roleplay: Design for active learning. *European Journal of Engineering Education*, *29*(4), 477–490.

McLaughlan, R. G., Kirkpatrick, D., Maier, H. R., & Hirsch, P. (2001). Academic and institutional issues related to the planning and implementation of a multi-disciplinary roleplay-simulation involving collaboration across institutions. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the Crossroads: Proceedings of the 18th Annual Conference of the Australian Society for Computers in Learning in Tertiary Education* (pp. 407–415). Melbourne: University of Melbourne Biomedical Multimedia Unit.

McLaughlan, R., Kirkpatrick, D., Maier, H., & Hirsch, P. (2002). Description of Mekong e-sim: An online role-play simulation about international natural resource management issues. Retrieved April 5, 2008, from Learning Designs Web site: http://www.learningdesigns.uow.edu.au/exemplars/info/LD42/index.html

Oliver, R. (1999). Exploring strategies for online teaching and learning. *Distance Education*, *20*(2), 240–254.

Oliver, R., Harper, B., Hedberg, J., Wills, S., & Agostinho, S. (2002). Formalising the description of learning designs. In A. Goody, J. Herrington, & M. Northcote (Eds.), *Proceedings of the 2002 Annual International Conference of the Higher Education Research and Development Society of Australasia (HERDSA): Quality Conversations*, Perth, Australia.

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Edith Cowan University: Western Australia.

Oulton, C., Dillion, J., & Grace, M. M. (2004). Reconceptualizing the teaching of controversial issues. *International Journal of Science Education*, *26*(4), 411–423.

Richards, G. (2005). Designing educational games. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 227–237). Netherlands: Springer.

Starkey, B. A., & Blake, E. L. (2001). Simulations in international relations education. *Simulation & Gaming*, *32*, 537–551.

Thomas, M. J. W. (2002). Learning within incoherent structures: The space of online discussion forums. *Journal of Computer Assisted Learning*, *18*, 351–366.

Vincent, A., & Shepherd, J. (1998). Experiences in teaching Middle East politics via Internet-based role-play simulations. *Journal of Interactive Media in Education*, *98*(11), 1–35.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wills, S., & McDougall, A. (2006). Facilitating uptake of online role play: Reusability, learning objects and learning designs. In *Proceedings of the 23rd Annual Ascilite Conference: Who's Learning? Whose Technology?* Sydney, Australia.

Woofe, J., & Crookall, D. (1998). Developing a scientific knowledge of simulation/gaming. *Simulation & Gaming*, *29*(1), 7–19.

KEY TERMS

e-Sim: Used to describe a roleplay-simulation which is facilitated and supported through the use of information and communications technology.

Role-Play Simulation: Combines the attributes of both simulations and role-plays where participants adopt a functional role or persona within a simulated environment or scenario.

Chapter XV
Facilitating Learner-Generated Animations with Slowmation

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ABSTRACT

Digital animations are complex to create and are usually made by experts for novices to download from Web sites or copy from DVDs and CDs to use as learning objects. A new teaching approach, "Slowmation" (abbreviated from "Slow Motion Animation"), simplifies the complex process of making animations so that learners can create their own comprehensive animations of science concepts. This chapter presents the learning design that underpins this new teaching approach to facilitate the responsibility for creating animations to be shifted from experts to learners. The learning design has four phases which guides instructors and learners in creating animations of science concepts: (i) planning; (ii) storyboarding; (iii) construction; and (iv) reconstruction. This learning design will be illustrated with two examples created by preservice primary teachers in science education as well as providing a discussion about possible future directions for further research.

INTRODUCTION

Over the last 100 years, developments in the techniques of animation have been related to advancements in technology. As computers and software have become more sophisticated, the use of animation to tell stories has become more comprehensive as evident in the recent commercial success of films such as *Harvey Crumpet*, *Wallace and Gromit,* and *Chicken Run*, which use clay animation, and *Happy Feet, Shrek*, and *Finding Nemo,* which use computer-generated animation. Both of these forms of animation are very complex and labour intensive to create, and so educational resources that use animation for teaching concepts in schools and universities are mostly made by experts. Rarely do learners design and make animations of educational concepts.

There are three main forms of animation with various subtypes that are categorised according to how the images are created, the materials involved, and technology used (Taylor, 1997). The first form is called traditional or hand-drawn animation. This includes the many cartoons and feature length films that were made in the past 70 years which is sometimes called "cel animation." This term refers to the transparent acetate sheets that the diagrams are drawn or traced on and photographed onto film so they can be shown quickly to create an illusion of movement. A second form, stop-motion animation, involves taking digital still photographs of objects or pictures after they have been moved manually to simulate movement. This form includes clay animation which was first introduced in the early 1900s and was made famous by "Gumby" and Will Vinton's use of the term "claymation" in 1978 (Wells, 1998). A third form and the most popular, computer-based animation, has images that are created digitally on a computer using a wide variety of new techniques and software programs. Table 1 summarises these three forms of animation.

But no matter which of the three types of animation is used, they all have two features in common. First, the purpose of animation is to create an illusion of movement with the speed of the frames being played at 24 frames/second (video is 30 frames/second) in an attempt to create a seamless "persistence of vision." Second, the process of making of an animation is complex and tedious so that it is usually left to professional animators and information and commmunication technology (ICT) experts to create. Because of this complexity, nearly all educational animations are made by experts and classified as *learning objects.* These have been defined as:

Digital, re-usable pieces of content that can be used to accomplish a learning objective. That means that a learning object could be a text document, a movie, an mp3, a picture or maybe even a website.

Table 1. Forms of animation

Form of animation	Feature	Types	Examples
1. Hand-drawn animation (cel animation)	Images are hand-drawn and copied or scanned onto a computer	Cartoon animation Character animation Limited animation Rotoscoping	Flintstones Jetsons The Lion King Disney Cartoons
2. Stop-motion animation	Objects, models, or images are created and small movements are made by hand and the models individually photographed	Clay animation Cut out animation Model animation Object animation Puppet animation Silhouette animation	Wallace and Gromit Gumby Chicken Run The Muppets Harvey Crumpet Monty Python (dada animation)
3. Computer-generated animation	Images are created digitally and manipulated on a computer	2-D and 3-D animation Skeletal animation Motion capture animation Morph target animation Flash animation PowerPoint animation	Shrek Cars Happy Feet Finding Nemo

The key is to describe why something is a learning object and in what context a person might learn something from it. (Botts, 2004, para. 1)

For example, the hundreds of animations produced by the National Science Foundation projects in the USA, such as the Technology-Enhanced Learning in Science Center and the Concord Consortium are learning objects to promote science education (Viadero, 2007). And in Australia, The Learning Foundation, which is an $80 million initiative of the state, territory, and federal governments of Australia and New Zealand, have produced large numbers of animations that are freely available on a Web site or CD for use as learning objects in teaching science (Federation, 2006). As such, novices can download or copy the animations and follow the steps to learn content that has been designed and sequenced by experts.

In contrast, the rarity of learner-generated animations is evident by the absence of literature in this area. An extensive review using the terms *claymation, clay animation, stop motion animation*, and *stop frame animation* in the databases *Proquest Educational Journals, Informit, Web of Knowledge, ACM Digital Library, Synergy*, and *Web of Science* produced a paucity of research publications on learner-generated animations. Of the 423 articles found, 418 were "professional articles" describing the procedures for making claymation or explaining the use of new technologies. Only one article described claymations made by preservice teachers to encourage visual literacy (Witherspoon, Foster, Boddy, & Reynolds, 2004), one article described clay animation made by school children to promote their literacy skills (Gladhart, 2002), and one argued for the value of claymation for collaboration by school children (Gamble, McLaughlin, Helmick, & Berkopes, 1995). Alternatively, literature on expert-generated animations is much more prolific as a consequence of large sums of money spent on professionals designing animations as learning objects. Commonly designed using a cognitive theory of multimedia learning, which explains that people learn better from pictures and words than words alone, many different types of computer animations have been created (Mayer, 2005). Importantly, Mayer explains that there are two approaches to multimedia design: (i) technology-centred approaches, which are underpinned by the functional capacities of new technologies and so accentuate the affordances of the technology; and (ii) learner-centred approaches, which are underpinned by an understanding of student learning and how multimedia design can be adapted to enhance student learning. What is significant in regard to this chapter of the handbook is that both technology-centred approaches and learner-centred approaches to designing multimedia involve experts designing animations *for* learners to use with less attention to the creation of animations *by* learners.

But whilst many educational animations exist (most are constructed using the computer program Macromedia Flash), research has shown that their value for enhancing student learning has been limited (ChanLin, 1998; Rieber & Hannafin, 1998; Weerawandhana, Ferry, & Brown, 2005). A comprehensive review of literature on expert-generated animations for learning educational concepts found that they often present key concepts too quickly and do not explain concepts well, as they are often designed to demonstrate educational concepts in real time (Tvertsky, Morrison, & Betrancourt, 2002). The recommendation was that the educational value of animations could be improved if they were slower and annotated with appropriate facts and explanations to highlight the key features to be learned:

Animations must be slow and clear enough for observers to perceive movements, changes, and their timing, and to understand the changes in relations between the parts and the sequence of events. This means that animations should lean toward the schematic and away from the realistic.

…It also may mean annotation, using arrows or highlighting or other devices to direct attention to the critical changes and relations. (p. 260)

Some researchers argue that the impact of animations for learning educational concepts has also been limited because they are mostly made by experts for learners to use as consumers of technology, whereas animations would have more value if the learners themselves had more control in using the animations (Chan & Black, 2005). According to Bransford, Brown, and Cocking (2000), technology is a powerful tool for learning especially as ‘learners might develop a deeper understanding of phenomena in the physical and social worlds if they could build and manipulate models of these phenomena’ (p. 215). The purpose of this chapter, therefore, is to explain a new teaching approach or learning design, called Slowmation (abbreviated from “Slow Motion Animation”) which guides learners in making their own educational animations. In particular, this chapter will focus on explaining the four phases of the learning design that guides pre-service primary teachers in creating animations of science concepts. A learning design to guide novices in making animations has not previously been described in the educational literature.

CONCEPTUALISING A LEARNING DESIGN FOR A NEW TEACHING APPROACH

As evidenced by the lack of literature on learner-generated animations, nearly all existing examples of animations are classified as learning objects because they are made by experts for novices to reuse. Alternatively, teachers can use a new framework for guiding students in how to design and make animations. This shift in responsibility for designing and making animations from experts to learner/novice necessitates a framework to guide such a process. This procedure or framework is called a *learning design*. A learning design has been defined as “a representation of teaching and learning practice documented in some notational form so that it can serve as a model or template adaptable by a teacher to suit his/her context” (Agostinho, 2006). A learning design therefore is a conceptual framework for structuring a digital environment to support student learning and identifies the key elements, steps, or components to enable this learning to occur. Furthermore, there are different ways of representing learning designs.

Oliver (1999) provided one framework, which analysed digital technologies into tasks, resources, and supports that was later developed into a visual sequence (AUTC, 2003). Importantly, the sequence of how these aspects interrelate is shown by a representation of arrows as a way of providing scaffolding for the teacher. Hill and Hannifin (2001) note that digital technologies can be categorised according to the resources (static or dynamic), contexts (directed, learner generated, or negotiated), tools (searching, processing, manipulating, communicating), and scaffolds (conceptual, procedural, or strategic). A project funded by the Australian University Teaching Committee (2003) called “Information and Communication Technologies and Their Role in Flexible Learning” provided a categorisation of learning designs. They identified five types of learning activities, each with a particular focus: (i) collaborative with an emphasis of the learning design in interaction and collaboration; (ii) concept/procedure focus with an emphasis on consolidating student learning about concepts and/or procedures; (iii) problem based learning focus with an emphasis on the process of students solving a real world problem; (iv) project/case focus with an emphasis on students creating a product or addressing a project need; and (v) role play focus with an emphasis on taking on simulated responsibilities or roles to address an issue or problem. Importantly, Kozma (2000) highlighted the importance of context, learning outcomes, and materials in the design of digital learning environments.

Slowmation is a new teaching approach that simplifies the normally complex process of making animations to enable learners to create comprehensive animations about science concepts (Hoban, 2005, 2007; Hoban & Ferry, 2006). It has been developed in science education classes at the University of Wollongong, Australia over the last two years. It is underpinned by a learning design that could be considered a "concept/procedure development focus" according to the AUTC learning design exemplars, as the purpose is to make an animation as a representation of a particular science concept. Other representations of science concepts have previously been demonstrated such as the use of metaphors (Gurney, 1995), mind maps (White & Gunstone, 1992), different forms of writing (Hackling & Prain, 2005), and use of commercial CD-ROMS. Slowmation is a form of stop-motion animation involving the manual manipulation of materials with digital still photos taken of each step that are then played in a sequence to create an illusion of movement. It is similar to clay animation involving students researching information, scripting, storyboarding, designing models, capturing digital still images of small manual movements of the models, and using computer programs such as QuickTime Pro™ to play the images in a sequence. Slowmation, however, is different from claymation in five key ways as shown in Table 2.

Slowmations are like "mini-movies" of science concepts averaging 2–3 minutes in length. Over the last two years over 200 have been made by preservice primary teachers about many science concepts including day and night, seasons, lunar cycles, life cycles of various animals, particle motion, magnets, fungi life cycle, plant reproduction, weather, movement of the planets, water cycle,

Table 2. Comparative features of Slowmation and Claymation

Feature	**Claymation**	**Slowmation**
Content/purpose	Tell a narrative	Explain a science concept
Materials	Clay or plasticine	A variety such as soft play dough, plasticine, 2-D pictures, drawings, existing 3D models, felt, cardboard cut outs, and every day classroom materials and natural materials such as leaves, rocks, paper, or fruit.
Orientation	Models are made to stand up vertically and be moved incrementally as they are photographed with a digital still camera mounted on a tripod looking across at the models	Models are mostly made on the floor and moved horizontally as they are photographed with a digital camera mounted on a tripod looking down at the models (this is not always the case, however, as existing plastic models can be photographed in the usual way).
Learning Prompts	The art of telling the story explains the experience	Prompts are included to help explain the scientific concept such as audio narration, music, authentic photos, humour, diagrams, models, labels, questions, static images, repetitions, and characters
Timing	12–24 frames/second to simulate real movement	2 frames/second to slow down movement

simple machines, mitosis, meiosis, and phagocytosis. Because slowmations are played 10 times slower and are easier to make than traditional animations, preservice teachers can represent *their own understandings* of science concepts in very comprehensive ways (Hoban & Ferry, 2006). For example, a slowmation called "The Earth and Its Surroundings" has 600 digital photos, plays for 5 minutes, explains the concepts of day and night and phases of the moon, commences with moving 2-D images of day and night using cut out felt that is moved manually and then progresses to moving 3-D polystyrene models, and has the learning prompts of music, questions, diagrams, and captions explaining the science content. In all, it took a preservice teacher 25 hours to create at home in a room with a dimmer to simulate effects of changing light on the earth and moon.

The learning design underpinning Slowmation has evolved over the last two years from examining different ways in which preservice teachers have made slowmations as well as research in university classes (Hoban, 2007; Hoban & Ferry, 2006) and in primary school contexts (Hoban, Ferry, Konza & Vialle, 2007). Although the teaching approach or learning design is still evolving, at this stage there are four distinct phases that constitute its learning design which is now explained in the context of preservice primary teachers designing slowmations for the teaching of science.

THE LEARNING DESIGN UNDERPINNING SLOWMATION

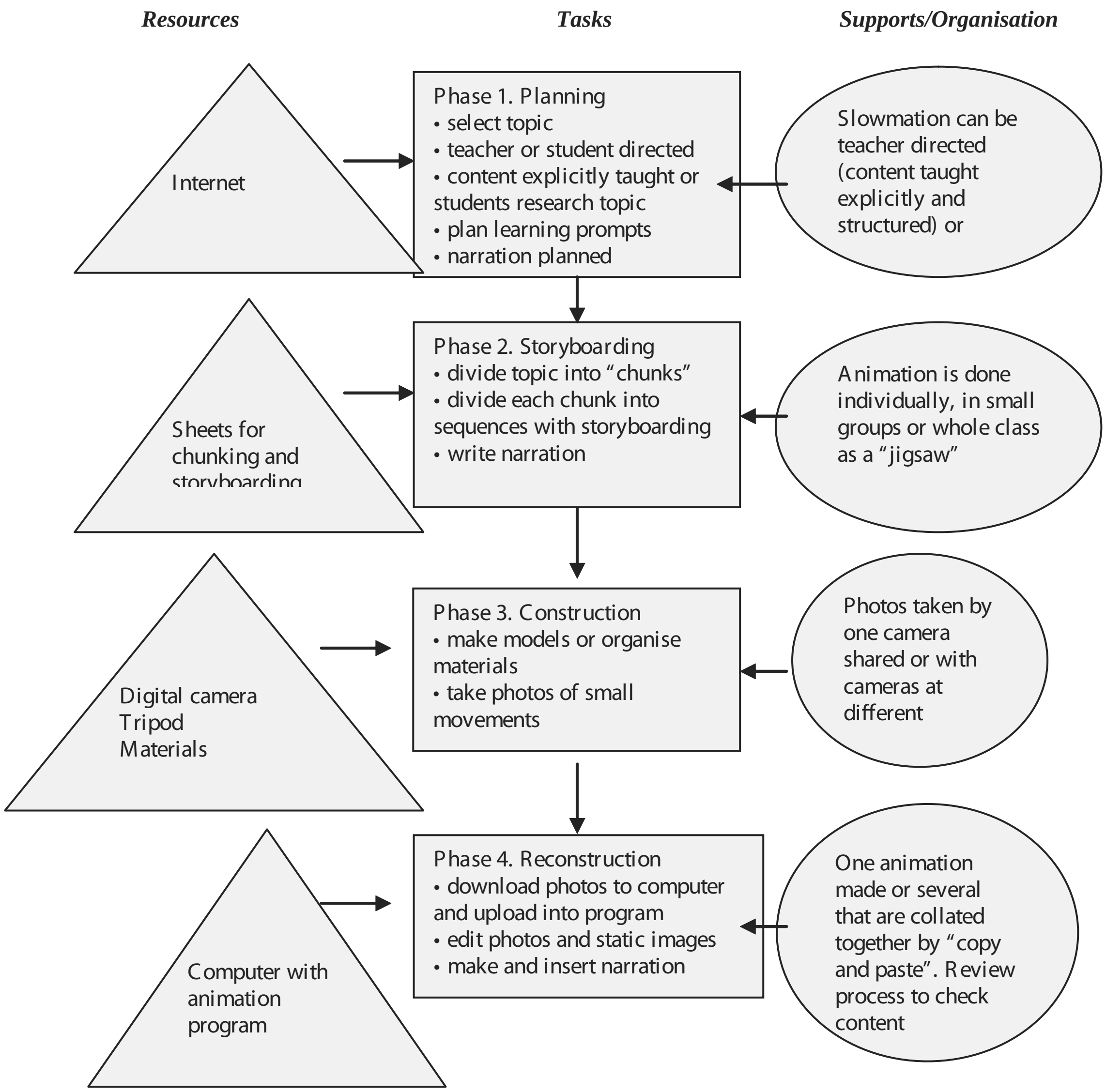
Phase 1. Planning

The instructor and/or preservice teachers *plan* a topic or concept to represent which involves change. This may mean students conducting *research* on a particular topic in order to have enough information to identify a sequence with different stages, segments, or episodes. Alternatively, the instructor may explicitly teach about a topic or concept to give students a "big picture" representation of the relevant concept. In a primary/elementary science context, this could include topics such as the four seasons, seed germination, life cycle of a frog, the water cycle, life cycle of a caterpillar, why boats float, a rocket lift off, chemical reactions, particle motion, phases of the moon, development of a volcano, plate tectonics, mountain building, weather patterns, geological movements digestion, or movements in the solar system.

Phase 2. Storyboarding

There are two levels of analysis in the second phase—*chunking* and *sequencing*—both of which involve a form of storyboarding. First, the concept needs to be broken down into several "chunks" or scenes which are the main parts of the concept. Second, each "chunk" needs to be sequenced into 10–20 movements which is a form of storyboarding. Analysis can guide an individual or group in making a complete slowmation or each chunk can be allocated to a group of students similar to a "jigsaw" approach so that the animation becomes a class project. For example, a chunk could include one of the life stages of a frog, one of the four seasons, one of the stages of a rocket take off, one stage of a volcano developing, one part of meiosis or mitosis, or one part of a chemical equation. A key activity in sequencing is *storyboarding* and *scripting* to plan the narration. At this stage, it could be decided if the slowmation is going to be only photographs and labels or it will also have a narrated explanation and/or music. It is unwise to have too much text and narration as it presents too much information and can be confusing as outlined in Sweller's cognitive load theory (Sweller, 2006). Decisions also need to be made as to whether the slowmation is going to be constructed on a blank cardboard sheet or the sheet will be rendered as part of a background.

Figure 1. Learning design for slowmation



Phase 3. Construction

This phase involves *making* and *photographing* of the models. It is best if the models are made on a sheet of project cardboard or butcher's paper on the floor. Existing models that are readily available in a classroom can be used or new models can be made with play dough or modeling clay. Specific responsibilities can be allocated to the members of each group. If roles are to be allocated, they could include storyboarder, model maker, script writer, sign maker (for title, end, or descriptions for a particular photo), photographer, and background designer. A digital camera needs to be mounted on a tripod and positioned over a sheet of cardboard so that pictures can be taken vertically looking down. The students make each of the small movements in the model manually, and a photograph is taken at each step. The photographer needs to take at least 20–30 photographs of each chunk. It is simpler if the photographs are taken in order of the presentation of the chunks for the whole story. Another way is for each group to have their own camera and then have the different QuickTime movies collated together when editing.

Phase 4. Reconstruction

Once all the digital still photographs are taken, they need to be *downloaded* onto a computer, copied onto the desktop, and *imported* into a computer program to put the photos in a sequence to create the animation. A program such as QuickTime Pro or iStopMotion is needed to import the photographs. QuickTime Pro is commonly used because it is simple to use, the playback speed can be readily selected (usually two frames per second), and a QuickTime movie is produced that can be played on any computer, PC or Mac. The command "open image sequence" from the File menu allows you to select which sequence of photographs you want to import. Different QuickTime movies can be made showing the process at different speeds. Once the initial animation is created, refinements need to be made to *enhance* and *edit* the animation. These can be made in several ways such as importing into iMovie, adding music, factual text as static images, transitions, other backgrounds, or a narration. Research has showed that it is important for students to add a narration as this is the final layer of reflecting to explain a science concept. If the students have worked on different chunks of the process, they need to know what the other chunks were about. The value of a slowmation is that a QuickTime movie can be easily made again to show the movie at different speeds for different purposes. Initially teachers can show the slowmation at 2–4 frames/second to give the overall change process. It can then be slowed down even more and shown at 5 or 10 seconds per frame so each group can explain the details of their segment to the rest of the class.

Figure 1 shows a diagrammatic representation of the learning design for slowmation using the framework developed by Oliver (1999) who analysed digital technologies into tasks, resources, and supports that was later developed into a visual sequence (AUTC, 2003).

EXAMPLES OF THE LEARNING DESIGN UNDERPINNING SLOWMATION

In 2006, 180 preservice primary teachers at the University of Wollongong completed a science method course in their Bachelor of Teaching, and one assignment involved designing and making a resource for teaching science. The students had a choice of creating an interactive big book or a slowmation. Forty of the students decided to create a slowmation, and interviews were held with 10 preservice teachers about the process of creating them. A key part of the interview was analysing their slowmation as an artifact of their learning and interviewing them about the design and what they learned as a result of the process. In particular, interviewing them about the design process assisted in formulating the learning design that underpins slowmation. The interviews showed that making slowmation is highly engaging because they enjoyed using digital technologies, and the process helped them to understand science content because they need to learn the science in order to explain it in their animation (Hoban, 2007). Also, because the animations are made in sections, the design process prompts them to deconstruct or analyse the science concept into "chunks" and reflect upon what content knowledge needs to be introduced as factual text or narration to best explain each section. Two case studies are now presented with sections of interviews inserted to illustrate the learning design that underpins slowmation.

CASE STUDY 1: WENDY AND HER HONEY BEES

Phase 1. Planning

Wendy was a first year preservice primary teacher who wanted to make a slowmation about the life cycle of a honey bee. The animation made goes for 3 minutes and includes about 400 photos. She said that the animation took her a week to complete which involved about 30 hours of work. The animation is played at 2 frames/second, and she used a good deal of authentic materials in the animation such as real flowers, honey, and models that she laid down horizontally and took photos with a digital camera mounted on a tripod looking down at the models. She explained why she chose the honey bee as the topic:

Wendy: I think because a bee is so important to so many different things in life and that's probably not a well known fact. There's also a lot of information out there about honey bees so it was fairly easy to get the information to generate the animation. It's something that kids already have some background knowledge on, so it's not completely unfamiliar to them.

Int: Was it something that you knew a lot about anyway in terms of the actual content or there were things there you had to find out?

Wendy: I had a fairly basic understanding of a bee, like in the role that it plays, but I certainly had to do a lot of reading. Because I guess without all that other extra information is, I guess it's just about making honey. Whereas when you've got all the other information it becomes a bigger area for further investigation. Like through that you can investigate the life cycle of a bee. You can investigate pollination of flowers, the making of honey, like what goes on in a bee hive. Like there's a lot of different areas that you can go to. So I guess the extra information that I've learned has now broadened what I knew.

Phase 2. Storyboarding

Once Wendy had done her planning, she then had to decide upon the chunks or main scenes to organise her slowmation and the subsequent sequencing of the small movements within each chunk as shown in Figure 2.

Once I had all of the information and once I'd worked out exactly how I was going to set it out and what scenes I needed, then putting it altogether was fun. I did a bit of story map, I suppose. First, I worked out the broad areas that I wanted to put in the animation, and then I did a bit of a story map. So I thought you know my first scene will be all of the things that a bee contributes to in our life. And then I thought well I'll go onto pollination of flowers and fruit, as well as explain what happens. Very basically what happens in the hive, like how we get the honey out of a hive, and then some of the things that we use the nectar and honey and stuff for. So I mapped that out on paper first and then I went and collected all of my resources.

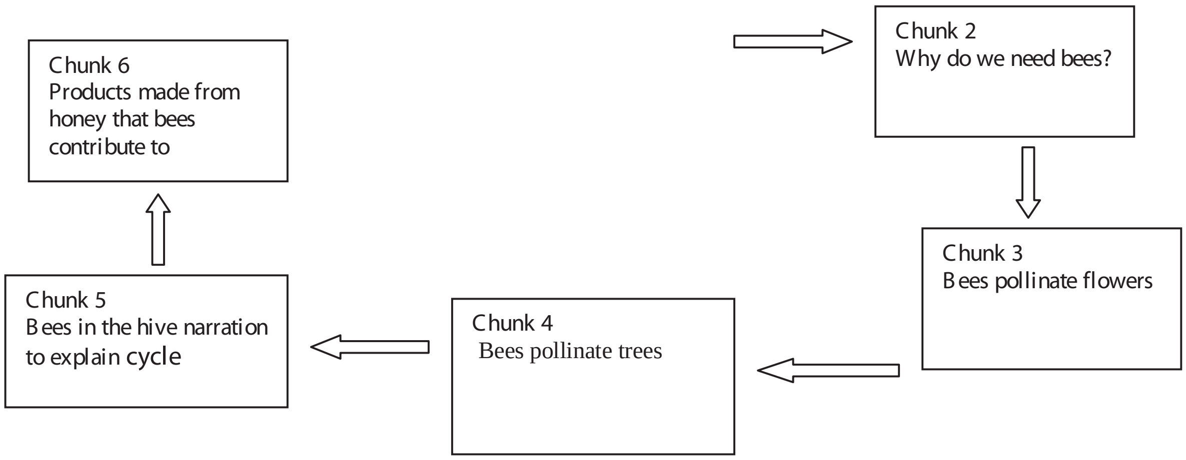
Phase 3. Construction

Figure 3 shows photos from each chunk with a brief description.

A feature of Wendy's slowmation was the way she inserted text and labels to explain the science or ask questions. In the interview, she explained that she used a graphic program to open the photos and write the text and then made multiple copies of this one slide to be a static image for several seconds so that she could record a narration and the photo would stay suspended on the screen:

Wendy: I had all my photos in order and I used a photo program or you could use a drawing program or whatever, and I manually went through them. I spaced through each of them just to make sure it all flowed (this is before I even used the animation software) and I worked out exactly which photos I wanted to put in text in. And so then the photos that I

Figure 2. Chunking for Wendy's honeybee story



wanted to add text to I made copies of those, so that I had originals if something went wrong, and I'd put my text in. And then I'd go back and go through it again and make sure that the text made sense and flowed through. If I didn't like the text or I realised there was a spelling mistake or something like that, then I would just grab the original copy of the photo and put it, replace the photo with the text and start the text again, before I came in and did the animation software. And then in the QuickTime software, when you get to the photo that's got the text on it you would just do the copy and paste. I didn't do multiple copies of that file, I just used the QuickTime stuff.

Phase 4. Reconstruction

Once Wendy had constructed the animation using QuickTime Pro, she had the text in place, and these images were copied so that they stayed on the screen for the right amount of time so that she could record a narration.

Wendy: Yes. It is narrated. So yes, after I did all the text and everything I then went back in and did the recording.

Int: So you didn't have problems with that?

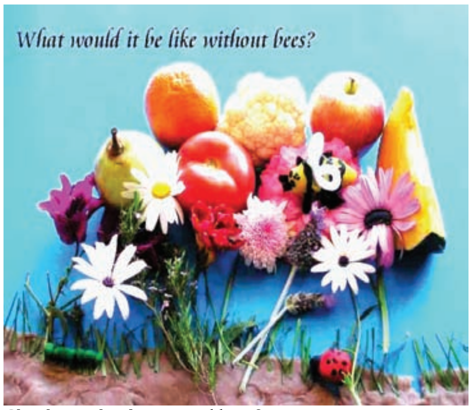
Wendy: No. That was fine. And that's also when you find out whether it was too long and whether having the text on the screen was long enough, because sometimes you'd be reading it out loud and then you'd have to do another copy and paste to make it stay up a bit longer. I recorded in at home because it's a bit noisy in the lab. So I recorded my narration at home and came in and put it in as a file.

CASE STUDY 2: AARON AND HIS CIRCLE OF LIFE

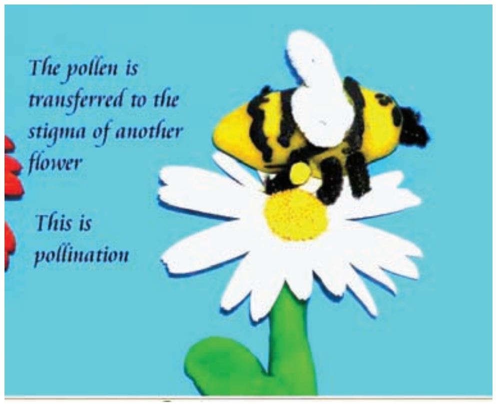
Phase 1. Planning

Aaron was a first year preservice primary teacher who wanted to make a slowmation called the "Circle of Life" about the relationship between earthworms and plants in a garden. He described

Figure 3. Photo from each chunk



Chunk 2. Why do we need bees?



Chunk 3. Bees transfer pollen from flower to flower

Chunk 4. Bees in their hive

Chunk 5. Products that bees contribute to.

himself as an "inexperienced user of technology" and that the hardest part of the technology was getting the number for the QuickTime pro licence from the Apple Web site. His animation goes for two minutes and includes about 350 photos. He got the idea by browsing though some books in a school library:

It's sort of essentially like a simple life cycle, I was actually at my mum's school trying to get some ideas and I went to the library section where there's a lot of science and technology books and I was looking through and I saw the life cycle of the earthworm. So I looked at that and thought that's pretty simple, it doesn't need to be too complicated, I can use simple, factual information and it was something I felt I could easily reproduce so I thought I'd go with that idea that basically the trees, everything around you in the environment, when it hits the soil it breaks down and the *earthworm eats part of that in the soil and when they go to the toilet it makes nutrients within the soil making the soil nice for other things to grow and life sort of basically continues.*

Phase 2. Storyboarding

Once Aaron had done his planning and research in the overview phase, he then decided upon the chunks to organise his slowmation as shown in Figure 4. Importantly, he checked his science understandings because he wanted the knowledge to be accurate in the animation:

Aaron: I looked up the science and technology books from the primary school and it had information about earthworms and so I just went through those books and sort of just made, I guess you could say, mind map lifecycle book of what actually happens and then I just used that information and put it onto the animation. I mean I knew some of it off the top of my head, but I had to actually make sure it was correct.

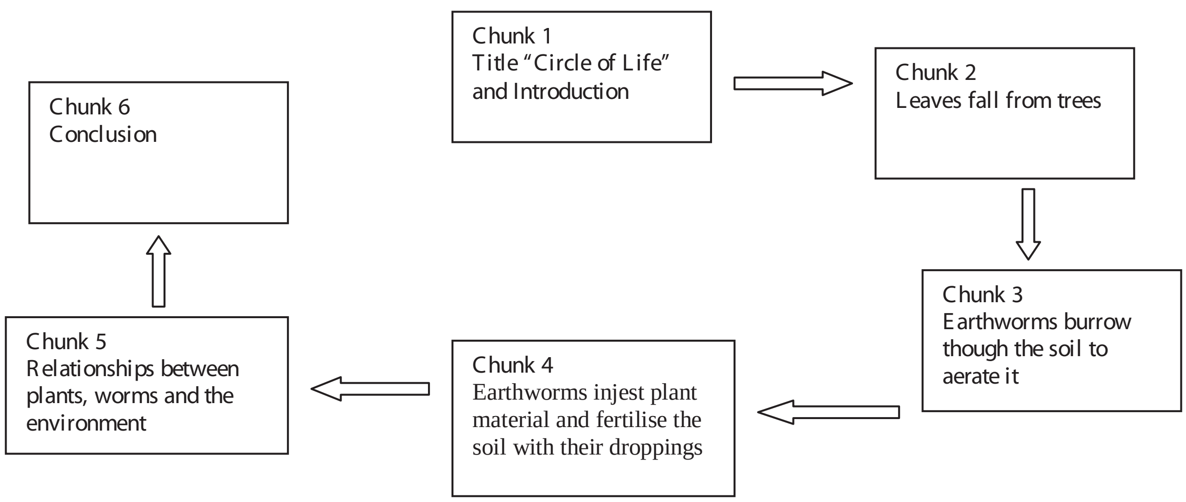
Int: So what was new then? Why did you have to make sure it was correct?

Aaron: Oh well I don't want students to see it and see it's wrong.

Int: Ok, so what were some of the things you got from, some of the factual information that you didn't know?

Aaron: How earthworms help the soil I guess. How they actually eat the leaves and everything that's breaking down. I wasn't sure what earthworms actually ate, actually while they're in the soil. And I mean I know you put your compost, bits of fruit and vegetables into the compost bin and worms help but I wasn't actually sure what they ate. So I found out that they ate leaf matter, they ate raw vegetables, anything that you basically put in they try to eat and they sort of purify it somehow and create the waste they put out neutralises the soil and helps other plants grow in the process. So that's basically the new sort of information that I learned.

Figure 4. Chunking for Aaron's circle of life



Phase 3. Construction

Figure 5 shows photos from each segment with a brief description of each. One of the problems Aaron had to deal when making the animation was how to insert text in a static image and have it suspended for a few seconds in order to read it. He found this disconcerting as it interrupted the flow of the animation:

Aaron: Being the first time you're just experimenting with everything. The thing that I found sort of was a little bit disappointing at the end was the amount of sort of pausing that went on throughout. You know how you have to pause it for the information to read it, I found it a little bit disappointing because there's a lot to read. To begin with I just feel that it flowed through quite well but of course you can't read the information because it's not up there long enough. While I was filming and I tried to take photos of it moving a little bit with the information staying there. But you know how you pause it, you read the information, the whole animation sort of stops. I did a lot of copy and pasting and that's what I found a little bit disappointing. If I did it again I would make sure that I take more photos of the information up there whilst the animation is still moving a little bit.

Int: Ah right, just for a visual effect.

Aaron: Yeah for a visual effect because I found, especially like for leaf matter when it was breaking down, I was taking photos and I had information up there and the leaf stops breaking down, it pauses while you read it and then you go back and then it starts breaking down again. So that's something that I'd like to change a little bit if I did it again. Just to keep the animation moving. None of this start, stop, start, stop, because I mean you could still see it, you can still see how the leaf breaks down but it starts breaking down then it stops a little bit and then it continues breaking down. The same with the earthworm moving through the soil, it's moving and then you come up with some information, like it's moving a little bit then I've had to copy and paste and it stops while you read the rest of it and then it continues moving. I think it would be good if it was just still moving a little bit while you're reading the text.

Phase 4. Reconstruction

A particular feature of Aaron's slowmation is the music that he selected to put down as a track because he wanted the music to match the actions and the interactions in the animations. He even extended the animation so that the music fitted with the actions represented:

Aaron: The only difficulty I really had was putting the music on. Because, I was going to try some different music to begin with and it wasn't, it was too long. And so after the animation finished the music kept going. So I couldn't work out how to make the music fit perfectly with the animation. But the music was purely coincidental in the end actually. I was listening to my sister downloading music and I heard it and I thought, that sounds quite good… And it builds up though.

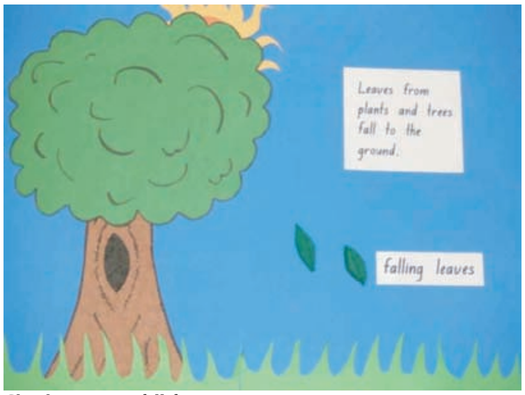
Int: I thought it was really carefully selected actually. Was it an accident?

Aaron: No, I thought it was quite appropriate when I heard her play it. I thought that was really good and when I put it on I noticed when it got to the plant it built up and the plant started growing.

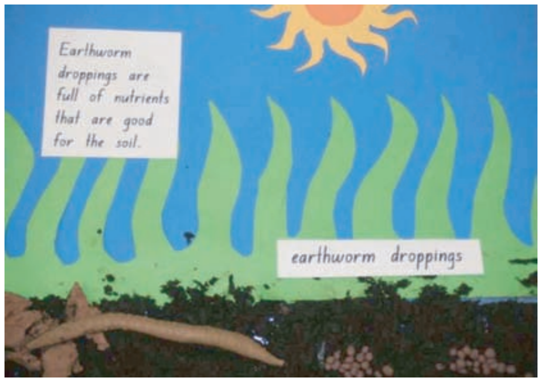
Int: It's a crescendo.

Aaron: And I thought I'll definitely use this and it was pretty much exactly the same as the animation. So I extended the animation a little bit and then put the music with it and it worked perfectly.

Figure 5. Photo from each chunk

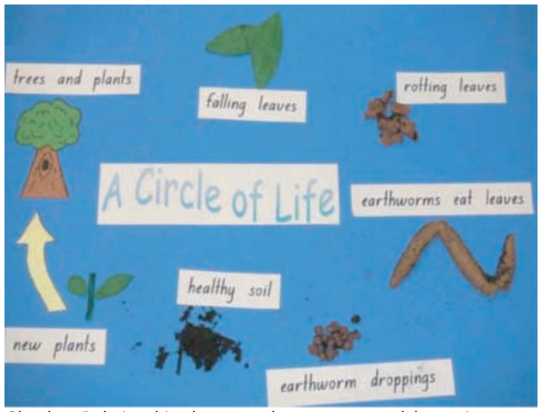


Chunk 2. Leaves fall from trees



Chunk 3. Earthworms burrow though the soil to aerate it

Chunk 4. Earthworms injest plant material and fertilise the soil with their droppings



Chunk 5. Relationships between plants, worms and the environment

DISCUSSION

In the last 20 years, many animations have been produced by experts as educational resources for the teaching of science in schools and universities. These animations are available on CDs and DVDs, and many can be downloaded from the World Wide Web. They have been useful to support student learning as reusable learning objects. It is clear, however, that the vast majority of these animations do not involve learners in the creation process. For example in *The Cambridge Handbook of Multimedia Learning*, edited by a world expert on multimedia, Richard Mayer, there is little research on multimedia (including animations) created by learners. Although Mayer identifies two broad types of multimedia instructional design, technology-centred approaches and learner-centred approaches, both types are made by experts for learners. Importantly, a review of literature regarding animations indicates that not all of them are useful for student learning (ChanLin, 1998; Rieber & Hannafin, 1998; Weerawandhana et al., 2005).

Some researchers suggest that animations need to be "slower and annotated" (Tvertsky et al., 2002), involve learners in the "design of animations" (Chan & Black, 2005) while still maintaining "accuracy of the content" (Lowe, 2006). Slowmation is a teaching approach that promotes learner-generated animation and attempts to incorporate these suggestions. Moreover, the four phase learning design that underpins slowmation—planning, storyboarding, construction, and reconstruction—has many processes embedded in it to support preservice teachers engaging with the science concepts such as reflecting, planning, designing, making, and editing slowmations. In essence, the slowmation approach encourages learners to select a concept, break it down into its components, make them, and use technology to put it all back together again as a narrated animation. The key feature of slowmation is that it simplifies the complex processes of stop-motion animation by making models (or using existing models) that are manipulated in the horizontal plane and plays the animations at 2 frames/second. Engaging preservice teachers in the designing and making process of an animation supports the notion proposed by Bransford et al. (2000) that using technology to make models of various concepts helps learners to develop a deeper understanding of science concepts.

Although the slowmations produced by learners are not of the same standard as professionally made animations, it is clear from the examples provided in this chapter that the process engaged the preservice teachers in understanding the key science concepts. For example, although Wendy knew that honey bees were important for making honey, she did not know that they played such an important role in the wider ecological system of plant reproduction. In the second example, Aaron knew some factual information about earthworms but did not know some details about how important earthworms are to the soil until he did some research about this in preparing to make his slowmation. Hence, slowmation engaged the preservice students in learning science content because they have to represent it and explain it in their animations. This motivation to represent and explain the science concept accurately is enhanced if the slowmations are to be shown to other preservice teachers or school children.

A problem, however, with learner-generated animations is that the learners may misrepresent the science concept or may not explain it in the best possible way because some may not have a deep understanding of the science content knowledge in the first place or not do sufficient research on the concept (Hoban, 2007). In contrast, it has been argued that expert-generated animations should enable users to have more control over the playing of the animation such as having options to stop an animation or to play it at different speeds (Lowe, 2006). Whilst a valuable suggestion, Lowe's framework still focuses on experts designing and organising information for users to manipulate, not to actively engage learners as designers and creators. Hence, the scientific accuracy of learner-generated animations such as slowmations would be improved if the preservice teachers thoroughly checked the science content before they included it in their slowmations, or that a framework be devised to review the accuracy of the science content. Clearly, there is a role for both expert-generated and learner-generated animations to support the learning of science content by preservice teachers.

CONCLUSION AND FUTURE DIRECTIONS

This chapter has explained the learning design that underpins a new teaching approach which encourages learners to use technology to design and make their own animations of science concepts. Research has shown that this approach encourages learners to engage with the content because they want to demonstrate and explain the science accurately in their animation. However, whilst creating slowmations increases preservice teachers' understanding of science concepts, it is a major problem that the science may be misrepresented, especially if the slowmations are to be shown to school children. For this reason, more emphasis is going to be placed on the reconstruction phase of the learning design to provide a clear and accurate narration of the science concept as well as placing less text in the animation, which can sometimes detract from the overall meaning. A research project being implemented 2007 is to have preservice students create slowmations of science concepts and then to upload them to "Teacher Tube" so that they can be critiqued to allow feedback and perhaps modification to improve the science content. Because the narration in a slowmation is a separate QuickTime audio file, a narration can be easily modified to make the content more accurate as long as the preservice teachers keep a copy of the images only file. Further studies are also planned to introduce the slowmation approach to preservice students to support their learning of mathematics and English content.

NOTE

Slowmation won both categories of the 2006 "Technology Leadership Awards" presented by the international Society for Information Technology and Teacher Education (SITE) which is one of the three subgroups of the Association for the Advancement of Computers in Education (AACE). The author of this chapter won the category *Exemplary Use of Technology to Teach Content in a Teacher Education Methods Course* and his B. Ed (Hons.) students won the other category *Exemplary Use of Technology to Teach Content in the Induction Years in School*. The author would also like to acknowledge the support of EmLab (Educational Media Laboratory) at the University of Wollongong, Australia for their assistance in developing slowmation and to Jan Herrington for her encouragement to apply for the awards.

REFERENCES

Agostinho, S. (2006). *The use of a visual learning design representation to document and communicate teaching ideas.* Retrieved April 5, 2008, from http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p173.pdf

AUTC. (2003). *Information and communication technologies and their role in flexible delivery.* Retrieved April 5, 2008, from http://www.learningdesigns.uow.edu.au/index.html

Botts, N. (2004, June 3). *Learning about learning objects.* Retrieved April 5, 2008, from http://www.learning-objects.net/

Bransford, J. D., Brown, A. L., & Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience and school.* Washington, DC: National Academy Press.

Chan, M. S., & Black, J. B. (2005). *When can animation improve learning? Some implications for human computer interaction and learning.* Paper presented at the Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2005, Norfolk, VA (pp. 2581-2588).

ChanLin, L. J. (1998). Animation to teach students of different knowledge levels. *Journal of Instructional Psychology, 25*(1), 166-125.

Federation, T. L. (2006). *The learning federation online curriculum content initiative*. Retrieved April 5, 2008, from http://www.thelearningfederation.edu.au/tlf2/

Gamble, H., McLaughlin, S., Helmick, S., & Berkopes, S. (1995). Clay animation: A lesson in collaboration. *Arts and Activities, 117*(5), 12.

Gladhart, M. A. (2002). *Using animation and interactivity: To enrich reading and writing activities*. ERIC ED468664.

Gurney, B. (1995). Tugboats and tennis games: Preservice conceptions of teaching and learning revealed through metaphors. *Journal of Research in Science Teaching*, *32*(6), 546-583.

Hackling, M., & Prain, V. (2005). *Primary connections: Stage 2 research report*. Canberra: Australian Academy of Science.

Hill, J., & Hannifin, M. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology, Research and Development*, *49*(3), 37-50.

Hoban, G. F. (2005). From claymation to slowmation: A teaching procedure to develop students' science understandings. *Teaching Science: Australian Science Teachers Journal*, *51*(2), 26-30.

Hoban, G. F. (2007). Using slowmation to engage preservice elementary teachers in learning science content knowledge. *Contemporary Issues in Technology and Teacher Education, 2*(1), 1-15.

Hoban, G. F., & Ferry, B. (2006). *Teaching science concepts in higher education classes with slow motion animation (slowmation).* Paper presented at the E-Learn, Conference for E-Learning in Higher Education, Business, Honolulu, Hawaii.

Hoban, G. F., Ferry, B., Konza, D., & Vialle, W. (2007). Slowmation: Exploring a new teaching approach in primary school classrooms. In *Proceedings of the Australian Teacher Education Association Conference*, University of Wollongong.

Kozma, R. (2000). Reflections on the state of educational technology research and development. *Educational Technolology and Development, 48*(1), 5-20.

Lowe, R. (2006). *Educational animation: Who should call the shots?* Paper presented at the ASCILLITE, Sydney University.

Mayer, R. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multmedia learning* (pp. 31-48). New York: Cambridge University Press.

Oliver, R. (1999). Exploring strategies for online teaching and learning. *Distance Education, 20*(2), 240-254.

Rieber, L. P., & Hannafin, M. J. (1998). Effects of textual and animated orienting activities and pratice on learning from computer-based instruction. *Computers in the Schools, 7,* 77-89.

Sweller, J. (2006). Discussion of emerging topics in cognitive load research: Using learning information characteristics in the design of powerful learning environments. *Applied Cognitive Psychology, 20*, 353-357.

Taylor, R. (1997). *The encyclopedia of animation techniques*. Sydney: Simon and Schuster.

Tvertsky, B., Morrison, J., & Betrancourt, M. (2002). Animation: Can it facilitate? *International Journal of Human-Computer Studies, 57*(4), 247-262.

Viadero, D. (2007). Computer animation being used to bring science concepts to life. *Education Week, 26*(26), 12-13.

Weerawandhana, A., Ferry, B., & Brown, C. (2005). *Developing conceptual understanding of chemical equilibrium through the use of computer-based visualization software*. Paper presented at the International Conference for Computers in Education.

Wells, P. (1998). *Understanding animation*. London: Routledge.

White, R., & Gunstone, R. (1992). *Probing understanding.* London: Falmer.

Witherspoon, T. L., Foster, M. S., Boddy, G., & Reynolds, K. V. (2004). *Clay animation: Encouraging visual literacy.* Paper presented at the

World Conference on Educational Multimedia, Hypermedia and Telecommunications, Lausanne, Switzerland.

KEY TERMS

Construction: The third phase of the learning design underpinning slowmation that involves the learners making the models and photographing their small movements with a digital camera.

Learning Design: A framework for designing student learning experiences that explains a sequence of activities, procedures, or interactions.

Learning Object: A digital, reusable product such as a a text document, movie, mp3, picture, or Web site.

Planning: The first phase of the learning design underpinning slowmation involving the conceptualising and researching about a science concept.

Reconstruction: The fourth phase of the learning design that involves the learners uploading the digital photos into an animation program, editing it and providing a narration to explain the science content.

Slowmation: A new teaching approach that simplifies the normally complex process of animation to enables learners or novices to be the designers and makers of animations about science concepts.

Storyboarding: The second phase of the learning design underpinning slowmation that encourages the learner to break a concept into smaller “chunks” and to plan the sequence of movements in each chunk.

Chapter XVI
Representation of Coordination Mechanisms in IMS LD

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ABSTRACT

Group interaction has to be meticulously designed to foster effective and efficient collaborative learning. The IMS Learning Design specification (IMS LD) can be used to create a formal representation of group interaction, and the model can then be used to scaffold group interaction by means of coordination support at runtime. In this chapter, we investigate the expressiveness of IMS LD in representing coordination mechanisms by using coordination theory as an analytical framework. We have found that IMS LD can represent almost all the basic coordination mechanisms. We have also identified some hurdles to be overcome in representing certain coordination mechanisms. According to coordination theory, common coordination mechanisms can be reused in different settings. We briefly explore the feasibility of representing coordination mechanisms at a high-level of abstraction, which will be easier for instruction designers and teachers to understand and use.

INTRODUCTION

Group-based learning is an instructional strategy that provides a group of learners with intensive group interaction that can deepen individual learners" understanding. Well-organized group-based learning may result in collaboratively produced knowledge objects or conceptual artifacts which could not be created by any individual learner in the group acting alone. However, the benefits of this instructional strategy have a cost because additional coordination activities have to be carried out while learners perform learning activities. Examples of such coordination activities are allocating tasks, distributing and exchanging information, and managing work sequences. Although coordination activities do not directly contribute to the production of knowledge objects or conceptual artifacts, they have an influence on the effectiveness and efficiency of group-based learning, and sometimes on its success or failure.

In face-to-face learning, rich communication channels are available to support group interaction. These are lost in computer-based learning, and so in this environment, there is a need to provide computational coordination mechanisms. One promising technical solution is to provide a formal model of a well-designed group interaction by using a process modeling language, and then to coordinate learners" interactions according to this model in a language-compatible execution environment. This enables learners to focus on learning activities without having to pay too much attention to coordination problems, and so supports enhanced effectiveness and efficiency of group-based learning in computer-based environments.

IMS Learning Design (IMSLD, 2003) is an educational process modeling language which can be used to model a wider range of pedagogical strategies, including collaborative learning (Koper & Olivier, 2004). A basic introduction to IMS LD is available in the chapter ("Using the IMS LD Standard to Describe Learning Designs" by Koper and Miao in this book). The purpose of this present chapter is to systematically investigate the expressiveness of IMS LD in representing coordination mechanisms which support group interaction, and the approach taken is to use coordination theory as an analytical framework. We also provide XML (Extensible Markup Language) code to illustrate how group interaction can be represented in IMS LD.

It is important to note that characteristics of group-based learning processes vary from well-structured to highly fluid. Highly fluid collaborative processes, in which it is unpredictable who will take which action when and how other group members will respond, are not well suited to coordination using computational mechanisms. The attempt to specify a fluid collaborative process in detail often raises the so-called "over-scripting" problem (Dillenbourg, 2002), which may restrict group interaction to some extent. Some fluid collaborations are suited to coordination by human users. These may be defined in IMS LD, for example, as a collaborative activity with a conference service (e.g., an audio/video conferencing, text-based chat tool, or a discussion forum). The users (e.g., tutors and students) are expected to solve their coordination problems by using functions offered by the service. It may be seen that using this approach the coordination within an activity is not specified at the process level in the learning design, and that responsibility for process control is shifted to the user at execution time. This is, therefore, outside the scope of this chapter, which focuses on how computational mechanisms can be represented in IMS LD.

BACKGROUND

This section briefly introduces group-based learning and coordination theory.

Group-Based Learning and Collaboration Scripts

Learning in small groups has been intensively researched since the 1970s. According to Tribe (1994), there are two main types of purpose for group-based learning in higher education: those related to skills acquisition and those related to academic aims. As Tribe (1994) summarized, the skills acquired in group-based learning cover such interpersonal competences as oral communication, active listening, group leadership, group membership, ability to examine assumptions, and ability to tolerate ambiguities. All of these skills are highly valued in employment. The academic objectives which build on these employment skills include the ability to understand a text, question a line of argument, follow up a lecture, and gauge an individual's progress on a particular course or evaluate a course.

According to Strijbos and Martens (2001) and Strijbos, Martens, and Jochems (2004), there is agreement on five components of "group-based learning." As Strijbos et al. summarize first that groups are composed of either a minimum of two and up to six participants. Second, group-based learning is characterized by "positive interdependence," which refers to the degree to which the performance of a single member is dependent on the performance of all others (Johnson, 1981). A third component is the task, which must be a genuine group task, in which the effort of all group members is needed. A fourth component is "individual accountability." This refers to each student's individual responsibility for a specific aspect of the group process or group performance (or both). Individual accountability is enhanced through grading students for their individual effort or performance, as well as the group's performance. The fifth and final component is a shift from "teacher centered" to "student centered."

Early studies on group-based learning focused on the role of independent variables that might influence the learning outcome, for example, group size and group dynamics. Recent studies, however, analyse group interactions in order to ground the design of the support to be provided. According to Dillenbourg (1999), the key to understanding collaborative learning is to gain an understanding of the interactions among individuals. Recently, in the computer-supported collaborative learning (CSCL) community, the design of collaboration scripts has been a new focus area. The basic idea is to formally describe group interaction by using a scripting language and then to coordinate group members and their actions by executing collaboration scripts (Dillenbourg, 2002; Fischer, Kollar, Mandl, & Haake, 2007; Kollar, Fischer, and Slotta, 2005; Miao, Hoeksema, Hoppe, & Harrer, 2005; O"Donnell & Dansereau, 1992; Weinberger, Stegmann, & Fischer, 2005). Some efforts (e.g., Caeiro, Anido, & Llamas, 2003; Hernandez, Asensio, & Dimitriadis, 2004; Miao et al., 2005; Van Es & Koper, 2006) have been made to investigate whether IMS LD is sufficiently expressive to represent collaborative learning processes effectively, usually by analyzing special cases. The most serious research in this direction was done by Van Es and Koper (2006), which investigated many examples, randomly selected from 6,034 lesson plans. In the research described in this chapter, not only a case study method (the case used here is mainly for the purpose of explanation), but also a theory-based analysis method is adopted to systematically test the capacity of IMS LD in representing coordination mechanisms.

Coordination Theory

Coordination theory concerns the interdisciplinary study of coordination, which is defined as the process of managing dependencies between activities. Malone and Crowston (1994) analyzed processes in terms of actors performing interdependent tasks. These tasks might require or create resources of various types. Coordination theory provides a theoretical framework for analyzing coordination in complex processes, thus contributing to user task analysis and modeling. It has been applied in many fields, including computer science, organization theory, economics, management science, sociology, social psychology, anthropology, linguistics, law, political science, and so on. The research reported here is the first time that coordination theory has been applied to education.

One of the most powerful contributions of coordination theory is to systematically identify and analyze a wide variety of *dependencies.* Three elementary dependency types are identified in coordination theory: (1) *Sharing,* (2) *Flow*, and (3) *Fit.* In sharing dependencies, two or more activities share the same resource(s). *Sharing dependency* frequently occurs when one resource is used by a number of people or activities, whether that resource is a machine on a factory floor, a budget, or a room, or anything else which is used in multiple activities. In *flow dependencies,* resources produced by one activity are consumed by one or more subsequent activities. The concept of flow is intuitive and ubiquitous, emerging from the succession of events in human activity. In *fit dependencies,* two activities concurrently produce the components of the same resource, and these have to fit together. A good example of *fit* is the design of a car, where one engineer designs the engine, another designs the body, and so forth. Dependencies arise between the activities because all the parts have to fit together in the same car.

It is important to note that these three dependency types can be further specialized. For example, the flow dependency can be divided into three subdependencies: *precedence*, *transfer,* and *usability*. *Precedence dependency* indicates that the actor performing the second task has to know when the resource is available and the task can be started. *Transfer dependency* indicates that the resource must be moved from the activity in which it was created to the activity in which it is consumed. Finally, *usability dependency* indicates that the resource created by the first task must be appropriate for the needs of the second task. The fit dependency can be further specified as a *decomposition dependency* between task and subtask.

According to coordination theory, all dependencies in any relationship can be analyzed as either combinations of, or more specialized types of, these three elementary types or their subtypes. The theory describes how these dependencies can present actors in organizations with *coordination problems* which constrain the efficiency of task performance. To overcome coordination problems, actors must perform additional activities such as allocating tasks and control workflow and information flow, which Malone and Crowston (1994) called *coordination mechanisms* or *coordination activities.* Many such mechanisms to manage dependencies have been identified in organizations. Different organizations which have similar goals and achieve them using more or less the same set of coordination activities will have to manage the same dependencies. Nevertheless, they may choose to use different coordination mechanisms, thus resulting in different processes (Crowston & Osborn, 1998). The best process to use depends on situational factors and often involves trade-offs.

REPRESENTATION OF COORDINATION MECHANISMS IN IMS LD: A CASE STUDY OF GROUP-BASED LEARNING

In this section, based on coordination theory, we analyze the coordination problems which arise in group-based learning processes, and also systematically explore the degree to which IMS LD can represent possible coordination mechanisms for supporting group interaction, either directly or indirectly. The investigation is conducted and explained using the "Knowledge Convergence Script" use case, which is briefly introduced at the beginning of this section.

Knowledge Convergence Script

We have chosen to model an example of group-based learning which is well documented in the literature (Weinberger, Fischer, & Mandl, 2004). This was conducted in a Web-based environment, with a small group of three learners who were required to write three reports about three cases. Following the original design, the whole process is carried out in four stages:

1. Case reporting: Each learner reads a different case and writes a report about the case read. When all three learners have finished their reports, they pass them on to designated colearners in the first round of a predefined pattern of rotation.
2. Criticizing 1: Each learner comments on the report received. When all three have finished the first round of comments, they rotate the reports again, together with the first round comments.
3. Criticizing 2: Each learner comments on the newly transferred report and the associated comment. When all three have finished the second round of comments, they rotate the reports again, together with the first and second round comments.
4. Finalizing the report: Each report returns to the original author with two comments. Each learner revises his or her own report (writes a synthesis to merge the ideas of other learners) in the light of comments received.

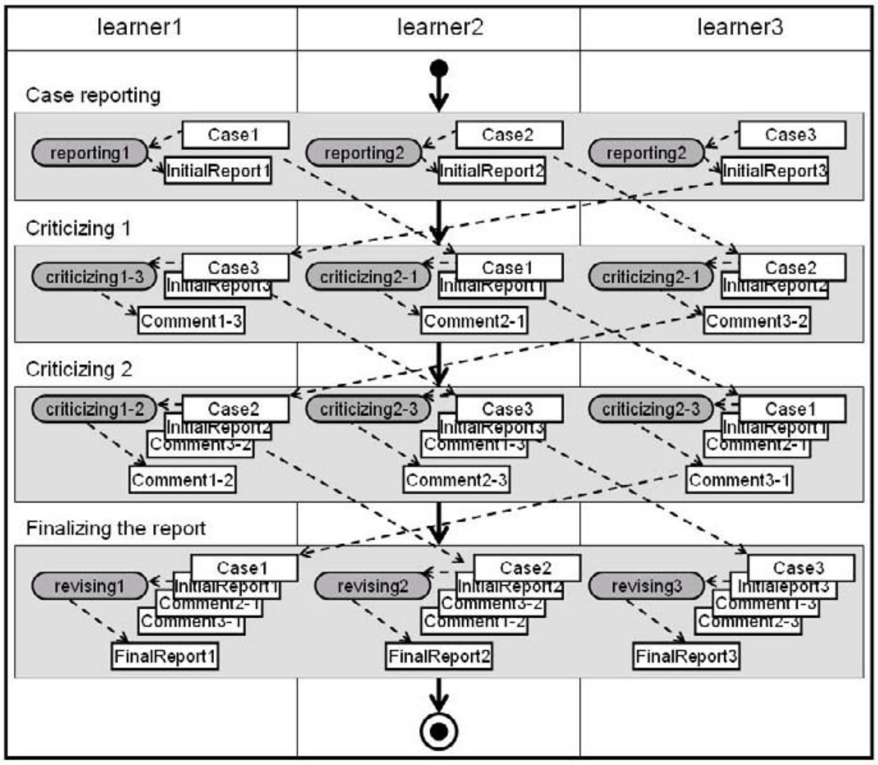
The "Knowledge Convergence Script" has been implemented in a Web-based collaborative learning environment, and it is reported that this group-based learning strategy is effective and efficient (Weinberger et al., 2004). In supporting this group-based learning strategy, we use process modeling and execution approach, rather than a software development approach. Figure 1 illustrates the process model, using the following conventions:

- light-gray rectangles represent stages
- dark-gray rectangles represent activities
- white rectangles represent artifacts
- solid arrows indicates workflows
- dashed arrows indicate information flows

Three learners are shown in Figure 1: *learner1*, *learner2*, and *learner3*, who work through a four-stage work procedure, including *Case reporting*, *Criticizing 1*, *Criticizing 2*, and *Finalizing the report*. At each stage, three learners perform activities in parallel to produce artifacts which will be used as input of succeeding activities carried out by their peers. For example, at the first stage, *learner1* performs activity *reporting1*. He/she reads *Case1* and produces artifact *InitialReport1*, which is then transferred to the activity *criticizing2-1* at the second stage. *Learner2* produces artifact *comment2-1*, which is then transferred together with *Case1* and *InitialReport1* to *learner3*. At the third stage, *learner3* reads *Case1*, *InitialReport1*, and *Comment2-1* and writes *Comment3-1*. Finally, all documents associated with *Report1* are transferred to *learner1*. He/she improves *Report1* based on the received comments and then produces a final version of the case report *FinalReport1*.

We use IMS LD to specify this strategy in the form of XML. The resulting model (KCS uol, 2007) can be executed in any IMS LD compliant runtime environment, such as CopperCore (Vogten, Martens, Tattersall, Van Rosmalen, Nadolski, & Koper, 2006). Figure 2 shows a screenshot of CopperCore used to run this script when *learner1* is writing the final report. The top-left pane shows the work procedure of the user. The bottom-left part shows all *environ-*

Figure 1. An activity diagram of "Knowledge Convergence Script"

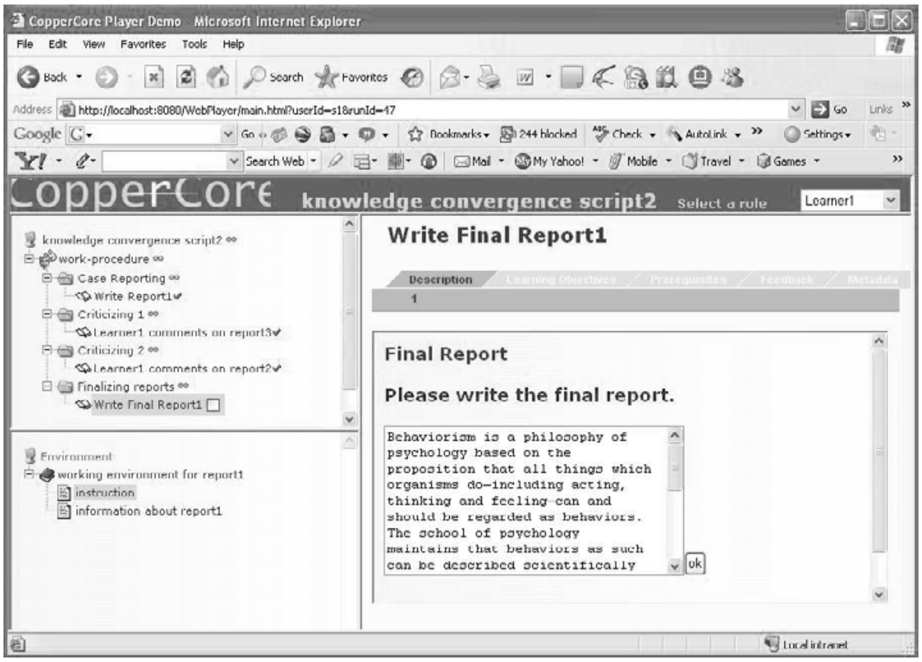


ments associated with the activity currently being performed, which include the documents to be accessed by the user. When the user clicks a learning object (such as a case and a comment made available in the environment), the content of the learning object is presented in the right part of the window. In Figure 2, the user has selected the final activity *write final report*. The main area of the window presents the activity-description of *write final report* activity, in which the user writes the final version of his/her case report as shown in Figure 2. It is important to note that the main goal of this research is not to study whether this group-based learning strategy is effective or efficient, but to investigate and demonstrate the expressiveness of IMS LD in modeling group-based learning strategy. Moreover, we observe that various group-based learning strategies can be adopted to achieve the same learning goal and that no single strategy is ideal for all situations. Accordingly, we designed some alternatives, which are not intended to improve this group-based learning process, but rather to provide the basis for a discussion of possible coordination mechanisms.

Analyses of Dependencies and Possible Coordination Mechanisms in Group-Based Learning Processes

In this section, we investigate various forms of dependencies in group-based learning processes

Figure 2. A screenshot of CopperCore running the "Knowledge Convergence Script"



from the perspective of coordination theory. The "Knowledge Convergence Script" and its alternatives are used as examples to analyze and explain the coordination mechanisms to manage various dependencies in group-based learning processes.

Sharing Dependencies

In the activities carried out in this use case, each learner has to read three cases and make contributions to each report. Thus, the resources shared by the activities are three learners and three cases. If learners work without any coordination mechanism for managing the sharing dependencies described above, the result will be disorder with each learner performing any task at any time.

The coordination mechanism used in the original design is to predefine the allocation of learners and cases to activities so that some are carried out concurrently and others at different times. In order to support this coordination mechanism, it is necessary to represent the bindings between the actors and the activities which they will carry out, either concurrently or at different times. It is also necessary to ensure that actors have access to the appropriate cases when they have to carry out a particular activity. Another possible coordination mechanism for managing sharing dependencies is that three learners and one case will be allocated to individual activities in turn. Each activity is itself a collaborative task. In order to support this coordination mechanism, it is necessary to represent the binding between the multiple actors and the same activity at the same time and to represent the use of the communication tools used to exchange their ideas and create the report.

These two strategies are static coordination mechanisms, which manage the sharing dependencies in a predefined manner. If it is not decided in advance which learner will be responsible for reporting on which case, then a dynamic coordination process will be required which responds to the dynamics of the learning process. An example of a dynamic coordination mechanism is "first come, first served," and this mechanism can be applied to determining the pattern of rotation. For example, we could add a register activity for each role, but not allocate any activity to any role in design time. At runtime, three users will register to carry out the process, and according to the sequence of their registrations, the activities will be allocated and the artifacts rotated.

Flow Dependencies

As mentioned before, the flow dependency has three subdependencies: (1) *precedence*, (2) *transfer*, and (3) *usability*. We now analyze these types of dependencies in the group-based learning.

1. *Precedence:* In the use case, there are precedence dependencies between some activities. For example, when one learner has finished the activity of creating an initial report, the other two can comment on it in turn. Only after other two learners provide their comments can the first learner write a synthesis.

Normally, the coordination mechanism used to manage precedence dependencies is event-driven. This means that an event (e.g., the termination of an activity and the available of a resource) triggers the start the succeeding activity. In complex learning process, branching, forking, and joining are possible coordination mechanisms. Branching means a control that only one succeeding activity will be triggered among several candidates according to a condition. Forking refers to the control that two or more succeeding activities will start in parallel after the termination of an activity. Joining is a control that the termination of all preceding activities triggers the start of a succeeding activity.

In the original "Knowledge Convergence Script" design, a four-step process is used. In each phase, three activities are performed in parallel. Only when all activities in one step are finished will all the activities in the next step be triggered. This is a synchronization coordination mechanism. However, if the concurrent tasks performed within a step are not balanced, the efficiency of this coordination mechanism is not high. For example, if one of the three cases is more difficult and takes longer to understand and to develop ideas, then at each step, the activity handling will take longer. Using synchronization, each step takes as long as the most difficult case takes to resolve.

In order to enhance the efficiency, a task-driven approach can be used so that when a learner finishes the current task, the learner can perform the succeeding activity without having to wait. When there are unbalanced tasks, this coordination mechanism can reduce the total learning time. Another possible coordination mechanism is to trigger an activity by an event indicating that all necessary resources are available (data-driven). For example, each learner is responsible for performing four activities: creating an initial report, commenting on two other reports, and writing a final report. Using this approach whenever an initial report written becomes available, the corresponding activity for commenting on it is triggered, even if the learner who will carry it out is still working on the initial report.

2. *Transfer:* In group-based learning, an artifact is usually employed as a means of coordinating group interaction and constitutes a collaboratively produced knowledge object. In the use case, there are transfer dependen-

cies between some activities. For example, artifacts such as initial reports and comments produced in an activity are transferred to other activities.

The basic coordination mechanism for managing transfer dependencies is to capture the artifact produced in the activity and to present the captured artifact in other activities.

3. *Usability*: In the use case, there are usability dependencies between activities. For example, an initial report of a case should transfer to an activity which has the aim of commenting on this report.

As mentioned above, in e-learning processes, the objects to be transferred are information objects. The coordination mechanisms for managing usability dependencies should check whether the class of the artifacts, data type, size, and other constraints meet the requirements.

Fit Dependencies

In the use case, each final report is a synthesis of ideas from all the learners, while the production of each report is split into four activities. The use case could be extended so that the three cases are specified as behaviorism, cognitivism, and constructivism, with the three reports being assembled into a general report about learning theories. In this extended case, the activities of writing the three reports would have fit dependencies. A basic coordination mechanism for managing fit dependencies is to check whether the classes of the artifacts, data types, sizes, and other constraints are compatible. A basic coordination mechanism for managing decomposition dependencies between task and subtask is also needed.

Representation of Coordination Mechanisms in IMS LD

In this section, we analyze whether IMS LD can represent the coordination mechanisms for managing various dependencies within group-based learning processes which we have identified above. There are two kinds of activities defined in IMS LD: learning activity and support activity. It is not necessary to distinguish them for our present purpose, so we simply use the term *activity*. The notations representing resources in IMS LD are *role, environment, learning object,* and *learning service*. For the sake of clarity, we discuss these in turn for fit, flow, and sharing.

Representation of Coordination Mechanisms to Manage Fit Dependencies

IMS LD has no notation which explicitly represents artifacts, and so no computational coordination mechanism is available to check whether the components of an artifact fit together. In IMS LD, a general notation *property* can be used to represent a variety of concepts, including artifacts created in the learning processes. Depending on its scope, an artifact can be defined as a *global property* or a *local property* (run property). Similarly, an artifact can be defined as a *personal property*, a *role property*, or a *general property*, depending on its owners. A property cannot represent complex, structured information objects because it can only have a primitive data type such as integer, real, string text, URL, file, time, and so on. Consequently, IMS LD provides no computational mechanism for coordinating the assembly of components produced simultaneously in different activities. As shown in the use case, the merging work is performed without computational support. Of course, as a general process modeling language, IMS LD should not and cannot directly support any specific artifact. One possible solution is to use a file type suitable for the representation of structured information (e.g., XML files). If external learning services were integrated which checked and assembled components and handled specific artifacts, then the IMS LD engine could communicate with these mechanisms in order to manage the specific fit dependencies. This is a complicated technical issue, however, and so we do not discuss it in detail in this chapter.

Although IMS LD can only manage artifact decomposition dependencies indirectly, it provides several coordination mechanisms which can be used to directly manage task decomposition dependency. In IMS LD a learning process can be decomposed into *plays, acts,* and *role-parts.* Each role-part consists of a role and an *activity* or an *activity-structure* that is recursively decomposable. All these notations can be used to represent a set of tasks with a variety of granularities as a hierarchical structure. However, the restriction to activity-structure in which all activities have to be performed by the same role makes it inconvenient to represent a sequence of activities performed, for example, by different roles in turn. If IMS LD had a construct corresponding to a role-part sequence, then it would be easier to represent a group-interaction sequence involving various roles.

In IMS LD, a role can be decomposed into subroles at arbitrary levels. For each role, some attributes can be used to restrict the role, such as max-members, min-members, inclusive/exclusive, and so on. However, no constraint specifies how a role should be composed of subroles. As a result, it is sometimes difficult to define the formation of a group when it is modeled using role notation. For example, if a group must be formed by three (two female and one male) learners with backgrounds in pedagogy, psychology, and computer science, respectively, it is difficult to represent such a constraint in IMS LD. As a consequence, no computational mechanism can be used to check whether the group has been correctly formed. We do not go into this in greater detail because there is no a simple method to resolve the issue, and in any event, the case under discussion does not raise this particular problem.

In order to clarify how to model group interaction in IMS LD without going into too much technical detail, we now introduce a restricted pseudocode, based on IMS LD. Figure 3 illustrates some definitions of the structure of roles, properties representing artifacts, and activity decompositions. Figure 3a defines three learners: *learner1*, *learner2*, and *learner3*. The constraints for each role are that one and only one user can play a role, and a user cannot have more than one role in this process. The code shown in Figure 3b specifies several properties *InitialReport1*, *Comment1-2*, *Comment1-3*, and *FinalReport1*, which represent artifacts produced by *learner1*. Figure 3c defines four activities performed by *learner1*. Each activity will be carried out in an associated environment. Note that the corresponding set of properties and activities relevant to *learner2* and *learner3* are omitted.

Representation of Coordination Mechanisms to Manage Flow Dependencies

Precedence: IMS LD provides several built-in mechanisms to manage the precedence dependencies, such as acts in a play and activity-structure with a sequence type. Note that such sequences are weak coordination mechanisms because the sequences are no more than suggestions. The users can work following the sequences or vary them because all acts and activities are accessible at any time. They can even access completed activities. This has advantages because it provides flexibility for the users to carry out tasks as they wish. It is sometimes difficult to judge if an activity has really terminated, especially in learning processes. For example, when learners work on reading and understanding an article and after

Figure 3. The definitions of roles, properties, and activities

Figure 3a. The definitions of three roles

```
<learner create-new=”not-allowed” identifier=”learner1” match-persons=”exclusively-in-roles” max-persons=”1” min-persons=”1”>
    <title>Learner1</title>
</learner>
<learner create-new=”not-allowed” identifier=”learner2” match-persons=”exclusively-in-roles” max-persons=”1” min-persons=”1”>
    <title>Learner2</title>
</learner>
<learner create-new=”not-allowed” identifier=”learner3” match-persons=”exclusively-in-roles” max-persons=”1” min-persons=”1”>
    <title>Learner3</title>
</learner>
```

Figure 3b. The definitions of properties relevant to learner1

```
<!— the definition of the property representing the initial report written by learner1 -->
  <loc-property identifier=”InitialReport1”>
    <title>Initial Report1</title>
  </loc-property>
<!— the definition of the property representing the comment written by learner1 on the initial report2 written by learner2 -->
  <loc-property identifier=”Comment1-2”>
    <title>Comment1-2</title>
  </loc-property>
<!— the definition of the property representing the comment written by learner1 on the initial report3 written by learner3 -->
  <loc-property identifier=”Comment1-3”>
    <title>Comment1-3</title>
  </loc-property>
<!— the definition of the property representing the final report written by learner1 -->
  <loc-property identifier=”FinalReport1”>
    <title>Final Report1</title>
  </loc-property>
```

Figure 3. The definitions of roles, properties, and activities (continued)

Figure 3c. The definitions of activities relevant to learner1

```
<!—the definitions of an activity arranged for learner1 to write a case report -->
<learning-activity identifier=”LA-write-initial-report1”>
  <title>Write Report1</title>
  <environment-ref ref=”ENV-for-report1”/>
  <activity-description>
    <title>Write Report</title>
    <item identifier=”ITEM-write-report1” identifierref=”RESO-write-report1” />
  </activity-description>
</learning-activity>
<!—the definitions of an activity arranged for learner1 to comment on the InitialReport2 written by learner2 -->
<learning-activity identifier=”LA-comment-1-2”>
  <title>Learner1 comments on report2</title>
  <environment-ref ref=”ENV-for-report2”/>
  <activity-description>
    <title>Commenting</title>
    <item identifier=”ITEM-write-comment-1-2” identifierref=”RESO-comment-1-2” />
  </activity-description>
</learning-activity>
<!—the definitions of an activity arranged for learner1 to comment on the InitialReport3 written by learner3 -->
<learning-activity identifier=”LA-comment-1-3”>
  <title>Learner1 comments on report3</title>
  <environment-ref ref=”ENV-for-report3”/>
  <activity-description>
    <title>Commenting</title>
    <item identifier=”ITEM-write-comment-1-3” identifierref=”RESO-comment-1-3” />
  </activity-description>
</learning-activity>
<!—the definitions of an activity arranged for learner1 to write the FinalReport1 -->
<learning-activity identifier=”LA-write-final-report1”>
  <title>Write Final Report1</title>
  <environment-ref ref=”ENV-for-report1”/>
  <activity-description>
    <title>Write Final Report</title>
    <item identifier=”ITEM-AD-write-final-report1” identifierref=”RESO-write-final-report1” />
  </activity-description>
</learning-activity>
```

Figure 4. The definition of a sequence of acts in a play

```
<!—the definitions of four acts in a play -->
<play identifier=”PL-work-procedure”>
  <title>work-procedure</title>
  <!—the definitions of the first act-->
  <act identifier=”ACT-case-reporting”>
    <title>Case Reporting</title>
    <role-part identifier=”RP-write-report1”>
      <title>learner1 writes report1</title>
      <role-ref ref=”learner1”/>
          <learning-activity-ref  ref=”LA-write-initial-re-
port1”/>
    </role-part>
    <role-part identifier=”RP-write-report2”>
      <title>learner2 writes report2</title>
      <role-ref ref=”learner2”/>
          <learning-activity-ref  ref=”LA-write-initial-re-
port2”/>
    </role-part>
    <role-part identifier=”RP-write-report3”>
      <title>learner3 writes report3</title>
      <role-ref ref=”learner3”/>
          <learning-activity-ref  ref=”LA-write-initial-re-
port3”/>
    </role-part>
  </act>
  <!—the definitions of the second act -->
  <act identifier=”ACT-criticizing1”>
    <title>Criticizing 1</title>
    <role-part identifier=”RP-comment-1-3”>
      <title>learner1 comments on report3</title>
      <role-ref ref=”learner1”/>
      <learning-activity-ref ref=”LA-comment-1-3”/>
    </role-part>
    <role-part identifier=”RP-comment-2-1”>
      <title>learner2 comments on report1</title>
      <role-ref ref=”learner2”/>
      <learning-activity-ref ref=”LA-comment-2-1”/>
    </role-part>
    <role-part identifier=”RP-comment-3-2”>
      <title>learner3 comments on report2</title>
      <role-ref ref=”learner3”/>
      <learning-activity-ref ref=”LA-comment-3-2”/>
    </role-part>
  </act>
  <!—the definitions of the third act -->
  <act identifier=”ACT-criticizing2”>
    <title>Criticizing 2</title>
    <role-part identifier=”RP-comment-1-2”>
      <title>learner1 comments on report2</title>
      <role-ref ref=”learner1”/>
      <learning-activity-ref ref=”LA-comment-1-2”/>
    </role-part>
    <role-part identifier=”RP-comment-2-3”>
      <title>learner2 comments on report3</title>
      <role-ref ref=”learner2”/>
      <learning-activity-ref ref=”LA-comment-2-3”/>
    </role-part>
    <role-part identifier=”RP-comment-3-1”>
      <title>learner3 comments on report1</title>
      <role-ref ref=”learner3”/>
      <learning-activity-ref ref=”LA-comment-3-1”/>
    </role-part>
  </act>
  <!—the definitions of the final act -->
  <act identifier=”ACT-finalizing-report”>
    <title>Finalizing reports</title>
    <role-part identifier=”RP-write-final-report1”>
      <title>learner1 writes the final report</title>
      <role-ref ref=”learner1”/>
      <learning-activity-ref ref=”LA-write-final-report1”/>
    </role-part>
    <role-part identifier=”RP-write-final-report2”>
      <title>learner2 writes the final report</title>
      <role-ref ref=”learner2”/>
      <learning-activity-ref ref=”LA-write-final-report2”/>
    </role-part>
    <role-part identifier=”RP-write-final-report3”>
      <title>learner3 writes the final report</title>
      <role-ref ref=”learner3”/>
      <learning-activity-ref ref=”LA-write-final-report3”/>
    </role-part>
  </act>
</play>
```

a period of time they think the task has been finished, they terminate the activity and move on to the next one. However, they may recognize that they did not fully understand the article and go back to read it again. Weak sequence control mechanisms make it possible for users to carry out such tasks flexibly and handle exceptions manually. On the other hand, users have to pay attention to coordination problems, to a greater or lesser extent. Moreover, such freedom for users to decide the actual work sequence may create problems, especially in situations where a strictly defined route is required. Fortunately, IMS LD provides additional mechanisms to support strong controls for sequence of acts and sequence of activities. The following paragraphs will present how weak and strong sequencing mechanisms can be represented in IMS LD.

Figure 5. The definition of a condition managing a strong precedence dependency between two activities

```
<if>
  <complete>
    <learning-activity-ref ref=”LA-write-initial-report1”/>
  </complete>
</if>
<then>
  <hide>
    <learning-activity-ref ref=”LA-write-initial-report1”/>
  </hide>
  <show>
    <learning-activity-ref ref=”LA-comment-1-3”/>
  </show>
</then>
<else>
  <hide>
    <learning-activity-ref ref=”LA-comment-1-3”/>
  </hide>
</else>
```

As shown in Figure 4, the work procedure of this group-based learning is modeled as four acts titled *Case Reporting*, *Criticizing 1*, *Criticizing 1*, and *Finalizing reports*. Each act represents a stage, in which the person responsible for doing which activity is specified as a role-part. In the first act titled *Case Reporting*, for example, *learner1* is assigned to perform the activity titled *Write report1*, which is defined in Figure 3 using identifier *LA-write-initial-report1*. Using a weak sequencing mechanism, we can represent four acts in sequence without control as shown in Figure 3. However, it is possible to represent a strong sequencing mechanism in IMS LD in a way to specify the completion condition for an act. One such condition is that an act will be terminated automatically by the system when all role-parts in the act are completed. For example, the first act completes when all learners finish the activities to create their initial reports, and then the

Figure 6. The definition of a condition representing a data-driven coordination mechanism

```
<if>
  <not>
    <no-value>
      <property-ref ref=”InitialReport1”/>
    </no-value>
  </not>
</if>
<then>
  <show>
    <learning-activity-ref ref=”LA-comment-2-1”/>
  </show>
</then>
<else>
  <hide>
    <learning-activity-ref ref=”LA-comment-2-1”/>
  </hide>
</else>
```

activities in the succeeding act titled *Criticizing 1* become accessible.

In order to support strong precedence dependencies between activities, we can represent the sequence by using conditions to set the visibility of activities. Figure 5 shows an example which supports strong precedence dependency between two activities using a condition. As shown in Figure 5, if and only if the first activity, which identifier is *LA-write-initial-report1*, is completed, the second activity, which identifier is *LA-comment-1-3*, becomes accessible. Meanwhile, the first activity

Figure 7. Transference of an artifact via an environment

Figure 7a. The definition of the activity in which learner1 creates the initial report1

```
<learning-activity identifier=”LA-write-initial-report1”>
   <title>Write Report1</title>
   <environment-ref ref=”ENV-for-report1”/>
   <activity-description>
      <title>Write Report</title>
   <item identifier=”ITEM-write-report1” identifierref=”RESO-write-report1” />
   </activity-description>
</learning-activity>
```

Figure 7b. The content of the resource file “RESO-write-report1”

```
<p>Please write the initial report.</p>
<ld:set-property ref=”InitialReport1” property-of=‘self” />
```

Figure 7c. The definition of the activity that is associated with an environment

```
<learning-activity identifier=”LA-comment-2-1”>
   <title>Learner2 comments on report1</title>
   <environment-ref ref=”ENV-for-report1”/>
   <activity-description>
      <title>Commenting</title>
            <item identifier=”ITEM-write-comment-2-1” identifierref=”RESO-comment-2-1” />
   </activity-description>
</learning-activity>
```

Figure 7d. The definition of the environment storing the initial report1

```
<environment identifier=”ENV-for-report1”>
   <title>working environment for report1</title>
   ……
      <learning-object identifier=”LO-information-about-report1”>
        ……
        <item identifier=”ITEM-report1” identifierref=”RESO-presentation-of-report1” isvisible=”false”>
           <title>report1</title>
        </item>
        ......
   </learning-object>
</environment>
```

Figure 7e. The content of the resource file “RESO-presentation-of-report1”

```
<h3>Initial Report 1:</h3>
<ld:view-property ref=”InitialReport1” view=”value”/>
```

becomes inaccessible unless it is specifically set to be visible in other conditions.

The coordination mechanisms discussed above for managing precedence dependencies are task-driven mechanisms. In IMS LD, conditions can also be used to represent data-driven mechanisms. For example, if *learner1* submits the initial case report, *learner2* can start to perform the activity (its identifier is *LA-comment-2-1*). Otherwise, this activity will be kept hidden from its actor. Figure 6 illustrates this example.

Transfer: IMS LD has no notation which explicitly represents the transference of an artifact produced in an activity and consumed by other activities. However, the transference of an artifact can be represented indirectly. Figure 7 shows an example which transfers an initial report created by *learner1* in the activity *Write Report1* to the activity *Learner2 comments on report1.* Figure 7a shows the definition of the first activity *Write Report1*, in which learner1 writes initial *report1* using the information item *ITEM-write-report1* that refers to a resource *RESO-write-report1.* Figure 7b shows the content of resource file *RESO-write-report1*, in which a global element *set-property* is used to input the initial *report1* captured by the property *InitialReport1.* Figure 7c defines the second activity titled *Learner2 comments on report1* which is associated with the environment *ENV-for-report1*, defined in Figure 7d. This environment contains a learning object *LO-information-about-report1*, which has an information item *ITEM-report1.* This item refers to the resource *RESO-presentation-of-report1,* and it will become visible when the *InitialReport1* is made available. Figure 7e shows the content of resource file *RESO-presentation-of-report1*, in which a global element *view-property* is used to view the initial report1. In fact, the rotation of artifacts is implemented through rotationally binding environments with activities in the original design.

Another solution is to present all imported artifacts in the same information item of the activity which consumes the artifacts. Rather than using an environment, the artifact is transferred by means of the activity-descriptions of the activities which produce and consume the artifact. Because of the limited space available here, we omit the code illustrating this approach.

Usability: As mentioned above, in IMS LD, a property can be used to represent artifacts. Because a property in IMS LD has a primitive data type such as *integer*, *string*, *duration*, and os forth, the coordination mechanism for managing usability dependency is simply to check the data type and constraints of the property. In this use case, all properties should be defined as type *text.*

Representation of Coordination Mechanisms to Manage Sharing Dependencies

In IMS LD, task allocation is represented as a role-part. As shown in Figure 4, a set of role-parts are defined to represent three learners who are assigned to perform different activities. These activities share the labor resources at different times. We can represent another coordination mechanism for managing sharing dependencies in IMS LD: three sequential activities in each of which three learners work together. Each activity is designed as a collaborative activity leading to the production of a report. Each activity has an environment containing certain learning services such as chat, forum, shared text editor, shared whiteboard, audio/video conferencing, and so on. As mentioned before, in a fluid collaboration, learners can use these collaborative tools to coordinate their actions at a finer grained level and produce shared artifacts. Because the code representing this coordination mechanism is extensive, it is not included here.

IMS LD provides static coordination mechanisms for managing sharing dependencies, but it is difficult to support dynamic coordination mechanisms, for example, the "first come, first

Figure 8. An example of dynamic coordination mechanism

Figure 8a. The declaration of three roles and twelve activities

<!—the three roles and twelve activities are defined as those defined in the original design. -->
Role: learner1, learner2, learner3;
Activity: registering1, registering2, registering3, reporting1, ……, revising3;

Figure 8b. Three properties are defined for representing when each learner registers

<!—the four activities performed by the same learner are defined as a sequence activity-structure. Therefore, three activity-structures are defined -->
Activity-structure: activity-structure1 := reporting1 + criticizing1-3 + criticizing1-2 + revising1;
activity-structure2 := reporting2 + criticizing2-1 + criticizing2-3 + revising2;
activity-structure3 := reporting3 + criticizing3-2 + criticizing3-1 + revising3;

Figure 8c. When a learner has finished registration, the registration time will be recorded.

<!—three properties are defined for representing when each learner registers -->
Property: T1 := 0, T2 := 0, T3 := 0;

Figure 8d. According to the sequence in which three learners register, the activity structures will be assign to the learners first-come, first-served.

<!—when a learner has finished registration, the registration time will be recorded -->
If (registering1 complete) then T1 := current time;
If (registering2 complete) then T2 := current time;
If (registering3 complete) then T3 := current time;

Figure 8e. Notifications are used to allocate tasks dynamically

<!—according to the sequence in which three learners register, the activity structures will be assign to the learners in the way first-come-first-served -->
If ((T1 is not 0) and (T2 is not 0) and (T3 is 0) and (T1<=T2)) then notification (learner1 activity-structure1), notification (learner2 activity-structure2), notification (learner3 activity-structure3);

If ((T1 is not 0) and (T2 is not 0) and (T3 is 0) and (T1>T2)) then notification (learner1 activity-structure2), notification (learner2 activity-structure1), notification (learner3 activity-structure3);

If ((T1 is not 0) and (T2 is 0) and (T3 is not 0) and (T1<=T3)) then notification (learner1 activity-structure1), notification (learner2 activity-structure3), notification (learner3 activity-structure2);

If ((T1 is not 0) and (T2 is 0) and (T3 is not 0) and (T1>T3)) then notification (learner1 activity-structure2), notification (learner2 activity-structure3), notification (learner3 activity-structure1);

If ((T1 is 0) and (T2 is not 0) and (T3 is not 0) and (T2<=T3)) then notification (learner1 activity-structure3), notification (learner2 activity-structure1), notification (learner3 activity-structure2);

If ((T1 is 0) and (T2 is not 0) and (T3 is not 0) and (T2>T3)) then notification (learner1 activity-structure3), notification (learner2 activity-structure2), notification (learner3 activity-structure1);

served" mechanism. We can investigate how to model an alternative design, in which tasks are assigned to roles according to the time sequence that users register to the execution. Using this approach, it is unpredictable at design time who will come first in an actual execution, unlike for a predefined allocation of tasks as role-parts described in Figure 4. Because the XML code to implement this mechanism is too extensive, we describe and explain it using pseudocode as shown in Figure 8.

In order to control the execution of activities at the right time, data-driven mechanisms (similar to the code shown in Figure 6) are needed as a complete coordination mechanism. Figure 8a declares three roles, *learner1*, *learner2*, and *learner3*, and 15 activities, 3 registering and 12 activities illustrated in Figure 1. Figure 8b declares three activity-structures, and each activity-structure consists of four sequential activities: writing the initial report, commenting on the reports of two peers, and creating the final report. Figure 8c defines three properties representing the time when learners finish the registration. Figure 8d specifies how the values of three properties are assigned. Because three learners may complete registration at different points of time, the *current time* assigned by the system will have different values for different learners. In Figure 8e, the first statement specifies that if *learner1* and *learner2* have registered and *learner3* has not finished registration, and *learner1* registered before *learner2* did (or they registered at the same time), then *learner1* will be assigned to perform *activity-structure1*, *learner2* will be responsible for doing *activity-structure2*, and *activity-structure3* will be carried out by *learner3*. The following five statements specify the allocation tasks in the other five situations, in which three learners finish the registrations in different time sequences.

If notification is not used, it is necessary to enumerate all possible role-parts in the same act (the total number of turples is the combination of the number of roles and the number of activities, 3*12=36 in this use case), and set them to *invisible*. After the rotation pattern is determined, 12 activities are set to *visible* to make 12 associated role-parts active. If the number of users and cases increases, the complexities of the process model increase accordingly. The difficulties in representing dynamic coordination mechanisms are ascribed to (a) no *identifier* data type and no *collection* data type specified for the property and (b) insufficient operations such as "find a person whose personal property meets a condition," "add a person as an active role," "add a role-part within an act," and so on.

FUTURE TRENDS: THE REUSE OF COORDINATION MECHANISMS

As we have seen, representing coordination mechanisms is a time-consuming and error-prone task. It is necessary to explore whether coordination mechanisms can be represented at a more abstract level than XML, that is, at a higher level than the executable code. It is expected that the abstract representation could be more intuitively understood and used by practitioners (e.g., instruction designers and teachers) who do not have sophisticated technical knowledge and skills. The system would then automatically transform such an abstract representation into XML code. This process provides a means whereby coordination mechanisms could be reused without requiring users to understand how the executable code works. In this section, we discuss issues related to such reuse.

Identifying Common Dependencies and the Mechanisms for Managing Them

According to coordination theory, dependencies and the mechanisms for managing them are *general,* which means that a given dependency and a mechanism to manage it will be found in a variety of settings. For example, a common coordination problem appears when certain activities require specialized competences, thus constraining which persons can work on them. This kind of dependency arises in many situations, and there is a generic set of coordination mechanisms (managing this dependency) which appear over and over in different processes. Coordination theory also describes how several coordination mechanisms can often be used to manage a dependency. For example, mechanisms to manage sharing a dependency between roles and activities can include qualification-checking, priority-comparing, first-come-first-served, and so on. Because of this, it is valuable to identify and study common dependencies and their related coordination mechanisms in order to facilitate reuse.

Reusing Computational Coordination Mechanisms

Once the dependencies and corresponding coordination mechanisms have been identified, the next step is to represent the coordination mechanisms in IMS LD. As we have seen, the representation of some coordination mechanisms in IMS LD is a very complex task, even for users with sound technical knowledge. It is therefore desirable to make the representation of coordination mechanisms reusable. Through an analysis of the IMS LD manifest file and resource files, we have found that some parts of code are static and some parts of code are replaceable and related to particular elements. We can therefore store a fragment of code as an executable component in a library of an IMS LD authoring environment. We can refer to this using an abstract representation, which can have parameters with values which are assigned by the user at design-time. For example, if a user wants to model the transference of a document from one activity to another, the user can use an abstract representation: *transfer a document (parameter1) from an activity (parameter2) to another activity (parameter3).* The constraints for the parameters are that *parameter1* must be a property reference representing a document to be transferred, and *parameter2* and *parameter3* must be activity references. Once the user has applied a coordination mechanism (by choosing the corresponding abstract representation and assigning the values to parameters), the system automatically maps the abstract representation to the component.

In the same way, more complex coordination mechanisms needed in the "Knowledge Convergence Script" can be represented as well. For instance, the abstract representation: *distribute documents (document1, document2, document3) within activities (activity1, activity2, activity3)* indicates the one-to-one distribution of three documents between three activities. Similarly, the abstract representation, *rotate documents (document1, document2, document3) from activities (activity1, activity2, activity3) to succeeding activities (activity4, activity5, activity6),* means to transfer three documents produced in three activities to three succeeding activities as follows:

- transferring document1 produced in activity1 to activity5
- transferring document2 produced in activity2 to activity6
- transferring document3 produced in activity3 to activity4

It is clear that a high-level representation of coordination mechanisms of this kind is much easier to understand and use than a concrete representation codified using IMS LD and expressed in XML (see Figure 5), or using a programming language (e.g., JAVA). Currently, we are working on developing a high-level modeling language and mapping algorithms to transform a group-based learning design represented in the high-level modeling language to an executable model represented in IMS LD. This work is technical in nature, so we do not discuss the details in this chapter.

CONCLUSION

This research is a theory-based analysis. First, we briefly introduce group-based learning and coordination theory. Using coordination theory as an analytical framework, we analyze dependencies and possible coordination mechanisms for managing them in group-based learning. We identify a variety of dependencies and some related coordination mechanisms through the investigation of a use case and some of its variants. We then analyze the expressiveness of IMS LD in representing the identified coordination mechanisms. We conclude that in supporting group interaction, it is possible to represent almost all basic coordination mechanisms in IMS LD. In particular, IMS LD provides sufficient mechanisms to manage task and role decomposition dependencies, weak and strong precedence dependencies, and static resource sharing dependencies. However, we have also recognized that the representation of certain coordination mechanisms presents some challenges. Specifically, it is complex to represent: the coordination of the assembly of components, transference of artifacts in some complicated distribution patterns, complicated group formation and group dynamics, and allocation of tasks and resources using some dynamic coordination mechanisms. The reasons for these difficulties are briefly analyzed, and possible solutions are also discussed.

Based on this analysis, we have briefly explored the feasibility of reusing coordination mechanisms in modeling group-based learning processes. In comparison with IMS LD code in the form of XML, a representation of common coordination mechanisms at a high-level of abstraction may be more intuitively understood and used by practitioners. We are currently identifying and codifying generic coordination mechanisms which will be archived as a library in the IMS LD authoring environment for reuse on future occasions. We will implement an advanced IMS LD authoring environment in which the user can design group-based learning processes using the abstract representation. The system will then automatically generate IMS LD code based on abstract representations and the executable components in the library.

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REFERENCES

Caeiro, M., Anido, L., & Llamas, M. (2003). A critical analysis of IMS Learning Design. *In Proceedings of CSCL 2003* (pp. 363-367).

Crowston, K., & Osborn, C. (1998). *A coordination theory approach to process description and redesign*. Massachusetts Institute of Technology, Centre for Coordination Science.

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (pp. 1-19). Oxford: Elsevier.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL?* (pp. 61-91). Heerlen: Open Universiteit Nederland.

Fischer, F., Kollar, I., Mandl, H., & Haake, J. (2007). *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives.* Springer.

Hernandez, D., Asensio, J.I., & Dimitriadis, Y. (2004, August 30-September 1). IMS Learning Design support for the formalization of collaborative learning flow patterns. In *Proceedings of the 4th International Conference on Advanced Learning Technologies,* Joensuu, Finland (pp. 350-354). IEEE Press.

IMSLD. (2003). *IMS Learning Design specification*. Retrieved April 6, 2008, from http://www.imsglobal.org/learningdesign/index.cfm.

Johnson, D.W. (1981). Student-student interaction: The neglected variable in education. *Educational Research, 10*, 5-10.

KCS uol. (2007). Retrieved April 6, 2008, from http://hdl.handle.net/1820/1003

Kollar, I., Fischer, F., & Slotta, J.D. (2005). Internal and external collaboration scripts in Web-based science learning at schools. In *Proceedings of Computer Supported Collaborative Learning (CSCL2005): The Next 10 Years* (pp. 331-340). Mahwah, NJ: Lawrence Erlbaum Associates.

Koper, R., & Olivier, B. (2004). Representing the learning design of units of learning. *Journal of Educational Technology & Society, 7*(3), 97-111.

Malone, T.W., & Crowston, K. (1994). The interdisciplinary study of coordination. *ACM Computing Surveys, 26*(1), 87-119.

Miao, Y., Hoeksema, K., Hoppe, U., & Harrer, A. (2005). CSCL scripts: Modelling features and potential use. In *Proceedings of Computer Supported Collaborative Learning (CSCL2005): The Next 10 Years* (pp. 423-432). Mahwah, NJ: Lawrence Erlbaum Associates.

O"Donnell, A.M., & Dansereau, D.F. (1992) Scripted cooperation in student dyad: A method for analyzing and enhancing academic learning and performance. In R. Hertz-Lazarowitz & N. Miller (Eds.), *Interaction in cooperative groups: The theoretical anatomy of group learning* (pp. 120-141). London: Cambridge University Press.

Strijbos, J.W., & Martens, R.L. (2001, March 22-24). *Group-based learning: Dynamic interaction in groups.* Paper presented in EURO-CSCL Conference 2001. Maastricht, The Netherlands.

Strijbos, J.W., Martens, R.L., & Jochems, W.M.G. (2004). Designing for interaction: Six steps to designing computer-supported group-based learning. *Computer & Education, 42,* 403-424.

Tribe, D.M.R. (1994). An overview from higher education. In L. Thornley & R. Gregory (Eds.), *Using group-based learning in higher education* (pp. 25-31). London: Kogan Page Limited.

Van Es, R., & Koper, R. (2006). Testing the pedagogical expressiveness of IMS LD. *Educational Technology & Society, 9*(1), 229-249.

Vogten, H., Martens, H., Tattersall, C., Van Rosmalen, P, Nadolski, R, and Koper, R. (2006). CopperCore Service Integration - Integrating IMS Learning Design and IMS Question and Test Interoperability. *In Proceedings of The 6th IEEE International Conference on Advanced Learning Technologies*, 378-382, Kerkrade, The Netherlands, IEEE Computer Society.

Weinberger, A., Fischer, F., & Mandl, H. (2004). Knowledge convergence in computer-mediated learning environments: Effects of collaboration scripts. In *Proceedings of the 85th Annual Meeting of the American Educational Research Association (AERA),* San Diego, CA.

Weinberger, A., Stegmann, K., & Fischer, F. (2005). Computer-supported collaborative learning in higher education: Scripts for argumentative knowledge construction in distributed groups. In *Proceedings of Computer Supported Collaborative Learning (CSCL2005): The Next 10 Years* (pp. 717-726). Mahwah, NJ: Lawrence Erlbaum Associates.

KEY TERMS

Coordination: The process of managing dependencies between activities (Malone & Crowston, 1994).

Coordination Mechanism: Refers to additional activities that can be used to manage dependencies (Malone & Crowston, 1994).

CSCL Script: A formal description of an online collaborative learning design.

Group-Based Learning: An instructional strategy in which a small group of learners work together in a series of activities in order to achieve a shared learning objective.

IMS LD: An open e-learning technical standard used to model teaching and learning processes.

Learning Design: A description of a series of activities aiming at achieving learning objectives. In this chapter, the term *learning design* normally refers to the description of the learning process in IMS LD

Chapter XVII
Modeling Learning Units by Capturing Context with IMS LD

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ABSTRACT

In this chapter, we describe the process of modeling different theory-, research-, and best-practice-based learning designs into IMS-LD, a standardized modeling language. We reflect on the conceptual and practical difficulties that arise when modeling with IMS-LD, especially the question of granularity and the necessary and sufficient elements of learning design. We propose a four-layer model both to ensure the quality of the modeling process and as a necessary step towards a 'holistic' consideration and integration of the design process. These discussions speak to the core of IMS-LD integration, address the question of usability and end-user friendliness, and urge that more research and design needs to be conducted not only to mainstream (a) the use of IMS-LD and related visual instructional design languages, but also (b) the debate on appropriate and best instructional design practices.

INTRODUCTION

Instructional design is essential for every teaching, training, or instructing position. Where other design fields, like architecture, industrial design, and engineering, have very precise languages to communicate and share design specifications within their respective communities, the field of education does not possess such languages (Gibbons & Brewer, 2005). In the field of education, forms of sharing innovations include lesson plans and learning objects, products which implicitly embed design considerations, but do not explicitly address them. Crucial information on the context, the embedded instructional strategies, the theoretical foundations of the design, and the reflections of the teachers or designers are either not explicitly captured as in the case of learning objects, or are not accessible through a general standardized language as in the case of lesson plans.

In the last couple of years, the field of education saw several attempts to fill this gap by developing specific metalanguages or visual instructional design languages (VIDLs; see Botturi, 2005 for an overview). IMS-LD, an extension of the educational modeling language (EML) specification, is a prominent representative of VIDL. IMS-LD was developed to allow lesson plans and best practices to be structured using a common language based on a formal representation, to exist within an XML schema, and to be archived in a machine readable and searchable repository.

As powerful as the design language is, instructional designers, instructors, or teachers are still left with a variety of design decisions, which are not captured by the design language. For example: Which design is the most appropriate for a specific learning outcome? How much detail should be included in the design specification? Which elements are flexible or need to be modified by the context of the implementation? What context information does the design have to include to provide meaningful and sufficient information to subsequent designers, instructors, and so on? In view of these concerns, there are two purposes of this chapter:

- To provide a critical analysis of different design decisions that are pertinent for the use and implementation of IMS-LD, including: (a) the questions of boundaries, granularity, and details of the design; (b) the modularity and reusability of smaller learning objects within larger learning objects; (c) sufficient and necessary conditions of a successful reuse of a learning design; (d) the usefulness of detail in the design and reuse of learning designs; and (e) particulars of mapping of activities through IMS-LD.
- To provide a four-layer evaluation model for determining the quality of IMS-LD design. These four layers are: (1) syntax and grammar; (2) best design approaches to model a certain activity; (3) how accurate is the model representing what the learning design was; and (4) how well the models match sound theories or evidence-based research. These two purposes aim to reflect on the usefulness of IMS-LD as a communicative device to share and communicate learning design issues, including the variety of different ways to design the same instructional activity.

This chapter describes the experience developed over a year-long project in which best practice, theory-based, and evidence-based learning designs were formally described with IMS-LD. The presented arguments will be illustrated with a variety of designs, modeled from theories and activities, including behaviorist, cognitivist, and constructivist models, problem-based learning, and lesson plans from the area of K–12 education.

BACKGROUND

IMS LD

The purpose of educational modeling languages (EMLs) and the IMS Learning Design (IMS- LD) specification is to support the crafting of diverse learning experiences, embodying different kinds of activities and in different contexts. IMS-LD is a metalanguage that focuses on the settings (e.g., courses, course components, programs of study, etc.), associations of settings with content (e.g., multimedia, task descriptions, tests, assignments, etc.), and instructional and pedagogical strategies (e.g., roles, relations, interactions, and activities of students and teachers, etc.). In comparison to pure learning object frameworks, which focus entirely on content, in IMS-LD, activities and roles of students and teachers are directly specified.

The IMS Learning Design is a language that gives bindings in XML to specify learning content and processes. IMS-LD was developed to promote technical specifications for learning technology (IMS Global, 2003). Historically, the basis of IMS-LD is educational modeling language (EML; Tattersall & Koper, 2003), which was developed by the Open University of the Netherlands. Compared to other languages, like "PCeL patterns," for example (Derntl, 2005), it is independent of any specific pedagogy, and its main focus is to support any kind of instructional design. IMS-LD models who does what, when and which materials or learning services are used to achieve learning objectives. Elements like resources, instructions for learning activities, templates for interactions, and pedagogical models like problem-based learning, learning goals and outcomes, as well as assessment tools are included (IMS Global, 2004). The specification gives a binding in XML, resulting in an XML manifest for each learning process. This XML manifest can then be interpreted by an IMS-LD compliant application.

IMS-LD consists of three parts: Level A, B, and C. There are different XML schemas provided for each level, and each level extends the previous one. Level A is concerned with the basics. At level A, time ordered activities, which are performed by teachers and learners (roles), are specified within an environment of learning objects and services (IMS Global, 2003). At level B, there are also properties (additional information about persons or roles) and conditions. Notifications, which are added at level C, can trigger new activities, for example, noting whether a teacher has student questions to answer. In order to complete these levels, the best practice guide (IMS Global, 2003) recommends using a narrative description in order to initiate the analysis of an instructional scenario. In the next step, semiformal UML (unified modeling language) diagrams are drawn. Based on the UML activity diagram, the XML document instance is created.

IMS-LD stands as a prototype for the "shift in the e-learning focus from content to process—or activity" (de Filho Moura & Derycke, 2005, p. 2). As de Filho Moura and Derycke (2005) further argue, content issues, the primary focus of learning objects, have distracted and polarized the e-learning community from other important issues and so with IMS-LD, the field could begin turning its attention not only to what to learn but also how to learn.

Since IMS-LD claims to be pedagogically neutral (for a discussion, see Nodenot, 2006), meaning it does not enforce a particular instructional strategy or model (such as problem-based learning, drill and practice, guided, or inquiry), the decisions of design are left to the instructor or instructional designer. Because different instructional models consist of varying assumptions of what: (a) the teachers' role is; (b) the learners' role is; (c) activities students are engaging in; (d) which support structures and activities that need to be in place; and (d) sequence or path the students are following or choosing (see an overview by Reigeluth, 1999), there can be no template or even similar design structures when modeling different interactions. For example, since group work in an inquiry based project is different from group work in a guided Web quest, it becomes additionally important how granular the models are and how different interaction patterns can be best represented in IMS-LD.

Main Focus

In the next sections, we describe a year-long project in which we formally described best-practice, theory-based, and evidence-based learning scenarios using IMS-LD. The best-practice and evidence-based scenarios are derived from real lesson plans available at the Web site of LEARN Recit (a service agency for English school boards in the province of Quebec). The Web address is http://www.learnquebec.ca. The IMS-LD models are available at Paloma (http://helios.licef.teluq.uquebec.ca:8080/PalomaWebGlobe/), a learning object repository maintained by Télé-université, Québec. We reflect our modeling process, including our selection process and different learning scenarios, which we modeled with IMS-LD.

We worked with MOT Plus™ (Paquette, Léonard, Lundgren-Cayrol, Mihaila, & Gareau, 2006), an IMS-LD software editor (Level A currently implemented) that allows a visual modeling of learning design and an automatic translation from graphical designs into machine-readable IMS-LD XML files. All of the visual representations of the models presented in this chapter were created using MOT Plus™. We particularly chose a graphical interface for our learning designs to make our argument more accessible to end users like teachers and instructional designers. We felt the raw XML binding is harder to communicate to novices of IMS-LD than a visual representation.

Context of the Models

The project team decided to work with two different type of scenarios: (1) theory- and evidence-based instructional models and (b) best-practice cases. The theory- and evidence-based models included a behaviorist, a cognitivist, and a constructivist based model. These models were "translations" of theoretical literature and research studies into IMS-LD models. For an overview and a short description of the different models, see Table 1.

The best-practice cases were selected from a publicly available Web site maintained by RECIT/Learn, a nonprofit educational foundation supported by funding from the Québec-Canada Entente for Minority Language Education. RECIT/Learn supports and promotes pedagogical collaboration and innovation with information technology and modeling of best practices, primarily by providing teacher professional development in technology integration into the new learner-centered Quebec curriculum. The cases on the Web site were annotated with links to resources, contributed by teachers in the Quebec English Schools Network. Some of the cases included design considerations and reflections by the teachers. As displayed in Table 2, we designed a rubric to select existing lesson plans for inclusion in our project. The rubric contains criteria which were aimed to: (a) assess the quality of the instructional model and (b) provide quantity and quality indices of the description of the activities, roles, content, and so forth. The rubric served two purposes: (a) to select sound models of instructional design and (b) to ensure that enough high quality information is accessible to transfer the model into IMS-LD.

We utilized this rubric to translate existing learning designs, such as lesson plans, so they could be visualized and shared in different "languages" and modeled with IMS-LD. This rubric can be similarly employed to evaluate the quality of existing IMS-LD models and learning objects.

Table 1. Summary of IMS-LD models

Title	Type of model	Pedagogical type	Model describes	Environment structure	Comments
Figure 1: Model of Fieldtrip	Best practice	Inquiry-based learning	Communication process/ Collaborative learning	Two or more matched distance separated classes	Define simultaneous interaction
Figure 2: Snapshot of selected area in IMS-Model of constructivist learning	Theory-based	Constructivism	Generic structure for teaching within a constructivist design and teaching paradigm	Nonlinear/ flexible	Difficult to model flexibility of choices and sequences
Figure 3: Model of behaviorist teaching	Theory-based	Behaviorism	Generic structure for teaching within a behaviorist design and teaching paradigm	Linear/ sequential	Difficult to determine level of detail required for model
Figure 4: Snapshot of model on cognitivist teaching	Theory-based	Cognitivism	Generic structure for teaching within a cogntivist design and teaching paradigm	Linear/ sequential	Difficult to operationalize the different steps without a particular context: deeper or broader?
Figure 5: Model of "True Story" learning activity	Best practice	Cross curricular: Language Arts, Math, Art	Collaboration: Brainstorming, problem solving	Linear/ sequential	Struggled with questions of granularity

For all the models we created, one person on the team assumed primary responsibility. However, project meetings were utilized to co-model and discuss components of the models.

In the next section, we discuss the individual learning designs, the models (which will be at least partially depicted in graphical format), issues that arose from the modeling, and a preliminary reflection. After we describe our process through a set of models, we will synthesize the reflections by connecting them to literature on IMS-LD modeling and instructional design.

MODEL 1: CONNECTING A VIRTUAL FIELD TRIP WITH OTHER CLASSES

The Context

This model describes the design of a collaborative virtual experience, which also includes an actual field trip. A class that takes the field trip invites other classes, which cannot make the field trip, to join them virtually. Participating classes can send questions, hints, and already researched

Table 2. Rubric to select best-practice models

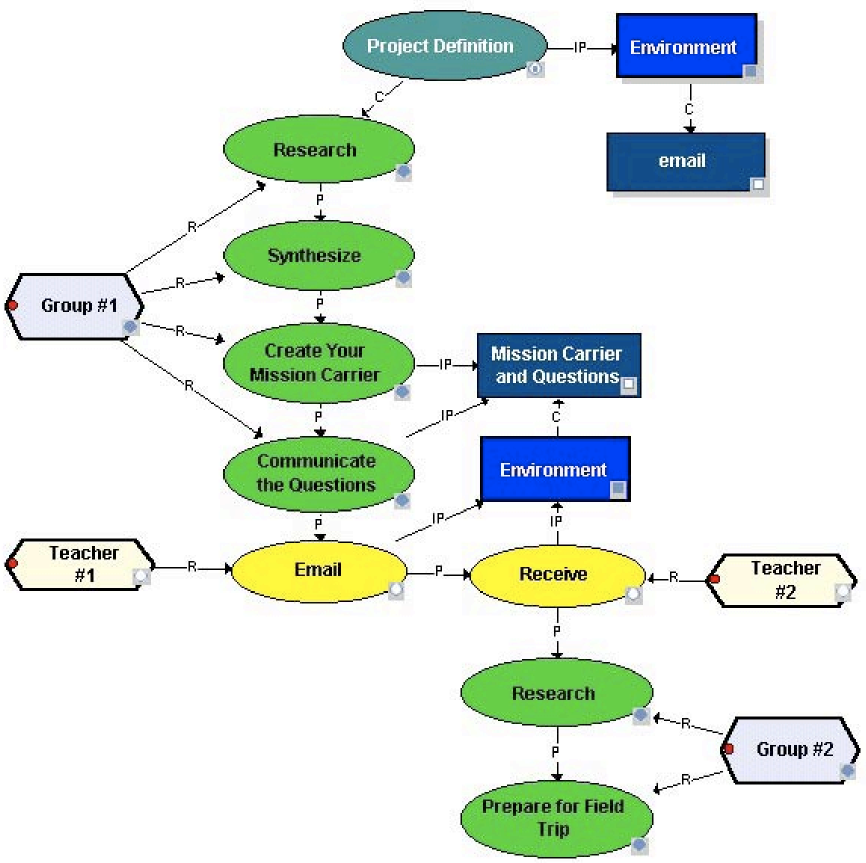
Category	0	1	2	3
Theory/Design	Cannot determine pedagogical theory or instructional design.	Material relies on an unstructured combination or not fully realized collection of theories and design principles.	Material relies on a structured or defined theory or set of ID rules. Could be more complete.	Theory and/or design is easily identified. Modifications are explained.
Qualitative Components	Example contains material that is incomplete – offers little to no detail.	Example contains material that has vague or sketchy details.	Example contains complete material but is lacking information related to teacher and/or student guidelines.	Example contains complete material that offers detail as well as information related to teacher and student guidelines.
Quantitative Components	Example contains too few components to work with.	Example contains some elements but has holes in some areas.	Example contains material in all areas but lacks reference to some resources.	Example contains enough material to create a complete model as well as links to available resources.
Criteria for Assessment	Example contains no criteria for assessment.	Assessment criteria are vague.	Assessment criteria is complete but is missing some information.	Assessment criteria is clear and easy to work with.
Learning Objectives and/ or Learning Outcomes	Learning objectives or outcomes are not stated.	Learning objectives and outcomes are poorly stated. Vague. Do not follow theory or ID.	Learning objectives and outcomes follow theory and design but could be more complete.	Learning objectives or outcomes are complete and closely follow identifiable learning theory and/or instructional design models.
Classroom Student–Teacher Interactions	Not applicable or not discussed.	Only vague or very brief guidelines.	Guidelines for interaction are included but could be more complete or more realistic.	Comprehensive and realistic guidelines for interaction are included
Preparation/Pre-Activity Instructional Design	Not discussed. No preparatory ID appears needed or possible, or else discussion of ID includes fundamental misunderstandings of the process or fallacies.	Vague or insufficiently detailed discussion of preparation needed. Some evidence that preparatory ID is needed, but discussion is vague or lacking in detail.	Discussion of preparation and preparatory ID is included but could be more complete.	Discussion of preparation and preparatory ID is complete. Discussion of preparatory ID reflects mastery of ID principles and process.

topics to the field trip class in order to uncover more information. The classes are in secondary education, and the model describes the communication process and the collaborative work used in answering questions.

The Process

This model is a best-practices model, meaning we modeled an existing course activity. The main selection criteria for the activity were the uniqueness of the lesson design, the utilization of a sound, theory-based pedagogical model, and the availability of accompanying material. For this model, we started building the smallest units first, such as how classes were matched, how questions were answered, which content was available at which stage of the activity, and so forth. After fine-tuning these individual aspects, we designed the overall structure and then modeled the relationships between the different elements. The smaller units or nuggets (Bailey, Zalfan, Davis, Fill, & Conole, 2006) were modeled as autonomous and closed units to ensure that they made sense by themselves and to avoid later reusability concerns. See Figure 1.

Figure 1. Model of field-trip learning activity (based on http://www.qesnrecit.qc.ca/cc/partners/indexen.htm)



Reflection

By modeling this activity, we faced many challenges. The first challenge was to define a unit or nugget in a way that was consistent and had boundaries that were set. In this course, the different activities were intertwined, could be employed nonsequentially, but had a fixed timeline (sequence). In many of the activities, several groups were supposed to be doing the same activity in parallel, and afterwards, they were to forward their results to the other groups. The challenge here was to define these interactions being precise regarding who is sending and who is receiving information. An additional challenge pertained to the distinction between necessary and sufficient information. For example, students were communicating the results back to the other classes via e-mail. For this design to work and for other designers to reuse the design, the decision to use e-mail is not a necessary one. The same communication could have been achieved via video-conferencing, chatting, or producing a Web site. Nevertheless, the concrete activity (e-mail) requires a different model than the use of a discussion board or the creation of a Web site. Therefore, questions remain concerning: (a) how to model the variety of activities or media that could be used; (b) modeling the particulars of the design; and (c) communicating the difference between necessary and optional aspects of the design. By modeling just one activity (e-mail), we felt the design was not as reusable as it could have been. Additionally, the differentiation between two different classes of smaller units seemed important either (a) nuggets, which described a particularly defined activity, or (b) nuggets that served to connect other nuggets to form a larger unit. While the first class is easier to reuse, the second class is much more contextual to the model at hand and harder to reuse.

MODEL 2: CONSTRUCTIVIST TEACHING MODEL

The Context

This theory-based model provides a generic structure for teaching within a constructivist design and teaching paradigm. The constructivist paradigm is characterized by nonlinear content interaction, complex and ill-structured problems, nonsequential pathways, and a variety of situation and context-sensitive support structures, like scaffolding, modeling, and coaching (for an overview, see Jonassen & Land, 2000). The constructivist paradigm cannot serve as a concrete design application of how to structure, for example, a discussion group around a particular class context. However, the constructivist-based design can provide a design template for building nonsequential, open-ended learning activities within the formalized IMS-LD model. Because it has a clear theory base, the model is more aptly described as a metamodel abstracting concepts from the many different design and teaching situations that were used to inform theory building.

The Process

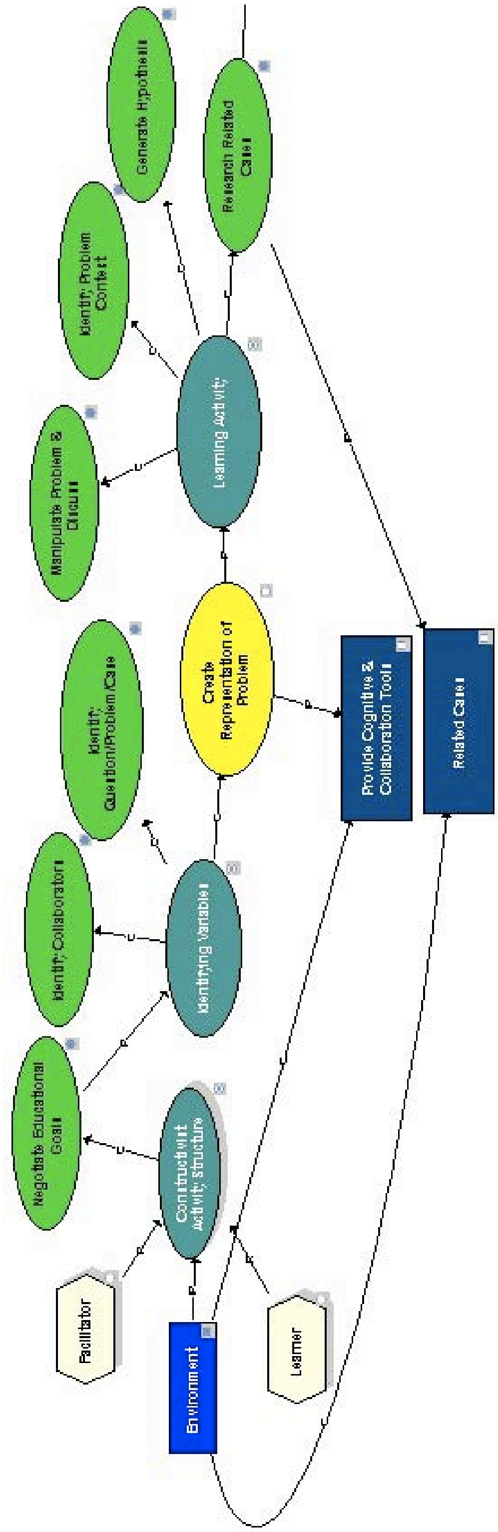
Because constructivism entails many different forms, our discourse was dominated by how its principles can be operationalized in a design model. Since we worked without the context of a particular instructional intervention, the components of the design stayed at an abstract level. We struggled with certain components of the process more than with others. For example, in many constructivist design models, not many fixed sequences exist and many student activities are iterative. This learner flexibility means there is a great deal of free choice regarding resource and activity selections, which are repeated with different content or different guiding questions.

Our challenge was to design activities and acts that were coherent within the design, which represented the flexibility of the activities and the adaptability of the resources and were not restricted by the design model as to when the activities had to be completed. Additionally, many microlevel elements were hard to incorporate due to the flexible nature of the theoretical underpinnings. Since many decisions within a constructivist learning situation are made by students in cooperation with each other and with the teacher, many conditional aspects needed to be modeled, and many alternative ways of achieving the same learning outcomes needed to be included. See Figure 2.

Reflection

The design of this model raised different questions and provided many challenges for the design team. The main challenge was whether one model would suffice for constructivism, not just because constructivism is an abstract model, but also because the models can have so many variations. The pedagogical strategies and philosophical assumptions of the paradigm we modeled greatly influenced our approach to modeling. General questions arose, especially concerning how different prototypes of the same model looked when created by different people. We realized different ways of modeling and found that the appearance of any one model was dependent on the personal preferences of the designer and his/her style of modeling. After determining that these idiosyncratic, abstract models of constructivism were syntactically correct with respect to the underlying coding language and were compliant with IMS-LD, questions arose concerning the best way to model a specific constructivist learning activity. Each one of us developed a unique style of modeling resulting in multiple ways of modeling a particular component, each of which was still compliant with IMS-LD. Modeling of learning scenarios was not a standardized activity

Figure 2. Snapshot of selected area in IMS-Model of constructivist learning



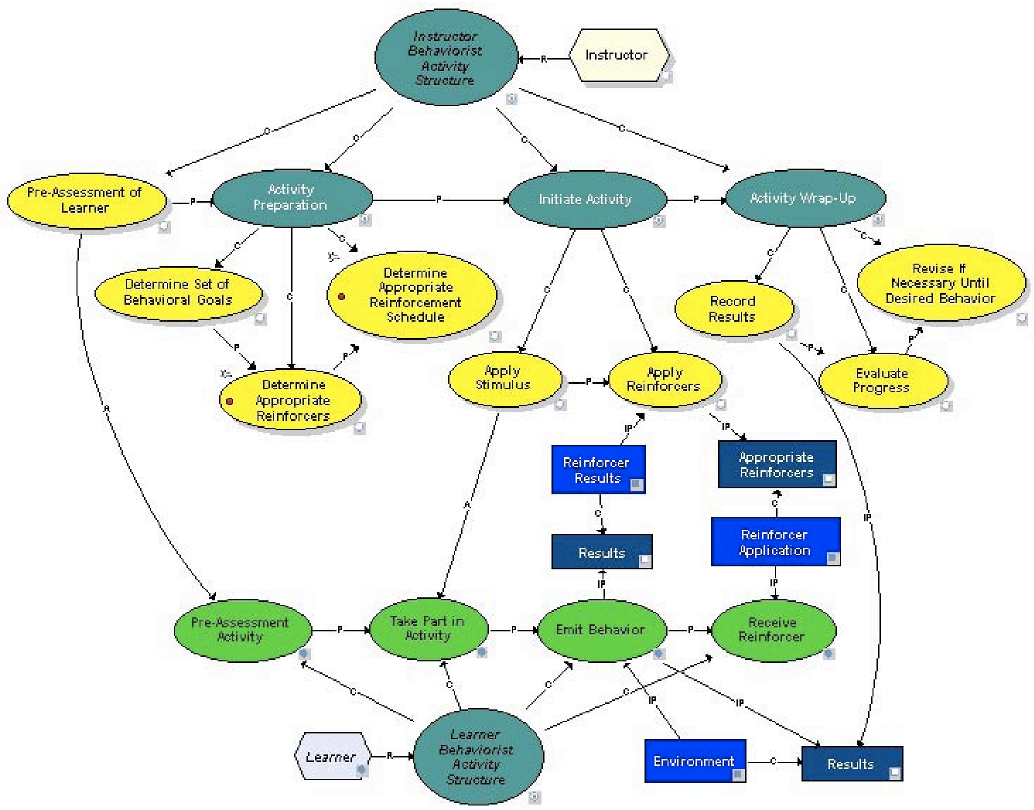
with a single, clearly described model. It was a process that depended more on the expertise of the modeler, the anticipated level of expertise of the audience, and the preferred styles of visual arrangement, which were used to highlight key instructional elements. These constraints and conditions, however, did not find their way into the models or into IMS-LD itself. In short, by struggling with the design of a constructivist model, we were in need of an annotation language to clarify our IMS-LD models, which we were not able to do within the model itself. Additionally, we found the need for "best-practice" models on how to model in IMS-LD.

MODEL 3: BEHAVIORIST TEACHING MODEL

The Context

This is a theory-based model, which provides a generic structure for teaching within a behaviorist teaching paradigm. Though it cannot serve as a template for structuring communication pattern in courses, it can provide a design template for aligning smaller aspects of course design within an overall structure. The model is a metamodel abstracting from the many different design and teaching situations that can be classified as behaviorist.

Figure 3. Model of behaviorist teaching



The Process

In this template, it was important for us to connect the classroom activities of the instructor with those of the students along with the preparation of the instructor. In dealing with instructor preparation, the model needed to also explicate what follows in the class. To do so, we spent some time exploring different components in the 2/3D dimensional space of MOT+. The feedback structure of behaviorism made it difficult to place every component in a way that was visually easy to follow. Although not as important as the design aspects, the visual aspects of arrangement, color-coding, and so forth are challenging ones for novice model builders.

The overall structure of the design was determined by the theoretical underpinnings; nevertheless, the modeling process raised additional questions especially with regard to the sequence in which the model had to be expanded. In our experience, determining the level of detail in the model was always a struggle. How much detail should the design contain? In best practice cases, the availability of material or insights into the design process was often the determining factor, even when we wanted to go into greater depth. In theory-based cases, the material and approaches were endless, and it was so much more difficult to set the boundaries. See Figure 3.

Reflection

The model was a great device for us to develop a better understanding of behaviorist forms of instruction. By engaging in the process, the discussion became focused on the model itself. A big challenge was the syntax and the design process itself. We found ourselves agreeing on the design sooner than on its visual representation and on its compliance with IMS-LD. For the design exercise, the many different ways of representing one element led us to question the validity and utility of a best practices approach to IMS-LD design.

MODEL 4: COGNITIVIST TEACHING MODEL

The Context

This is a theory-based model, and we had to make deliberate choices regarding which body of literature to rely on and operationalize. Though it cannot serve to illustrate the design of communication pattern in courses, the cognitivist approach can provide an IMS-LD design template for aligning smaller aspects of design with overall course structure. The model itself is a metamodel, which abstracts the many different design and teaching situations that can be classified as cognitivist.

The Process

The development of the cognitive model proved challenging. Like the other theory-based approaches, in a cognitivist model, it is hard to operationalize the different steps without having a particular instructional context for reference. When we attempted to design such concrete learning situations, the challenge was when to stop vs. when to go deeper or broader in representing key concepts. In contrast, it was quite the opposite with the design of theory-based models. There is not much chance to go deeper because the deeper one goes the more contexts plays a role, and different instructional variations need to be considered. For further modeling of theory-based approaches, the theory-based models need to be represented as metamodels, meaning that in addition to representing a generic design, these metamodels need to reference a variety of different nuggets as possible examples and variations within the larger design. In the metamodel approach, the broadening of the design means being faithful to the original attempt to design a generic model, while the deepening of the model means being able to represent particular learning contexts. Despite these concerns, the generic model has its benefits because describing an overall structure and visualizing key theoretical elements helps facilitate designs, which are internally coherent. See Figure 4.

Reflection

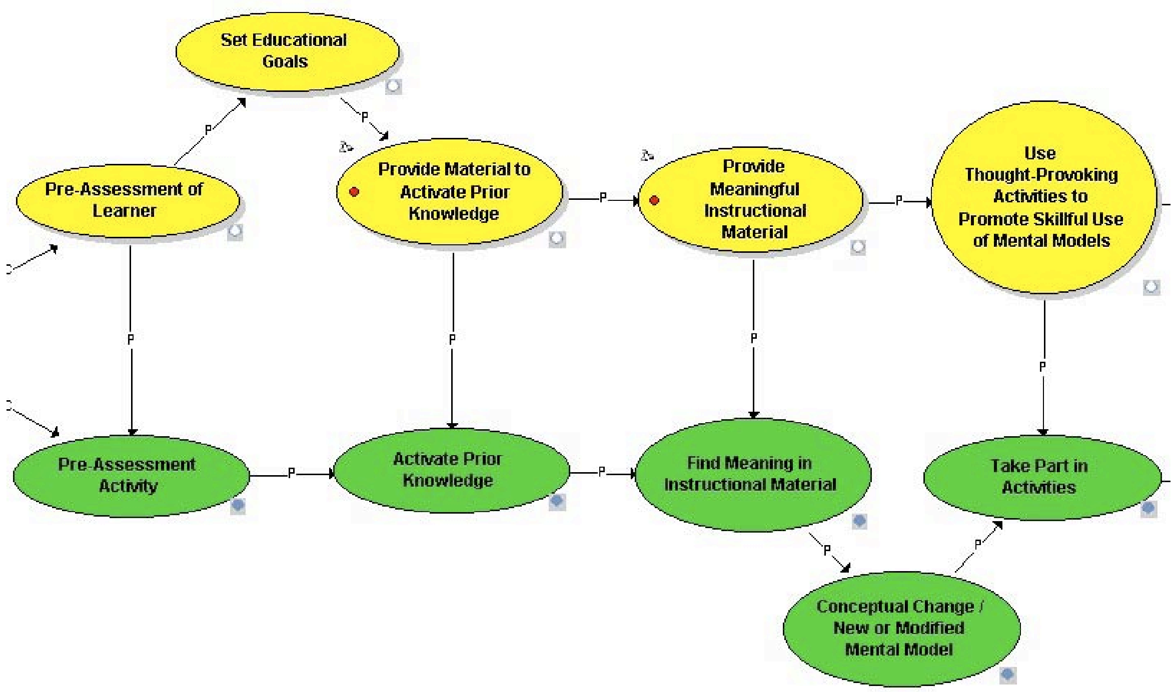
A benefit of our own modeling activity was that we understand the cognitivist approach in a more concrete way, although individual steps might still be hard to operationalize. Within this model, many of the instructor's activities are preparation-intense. In other models, we tried to incorporate the design process of the teacher as much as the classroom activities themselves. In this model, it was not easy to do that, and provided a challenge that was made more difficult by the lack of particular instructional contexts to draw on.

MODEL 5: "TRUE STORY" LEARNING ACTIVITY

The Context

This model describes a unit of learning in a K–12 context in which students utilize a variety of different technologies to represent a story from a children's book. Students were involved in a few evaluation tasks in which they had to compare one story account with another. Beyond that particular context, the model can be utilized as a template

Figure 4. Snapshot of model on cognitivist teaching



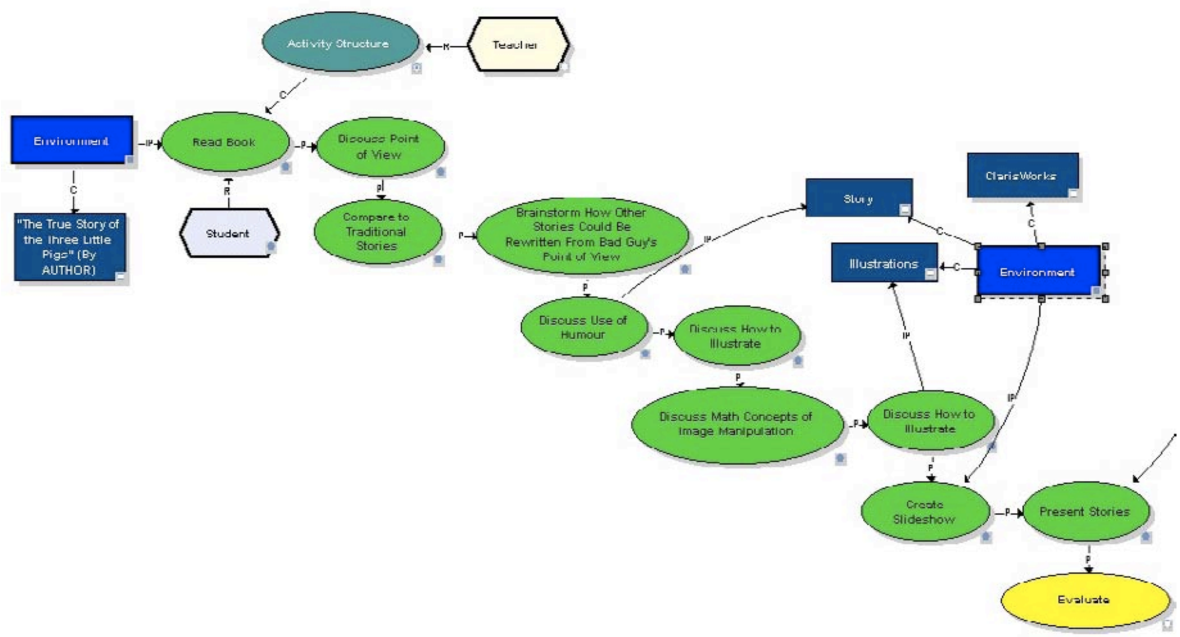
to build cross-curricula instruction and allow the integration of math-, language-, and technology-rich class activities.

The Process

This model took a best-practices approach by modeling an existing lesson. We developed the model following the systematic description that the instructor outlined in the lesson plan. Similar to most of our modeling, we ran into the problem of representing depth and breadth of instruction. Additionally, since we modeled a rather large section of a class activity, we questioned the value of modeling this large section and not just little nuggets. Other ones could replace most all of the activities that we built. For example, the discussion of the book could have been done in a multitude of ways. Furthermore, by not directly specifying the discussion process, the instructor left a considerable amount of detail out of the lesson plan. This detail will need to be determined by the individual instructor who reuses the model. The value of the particular structure lays more in the entirety of the plan. The challenge for us was how to model the activities as independently from each other as possible so other usable nuggets could easily replace the existing ones. A particular difficulty of modeling in this "object-oriented" way is that transitional aspects of the model (like leading from one activity to the other) become secondary or redundant.

For our own modeling purposes, we yet have to come up with a way of consistently and systematically distinguishing between core elements of the design and redundant, exchangeable, or even negligible elements within the model. In other words, what are the necessary and what are the sufficient elements and attributes of certain designs? Another example might highlight

Figure 5. Model of "true story" learning activity



this difficulty. A set of students (A) is using a discussion board to communicate the results of a research study to another set of students (B) who can ask questions or make requests for additional research in return. While group A utilized a discussion board, they could have used other forms of two-way communication (blogs, e-mails, video-conferencing, etc.). Each form of communication would require different training, calls for different exchange patterns, requires different preparation time between communication periods, and so forth. For the overall design of the course, it is important to model that students engage in two-way communication, but how important is it to model the specific way of communicating and the specific activities associated with the means of communicating? Another teacher trying to adapt the learning design is left to decide which of the elements are pedagogically crucial, exchangeable, or even negligible for his/her own teaching. To identify the adaptability or redundancy of certain design elements, either pedagogical and instructional knowledge of the design is necessary or the original instructional designer should somehow embed appropriate alternatives.

Reflection

As mentioned earlier, the modeling process is a valuable communicative device to plan and discuss learning design. Additionally, the modeling process becomes a reflective device. Through the modeling of approximately 15 designs, we found ourselves questioning instructional decisions in lesson planning. Unfortunately, it is not very visible within the process how the design grew before we modeled it. Additionally, since most instructors build and adapt their teaching from session to session, we do not see in the modeling process the different alterations and changes the instructor utilized. In that sense, the model has no history or is incapable of keeping history.

SYNTHESIS AND DISCUSSION

We described our process of modeling specific theory and best-practices learning activities. In the following section, we will synthesize issues arising from the modeling experience and discuss and situate them within the larger body of literature on learning design and instructional design.

Granularity

By breaking down and assembling structures and complex performances of instruction, the question emerges as to what constitutes an "atomic" chunk or part. In other words, what is the smallest meaningful unit of modeling and what should the degree of granularity be? The definition of granularity has implications not only for the boundaries of a model but for the reuse of model components in different designs.

The topic of granularity is not new to the field of instructional design and appears frequently in the learning design and the learning objects literature. Many instructional design guidelines argue for breaking down complex structures into smaller sizes, for example, as argued by learning taxonomy proponents (e.g., Bloom, 1956) and as illustrated in instructional design models (see Reigeluth's 1999 elaboration theory as an example). Traditional conceptualizations of granularity are delivery-centric or as Wiley, Gibbons, and Recker (2000) call it, "media centric." In a delivery-centric view, pieces of the design are well-defined by the hierarchies of a course, the course being the largest grain size and a text element in a course description being the smallest "atomic" element. IMS-LD distinguishes between the smallest elements, combined small elements (which become level 1), and combined level 1 elements (which become level 2).

There appears to be a move away from the conceptualization of granularity as mainly an issue of the size of a learning object to a more "holistic" view in which more factors of the instructional design process are considered. “In determining the robust granularity of a learning object, one might ask, ‘what elements of the model, message, instructional strategy, representation, and media-logic layers are compressed within this learning object?’ The larger the count, the larger the grain size of the learning object” (Wiley et al., 2000, p. 5).

The move to a “robust” or “holistic” approach to granularity would address several issues: (a) It could provide an alternative picture to the simplistic view of teaching as delivery of disaggregated learning objects assembled in a well-defined preconceived combination (the course structure; see Russell, 2003 for a further argument). (b) It could highlight the very complexity of the instructional design process embedded in the learning object and so preserve some of the context which learning objects were criticized for leaving behind (see Jonassen & Churchill, 2004 for a detailed criticism).

This move to a more “holistic” approach means that granular or smaller objects of design are similarly complex as larger pieces, so by breaking down complex learning design, we will not facilitate a more manageable task of “divide and conquer” but create rather hydra’s head, the beast in Greek mythology which grows two heads for everyone cut off. Implications of this “hydra head” model are numerous: (a) the size of a learning object does not communicate something about the simplicity of complexity of the learning object, (b) there are no simple learning objects, and (c) the larger context or the relationship with other learning objects become more important in order to create or reuse the learning object.

Boundaries/Details

In many of our models, we encountered the problem of specifying the boundaries of a particular learning activity (i.e., how to integrate prior or subsequent learning activities which are linked to the activity at hand). Similarly, issues of external boundaries arose when we debated whether to include the teacher’s or instructional designer’s activities within our model of a learning activity. This question becomes particularly important considering that most models are not blindly reused but are carefully selected and adapted by other instructional designers or teachers, so additional information on the design process might be useful and provide more context.

In addition to external boundaries (whether and how to include events and material outside the learning activity per se into the design model), internal boundaries of the design have also to be considered. The question of “how much detail should the model include?” sets the direction of the internal boundary of the design model. The structure of IMS-LD with its stage metaphor, including activities and acts, might be perceived as already determining the question, however IMS-LD does not provide an answer about the depth of detail. For example, is it sufficient to describe that students are supposed to work in teams or do details on the structure of the teamwork need to be included?

Sufficient and Necessary Conditions/Possibilities

A related question to the issue of boundaries is the determination between necessary and sufficient information. As seen earlier in the model of the field trip (see Model 1), the design asked students to communicate their field-trip results back to other classes. In this particular instance, students used e-mail as the communication medium. However, the design could have asked the students to communicate via a discussion board, video-conference, or by creating their own Web site. All of these interventions fulfill the goal of this aspect of the activity—to communicate results. When breaking down the activities into smaller, detailed acts and processes, all of these different interventions require different kinds of material, training for students, teacher roles, and actions by students. We argue that the goal to communicate is a necessary condition to be modeled, meaning it cannot be missed, but the modeled activity of e-mailing is only a sufficient condition, meaning it can be replaced with other activities, which fulfill the same goal. To illustrate the distinction, consider the following: If somebody is trying to reuse the learning design in another context, the goal needs to be shared (to communicate), but the designer should also be able to integrate other technologies, activities, and associated actions to fulfill this goal. In IMS-LD, no space is provided to communicate sufficient uses or necessary conditions. This does not allow designers to share crucial design decisions. By just modeling one activity (i.e., e-mail), the design would not be as reusable, especially when certain technologies do not exist.

Ultimately, this could mean that the learning design of an activity would need to draw from a large bank of substitute components, which could replace the actual modeled structure when constraints of a new design require that. Additional metadata on the necessity of the components and an alert on which crucial parts of the design need to be expanded are necessary. If in our example, e-mail communication was exchanged with the creation of students' own Web sites, training for the Web site creation might be a necessary addition when designing the activity.

Furthermore, an additional distinction can be drawn between two classes of design components. There are activity and material components, which describe which activities students are engaged in and which material is utilized. The design model contains also bridge components, elements that are necessary to connect activities with other activities or with necessary resources. In the learning design, bridge components are secondary, because they do not carry many instructions, but rather provide segues between the core designs. IMS-LD does not distinguish between bridge and core components.

Usability and User-Friendliness of IMS-LD

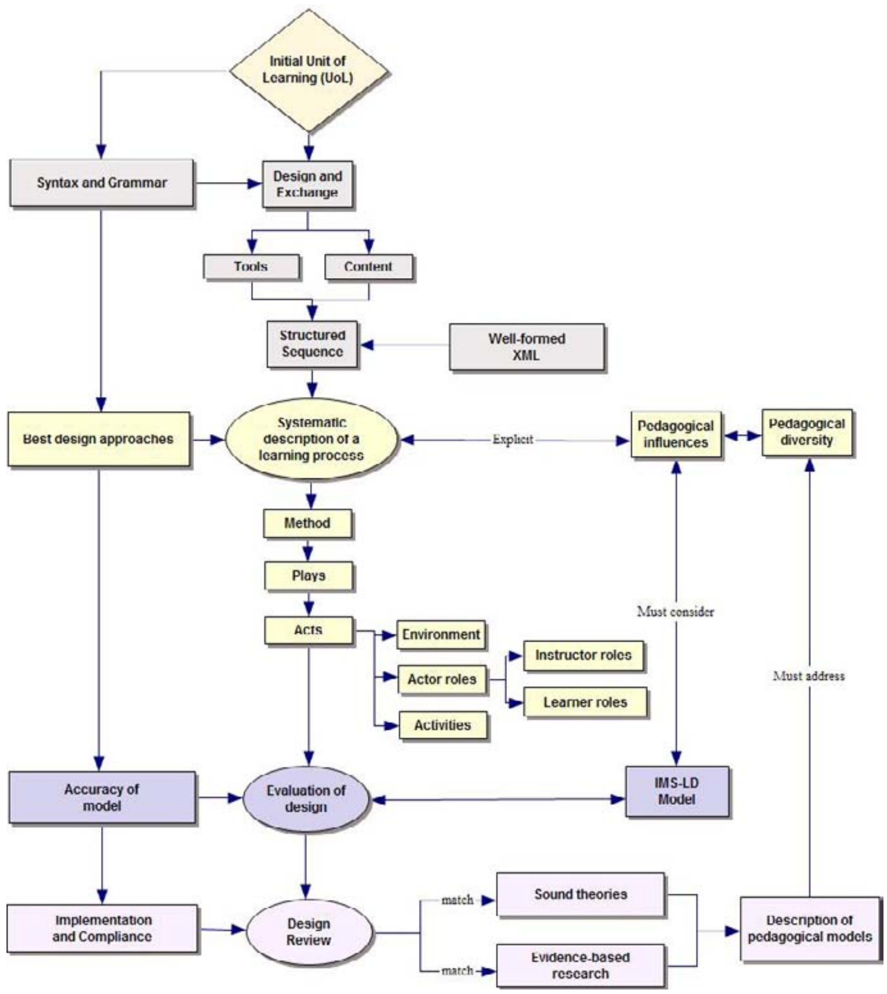
Our experience in the role of end users with IMS-LD through a visual editor confirmed previous systematic usability testing of formal standardized languages to capture learning designs. As van Rosmalen, Vogten, Van Es, Passier, Poelmans, and Koper (2006) describe, the weaknesses of IMS-LD are that the required knowledge of IMS-LD and the complexity of the IMS-LD specific concepts assumes a great deal of knowledge and the editor itself requires considerable training. Finally, the interface is based on a technological view of learning design rather than an educational view (see van Rosmalen et al., 2006, p. 8 for a detailed description). We experienced very similar issues with the usability and user-friendly aspects of IMS-LD.

The usability of both IMS-LD and the graphical tool cannot be reduced to the techniques, technologies, and processes of modeling, however important they are. There are other large questions of usability in this context. How does IMS-LD connect with the practice and experience of end users? Is the language mature enough to become an every-day tool in the hands of instructors and instructional designers? What other barriers exist before IMS-LD is integrated into every-day practice. These questions go beyond the typical usability questions such as are concepts well-explained, buttons well-placed, and processes well-described. Throughout the work on our particular project, these larger usability questions moved from the background to the foreground. IMS-LD and its graphical editors in their current stage are not sufficient to support IMS-LD becoming mainstream and becoming usable for instructors or instructional designers. Much literature and debate on learning design are still too technical for the layperson to understand and are lacking a connection to the every-day practices of designers and instructors.

FOUR-LAYER MODEL OF DESIGN

Apparent throughout the modeling exercise and the issues addressed in our synthesis, the pedagogical neutrality of IMS-LD adds a layer of complexity and leaves questions which need to be adequately addressed. Of particular importance is the question of the quality of the learning design as modeled by IMS-LD. In this last part of this chapter, we argue for a four-layered model of quality assurance when utilizing IMS-LD. This four-layer model includes pedagogical and instructional criteria not addressed by IMS-LD, but essential for the quality of the learning objects and designs it produces. As can be seen in Figure 6, the four layers are (1) syntax and grammar, (2) best design approaches, (3) accuracy of the models, and (4) implementation and compliance.

Figure 6. Four layers of quality in modeling learning context with IMS-LD



Syntax and Grammar

In the syntax and grammar level, the focus lays on the correct use of the IMS-LD specification to appropriately design the unit and ensure compliance in the exchange process. This includes the correct labeling of relationships between individual components (sequential, free choice), the proper breakdown of the initial unit of learning into activities, actions, roles, and the associated materials and settings (tools and content of the instructional unit). Additional value is placed on the appearance of a structured sequence that maps the learning activity and the sufficient support through proper tools and content resources. Quality in this level is measured by the compliance to the XML structure and whether the design produces well-formed XML. Through its orientation on XML compliance, this level is very technically oriented and does not address pedagogical or instructional quality issues. Most papers, which address the quality of IMS-LD, address this particular level (see for an example Berlanga & Garcia, 2005).

Best Approaches to Model a Certain Activity

Compliance with the IMS-LD data structure (as measured in layer 1) does not guarantee the most appropriate breakdown of the unit of learning into components that make stronger sense than others. Since everybody in our team was modeling components and even the same unit of learning, the question emerged: What determines the better model? Not only could the same activities be modeled differently, some models use more extensively bridge components or nested activity structures, in which activities are embedded in other activities. Some modeling solutions of the same activity in our visual editor became easier to communicate or were more elegant or minimalist in their approach. From this level forward, the IMS-LD model should become a communicative device that facilitates the process of clarification between different instructional designers or teachers.

Accuracy of the Model

Going beyond the compliance with IMS-LD standard specifications (layer 1) and the question of the most appropriate way of representing the same learning design (layer 2), the design has to be verified against the initial description of the activities, the interaction of learners, and the lesson plan. The actions of learners and teachers, the interaction between activities and roles, and the material and resources of the model have to be checked to determine whether they are a true representation of what was happening in a classroom or if the model matches the narrative plans for a particular learning unit. At this level, elements in the learning design are in the spotlight either for being vaguely planned or lacking in information on how they were implemented. Any ambiguities in the process of validation raise additional questions of whether the language is precise enough or whether the process of design needs to be more detailed.

Implementation and Compliance

Since IMS-LD is pedagogically neutral, there is no place to discuss the appropriateness of certain design choices to the learning process within the IMS-LD model. For sharing instructional design and learning design models to guide reuse and inform practice, information on the design rationale in light of appropriate learning theories and models requires sufficient space. This can be captured by either including aspects of the design process in the learning design model itself (i.e., a teacher planning activity component) or by supplementing the design with links to theoretical or evidence-based research literature.

FUTURE TRENDS

Our proposed four-layered model integrates IMS-LD within the larger context of instructional design and introduces pedagogically sound design back into a standard, which was designed and proclaimed to be pedagogically neutral. Many questions we raised concerning the complexity of instructional design and the intersection with IMS-LD would suggest that IMS-LD's claim of pedagogical neutrality is difficult to uphold. Inevitably, when designing models in IMS-LD, pedagogies find their form, but do not yet find a space to be labeled or reflected upon. While IMS-LD does support different models of instructional design, the process of evaluation and sound learning design is not equally supported in the design of units of learning. While IMS-LD as a technical standard to model learning activities might be mature, the tools available and the standardized language are far from being usable at an end-user level, especially for teachers. More research is necessary to investigate designers' use of IMS-LD and different training strategies to further support IMS-LD becoming a mainstream application.

CONCLUSION

In this chapter, we described the process of modeling different theoretical and best-practices learning designs into IMS-LD, a standardized modeling language. We reflected on the conceptual and practical difficulties that arise when modeling with IMS-LD, especially the question of granularity and necessary and sufficient elements of design. We proposed a four-layer model to ensure the quality of the modeling process and as a necessary step towards a "holistic" consideration and integration of the design process. Finally, we raised the question of usability and end-user friendliness of the IMS-LD specification and urge that more research and design needs to be conducted not only to (a) mainstream the use of IMS-LD and related visual instructional design languages, but also (b) to mainstream the debate on appropriate and best instructional design practices.

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REFERENCES

Bailey, C., Zalfan, M. T., Davis, H. C., Fill, K., & Conole, G. (2006). Panning for gold: Designing pedagogically-inspired learning nuggets. *Educational Technology & Society, 9*(1), 113-122.

Berlanga, A., & Garcia, F. (2005). IMS LD reusable elements for adaptive learning designs. *Journal of Interactive Media in Education, 11*, 1-16.

Bloom, B. S. (1956). *Taxonomy of educational objectives* (Handbook I: The Cognitive Domain). New York: David McKay Co Inc.

Botturi, L. (2005). Visual languages for instructional design: An evaluation of the perception of E2ML. *Journal of Interactive Learning Research, 16*(4), 329-351.

de Filho Moura, C. O., & Derycke, A. (2005, September 22-23). Pedagogical patterns and learning design: When two worlds cooperate. In R. Koper, C. Tattersall, & D. Burgos (Eds.), *Current State on IMS Learning Design: Proceedings of the UNFOLD/Prolearn Joint Workshop*, Valkenburg. Heerlen: Open University of The Netherlands.

Retrieved April 6, 2008, from http://dspace.ou.nl/handle/1820/474

Derntl, M. (2005). *Patterns for person-centered e-learning*. Unpublished doctoral thesis, University of Vienna, Vienna, Austria.

Gibbons, A. S., & Brewer, E. K. (2005). Elementary principles of design languages and design notation systems for instructional design. In J. M. Spector, C. Ohrazda, A. Van Schaack, & D. Wiley (Eds.), *Innovations to instructional technology: Essays in honor of M. David Merrill* (pp. 111-129). Mahwah, NJ: Lawrence Erlbaum Associates.

IMS Global. (2003). *IMS Learning Design best practice and implementation guide*. Retrieved April 6, 2008, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html

IMS Global. (2004). IMS specifications. Retrieved April 6, 2008, from http://www.imsglobal.org/specifications.cfm

Jonassen, D. H., & Churchill, D. (2004). Is there a learning orientation in learning objects? *International Journal on E-Learning, 3*(2), 32-41.

Jonassen, D. H., & Land, S. L. (2000). *Theoretical foundations of learning environments*. Mahwah, NJ: Lawrence Erlbaum Associates.

Nodenot, T. (2006) Towards Pedagogically Neutral EML Making Use of De-Contextualized Learning Objects: Myth or Reality?. in: Proceedings of the Sixth IEEE International Conference on Advanced Learning Technologies (ICALT), pp. 1028-1030.

Paquette, G., Léonard, M., Lundgren-Cayrol, K., Mihaila, S., & Gareau, D. (2006, January). Learning design based on graphical knowledge-modeling [Special issue on learning design]. *Journal of Educational Technology and Society, 9*(1), 97-112.

Reigeluth, C. M. (Ed.). (1999). *Instructional-design theories and models: A new paradigm of instructional theory*. Mahwah, NJ: Lawrence Erlbaum Associates.

Russell, B. (2003). Learning objects: Weapons of mass instruction. *British Journal of Educational Technology, 34*(5), 667-669.

Tattersall, C., & Koper, R. (2003). *EML and IMS Learning Design: From LO to LA Educational Technology Expertise Centre*. The Open University of the Netherlands.

Van Rosmalen, P., Vogten, H., Van Es, R., Passier, H., Poelmans, P., & Koper, R. (2006). Authoring a full life cycle model in standards-based, adaptive e-learning. *Educational Technology & Society, 9*(1), 72-83.

Wiley, D. A., Gibbons, A. S., & Recker, M. M. (2000). *A reformulation of the issue of learning object granularity and its implications for the design of learning objects*. Retrieved April 6, 2008, from http://www.reusability.org/granularity.pdf

KEY TERMS

Boundaries of Design: Refers to the scope of the design model and which borders are drawn.

Granularity: Refers to the definition of size of a learning object. There is a distinction between delivery-centric and holistic granularity. Delivery-centric granularity is structurally oriented on a course (activities, assessment). Holistic granularity is focused on the embedded instructional design in every object and not just in the role the object plays within a course structure.

Granularity: Refers to the definition of "size" of a learning object or stands for the smallest meaningful unit when modeling learning designs.

IMS-LD: An XML-based language for specifying learning content and processes.

Learning Design: The entirety of design that is invested to create a learning environment, including material design, media design, instructional design, and activity and assessment design.

Nugget: Refers to small stand-alone learning objects, which can be combined with others to build larger units.

Syntax of Design: In this chapter, the syntax of the design refers to IMS-LD specifications as implemented in the XML structure. Compliance with the XML specifications is one step of the proposed four-layer model.

Visual Instructional Design Languages (VIDLs): Visual languages or notation systems that let instructional designers represent their instructional design visually. VIDLs are often compared to blue prints of buildings or architectural drawings. Examples are the Educational Environment Modeling Language (E^2ML) or IMS-LD.

Chapter XVIII
Design Guidelines for Collaboration and Participation with Examples from the LN4LD (Learning Network for Learning Design)

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ABSTRACT

This chapter presents some design guidelines for collaboration and participation in blended learning networks. As an exemplary network, we describe LN4LD (Learning Network for Learning Design), which was designed to promote learning and discussion about IMS-Learning Design. 'Lessons learned' from pilot implementations of this network over a period of five years are phrased as guidelines for future *learning network implementations. The chapter focuses on the positive influence of incentive mechanisms and face-to-face meetings on active participation. These successful interventions are explained from theories about self-organization, social exchange, and social affordances. Repeated measurements show the levels of both passive (accessing and reading information) and active participation (posting, replying, and rating) to significantly increase as a result of both interventions. Both the use of incentive mechanisms and face-to-face meetings can therefore be considered as valuable elements for future models for collaboration in learning networks and for establishing an international community of "learning designers."*

INTRODUCTION

Today's lifelong learner is in a constant need to update knowledge and competences, given certain personal or employment-related motives (Aspin & Chapman, 2000; Field, 2001). Online, distributed lifelong facilities can be designed that cater for these needs at various levels of competence development. However, merely introducing such facilities will not suffice. Potential learners should also be motivated to actually use and actively contribute (Fisher & Ostwald, 2002). So called 'free-riding' or lurking' is one of the main problems in online learning (Olson, 1965). Our work aims to derive design guidelines for these facilities to foster collaboration and dissemination.

The factors and mechanisms that motivate people to codify and share knowledge for the benefit of others have been identified as a priority area for individual companies (Smith and Farquhar, 2000). They represent the most commonly discussed topic among practitioners and academics at conferences on knowledge management (Prusak, 1999). To some, the encouragement of employees to contribute knowledge and collaborate is even more important than the more technical (interoperability) issues related to its capture, storage, and dissemination (Boisot & Griffiths, 1999). What might then motivate an individual to collaborate and participate actively in a learning network to respond to others' questions, contribute content, complete activities, and carry out assessments?

This chapter will address some critical design issues in setting up lifelong learning networks and will focus on the (successful) introduction of two mechanisms to increase (active) participation in such learning networks (i.e., reward systems and complementary face-to-face meetings). For this purpose, we use an exemplary lifelong learning network on the topic of learning design representation. The field of learning technology can be characterized as internationally oriented, highly specialized and fragmented, and developing rapidly. The rather heterogeneous community involved and interested in this field is in need of online, distributed facilities that cater for lifelong competence development.

Our main experiences over five years with setting up such facilities for learning about and discussing IMS-Learning Design (IMS-LD, 2003) will be presented, a learning technology specification currently considered as the worldwide default standard for representing (more complex) learning designs. We will distinguish three phases (initial experiences, introducing incentive mechanisms, and introducing face-to-face meetings). The chapter continues by describing some preliminary experiences (period: 2001–2004) in setting up facilities to promote learning in the area of educational modeling languages (Initial Experiences section). Self-organization and social exchange will be introduced as theories that provide us with guidelines on how to increase active participation. The following sections then describe more recent experiences (period: 2004–2005) during which we carried out studies on the additional value of incentive mechanisms and face-to-face meeting for increasing participation. Finally, the concluding section provides a summary of our main experiences and findings from our studies, deriving some design guidelines for future learning networks about learning design representation.

INITIAL EXPERIENCES

The Open University of the Netherlands (OUNL) launched educational modeling language (EML) (Koper, Hermans, Vogten, & Brouns, 2000) for public use in December 2000 as a specification that enables the modeling of both content and processes in e-learning. To promote use in contexts outside of OUNL, a Web site (eml.ou.nl) was created through which the specification could be downloaded and from which newsletters were sent to subscribed participants. In the years 2001 and 2002, the amount of subscribers gradually grew towards a number around 2,800. Although many subscribers regularly visited the Web site to download or study additional information, no channel was available to seek guidance, share experiences, offer examples, and help distribute the load of training about EML beyond the originators of the specification.

In order to open up possibilities for guidance and exchange, the subscribers were migrated onto another platform (www.learningnetworks.org) offering forums to post and receive messages implemented in VBulletin (2004). The new facility was promoted in 2003 and 2004, but the number of subscribers only slightly grew to a little over 3,000. The amount of page views per day (passive participation) numbered several thousand, which we considered to be quite satisfactory. However, the number of contributions made (besides those made by the originators of the facility) by posting or replying to posts (active participation) remained extremely low (i.e., 20 and 11, respectively), which we considered to be quite disappointing.

We concluded that making communication channels available alone does not guarantee that participants will take a more active role. These initial experiences with participants not contributing, but merely 'lurking' the network, led us to take a different approach towards implementing a learning network based on ideas around self-organizing systems and 'seeding.' In the meantime, EML had been adapted to become an internationally standard known as IMS-Learning Design (IMS-LD, 2003). The first pilot implementation of the learning network therefore became known as LN4LD (Learning Network for Learning Design). We used a combination of PHP-Nuke (2004) to implement the learning network-layer of the facility, and Moodle (Dougiamas, 2007) to implement the learning activities and forums.

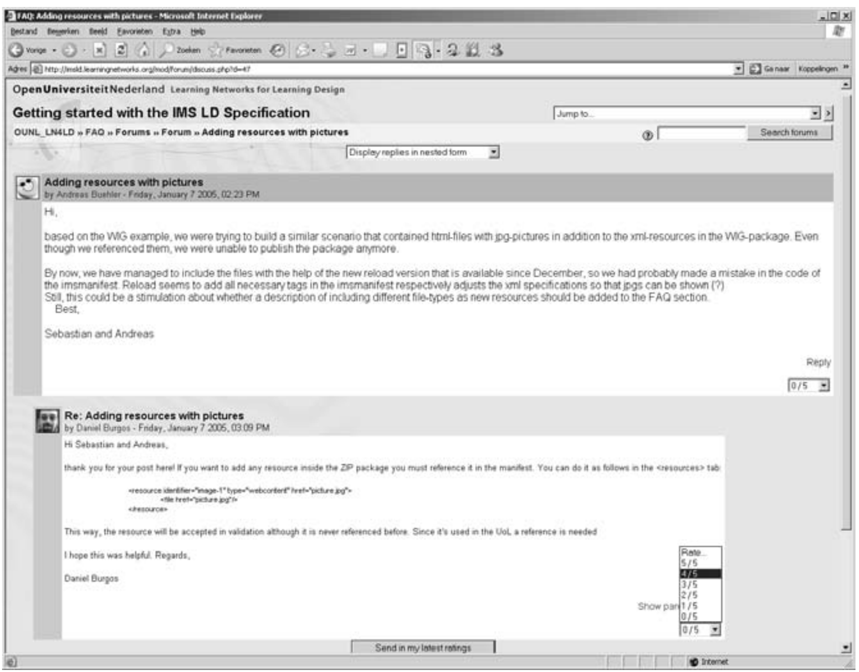
Learning networks (Koper & Sloep, 2003) are designed as two-mode networks represented as a graph with nodes, where the nodes are 'LN members' and 'Activity Nodes,' organized in such a way that the network can self-organize (Koper, Pannekeet, Hendriks, & Hummel, 2004). Activities can be anything that is available to support learning, such as a course, a workshop, a conference, a lesson, an Internet learning resource, and so forth. Activities can or cannot be modeled according to IMS-LD and, when they are modeled with LD, are usually referred to as "units-of-learning."

Self-Organizing Social Systems

In the literature on building effective learning environments, there is some dispute about the amount of structure that is needed for effective learning. Some researchers (Mevarech & Kramarski, 2003, p. 450) stated that for effective problem-solving during collaboration, there 'seems to be a need to structure the learning in small group interaction in advance in a way that will prompt students to elaborate the problem, reflect on the solution process, and really construct relationships between prior and new knowledge.' However, by which means and to which extent collaboration should be structured in advance, whether this should be face-to-face or computer-supported, how individual and group support could be balanced, how groups should be formed, and what 'collaborative tools' could be applied in collaboration remain largely unresolved issues. Wiley and Edwards (2003) investigated the potential of online self-organizing social systems (OSOSS) in which students provide each other with peer feedback without any guiding authority, such as learning through collaborative problem solving (CPS). According to Nelson (1999), the attributes of the ideal CPS learning environment are conducive to collaboration, experimentation, and inquiry, an environment which encourages an open exchange of ideas and information. Wiley and Edwards focus their research on Web-based CSCL infrastructures that are considered a 'fertile primordial soup' from which OSOSS can just 'simply' emerge without a central authority adding content, commentary, structure, or user support in advance. We took an intermediate stance by adding some initial content and structure to 'seed' the information space for others to add and elaborate, based on the concept of *'courses as seeds'* (De Paula, 2003; De Paula, Fisher, & Ostwald, 2001).

Before launching LN4LD (in July 2004), we 'seeded' the learning network with five initial learning activities containing forums, assignments, additional information, and some self-assessment questions. Activities were offered as Moodle courses. When specific discussions arose, each member was allowed to create new activities, like the instigators did for 'IMS Learning Design and meta data.' It was possible to rate

Figure 1. Rating in a Moodle forum



activities (in PHP-Nuke) and individual postings or replies (in Moodle, like is depicted in Figure 1). We further identified the various stakeholders in the field of learning design representations by means of learning technology. The international community of professionals interested in this topic was divided into subgroups for learning designers (or teachers), for learning providers (or vendors), for system developers (or programmers), and for PhD students, to improve shared interest and focus. The LN4LD was mainly directed towards the first subgroup of learning designers.

Central to the notion of a learning network (LN) is the idea that all LN members are in a position to contribute within the constraints of any policies that may be operating. In this respect not only the *usability* aspects of a facility, such as a LN, are of importance but also *sociability* (Preece, 2000). Sociability requires careful communication of the purpose and policies (values) of the community. Therefore, we have explicitly stated requirements for joining or leaving, codes of practice for communication, rules for moderation, and issues of privacy and trust, amongst others).

Relating to the general design issues of clear policies, high usability, and understandable structures, we learned from this initial setup that there remained a lot to be improved. *Policies* should not only be stated very clearly, but should also be very visible and placed on a central spot in the LN. We first intended to have participants submit a real life problem to get access to the activities, but this entry policy appeared too high a threshold. A description of policies was contained in a separate document, but only a minority of learners actually found and read it, so no new activities were added. The initial two-layered architecture (PHP-Nuke/Moodle) was not transparent to most participants, indicated by the observation that the majority (80.8%) could not find the way towards the Moodle-layer. Measures we have later taken up to improve the *usability* were: adding more dynamic content (initially very text-oriented), adding lower level content (initially information about IMS-LD appeared more appropriate for a small group of advanced users of this specification), adding worked-out examples, and decreasing the complexity of the navigation. Regarding *structure*, we learned from the initial setup that there might have been too many assignments and forums. There were simply too many parties going on for too few participants. David Wiley (personal communication, September 20, 2004) argues that budding communities of practice might be nipped in the bud by providing too many facilities, leaving no room for the community to self-organize their own structure and facilities. He proposes starting with a minimal set, consisting of (1) one or two forums, (2) identifiable contributions (accounts) and kudos (rewards), and (4) fire alarms (punishments). Although this minimal set appears present in the LN4LD, forums and content appeared too complex to start with. In the next section, we discuss how we introduce a 'token economy' to allow users to earn points for making contributions in order to attain a certain reward (kudo).

Initial Participation Data in LN4LD

We view learner participation from the information ecology perspective (e.g., Card, Robertson, & York, 1996). As Guzdial (1997) notes, participation and exchange can be studied at a high level of aggregation to understand information spaces in terms of searching, making (contributing), and using (consuming) information. In learning ecologies, activity can be monitored without knowing whether actual learning is taking place. Our aggregated analyses focused on reading, writing, and rating in forums as indicators of participation.

An initial, small group of 104 registered users was monitored during the first three months after launching LN4LD (July–September 2004). A more elaborate treatment of this study has been published as Hummel et al. (2005a). Again, passive participation was much higher than active participation. We counted 12,011 page views, and people downloaded 427 items. Only 25 articles were posted in both Nuke and Moodle forums. Besides the instigators, no other users created new activities themselves. Exchange of information on the level of active participation in LN4LD was still quite disappointing, although it was a substantial improvement when compared to its VBulletin predecessor. For instance, when we take the (number of active posts/number of registered users) ratio as a measure, we observe an increase from 5% to 50% over both facilities.

Possible problems underlying the disappointing numbers of participants and low level of active participation were identified: relative invisibility of policy statements; various usability issues in registering and navigation (due to the rather complex two-layer Nuke-Moodle infrastructure); lack of suitable content (content was found to be at a rather complex level and mainly text-oriented); and complex structure (too many assignments and forums for too little users).

INTRODUCING INCENTIVE MECHANISMS

After the first study period of three months, we continued monitoring participation in LN4LD during the following period of three months (October 2004–January 2005). Within a second, improved pilot implementation (now available at http://imsld.learningnetworks.org) of the LN4LD, we carried out experimentation with an incentive mechanism aimed to increase active participation.

Social Exchange Theory

Experimentation during this second phase was heavily inspired by social exchange theory, which informs us that participants will contribute more when there is some kind of intrinsic or extrinsic motive (or reward) involved. This theory (Constant, Kiesler, & Sproull, 1994; Thibaut & Kelly, 1959) comes from economics' rational choice theory, suggesting a relation between a person's satisfaction with a relation (i.e., with the learning network) and a person's commitment to that relation (i.e., his willingness to actively participate). It furthermore suggests four main mechanisms to motivate and encourage participation: (1) *personal access*, or anticipated reciprocity: learner has a pre-existing expectation that she will receive actionable and useful (extra) information in return; (2) *personal reputation*: learner feels he can improve his visibility and influence others in the network, for example, leading to more work or status in the future; (3) *social altruism*: learner perceives the efficacy of the LN in sharing knowledge as a 'public good,' especially when contributions are seen as important, relevant, and related to outcomes; and (4) *tangible rewards*: learners negotiate to get some kind of more tangible asset (financial reward, bond, book, etc.) in return. Other distinctions have been made between individual (access, reputation, reward) vs. interpersonal factors (altruism) (Deci, 1975, 1985); hard (e.g., access, money) vs. soft (e.g., satisfaction, altruism) rewards (Hall, 2001); quantitative vs. qualitative gain, intrinsic vs. extrinsic factors, and others. In each of the above cases, incentive mechanisms for knowledge sharing should match the spirit of what has to be achieved (Sawyer, Eschenfelder, & Hexkman, 2000). If this is finding and exchanging information about LD, research suggests that incentives to gain extra personal access to more information about LD can be expected to render best results.

Participation Data When Introducing an Incentive Mechanism

To test this assumption, we introduced an incentive mechanism in LN4LD (participants could earn extra access by making contributions). We divided the three-month period into three consecutive periods of one month each and monitored our participants. The incentive mechanism was being introduced and only available during the middle period of one month. The sample used for this study consisted of all 125 individuals who had enrolled and accessed the learning network during the experimental period. Seventeen countries were represented as the origin of these participants. A more elaborate treatment of this study was published as Hummel et al. (2005b).

The mechanism allowed participants to earn points for contributions with the reward scheme including both quantitative and qualitative components. On the quantitative side, points could be earned for: (1) forum postings (20 points for each, labeled 'pointsforpost'); (2) replying to posts (10 points for each, labeled 'pointsforreply'); and (3) rating of posts (3 points for each, labeled 'pointsforrate') (see Table 1). With respect to the quality of postings, contributors received additional points for: (4) each time their contribution prompted a reply (5 points for each reply to a post, labeled 'pointsforreplyrec'); and (5) each time the originator's posting was rated (3 points * rating value, labeled 'pointsforraterec'), whereby the ratings ranged from 1 (very poor) to 5 (very good).

A simple interrupted time series with removal design (Robson, 2003) was applied with (active and passive) participation as the independent variable. The main research aim of this experiment was to measure the hypothesized increase in active participation, but we also monitored data on passive participation. Both types of participation contribute to the collective behavior of the learning network and were considered worthwhile to be studied. Although both types of participation increased significantly after introducing the reward system, in this paper, we will restrict ourselves to data on active participation.

Table 1 shows that most active participation points were earned by making postings to forums (320 points in total, with 220 of these in period B). Over time, the total amount of active participation points was divided as follows: 117 points in period A, 566 points in period B, and 141 points in period C. The average total points for active participation earned by active participants (n = 17) is 48.47, and by all participants (n = 125), it is 6.6. The repeated measures ANOVA, using time of measurement as a within-subjects factor, reveals that 'period' indeed is a very significant factor in explaining the average total amount of points (F (2, 122) = 14.17, MSE = 24,966.08, $p < .001$, $\eta_p^2 = .104$), even with the majority of participants not actively contributing. When we include 'scoring' (either 'those who did not score' or 'those who did score') as a between-subjects factor (period * scoring) appears to be an even more significant factor (F (2, 122) = 31.21, MSE = 24,966.08, $p < .001$, $\eta_p^2 = .204$) in the linear model. So, even if we look at the total community (of which about 85% remained passive), the introduction of the

Table 1. Total active participation points for each period (A-C) and parameter for all participants (n=125)

Points X Period	Total points	Points forpost	points forreply	points forrate	points forreplyrec	points forraterec
A.	117	60	20	3	10	24
B.	566	220	120	42	100	84
C.	141	40	30	12	35	24
A-C.	824	320	170	57	145	132

incentive mechanism still introduced clear and significant effects on active participation.

INTRODUCING FACE-TO-FACE MEETINGS

Since August 2004 until late 2006, the LN4LD was maintained under the umbrella of the 6th framework UNFOLD project, an initiative sponsored by the European Commission to improve the further dissemination and uptake of IMS-LD in Europe. The initial LN4LD implementation had been adapted for use as the CoP (community of practice) for learning designers (now available at http://imsld.learningnetworks.org). In the third phase under study in this article (the next period of six months, between January and July 2005), UNFOLD organized a number of face-to-face meetings in relation to the LN4LD. Although this blended learning approach was not deliberately designed to study the effects on participation, the introduction of face-to-face meetings offered opportunities for further study on this issue. In the context of our research on participation, we measured the influence of this blend on the participation data and appreciation of the LN4LD during this period. During this third phase, face-to-face meetings were set up and carried out by the UNFOLD project in February (Valkenburg, The Netherlands), in April (Barcelona, Spain), and in June (Braga, Portugal). An average attendance of 70 persons for each meeting, with people coming from more than 15 countries, could be observed. During this period, also a number of short presentations about LD were given in various conferences on related topics taking place in Paris, Sheffield, and Madrid. However, these presentations were not organized on purpose like the UNFOLD meetings and not directly related to the LN4LD.

Social Affordances in Blended Learning

Social interaction and active participation are crucial issues for the quality of both the real world and virtual collaboration of communities. An important pitfall would be to assume that interaction and participation would simply occur when the possibility of asynchronous communication becomes available. It goes without saying that this will not be the case. Besides this, when designing means of communication we cannot just translate all mechanisms for face-to-face learning groups (e.g., didactical guidelines that appear useful for classical instruction and interaction in real life) to distributed learning groups (e.g., these very same guidelines may appear quite useless there). Asynchronous communication offers specific possibilities but also specific barriers that are non-existent in face-to-face settings. Setlock, Fussell, and Neuwirth (2004) have noticed several differences between face-to-face and virtual groups who carry out the very same tasks.

The potential of teamwork or other types of face-to-face collaboration for online learning has already been demonstrated by various studies in a variety of domains, both for individual online learning environments (Barlow, Phelan, Harasym, & Myrick, 2004; Pawar & Sharifi, 1997; Pearce & Ravlin, 1987), as well as for computer-supported collaborative learning (CSCL) environments (Gunawardena, Carabajal, & Lowe, 2001; Gunawardena, Lowe, & Anderson, 1997). The interaction between learners (both in face-to-face settings and in CSCL) can lead to further elaboration and refinement of individually constructed schemas, since it incites learners to explicate the actual level of schema development and demands them to explicitly compare their own schemas with schemas of others as to defend or criticize (Jeong & Chi, 2000).

Warketin, Sayeed, and Hightower (1997) have found that creating a feeling of closeness and trust can be achieved by interlacing real and virtual encounters. 'Spatial and temporal proximity' in learning networks can be influenced by interlacing distributed and face-to-face learning. Other researchers echo this beneficial influence on participation when combining virtual and face-to-face communication and events. For instance, Biesenbach-Lucas (2003) and Thoennessen (1999) noticed the positive influence of face-to-face lessons on threaded online discussion. Meyer (2003) found additional face-to-face meetings to have an added value for motivation and higher-order thinking during online discussions. Coppola, Hilz, and Rotter (2004) compared face-to-face groups with virtual communities. They seeded the community with 'swift trust actions' to show that a blended learning approach achieves a richer and more profound basis for collaboration. Based on these research findings, we hypothesized that a blended approach, combining online activities and face-to-face meetings related to them, could indeed improve active participation in a learning network.

According to the 'ecological approach' to CSCL (Gaver, 1996; Kreijns, Kirschner, & Jochems, 2002), social interaction would be stimulated when specific characteristics of the real world environment would be related to or get included in the asynchronous communication. Kreijns (2004) defines 'social affordances' as the facilitators originating from the real world context which can stimulate interaction in a virtual, collaborative environment (e.g., the image of a door on the screen reminds us of 'something that can be opened,' and will increase the odds the user wants to, or at least knows how to, access this space). Such 'social affordances' would stimulate social interaction in the virtual environment and compensate for some of its barriers. He stimulated informal and casual conversations in CSCL by simulating impromptu encounters to bridge the time-gap imposed by asynchronicity. According to his research, social affordances can be expected to increase when face-to-face meetings in the real world become part of the historical awareness in a community's virtual environment (e.g., "Ah, that's a posting from the guy I met at a conference fifteen years ago. Let's reply to him about …"). According to this ecological approach, such social affordances would, in their turn, stimulate the amount of active participation in the virtual environment.

Participation Data When Introducing Face-to-Face Meetings

Table 2 shows the participation data during the period in which face-to-face meetings were organized.

We did not differentiate between active (postings, ratings) or passive participation (page hits, downloads) during this phase, but just logged all activities. The table shows an increase in the amount of activities (activity nodes), related to the UNFOLD meetings and related events. The table also shows a substantial increase in activity after the introduction of face-to-face meetings.

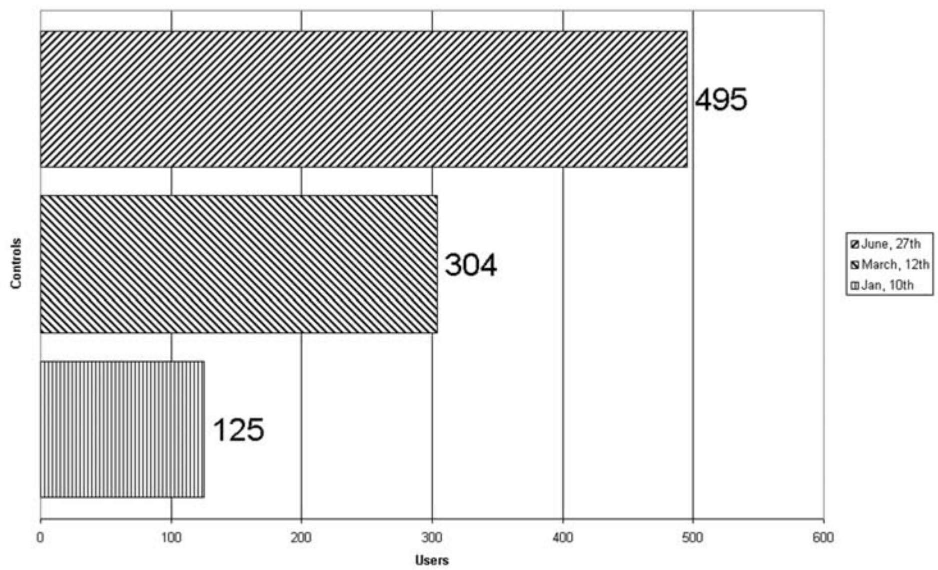
Data analysis shows the increase of participation from January–March 2005 to be 48% of participation between March–June 2005. Participation went from 3,750 actions until January to 17,553 actions in March and to 26,028 actions in June, meaning an increase of 8,475 actions from March and 22,278 actions from January.

Concerning the amount of registered users, Figure 2 shows progress from 125 members in January to 304 in March and 495 in June. This means an increase of 243% in March and a cumulative increase of 396% in June. All these figures show a continuous, gradual increase of percentages and raw numbers on both actions taken and registered users during this last period of study. This growth has continued after the last period under study, and in late 2006, about 3,000 registered users could be counted.

Table 2. Participation data about actions

Activity Nodes 270605	Actions	Actions	Actions	New actions	% of new	% of new
	100105	**210305**	**270605**		March-June	January-June
Advanced Issues with IMS Learning Design		253	395	142	56	
Change Proposals IMS LD Specification		674	812	138	20	
Experience a running Unit of Learning		1.319	1.531	212	16	
Getting started with the IMS LD Specification		3.033	4.294	1.261	42	
How to modify a Unit of Learning		1.342	1.703	361	27	
IMS Learning Design and Metadata		1.015	1.198	183	18	
Online Educa Madrid Mayo 2005 (en castellano)			477	477	100	
PROLEARN/UNFOLD Heerlen September 2005		73	271	198	271	
Runnable LD Example Units of Learning		3.269	6.252	2.983	91	
Understanding the basics of IMS Learning Design		2.041	2.795	754	37	
UNFOLD CoP Meeting in Barcelona April 2005		143	1.055	912	638	
UNFOLD CoP Meeting in Braga (Portugal) June 2005			286	286	100	
UNFOLD hands-on meeting in Valkenburg 2005		3.496	3.893	397	11	
UNFOLD Paris Workshop March 2005		27	80	53	196	
UNFOLD Presence at Alt-i-lab June 2005			54	54	100	
UNFOLD Presence at Campus Virtual June 2005 (en castellano)			38	38	100	
UNFOLD presence at the Online Educa Berlqn 2004		289	313	24	8	
UNFOLD session at the EADTU 2004 conference		421	422	1	0	
UNFOLD Workshop at EUCEN Conference 2004		158	159	1	1	
	3.750	17.553	26.028	8.475	48	594
Without logins	13803					
		8475				
	22278					
	3.750	20.063	30.235	14.653	73	706
With logins	16313					
		10172				
	26485					

Figure 2. Growth of registered users (January, March, June 2005)



Of all participants, about half (44.4%) answered that they participated regularly in the online forums, and about half (47.2%) expressed to prefer forums over e-mail. A vast majority (88.8%) feels to benefit most from face-to-face meetings (especially hands-on work and discussions in a group with experts around to help), but realizes this is not always a feasible option due to the geographical spread of most participants.

Appreciation Data from Questionnaires and Interviews

A number of evaluation activities were carried out under the umbrella of UNFOLD: face-to-face and online evaluations, Web site usability trials, log analysis of Web servers, phone interviews, and benchmarking studies. Generally speaking, participants expressed appreciation for the setup of the blended learning network. We noted a consistent increase in both the usage of the LN4LD (and the uptake and use of IMS-LD during the period of study, the latter still centering on using LD-tools and not yet on a wider use with actual learners).

During the face-to-face meetings, we requested the participants fill in a questionnaire and conducted a small number of short interviews with some core-participants in order to collect more qualitative data on the appreciation of the blended approach. For more detailed information about these instruments, we refer to Burgos (2006). A total of 78 valid (complete, blind, understandable; response rate of about 80%) questionnaires were collected and analyzed from active participants, learning design professionals that are playing a significant role in the field of learning design representation and within the LN4LD. Additionally, a total of 16 qualitative interviews were conducted with a selected group of these participants. These were carried out by phone and by one of the UNFOLD facilitators (of which one is the first author of this article). Both the questionnaires and interviews consisted of questions about the state of IMS-LD, the organization of the meeting, the content of the meeting, and about the participation in LN4LD. Answers to the questionnaires were to be provided as either a selection from multiple options, ratings (on five-point scales) or open suggestions.

In this section, we will focus on describing the main qualitative findings from the questionnaires and interviews that relate to the participation in LN4LD. The information collected by the questionnaires could be complemented by more detailed interviews with some members of the community who were considered to be key UNFOLD members. The goal was to get a deeper understanding and evaluation of what could be obtained from the questionnaires alone. The basic topics that were addressed during the interviews were the same. The procedure was based on a structured questionnaire for the interviews. Based on this structure, the interviewer encouraged the interviewee to elaborate, for instance, by posing follow-up questions in the light of answers obtained.

First of all, respondents underline the huge differences that exist between real world and virtual types of communication, and between synchronous and asynchronous communication. All types are considered to have specific possibilities and barriers. Most respondents consider the combination of types in a blended approach to be most optimal. For example, one of the respondents stated:

I am addicted to chats, because they are good for shy people like me. But F2F and online activities help each other. We also need F2F contact with demos once in a while, because they are richer, good for meeting people, and you can better explain your point of view in direct interaction. Then later in the forums and the chats, we can get more in depth to further address issues.

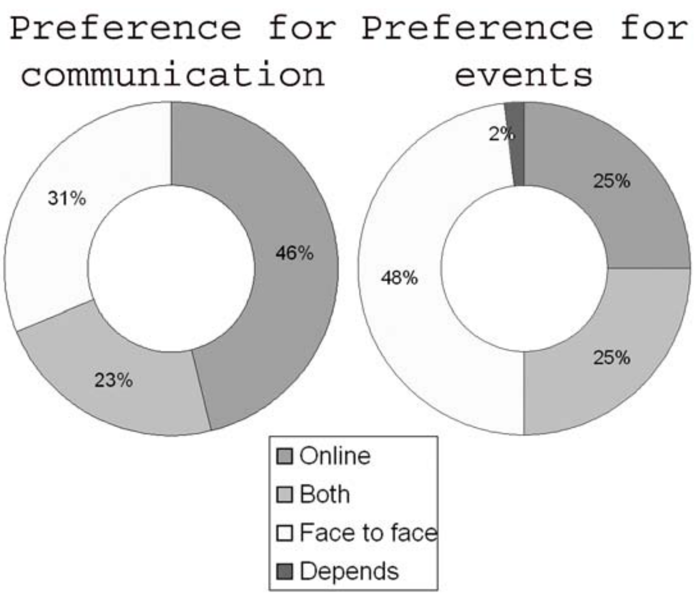
Generally speaking, respondents indicate the positive contribution of face-to-face meetings in the real learning network to the virtual learning network. They consider these types of communication as mutually dependent. Although most participants just share a general interest in a topic and do not consider themselves experts on the topic of IMS-LD, being involved in a heterogeneous community of practice in this area allows them to play their role and learn from participants that are more expert on the topic. We must note that the reported willingness to participate (91.7%) is much higher than the actual participation observed in the total community, which is probably caused by the fact that the group of respondents (active participants) cannot be considered as a representative sample.

As specific advantages of face-to-face communication, the following clusters were mentioned: the possibilities for more precise discussion; chances for a more efficient learning curve; the availability of direct contact and feedback; the opportunity to meet the experts; a higher level of motivation and interaction; more direct interaction which was seen as fundamental to establish contacts; and the enrichment of virtual contacts.

As specific advantages of virtual communication, the following clusters were mentioned: catering for geographical spread; enabling freedom of time (sources always available); the reduction of e-mails; in the long run, cost-efficiency; more opportunities for user interaction with more participants; permanent availability of a high number of resources and possibilities to keep up-to-date; allowing more time for thinking; and allowing for types of communication that are not possible during face-to-face meetings.

The most used facilities for asynchronous communication within LN4LD appear to be the group forums and personal e-mails. Together, these facilities provide a bidirectional and open access channel for both information consumption and information contribution in a learning network. When asked about their preference, 58.3% of the respondents indicated a preference for fo-

Figure 3. Preferences (online vs. face-to-face) for communication and events



rum communication. When comparing e-mail to forums, personal e-mails are said to provide more protection against criticism from others, provide feedback faster, allow for more time to answer, and to be easier to follow. Forums, on the other hand, are considered to be less intrusive and better structured (flow of discussion by threading), to archive discussions in the past, to be easier to ignore, and to allow for more brainstorming.

When asked about their preference for either face-to-face or online *communication*, 46% of the respondents indicated a preference for online communication, 31% for face-to-face communication, and 23% for their combination (see Figure 3). When asked about their preference for either face-to-face or online *events*, 48% of the respondents indicated a preference for face-to-face communication, 25% for online, and 25% for their combination (see Figure 3). So, for events, the preference clearly shifts from online towards face-to-face.

When asked about their participation online, especially during online events, 56% of the respondents indicated they did and 44% of the respondents indicated they did not participate in these events. The main reasons provided were the lack of time, no real engagement with the project, or lack of clear focus of the event. It is worthwhile to note though that of the 44% stating they did not participate, 36% showed interest in participating in future online events. All respondents that participated in the UNFOLD online events feel these events helped them find information, exchange ideas, share work, debate questions, and learn more about the field.

CONCLUSION

We presented some preliminary data on participation while setting up initial pilot implementations of a learning network for learning design (LN4LD) and described the setup and results from two studies that monitored collaboration and (active) participation by adding an incentive mechanism and face-to-face meetings, respectively. A number of general design guidelines for setting up effective learning networks could be derived from these studies. These guidelines can be based on relevant theories about self-organization, social exchange, and social affordances.

From the initial implementations, we derived some design guidelines and concluded that *usability*, simple *structure*, and clear *policies* are necessary requirements. The functional demands of facilities for collaboration and participation should always have priority (**design guideline 1**). More specifically, we found that users should not be overburdened by complex structures and too many facilities. Simply '*seeding*' the network with a minimal set of assignments and forums was found to cater best for the emergence of structure and activity (**design guideline 2**). We also concluded that additional policies were needed for effective exchange and active contributions (**design guideline 3**). Finally, for scoping and focused collaboration, it appeared useful to identify stakeholders and divide them into subgroups of shared interest (**design guideline 4**).

Introducing an *incentive mechanism*, in line with the general purposes of the learning network, appeared to significantly increase the level of collaboration and participation (both active and passive) (**design guideline 5**). Interlacing virtual activities with additional *face-to-face meetings* on the same topics yielded another substantial increase in both activity level and amount of users registering (**design guideline 6**). Adding incentives and meetings can therefore be considered worthwhile 'add-ons' to online, distributed learning networks in general.

Although these are promising findings about *what* happened (according to our ecological approach) and what could be designed to improve communities, they do not explain what caused these changes in behavior (*why* it happened). The questionnaires and interviews with some of the active participants in the community provide us with some initial, more qualitative impressions about what participants appreciate and feel is important in such (blended) learning networks. Most respondents indicated the added value of a blended approach, where the advantages of face-to-face and virtual communication and events can be used, and where practical barriers of each could be overcome. A serious limitation of this last study was that some of the appreciation data were difficult to interpret.

Future research will have to find out how exactly we should blend these types of communication. We should furthermore carry out more qualitative research into the actual drivers for people to register and actively participate in learning networks. More qualitative analysis of logged data (e.g., by using diary methods) or additional interview techniques to analyze personal motivations might provide a fruitful approach for this work.

Limitations of the studies described are also related to the relatively small group size of the community members being questioned and to the absence of any form of certification. Participants were widely distributed geographically and did not learn in the context of a single or formal organization, where their progress could have been more easily assessed against organizational standards. Similar results might not materialize for participants (students) entering more formal or larger communities. Therefore, replications of these findings on a larger scale and for various forms of (formal) learning, incentives and topics are also needed.

NOTE

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REFERENCES

Aspin, D. N., & Chapman, J. D. (2000). Lifelong learning: Concepts and conceptions. *International Journal of Lifelong Education*, *19*(1), 2-19.

Barlow, C., Phelan, A., Harasym, P., & Myrick, F. (2004). *Peer collaboration as a model for workplace learning in health care: Possibilities and challenges.* Retrieved April 7, 2008, from http://www.wln.ualberta.ca/ papers/pdf/03.pdf

Biesenbach-Lucas, S. (2003). Asynchronous discussion groups in teacher training classes: Perceptions of native and non-native students. *Journal of Asynchronous Learning Networks, 7*(3), 24-46.

Boisot, M., & Griffiths, D. (1999). Possession is nine tenths of the law: Managing a firm's knowledge base in a regime of weak appropriability. *International Journal of Technology Management*, *17*(6), 662-676.

Burgos, D. (2006). *Estudio de la estructura y del comportamiento de las comunidades virtuales de aprendizaje no formal sobre estandarización del e-learning* [The structure and behavior of virtual communities engaged in informal learning about e-learning standards]. Unpublished doctoral thesis in communication and journalism, European University of Madrid, Villaviciosa de Odón, Spain.

Card, S. K., Robertson, G. G., & York, W. (1996). *The WebBook and the Web Forager: An information workspace for the World-Wide Web.* Paper presented at the Conference on Human Factors in Computing Systems, Vancouver, Canada.

Constant, D., Kiesler, S., & Sproull, L. (1994). What is mine is ours, or is it? *Information Systems Research*, *5*(4), 400-422.

Coppola, N. W., Hiltz, S. R., & Rotter, N. G. (2004). Building trust in virtual teams. *IEEE Transactions on Professional Communication, 47*(2), 95-104.

Deci, E .L. (1975). *Intrinsic motivation*. New York: Plenum Press.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

De Paula, R. (2003, September 14-18). *Active learning networks: Designing for computer supported social networks in special education environments.* Paper presented at the ECSCW'03 Workshop on Social Networks, Helsinki, Finland. Retrieved April 7, 2008, from http://www.ischool.washington.edu/mcdonald/ecscw03/ papers/depaula-ecscw03-ws.pdf

De Paula, R., Fischer, G., & Ostwald, J. (2001). Courses as seeds: Expectations and realities. In *Proceedings of the European CSCL 2001*, Maastricht, The Netherlands.

Dougiamas, M. (2007). *Moodle*. Retrieved April 7, 2008, from http://moodle.org

Field, J. (2001). Lifelong education. *International Journal of Lifelong Education, 20*(1/2), 3-15.

Fischer, G., & Ostwald, J. (2002). Transcending the information given: Designing learning environments for informed participation. In *Proceedings of the ICCE 2002 International Conference on Computers in Education*, Auckland, New Zealand.

Gaver, W. W. (1996). Situating action II: Affordances for interaction. *Ecological Psychology, 8*(2), 111-129.

Gunawardena, C. N., Carabajal, K., & Lowe, C. A. (2001). *Critical analysis of models and methods used to evaluate online learning networks.* AERA: Seattle.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research, 17*(4), 395-429.

Guzdial, M. (1997). *Information ecology of collaboration in educational settings: Influence of tool.* Paper presented at the CSCL '97, Toronto, Canada.

Hall, H. (2001, April 10-11). Social exchanges for knowledge exchange. Paper presented at *Managing Knowledge: Conversations and Critiques*, University of Leicester Management Centre, Leicester.

Hummel, H. G .K., Tattersall, C., Burgos, D., Brouns, F. M .R., Kurvers, H. J., & Koper, E. J. R. (2005a). Facilitating participation: From the EML Web site to the learning network for learning design. *Interactive Learning Environments, 13*(1/2), 55-69.

Hummel, H. G. K., Burgos, D., Tattersall, C., Brouns, F. M. R., Kurvers, H. J., & Koper, E. J. R. (2005b). Encouraging contributions in learning networks using incentive mechanisms. *Journal of Computer Assisted Learning, 21*(5), 355-365.

IMS-LD. (2003). *IMS Learning Design specification*. Retrieved April 7, 2008, from http://www.imsglobal.org/ learningdesign/index.cfm

Jeong, H., & Chi, M. T. H. (2000). *Does collaborative learning lead to the construction of common knowledge?* Retrieved April 7, 2008, from http://www.ircs.upenn.edu.edu/cogsci2000/PRCDNGS/SPRCDNGS/posters/jeo_chi.pdf

Koper, E. J .R., Hermans, H., Vogten, H., & Brouns, F. M. R. (2000). EML 1.0. Retrieved April 7, 2008, from http://hdl.handle.net/1820/81

Koper, E. J. R., Pannekeet, K., Hendriks, M, & Hummel, H. G. K. (2004). Building communities for the exchange of learning objects: Theoretical foundations and requirements. *ALT-J Research in Learning Technology, 12*(1), 21-35.

Koper, E. J. R., & Sloep, P. B. (2003). *Learning networks: Connecting people, organisations, autonomous agents and learning resources to establish the emergence of effective lifelong learning.* Heerlen, the Netherlands: Open University of the Netherlands. Retrieved April 7, 2008, from http://hdl.handle.net/1820/65

Kreijns, K. (2004). *Sociable CSCL environments: Social affordances, sociability, and social presence*. Unpublished doctoral thesis, OTEC, Open Universiteit Nederland, Heerlen, The Netherlands.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society*, *5*(1), 8-22.

Mevarech, Z. R., & Kramarski, B. (2003). The effects of metacognitive training versus worked-out examples on students' mathematical reasoning. *British Journal of Educational Psychology, 73*, 449-471.

Meyer, K. (2003). Face-to-face versus threaded discussions: The role of time and higher-order thinking. *Journal of Asynchronous Learning Networks, 7(*3), 55-65.

Nelson, L. M. (1999). Collaborative problem solving. In C. M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (pp. 241-267). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pawar, K. S., & Sharifi, S. (1997). Physical or virtual team collocation: Does it matter? *International Journal of Production Economics, 52*(3), 283-290.

Pearce, J. A. I., & Ravlin, E. C. (1987). The design and activation of self regulating work groups. *Human Relations, 40*(11), 751-760.

PHP-Nuke. (2004). PHP-Nuke 4. Retrieved April 7, 2008, from http://www.phpnuke.org

Preece, J. (2000). *Online communities: Designing usability, supporting sociability.* Chichester: Wiley.

Prusak, L. (1999). What's up with knowledge management: A personal view. In J. Cortada & J. Woods (Eds.), *The knowledge management yearbook* (pp. 1-7). Boston: Butterworth Heinemann.

Olsen, M. (1965). *The logic of collective action*. Cambridge, MA: Harvard University Press.

Robson, C. (2003). *Real world research: A resource for social scientists and practitioner-researchers.* Blackwell Publishers.

Sawyer, S., Eschenfelder, K., & Hexkman, R. (2000). Knowledge markets: Cooperation among distributed technical specialists. In T. Srikantaiah & M. Koenig (Eds.), *Knowledge management for the information professional* (pp. 181-204). Medford, NJ: Information Today.

Setlock, L., Fussell, S., & Neuwirth, C. (2004). Taking it out of context: Collaborating within and across cultures in face-to-face settings and via instant messaging. *Proceedings of the ACM Conference on Computer Supported Cooperative Work*, *6*(3), 604-613.

Smith, R. G., & Farquhar, A. (2000). The road ahead for knowledge management. *AI Magazine, 21*(4), 17-40.

Thibaut, J., & Kelly, H. (1959). *The social psychology of groups.* New York: Wiley

Thoennessen, M., Kashy, E., Tsai, Y., & Davis, N. E. (1999). Impact of asynchronous learning networks in large lecture classes. *Group Decision and Negotiation, 8*, 371-384.

VBulletin. (2004). *VBulletin*. Retrieved April 7, 2008, from http://www.vbulletin.com

Warketin, M. E., Sayeed, L., & Hightower, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of a Web-based conference system. *Decision Sciences, 28*(4), 975-996.

Wiley, D. A., & Edwards, E. K. (2003). *Online self-organizing social systems (OSOSS): The decentralized future of online learning.* Retrieved April 7, 2008, from http://wiley.ed.usu.edu/docs/ososs.pdf

KEY TERMS

Blended Learning: Mix of (blend) regular and distance education or training. Blended learning is education that includes both physical presence and interaction with fellow students and teachers at certain times and places, as well as electronic learning environments that can be accessed at any point of time and place.

Collaboration: Any activity that includes the social exchange of information between people that work together.

Face-to-Face Meetings: Meetings where people are physically present together in a space (i.e., to learn and discuss about a certain topic of joint interest).

Incentive Mechanisms: A treatment or measure to motivate and encourage people (i.e., to participate in a learning network).

Learning Networks: Two-mode networks represented as a graph with nodes, where the nodes are "participants" (actors, members, learners) and "activities." Activities can be anything that is available to support learning, such as a course, a workshop, a lesson, an Internet learning resource, and others. Central to the notion of a learning network is that all participants are in a position to contribute.

Participation: The level of activity in a learning network that can be either passive (consuming information) or active (contributing information).

Self-Organization: A characteristic of complex and adaptive systems that display emergent behavior. A structure that self-organizes and gets its smarts from below; agents residing on a scale start producing behavior that lies one scale above them (e.g., ants create colonies, learners create learning communities).

Social Affordances: Properties of a CSCL environment that act as social-contextual facilitators relevant for the learner's social interactions.

Social Exchange Theory: Theory that informs us that participants will contribute more when there is some kind of intrinsic or extrinsic motive (or reward) involved. It suggests a relation between a person's satisfaction with a relation (i.e., with the learning network) and a person's commitment to that relation (i.e., his willingness to actively participate).

Section II
Learning Objects

Learning objects: the definitions are many, the promises have been grand. The concept of learning objects is not new—teachers have always developed and shared resources. However, the organisational investment in development, global reach, accessibility, and use in practice of digital learning objects has grown exponentially in the past 6 to 10 years. This section of the Handbook offers perspectives from the research and evaluation that has, necessarily and importantly, accompanied that growth. There is a particular emphasis on issues of design, evaluation, and accessibility of learning objects. Principles for learning object design have been a feature of the literature for some time. The chapters in this section offer particular perspectives derived from the research in areas relating to specific learners (for example those with non-English speaking backgrounds), specific contexts (such as higher education), and specific technologies (such as handhelds). The evaluation evidence from large scale, international learning object initiatives allows us to learn from the experiences of design, use, and reuse. This section provides both evaluation outcomes from Europe and Australia as well as considerations of approaches to evaluation for learning objects. The theme of accessibility is considered in this section in terms of different approaches to sharing learning objects. In particular, the chapters in this section cover the scalability of approaches, frameworks for repositories that may include a range of items and support collaboration, as well as the costs of repository models. One debate that can be identified among the chapters in this section, and the learning object design and evaluation literature in general, is the degree to which pedagogy should be embedded within a learning object. To what extent should pedagogy be within a learning object and/or structured around learning objects? This highlights the need for further theorisation and research in this area and links nicely to the issues highlighted Integration section of this Handbook.

Chapter XIX
The Design of Learning Objects for Pedagogical Impact

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ABSTRACT

This chapter argues that good design has to be at the heart of developing effective learning objects. It briefly outlines the "knowledge engineering" approach to learning objects based on metadata and packaging. The knowledge engineering approach, however, ignores the issue of how to design and develop pedagogically effective learning objects. The chapter concentrates on the central issue of the design and development of learning objects. The first part of the chapter outlines and illustrates key design principles. The middle part of the chapter examines how these can be embedded in an "agile" development methodology for developing learning objects. The following section shows how effective designs can be captured and made available in a tool to support the authoring and repurposing of learning objects. Finally, the chapter examines the wider picture linking learning objects and learning designs and points to the challenge of "layered learning design."

"The use of learning objects promises to increase the effectiveness of learning …"
– Duval et al. 2003

INTRODUCTION

Strong claims have been made for the pedagogical impact of learning objects. The bulk of the work on learning objects has been based on an approach that emphasises the description (through meta-data) and interoperability of learning resources across computer systems. This is embodied in the international standards for metadata (IEEE, 2002) and content packaging (IMS, 2007). This chapter argues that high quality design and development of learning objects is crucial before we get to issues of metadata and software packaging. The primary message of the chapter is good pedagogical design is at the heart of effective learning objects.

This chapter thus focuses on the issue of the design and development of reusable learning objects. The term "learning object" has been subject to considerable ambiguity in interpretation. The chapter clarifies the definition of learning objects that underpins the work described in the paper (the issue of clarification of the different meanings applied to learning objects is revisited later). The chapter then discusses two types of design principles: pedagogical design principles—to create effective learning experiences—and structural design principles to enhance the potential for reuse. The design principles are illustrated with several examples including the "learning objects for programming" project which won a European Academic Software award (EASA) in 2004.

The middle section of the chapter then examines how these design principles can be embedded in a full learning object development life cycle. It outlines the development methodology evolved by the CETL in reusable learning objects (Boyle, Windle, Leeder, Wharrad, Alton, & Cook, 2006). This emphasises a flexible, agile approach which covers the key life cycle functions from problem identification, through design, to production and evaluation.

The chapter then moves on to discuss the principles underpinning the development of a new, second generation of learning objects. In particular, it points to an increased emphasis on the pedagogical patterns (or learning designs) inherent in learning objects as the primary focus for reuse. It describes work in developing a model of "generative learning objects" (GLOs), which makes explicit these embedded designs. This work is realised in an authoring tool developed to enable tutors to create and repurpose learning objects based on these reusable design patterns.

The chapter culminates by examining the relationship between this work and wider approaches to reusable learning design. This discusses how major areas of work in learning design (AUTC Learning Designs, 2002; Dalziel, 2003; Harper & Oliver, 2002) may be related to the GLO work within a consistent conceptual framework.

The chapter refers extensively to the work of the Centre for Excellence in Teaching Learning (CETL) in reusable learning objects. This centre was set up in April 2005 with funding from the Higher Education Funding Council for England. It is a partnership or three universities: London Metropolitan University, the University of Cambridge, and the University of Nottingham. It has incorporated the work of the partners carried out prior to the advent of CETL, and further developed these areas extensively. The design principles, methods, and tools described in this chapter are incorporated in the work of the centre. The CETL Web site provides access to specimen learning objects and to the supporting methodologies and tools, mentioned in this chapterer, as these become publicly available (CETL-RLO, 2007).

APPROACHES TO "LEARNING OBJECTS" AND ENHANCED LEARNING

The quote at the beginning of the chapter by Duval, Hodgins, Rehak, and Robson (2003) expresses an aspiration that learning objects should increase the effectiveness of learning. Different strategies may be adopted to achieve this aim. One major focus has been the development of international specifications for learning objects. The central specifications are IMS Content Packaging, SCORM, and the IEEE Learning Object Metadata (ADL, 2006; IEEE, 2002; IMS, 2007). The IMS content specification provides a standard way of packaging learning objects so that they may be transported across software systems. The learning objects may then be unpackaged and reused within the client learning management system. The primary aim of IMS Content Packaging is thus to deal with the issue of interoperability. SCORM extends the IMS work by providing standards for runtime communication between the learning management system and the learning objects.

The IEEE LOM (Learning Object Metadata) provides a standard structure for describing learning objects. LOM aims to support the efficient search for and retrieval of learning objects by tutors. Thus, learning objects with LOM descriptions may be stored in repositories. Tutors can search the LOM descriptions to locate suitable learning objects. These learning objects may then be downloaded into the local learning management system, where they are unpacked and used. Tool support has been developed to support these specifications. Thus, for example, the RELOAD application can be used to package learning objects and add metadata (RELOAD, 2005). There are also several commercial learning object management systems, such as Intralibrary which underpins the UK National learning object repository (Intrallect, 2007).

A significant point about this approach is that it totally avoids the issue of pedagogical design. This is signaled in the IEEE LOM definition of a learning object as "any entity that…may be used for learning, education or training" (IEEE, 2002). The implication is that making available the standards for storage and description would, of itself, bring about the target pedagogical goal. However, the evidence does not support this assumption (e.g., Koppi, Bogle, & Lavitt, 2004; Margaryan, 2006).

There are a number of problems with this approach. First, there is no clear conceptual model of what a learning object is. This means that there are likely to be significant problems when people attempt to link these learning objects together. The second major problem is that creating large repositories of indifferent quality material does not seem a good strategy for enhancing the effectiveness of learning. It would seem that if one wants to enhance the quality of learning, then the pedagogical quality of the learning objects is crucial. A clear conceptual model of learning objects and good pedagogical design are thus crucial endeavours.

WHAT ARE LEARNING OBJECTS?

Despite numerous definitions (e.g., IEEE, 2002; Learning Objects Portal, 2007; Polsani, 2003), there remains considerable ambiguity about the term learning objects. Learning objects are referred to as if they are the basic stand-alone units, which may then be combined to form higher order pedagogical units. This is reflected in the "Lego brick" metaphor (Hodgins & Connor, 2000). At the same time, higher order units (anything up to whole courses) are referred to as learning objects. This is a source of ambiguity and conceptual confusion. At what level of granularity do learning objects exist?

It is important to clarify the approach taken in this chapter to learning objects, which represents the approach adopted by the CETL in reusable learning objects. This is not represented as a definitive view of learning objects; it represents rather a clear definition of how learning objects are treated in the RLO CETL work. This clarity of definition then has implications for more productive explication of the relationship between learning objects and learning designs. This is a major theme explored in the second half of the chapter.

The ambiguity in the definitions of learning objects results from the confusion between definitions based on technical interoperability and the search for basic pedagogical units. The technical interoperability approach aimed to develop software structures for interoperability that could deal in a universally applicable way with all units of education/learning. Hence it defined learning objects in a very open way as *any entity* concerned with learning or training (IEEE, 2002). In parallel, learning objects were treated as small, foundational pedagogical units. Thus, learning objects are defined as "the smallest independent structural experience" (L"Allier, 1997) or "small, independent chunks of knowledge or interactions" (Chitwood, 2006). The approach adopted in this chapter builds on an approach that sees learning objects as basic, pedagogically meaningful units of learning (Boyle, 2003). Learning objects are thus viewed as "the minimum, meaningful pedagogical unit required to achieve a learning goal or objective."

The unity of each learning object is based on the focus on one distinct educational objective or goal. Each learning object has to be designed to enable the learners to achieve this goal. This approach to learning objects is embodied in the learning objects developed by the RLO CETL. It has turned out to be very important in maximising potential for reuse. Key design issues that emerge are:

- How do you construct these basic learning objects to maximise pedagogical impact?
- How do you construct them in order to maximise potential for reuse?

DESIGN FOR LEARNING AND DESIGN FOR REUSE

Pedagogical Design of Learning Objects

Boyle (2003) sets out design principles for learning objects that tackle both the issues of pedagogical design and design for reuse. The background to this chapter was the need to tackle a significant and widespread educational problem. This problem, reported repeatedly in national and international workshops, was the difficulties students faced in learning to program. These difficulties were leading to high failure and dropout rates. This problem was tackled using a combination of blended learning with reusable learning objects. The resources were developed as reusable learning objects so that they could be used to tackle the wider national and international problem. This project was very successful leading to substantial improvements in pass rates (Bradley & Boyle, 2004). The learning objects developed went on to win a European Academic Software Award in 2004 (EASA, 2004).

The set of learning objects developed for introductory programming in Java embody a series of pedagogical techniques closely linked to the learning problems the students face. Thus, it was observed that a significant problem for students in learning to program was early alienation and disengagement. The programming concepts seemed alien and abstract to them and to have no relationship to their everyday life. Thus, multimedia illustrations were used to show that these ideas were not alien, but familiar in everyday life, and even fun. Graphic illustrations and animations are used to visualise abstract ideas. Learners are given control so that they can move through the learning experience at their own pace and can repeat sections where they desire. The learning experiences are made interactive, were possible, so that the learner can actively explore the concept, construct, or process. Techniques such as "scaffolding" are used to enable the learners to construct representations under controlled conditions and to provide a transition into the real world context with its extra distractions and complexity. These learning objects can be accessed online (Learning objects for programming, 2004).

These design principles may be summarised:

- Orient the learner in simple learner focused terms to the aim of the learning experience;
- Use visualisation, often with familiar examples, to engage the learner in understanding abstract or "alien" or difficult concepts;
- Provide interactive experiences so that the learner can actively explore the construct or process;

- Provide learner control so that they can move through the learning experience at their own pace and can repeat sections where they desire;
- Use "scaffolding" exercises to support them in making the transition into contexts (by providing a simpler, more supported version of the real world task)

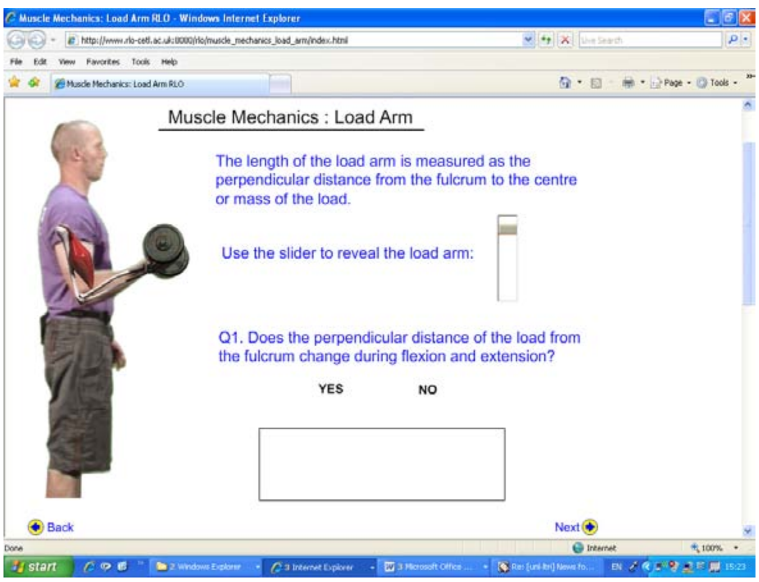
These principles are not exclusive. Creativity in devising and applying design techniques is encouraged. Creativity is required in the design of effective learning objects for challenging topics.

These design principles have been picked up and enhanced in the work of the CETL in reusable learning objects. The learning objects now cover a range of subject areas including business, mathematics, statistics, health science, study skills, and sports science. Figure 1 shows an illustration from one of these learning objects, developed by Carl Smith. Here a rich interactive animation allows the learner to peel back the layers of a human body, exposing first the muscle and then the bone structure in order to conceptualise the mechanical system acting at the elbow joint. This is a striking example of a rich multimedia visualisation serving an educational purpose.

Design for Reusability

A key feature of learning objects is that they are meant to be "stand-alone." However, this assertion has little meaning without design principles that specify how it can be achieved. The lack of such design principles has allowed considerable elasticity in how "stand-alone" is interpreted. How can we create small, modular standalone

Figure 1. Visualisation of muscle action and forces acting around the elbow joint



The learning object opens with a video of a person lifting a weight. As the learner can move the slider on the right of the screen he/she can reveal the underlying muscle action, and by further movement view a schematic of the relevant biomechanical forces.

learning objects that are highly reusable? Boyle (2003) advocates the principles of cohesion and decoupling. These principles affect the selection of the learning object goal and the structuring of the content and activities to achieve that goal.

The first key step in the design of a learning object is the selection and scoping of the goal. To design a learning object as a minimum, meaningful learning object, we need to select a clear, distinct goal. The learning objects on programming, for example, each deal with one clear concept in programming. Thus, if there are three types of constructs for "repetition" in a language this naturally leads to three distinct learning objects. Each learning object involves a meaningful achievement (understanding the target repetition construct). Operating in this way increases flexibility of access for learners (they can choose the specific topic that interests them) and potentiality for reuse. Higher order learning resources can be created by aggregating and linking the basic learning objects.

Having selected the goal the next principle is that of cohesion; each unit should do one thing and one thing only. The selection and organisation of the content and activities are focused on the learning goal and that goal alone. In order to provide this self-contained feature of learning objects, a further design principle is important. The principle of "decoupling," or more accurately minimised coupling, states that the learning object should have minimal bindings to other units. Thus the content of one learning object should not refer to and use material in another learning object in such a way as to create necessary dependencies. One object then cannot be used independently of the other.

The design of the content and activities within the learning object should be clearly focused on the goal of learning. Reference to other goals, for example, to distinguish them from the target goal, should not be included in the learning object. This produces unnecessary coupling. If such comparisons are pedagogically valid, then they should be the subject of a higher order learning object. This is not only a useful structural discipline to increase potentiality for reuse; it is also useful, pedagogically. Adding extra, unnecessary cognitive load to a learning object may cause failure to learn, where otherwise there would have been success. Teasing out the separate levels of complexity and letting the learner have control of the level, as far as possible, is an important principle. Tutors and learners naturally think at different levels within a subject. Learning objects should act as a mediating resource between the natural cognitive level of the tutor and that of the learners. Achieving this requires careful thought about the issue of being a "minimum, meaningful unit."

This point has been emphasised because of the implications for pedagogy and potentiality for reuse. It raises the issue, however, of how to deal with higher order learning objectives on Bloom's taxonomy. One answer is to produce a "higher order" learning object which may itself incorporate simpler, stand-alone learning objects. For example, the CETL has developed a learning object on reflective writing that coordinates a number of stand-alone learning objects to achieve this higher order pedagogical goal.

The vision then is of a group of cohesive and decoupled learning objects that can be selected and ordered to provide different learning experiences. Developing learning objects in this way enables tutors to select and sequence learning objects in higher order learning contexts. It also gives the learners greater freedom and flexibility; for example, these small learning objects are ideal for access over the new generation of mobile multimedia devices (Bradley, Haynes, & Boyle, 2005).

EMBEDDING DESIGN PRINCIPLES IN A FULL LIFE CYCLE

These design principles need to be embedded in a life cycle for the development of learning objects.

The CETL for Reusable Learning Objects has developed an agile method for developing rich, reusable learning objects. This method synthesises methods for the design and development of learning objects developed at London Metropolitan University, the University of Cambridge, and the University of Nottingham. The CETL combined the best of these processes to create a unified development framework for CETL projects. The aim is to provide a robust and flexible framework that will support the development of high quality learning objects.

Development is normally carried out by collaborative groups of academic tutors and multimedia developers, in which:

- The academic tutors are responsible for the conceptual (pedagogical) design of the learning object, while the multimedia developers provide expertise in presentation (multimedia) design and development;
- There is close involvement of academic staff and students in the whole life cycle of development, delivery, and evaluation of the learning objects;
- There is a strong emphasis on quality assurance and student evaluation.

Figure 2 shows one such collaborative group working at the early stage of developing a new learning object.

The framework emphasises the need to understand the problem before designing the solution. Projects start, therefore, with an analysis of the learners' needs. The output of this analysis informs the design and development process. Design and development is an iterative process involving a collaborative group, including centrally the aca-

Figure 2. Group working on the early design stages of a learning object at the RLO CETL residential event in Cambridge, June 2006

demic tutor(s) and a multimedia developer. An important feature of the method is that the learning objects are then used with significant groups of students. There is "use before reuse." The use with students provides a basis for evaluating the extent to which the learning objects have met the original objectives. Finally, and only at this stage, are the learning objects packaged, with full metadata description, and stored in a repository for wider reuse.

The purpose of the analysis phase is to understand and clarify the reasons for developing the learning object(s). What are the problems the students face? How might the availability of new learning objects help the students deal with these problems? The output of this phase is the set of requirements/challenges for the design and development phase.

The main development of the multimedia learning objects involves close, dynamic interaction between the module tutors and the multimedia developer. This supports a rapid prototyping style of development. The tutor will typically express their initial ideas on paper for the multimedia developer. This may lead to the development and initial prototype, which enables joint visualisation of the idea. Inspection of the prototype leads to ideas for further refinement and development. The prototype then "evolves" through several of these intense cycles. The cycles of *design ideas, prototype implementation, and critical evaluation* drive the development of the learning object. This is typical of approaches to software development known as agile or rapid application development (RAD) methods (Stapleton, 1997).

A major advantage of this approach for the tutor is that they can see the evolving visualisation of the idea. This can be a considerable help in translating their ideas into an animated visual format. Because iterative prototypes are produced, students can be asked to express their views of the evolving learning object. This approach thus permits critical, constructive evaluation to be incorporated early in the design phase. This permits problems to be detected early, and hopefully, corrected or removed.

Each new batch of learning objects is normally subjected to use and evaluation with local students before the learning objects are released for general (re)use. The evaluation is concerned with the extent and pattern of the students' use of the learning objects, their assessment of the learning objects, and evidence for the pedagogical effectiveness of the learning objects. The evaluation should be related to the requirements elicited in the analysis phase. The information collected should then be formally recorded and be available to be included in the learning object metadata. The CETL for reusable learning objects has produced a toolset for such evaluation which is available for downloading (CETL-RLO, 2007).

Learning objects are small and relatively self-contained. This means that parallel development on several learning objects can take place at the same time with partially overlapping personnel. The multimedia developer, for example, may be shared across different teams. Developing learning resources in higher education usually operates under conditions of time constraint and pressure on tutors. Small agile teams of tutors, working with multimedia developments to create learning objects, is a productive way of developing high-quality materials in a feasible way. A fuller description of the CETL agile development method is given in Boyle et al. (2006).

GENERATIVE LEARNING OBJECTS: REUSE BASED ON EXECUTABLE DESIGNS

The focus of the chapter so far has been on design principles for developing learning objects. In the RLO CETL, these design principles have been linked to an agile development method to underpin and support the production of high-quality learning objects. From the beginning, this approach has emphasised the importance of good design, but these designs have been embedded in particular artefacts—the specific learning objects. The present phase of development is concerned with extracting these designs and making the design pattern the basis for reuse. There are a number of reasons for making this significant switch in emphasis. It is quite an intensive business to create high-quality learning objects. Yet the potential impact of these handcrafted objects is limited in two major ways: productivity and acceptability. The original EASA multimedia learning objects, for example, were developed for the Java programming language. Many of the constructs, for example, loops and decisions, are generic to a range of programming languages. It would be much more productive if the designs can be reused for teaching many languages, with the specific programming code substituted. The explanations and pedagogical commentary in the original learning objects are in English. It would again be very useful if the commentary could be translated while the rest of the learning objects worked as normal. These operations are time-consuming with the original multimedia learning objects and require the help of a specialist Flash developer. It would be beneficial if the changes could be made quickly and easily by a tutor to create new instances of the same learning objects pattern.

A second major consideration concerns usability and acceptability. Our experience, and that of others, has been that many tutors want to repurpose or adapt the learning objects to meet local needs and preferences (Gunn, Woodgate, & O'Grady, 2005). The inability to adapt the learning object can become a significant barrier to reuse. It, therefore, seems sensible to provide learning objects formats that enable and facilitate such adaptation and repurposing.

These considerations, among others, led to the development of the concept of "generative learning objects" (GLOs) (Boyle, 2006). With GLOs the primary focus of reuse is not the specific learning object but rather the design pattern that underpins the object. This switch in emphasis raises two main challenges. The first is the development of a clear conceptual model to capture and represent design patterns. The second challenge is to make these patterns accessible to tutors through a tool that permits access to and adaptation of the elements of the pattern.

There were three major influences in developing the conceptual model for generative learning objects: linguistics, the pedagogical patterns literature, and object oriented design. In object oriented design and programming, it is not the object that is the basis for reuse; it is the underlying class of which the object is simply a concrete instance. The word "class" has other connotations in teaching and learning so the term "generative learning object" is used instead. The term is derived from generative linguistics which has provided a strong influence on the development of the concept. Generative linguistics distinguishes between the surface structure of a sentence (in our terms, the concrete "object") and the deep structure (the underlying design pattern) from which it is generated. It employs a parallel distinction to that made in object oriented design; in both approaches, it is the underlying deep structure that provides the basis for reuse.

Generative linguistics, in addition, provides models for how the generative process takes place. Capturing patterns, not as static templates, but as small grammars that generate a class of learning objects, turns out to be a very productive concept. The decisions at each node in these grammars are described using a format derived from the pedagogical patterns literature (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King, & Angel, 1997; Fincher & Utting, 2002). These descriptions elucidate the pedagogical meaning and the possible options for expressing that meaning. The theoretical basis for generative learning objects (GLOs) is described in more detail in Boyle (2006).

This approach provides a very powerful way of capturing underlying design patterns. However, these patterns need to be presented to tutors in a way that is understandable to them and enables their active engagement with the pattern. An abstract text-based description is unlikely to achieve these aims. A primary concern thus became to capture these design patterns in a tool that would provide a much more amenable representation of the designs, and enable tutors to manipulate these designs for repurposing learning objects or even creating new learning objects.

THE GLO AUTHORING TOOL

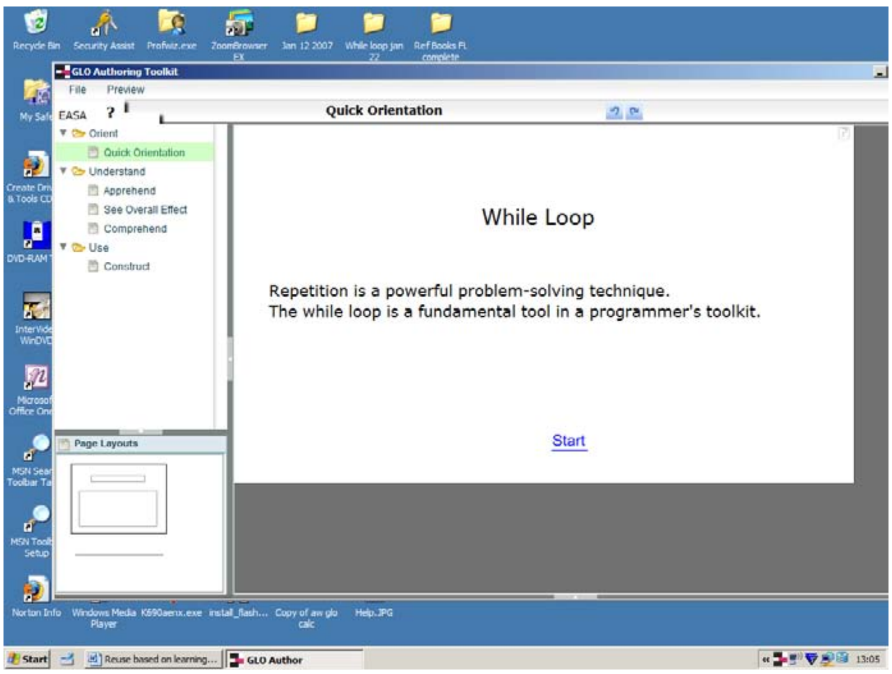
The GLO authoring tool captures design patterns in a form that tutors can manipulate to create new learning objects based on successful and tested patterns. Alternatively, the tutor can use the tool to easily and quickly produce adapted variants of existing learning objects. It thus tackles the problems of productivity and adaptability that are highlighted earlier.

The tool permits access to one or more underlying design patterns, which provide the basis for generating or adapting learning objects based on the chosen design. The initial design built into the tool is based on the learning objects that won the EASA award (Boyle, 2003; EASA, 2004). A careful and detailed analysis of these learning objects led to the extraction of the "pattern" underpinning the objects. This pattern was represented as a small production grammar that underpinned the creation of specific objects that instantiate (realise in a concrete form) this pattern.

Figure 3 provides a screenshot of the GLO tool, which illustrates the main elements of the tool.

The panel at the top left of the screen provides a snapshot of the pedagogical function selected in this pattern. The top level functions ("orient,"

Figure 3. Screen shot from the GLO tool

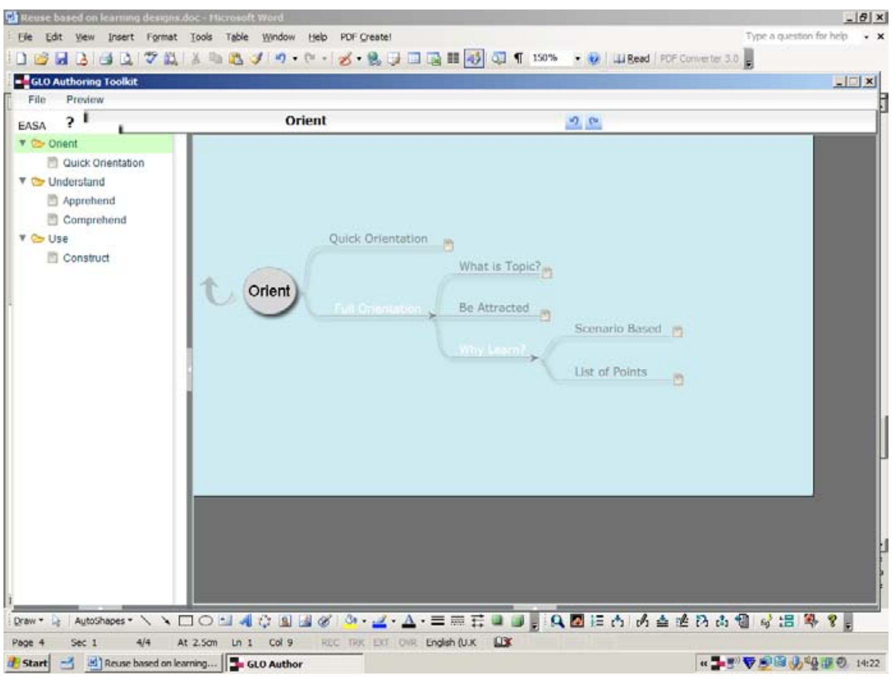


"understand" and "use") are expanded into more refined choices. Each of the options represented is mapped onto a "page" type that provides a default implementation for the function. Thus the function highlighted in the example ("quick orientation") is realised by a page that provides slots for a title and brief introduction to the learning object (as illustrated in the Figure). Further refinement is carried out at the level of components within the page frame, in terms of pedagogical functions such as "provide explanation" or "provide illustration." Each page type or significant component has pedagogical guidance attached (accessed through the light question marks on the screen) to explain the options available and to provide help on selecting the appropriate one to meet the tutor's requirements.

The tool may be used in different modes. The basic principle is to make easy things easy and more ambitious things possible. The simplest mode is to adapt or repurpose an existing object. If the tutor simply wants to change text, then he/she can directly access the text and change it. The tutor can then save and use the modified learning object. This is possible because the learning object is not directly saved as a Flash file. It is saved as an XML (structured text) file. This file drives a "player" program which renders the XML instructions as a Flash multimedia file. It is thus easy to create multiple variants of the "same" multimedia learning object. Instead of the text being locked in a multimedia file format it is made available to the tutor as a component that they can edit and change. Translation into different languages is thus greatly facilitated.

At a more ambitious level, the tutor may wish to change the structure of the learning object. Thus, the tutor may want a fuller introduction for the learners than that provided by the "standard" object. The mechanism for achieving this

Figure 4. Illustration of design options for expanding the Orient function



is illustrated in Figure 4. The tutor has selected the top level "Orient" function. This opens up a network (or small functional grammar) that illustrates the options open to the tutor. The small page icons show where a choice is mapped onto a default realisation "page." Thus, the tutor may select to replace "quick orientation" with a "full orientation" consisting of three parts: "what is the topic," "why is it attractive," and an explanation of "why learn it" (perhaps explained through the "list of points" option). Each choice is realised immediately by the provision of a default page type for implementing that function. The default page types simplify the choice of how to realise a function. Alternative page forms are also available. The variant pages are accessed through the panel illustrated at the bottom left of the screen shot in Figure 3. Each variant may be previewed in the main panel before the final choice is made.

The GLO tool is being used in three main ways. The first is to adapt an existing learning object (or set of objects based on the same design pattern). Thus, we had a tutor in the CETL who wished to convert a number of the original EASA learning objects to teach Visual Basic instead of Java. Although the tool was not fully developed at this time, a number of the learning objects were converted to work with the new programming language within a very short period with the full multimedia functionality of the originals retained. The second use is to develop new objects where the subject matter is different, but the pedagogical pattern is common. The GLO tool is being used to develop learning objects for business studies using the pattern originally developed for the learning objects for programming (EASA RLOs 2004). The third use is to capture new design patterns. At present, we are doing this as part of a UK JISC funded project. Learning designs, initially identified through collaborative workshops are being captured as new generative patterns in the GLO tool. This provides a set of patterns that the tutor/designer may choose from in creating a new learning object. As an example, we are working with the UK National Subject Centre for History, Classics and Archaeology to develop a GLO pattern for "evaluating multiple interpretations."

The development of the GLO tool opens up a rich new functionality for tutors. Tutors can directly access and modify multimedia learning objects to suit their needs. The ongoing development of the tool treats the issue of usability equally to that of functionality. The tool is structured to support collaborative development between tutors and multimedia developers. All learning objects produced using the tool are open to repurposing by local tutors. The generative learning object approach thus offers great advantages in moving towards the goal of widespread reuse and repurposing of rich learning resources.

LEARNING OBJECTS AND LEARNING DESIGNS: THE BIGGER PICTURE

When we view the work on learning objects at the broadest level, it becomes clear that the idea of learning objects really operates as a metaconcept; it refers not to one thing, but to a family of related things. By using the one term, however, it is implicitly assumed that there is some underlying theme or themes linking this family; that is, it is sensible to apply this metaconcept. Exploration of the broader learning object "metaconcept" requires linking the approach adopted in this chapter to the "knowledge engineering" and wider "learning design" strands of work.

Three major dimensions may be delineated in the wider discussion of the domain of learning objects. These dimensions are represented in Figure 5. This figure represents the learning object conceptual world as a three-dimensional space. This 3-D mapping helps us to see how important issues are represented in this broader space. The first dimension represents the transition from "raw" learning objects to those packaged using the international standards and specifications.

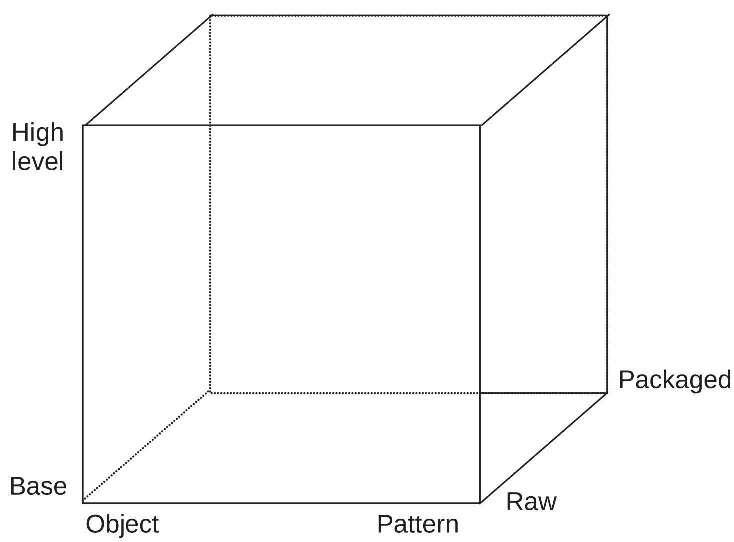
The second dimension referred to is that of "size." What is the relationship between basic learning objects and higher-order, more complex "learning objects"? The third dimension (represented as the horizontal dimension in the cube) refers to the relationship between learning objects and learning designs. A 3-D space based on these dimensions allows us to see how the various approaches to learning objects are related.

How we view "learning objects" depends on which perspective within the mapping space we adopt. The "*raw–packaged*" dimension explicitly separates the basic pedagogical learning object from its IMS or SCORM packaged form. It asserts that learning objects are pedagogical entities before they are packaged entities. Therefore, learning objects at this quadrant of the space must be defined in purely pedagogical and structural terms. If one views the space from the back pane—that dealing with packaging and metadata—however, then it is clear that everything in the space can be viewed as a learning object. The famous LOM definition of a learning object "as any entity that…may be used for learning, education or training" then makes sense (IEEE, 2002). The packaging and descriptive mechanisms were designed to be generic, so that everything in this space, whether it is object or design, can be "packaged" and described.

The "*instance–pattern*" dimension is covered in the work reviewed in this chapter on generative learning objects and the GLO tool. This work points to the pedagogical patterns inherent in learning objects and argues that the generation of new instances based on these patterns provides a powerful model for repurposing and reuse.

The "*base–high level*" (size) dimension has received a lot of attention in the learning object literature. The term "aggregation" has been used to refer to learning objects of different sizes and how they are related to each other. The concept of content aggregation, however, betrays a simplicity of perspective. It is as if "bigger" learning objects are created by sticking together smaller learning

Figure 5. Mapping the learning object space



objects. There are more sophisticated models, such as the "levels of patterning" of natural language, which can productively be applied to articulate this dimension. This points to the inadequacy of an approach to "size" based on content aggregation. This question is much more productively tackled by focusing on the righthand (design focused) side of the cube (Figure 5).

A major issue that remains is the relationship between learning designs at the generative learning object level and learning designs posited at higher levels of reuse, as in the IMS LD work (Britain, 2004). Learning designs operate at many levels of granularity from the small to the very large (Harper & Oliver, 2002). The IMS LD work has focused on learning designs at a higher level (around the lesson plan level). This is located conceptually at around the vertical midpoint on the righthand side of the cube. It then treats learning objects primarily as chunks of content that can be loaded into these plans (IMS LD, 2003). This approach to reusable learning designs is inadequate; it bypasses a whole conceptual area of the learning object cube.

How do learning designs at one level, for example, at the generative object level, relate to higher-order designs at the lesson plan level? The short-circuiting of the design space suggested in the IMS LD work is inadequate. By clarifying the learning designs at the base level, the generative learning object work opens up the question of how designs at this level may be related to and incorporated within higher level teaching/learning designs. This is a productive challenge for further research and development. It points to the challenge of elucidating different layers of learning design and how the designs at different levels relate to each another.

The challenge is to conceptually understand, and make work, an architecture where designs at one layer naturally use and incorporate "lower layer" designs in elegant and powerful ways. The concept of GLOs contributes to this work in two main ways. It establishes the importance of good (reusable) designs at the most basic level of learning. This, in turn, points to a model of "layered learning design" where higher layers of design incorporate and reuse more specific learning designs. In this approach, the next design layer (e.g., lesson/session plans) ought to be able to use the services supplied by the GLOs in a principled and productive way. Producing an architectural model to support such "layered learning design" is a significant challenge for future research.

CONCLUSION

Effective design is a central requirement if learning objects are to deliver on their potential to enhance learning. This has been ignored in the standards based knowledge engineering approach to learning objects, which takes the stance of being pedagogically neutral. This chapter has outlined a successful approach to learning object design and use. It has reviewed a set of principles for the pedagogical and structural design of learning objects. It then described the work of the CETL in reusable learning objects in developing methodologies and tool support to embed these design principles in a full development process.

The chapter then described an approach to reuse and repurposing based on capturing and making available the pedagogical patterns inherent in successful learning objects. Generative learning objects, incorporating successful pedagogical patterns, provide a new focus for reuse and repurposing. It is, in the end, the capture and reuse of effective pedagogical designs that provides the most powerful basis for ensuring the pedagogical impact of learning objects. Finally, the chapter has raised the issue of "layered learning design" as a major focus for future development. This research and development agenda is challenging, but it points towards an achievement that would have considerable conceptual power and practical significance.

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REFERENCES

ADL. (2006). Retrieved April 7, 2008, from http://www.adlnet.gov/Scorm/

Alexander, C., with Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A pattern language*. Oxford University Press.

AUTC Learning Designs. (2002). AUTC Learning Designs Project. Retrieved April 7, 2008, from http://www.learningdesigns.uow.edu.au/

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology, 19*(1), 46-58. Retrieved April 7, 2008, from http://www.ascilite.org.au/ajet/ajet19/boyle.html

Boyle, T. (2006, June 26-30). The design and development of second generation learning objects (Invited talk). In E. Pearson & P. Bohman (Eds.), *Proceedings of Ed-Media 2006 World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Orlando, Florida.

Boyle, T., Windle, R., Leeder, D., Wharrad, H., Alton, R., & Cook, J. (2006). An agile method for developing learning objects. In *Proceedings of the 23rd Annual Ascilite Conference: Who's Learning? Whose Technology?* Retrieved April 7, 2008, from http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p64.pdf

Bradley, C., & Boyle, T. (2004). The design, development and use of multimedia learning objects [Special issue on learning objects]. *Journal of Educational Multimedia and Hypermedia, 13*(4), 371-389.

Bradley, C., Haynes, R., & Boyle, T. (2005). Design for multimedia m-learning: Lessons from two case studies. In J. Cook & D. Whitelock (Eds.), E*xploring the frontiers of e-learning: Borders, outposts and migration: Research Proceedings of the 12th Association for Learning Technology Conference (ALT-C 2005).*

Britain, S. (2004, May). *A review of learning design: Concept, specifications and tools* (Report for the JISC E-learning Pedagogy Programme). Retrieved April 7, 2008, from http://www.jisc.ac.uk/uploaded_documents/ACF83C.doc

CETL-RLO. (2007). *Centre for Excellence in Teaching Learning (CETL) for Reusable Learning Objects*. Retrieved April 7, 2008, from http://www.rlo-cetl.ac.uk/

Chitwood, K. (2006). *The Wisc-Online Resource Center*. Retrieved April 7, 2008, from conference.merlot.org/2006/MICO6/MIC06Wednesday/ChitwoodWorkshop.ppt

Dalziel, J. (2003). *Implementing learning design: The learning activity management system (LAMS).* Retrieved April 7, 2008, from http://ilearn.senecac.on.ca/lop/information/script.htm

Duval, E., Hodgins, W., Rehak, D., & Robson, R. (2003). *Call for "Learning Objects 2003 Symposium: Lessons Learned, Questions Asked."* Retrieved April 7, 2008, from http://www.aace.org/conf/edmedia/symposium2003.htm

EASA. (2004). European Academic Software Awards. Retrieved April 7, 2008, from http://www.bth.se/llab/easa.nsf/

Fincher, S., & Utting, I. (2002). Pedagogical patterns: Their place in the genre. In *Proceedings of the 7th Annual Conference on Innovation and Technology in Computer Science Education*.

Gunn, C., Woodgate, S., & O"Grady, W. (2005). Repurposing learning objects: A sustainable alternative? *ALT-J, 13*(3), 189-200.

Harper, B., & Oliver, R. (2002). *Information and communication technologies in flexible learning* (Presentation of the outcomes of the AUTC project). Retrieved April 7, 2008, from http://www.iml.uts.edu.au/autc/

Hodgins, W., & Connor, M. (2000). Everything you wanted to know about learning objects but were afraid to ask. *Zine*. Retrieved April 7, 2008, from http://www.linezine.com/2.1/features/wheyewtkls.htm

IEEE. (2002). *Draft standard for learning object metadata*. Retrieved April 7, 2008, from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

IMS. (2007). *IMS Global Learning Consortium*. Retrieved April 7, 2008, from http://www.imsglobal.org/

IMS LD. (2003). *IMS Learning Design specification V1.0*. Retrieved April 7, 2008, from http://www.imsglobal.org/learningdesign/index.html

Intrallect. (2007). Retrieved April 7, 2008, from http://www.intrallect.com/

Koppi, T., Bogle, L., & Lavitt, N. (2004). *Institutional use of learning objects: Lessons learned and future directions. Journal of Educational Multimedia and Hypermedia, 13*(4), 449-463. AACE.

L"Allier, J. J. (1997). *Frame of reference: NETg's map to the products, their structure and core beliefs.* NetG.

Learning objects for programming. (2004). Retrieved April 7, 2008, from http://www.londonmet.ac.uk/ltri/learningobjects/list.htm

Learning Objects Portal. (2007). *Learning Objects Portal*. Retrieved April 7, 2008, from http://ilearn.senecac.on.ca/lop/information/script.htm

Margaryan, A. (2006, June 15). Community dimensions of learning object repositories (CD-LOR, Public summary of internal CD-LOR report). Retrieved April 7, 2008, from http://academy.gcal.ac.uk/cd-lor/CDLORdeliverable_UserInterviewsReport.pdf

Polsani, P. R. (2003, February 19). Use and abuse of reusable learning objects. *Journal of Digital Information, 3*(4), article no. 164. Retrieved April 7, 2008, from http://jodi.tamu.edu/Articles/v03/i04/Polsani/

RELOAD. (2005). Retrieved April 7, 2008, from http://www.reload.ac.uk/

Stapleton J. (1997). *Dynamic systems development method.* Addison-Wesley.

KEY TERMS

Agile Development Method: These are a class of software development methods that emphasise small, flexible teams, iterative prototyping with an emphasis on producing the right product rather than following the "right" bureaucratic process.

Generative Learning Objects (GLOs): The traditional approach to reusable learning objects is to separate content from the context in order to make the content reusable. GLOs invert this approach by focusing on the pedagogical form (or pattern) as the fundamental basis for reuse. Specific learning objects are generated from this underlying form.

Learning Designs: Attempt to capture, represent, and communicate structures and sequences of activities that lead to successful learning. Developments in this area have been parallel but separate to the pedagogical patterns work, but there are strong potential links between the two.

Layered Learning Design: An approach that identifies different layers at which learning design operates and seeks to elucidate the relationship between these layers.

Learning Objects: A learning object is viewed in this chapter as "the minimum, meaningful pedagogical unit required to achieve a learning goal or objective."

Pedagogical Patterns: Seek to capture successful solutions to pedagogical problems in the form of patterns that can be reused. This chapter deals with executable pedagogical patterns that provide the core structure for generative learning objects.

Chapter XX
Visual Meaning Management for Networked Learning

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ABSTRACT

This chapter introduces an approach to writing content for online learning over networked media. It argues that few resources currently utilise the fluid and multivoiced capacity of the Internet's networked nodal structure to provide multiple pathways through content, opportunities for independent research and reflection, or collaboration with peers in knowledge building. 'Learning objects' are one way to conceptualise content ideas and learning activities within this flexible environment. To effectively use this resource requires something quite different to traditional sequential writing. A more appropriate approach is to use nonlinear software that can map the nodes of the knowledge domain and make visible the internal relationships, connections, and paths of meaning. The purpose of this chapter is to provide the reader with a guide to developing a better understanding of how meaning is managed visually and proposes tools and strategies for a new structure of writing for networked media.

THE PROBLEM

A key issue for teachers in creating online learning objects for university students is bridging the considerable conceptual gap that lies between the understanding that underpins teaching and presenting learning in a print-media world and those understandings needed to teach effectively in a networked, electronic-media environment such as the Internet. In a book, an author's task is to construct a context and make possible paths made of learning objects through the content which in turn guides the reader towards building complex understandings. Because of the constraint of the medium (pages bound together as an ordered and discrete entity), authors often discard material that is peripheral to the central trajectory. They develop meanings in a direct sequence that can be relied on to remain as they were written for as long as the book lasts. In many cases, this discarded material would enrich the understanding were it able to be included in such a way that it would not inhibit nor interfere with the essential created meaning of the text. Footnotes are one way of dealing with this tangential material. This sequential method of writing imbues print-media with the perceived qualities of certainty, stability, and authority or control: qualities with which teaching and learning methodologies have long sought to be associated. The networked medium of the Internet, on the other hand, has very different qualities, each with consequences on the making of meaning.

This chapter focuses on rethinking the way we design teaching materials to accommodate and leverage those differences. If content can be reconsidered, redesigned, and married with the concept of 'learning objects,' as elements in a multinodal text, which allow readers/learners to map a path that supports their individual understandings, then a text can become a construction which potentially has greater meaning for the individual learner. These new approaches to writing are broader in their impact than simply making better use of the networked Internet for learning objects. They are relevant to all aspects of academic work because the Internet is changing the way communication is made.

There remains contention as to the form a learning object should take. Should it fit the SCORM model of small instructional components where reusability in different learning contexts is of prime importance (Wiley, 2000), or is a learning object more along the lines of Stephen Downes' (2003) definition: 'Anything—absolutely anything—can be used in learning. What makes it a learning object…is that there is some educational context in which the object was found to have pedagogical value.' In this chapter, learning objects are both the discreet learning object (comprising a purpose, activity, and way to assess achievement) and the broader educational context in which a number of learning objects (e.g., demonstration, skill tutorial, research questionnaire, practice activity, reflective module) are brought together into a pedagogical object with flexibility for independent activation and exploration.

Rethinking the writing of learning for networked media requires an understanding that we manage meaning visually and that meaning making is rarely straightforward. That we make meaning visually is not something new. A moment's reflection reveals that to build a coherent argument within a lecture (paper, book), academics organise the visual order of ideas and their connections one to the other, over the span of sequential pages. Their idea of appropriate paths to proficiency of knowledge in their domain is gained through their own experience of that domain under guidance of an expert. In the lecture theatre, the lecturer can provide the appropriate guidance, contextualisation, and strategic understandings that identify a learning domain simply by being there and talking in the language of that domain. In the stand-alone and online learning environment, other means are required to establish these discipline-specific understandings. This is where networked media, with its expanded expressive resources, can help take meaning management into new forms, branching out to a distributed map interface that emphasises the visual spread and plurality of connections between concepts. A concept map is a close visual approximation of this way of managing meaning.

Meaning management in a networked environment requires the development and expansion of visual rhetoric—the body of rules, methods, and means derived from experiences that make efficient communication at another time and/or space possible (Fowler, 1908). These rules are important because they establish a common ground that allows meaning to be communicated across boundaries of difference. In the concept map, the connections and relationships, or paths, between ideas, theories, and practices are made more visible than the same ideas expressed in a page of text. And the map accommodates the reality that many paths to an answer exist within a knowledge domain. It is in this area of path-making for networked media that there is a particular need for a common rhetoric. Guidelines deal with expressing a multiplicity of paths that go into, out of, and through the mapped concepts on the screen and into and out of other linked but separate networked documents, while sustaining the connection with the domain as a whole.

The aim of this chapter is to introduce teachers and academics to the need for change in how complex tertiary-level learning is composed in order to leverage the networked medium's unique capacities for expressing ideas and connecting these ideas in many meaningful ways. The chapter begins by tracing the swings in the historical debate regarding design of meaning for communication since Plato to give the reader an understanding of the ongoing polemic of visual rhetoric in meaning management and how it affects communication on a daily basis. It will describe the differences between print and the more conversational networked media and the potential in those differences. Particularly, it will explore the making of multiple linking paths in networked documents to achieve robust and focused meanings. To assist the reader, the chapter also discusses the type of tools that can be used for this new writing and provides a four-step procedure to apply in evolving a multipath networked document. Finally, the chapter considers the attributes for a provisional multimedia networked rhetoric.

ONGOING DEBATES IN VISUAL MEANING MANAGEMENT

The discussion about visual representation of information starts with the problem of rhetoric. Because rhetoric examines so closely the *how* of language and the methods and means of communication, it is frequently considered by writers and academics as something only concerned with style or appearances and not with the quality or content of communication (Burton, 2007). Throughout history in the West, there has been continuous debate over the effect expression has on ideas and their communication. The debate begins, in written records, when Gorgias (483–376 BC), a Sophist from Sicily, proposed three key philosophical ideas about human existence, the last of which is, 'if something *can* be known, it *cannot* be communicated' (Adams, 1999). Later in the *Republic*, Plato was to express his distrust of expressive forms, such as poetry and music. In his concern for 'truth' and its clarity, he believed that rhetoric was at best superficial, at worst, deceptive and damaging of man's virtue. He advocated that the means of conveying a message should be transparent (invisible), so that the content can shine in all its 'purity' (Planeaux, 1999). The countervailing attitude is that forms of expression (words, poetry, image, music) transcend verbal meanings and are capable of conveying the inexpressible and that visual/verbal expression is vital in the making of meaning for communication; without expression, there is no communication.

This recurring alternation between what became known in the nineteenth century as classic and romantic expression occurs throughout our history, swinging from one extreme to the other depending on local circumstances. Sometimes elaborate display is valued and in other periods, or within certain groups of the population, it is cursed as evil. For example, the Rococo period during the reign of the Sun King in sixteenthth century France was a time of extreme showiness expressing supreme power. In Puritan Holland of the early seventeenth century, the sermon and the religious tract were considered the highest expressions of Puritan art. The Roaring Twenties in the USA, also known as the Lawless Decade, are marked by a giddy ostentation, whereas on the other side of the Atlantic, a different reaction to the excesses of the first World War is expressed by the Bauhaus. The Bauhaus was a school of art and design (note that the debate is not just between academics and artists) established in 1919 in the Weimar Republic by architect Walter Gropius. In the Bauhaus is demonstrated the twentieth century's strongest drive for a return to the aesthetic ideals, 'the good' of the ancients. Bauhaus ideology is captured in the words *form follows function* (Tziamalis & Lambrou, 2002).

These examples represent the opposing ends of the debate concerning expressive communication. On one side is the 'idea' as pure and stand alone, that needs no expression in order to be communicated, and on the other side, appearances are the sole concern. To reconcile these points of view, it is worth considering the argument of designers like Edward Tufte (1983) that an idea that is not displayed, that cannot be seen or heard in ways that others can comprehend, cannot be said to have been communicated and cannot have meaning for others. Simply put, how one says something and the context in which it is said both contribute to the meaning of the idea being communicated. Tufte also makes clear that whereas effective expression adds value to an idea, the elaborate embellishment of documents with extraneous visual data—a trend very common with the advent of computers and clip art—is at best counterproductive, at worst, as Plato states, deceptive. If this is so, then we need to deal seriously with the issue of expression as it concerns learning objects, particularly in a medium where movement, image, and colour are added to typography as part of the expressive palette. Wherever the style of presentation for an idea is not built on the substance of that idea, if of itself the style does not assist in communication of an idea but exists for its own show, then as Plato points out, that expression distracts from and/or interferes with the clarity of meaning.

Figure 1. Tufte would call this "chart junk" because the extraneous visual details interfere with comprehension of the data. Pie Chart Clip-Art from Microsoft Word for Mac 2004.

For many academic writers, this polemic about expressive response and responsibility may seem irrelevant. It may seem that an article in a journal, for instance, is not designed but is just a simple presentation focused on the idea. This is the unseen power of rhetoric, for this document will employ a wide set of visually expressive clues to assist the making of meaning from the typescript. Commas, capital letters, paragraph breaks, first line indentation, to name a few, are all instances of visual meaning management assisting communication. They are susceptible to change. These are not the only visual clues to meaning. In a computer-focused office, a contemporary academic may be reading documents on screen that look exactly like print documents, black type on a white page. This is regarded as normal, not visual expression. But in a screen presentation, the use of a white background for black text results not from the needs of the computer or screen, but from the demand by consumers that the screen-world imitate the world of traditional printed documents.

This look is associated with authoritative academic writing. That the appearance of paper, however, is rendered by all light generators in the screen turned on full—making it the equivalent of looking into a fluorescent light all day—is not, where this fact is known, considered important enough to change rhetorical habits. (NB: Microsoft Word provides a setting of white type on a blue background which is less tiring on eyes.) The desire for things to look the same, feel the same, and carry the same rhetorical messages wins over best practice. The new working environment should not disturb or change traditional rhetorical practices that have 'always' been as they are, even if they have not. This is expressive meaning management in practice, and it does interfere with the meaning of communication. Networked electronic media is structured on hypertext-linked repositories of data, and not, as it appears in the page-like document on screen, the sequential pages in a book. And this networked structure is open to a conversational reciprocity that is totally different and counter to the permanence one associates with the printed word. A discussion of meaning management must inevitably consider the question of how authority and control are embedded in the rhetorical practices of print media.

The above debate about expression does not take issue with the inequalities of practice that have been codified in the mass communication environment, particularly since the invention of the printing press in the West in 1469. Brenda Dervin (1999) directs our attention away from the sanctity of content and the tendency to regard communication as somehow natural and not designed to consider how mass-media publishing, a one-to-many, top-down business model, disadvantages the many. It is a model that has also underpinned traditional teaching. Dervin foresees that the rise of the Internet and networked media will build communication systems that are also one-to-one and many-to-many, and that it is possible in this new networked communication to 'avoid the ways in which systems now automatically build inequities' (Dervin, 1999). It is this conversational and egalitarian potential in networked media that aligns with contemporary teaching practices. The power position of teachers in the classroom has long been contested by the theorists of constructivism and conversational learning. These theories advocate for the teacher to become the collaborative practitioner with the learner, building knowledge in conversation (Bransford, Brown, & Cocking, 1999; Laurillard, 2002; Riddle & Dabbagh, 1999). The learner/participants in networked media are actively looking for connections and moving from connection to connection—accumulating, negotiating, and acting as they go. It is this quality of networked communication that calls for new ways of thinking about how subject content is written and presented. Writing is no longer so much about linear progress in the presentation of facts to a certain end. Rather, it is about mapping multiple journeys through the knowledge domain that guides participants through a knowledge-constructing experience that allows them to acquire the skills, critical understandings, and practical capacity for appropriate independent action within that particular domain.

DIFFERENCES OF A CONVERSATIONAL STRUCTURE

The media takes expressive character from an underlying structure of networked nodes whose relationship cannot be predicted by proximity or order. These nodes are in potentially continual communication with other nodes, making a network of relationships that shifts and changes according to the demand of the reader. This circumstance of uncertainty does not serve the unfolding of a linear argument, but is effective for progressing the conversation of active learning (Laurillard, 2002). A traditional textbook is broadcast from a single source that is fixed, controlled, and unresponsive, qualities that often identify print-based pedagogical materials. In use, the Internet is more dialogic, joining peer to peer in active and negotiable transactions.

Because the Internet affects the way we experience communication, it will significantly change the way we 'know' and make 'sense.' The disconnected and instant jumps between texts on the Internet does not always present a problem to readers because sense is something dynamic that occurs while the user is within the content even when it is in linear form. Brenda Dervin defines sense in broad terms as a 'set of ontological and epistemological assumptions' arguing that humans 'make sense individually and collectively as they move: from order to disorder, from disorder to order' (Dervin, 1999). A book is structured so that it builds a persuasive internal momentum from order to disorder along a certain trajectory. This way of constructing a logical argument is often central to our ideas of education, and as a consequence, we expect logical, coherent, ordered, rigorous lines of discourse from our students.

It is useful at this stage to ask how logic, coherence, and rigour is to be sustained or even achieved when there is not one static document, but a conversational *mobility* between many documents. It is achieved in a similar way to print media. At the end of a paragraph of text, there is a need to telegraph to the reader what is coming in the next. Building these connective tissues of meaning management are part of the training in writing for the academic purposes. Kintsch (in McDonell, 2003) notes that 'we can remember what we have read as that information is still readily retrievable because the succeeding sentence most likely will contain retrieval cues that make it accessible in long-term working memory.' In the same way, readers make sense in an hypertext environment; however, new expressive devices are needed to maintain a sense of belonging within a discussion that can go backward and sideways as well as forward.

Just as the medium presents different challenges, so too it provides opportunities in a range of expressive resources much greater than print. Since the new medium is capable of greater communicative dynamics, it requires a broader palette of expressive devices for meaning management. The once innovative conventions of existing rhetorical practices embodied in print media now seem 'natural' or 'normal,' rather than as devices that were invented for a purpose. Because they are naturalised, it is difficult first to determine how much communication is shaped by the writer and how much the writer is shaped by the conventions [refer to DiMaggio & Powell, 1983, for further exploration of isomorphism and neo-institutional theory], or to understand the impacts that multidimensional expression will have on previously carefully constructed meaning management in printed texts. Understanding the potential implications of expressive mobility in networked media means understanding or 'seeing' that the Internet is a system within a diffuse and living network of connections.

It is critical that we begin to seek out the implications of networked media and adopt or invent new skills of writing for it even when the working environment allows little time for this activity. The U.S. report called 'The Case for Twentieth Century Learning,' in the series, *New Directions for Youth Development* (Schwarz & Kay, 2006), notes the perceived gap between the skills currently being taught in educational institutions and the new skill set students will need to succeed as twenty-first century citizens and workers in a global economy. These workers are the current and future students. The report notes that in order to be effective, learners need greater skills in critical thinking, problems solving, innovation, and communication (Schwarz & Kay, 2006). If, as has been demonstrated by researchers such as Gee (2003), an electronic networked learning environment can further assist students to learn how to communicate, collaborate, problem solve and innovate, think critically, and act independently, the different expressive characteristics should not be permitted to go unexplored.

Some discipline experts may still consider that dealing with the visual expression of text is more properly the domain of graphic designers, whereas it is clear the new media calls for new ways of writing, and for these new ways to be built on the discipline understanding of a subject expert. It is structural change that the new media requires of writers. The discipline expert knows the complex network of facts, theories, and relationships in their knowledge domain and the way these need to unfold to ensure they are in alignment with discipline knowledge. It is the discipline expert who can identify the relevant paths by which a participant can come to their own understandings. Participation of content experts driving the new rhetoric is crucial. It will ensure use of the new medium develops in ways that foreground discipline knowledge. The upside of the time invested in learning to write more visually is that because existing content is being approached from new angles, it opens up meanings and opportunities that may not have been previously seen. Of course, it is also important that linear and logical traditions of presentation are not discarded intentionally or unintentionally in the process, as they will remain core to our ways of thinking and knowing into the future. The Internet will not replace the book, but will form a fruitful partnership in which the Internet will be available both as an enhancing tool (Danton, 1999) and a supreme containment tool (Sofia, 2000), a medium that handles great volumes of hierarchical information while it enables nonlinear hyperspatial connections between the volumes of content.

Each knowledge domain has its own particular ways of thinking and acting, and it is these that are used in constructing the appropriate context for the acquisition of knowledge. Physics lecturer, David LaBrecque, talks about how the network of learning paths in his discipline resembles the complex network of facts and relationships that make up physics itself. He uses concepts like a hill to indicate increasing complexity.

We begin by mapping out learning paths on a multi-dimensional grid. For example the top of the hill…could represent a general concept like Newton's second law: F=ma. Height above the grid is a measure of complexity. Concepts like F=ma are complex because there [is] a vast network of relationships and facts needed to derive the concept and to apply it (LaBrecque, 1998).

While a learning design team, if an academic has access to such, will be able to make useful learning objects from discipline content in any form, if they are given linear content, it will remain essentially linear. Likewise, if a learning team is given multipath documents in which the discipline specific paths are drawn from the academic's individual experiences as a participant in the domain, the end product will reproduce them.

LEARNING PATHS

While it has been said that text on screen does not invite deep reading, that does not mean there can be no in-depth meaning making. Depth on screen is presented in very different ways. First, meaning paths do not just go forward; they move in all directions. Second, the difficulty in reading online might simply reflect the reader's expectations of the medium; they expect more than scrolling paragraphs of text.

When it comes to creating active learning paths, video games have much to offer as a model. In his book *What Video Games Have to Teach Us* (2003), Gee examines the informal learning environment of a typical video game (Gee uses 'video games' 'to cover all games whether on consoles or computers) and shows that far from being time-wasting, video games engage a player in an environment where they are active learners and have a great deal to offer academics designing formal learning objects. A player can make mistakes and attempt a problem many times until they succeed (action research), and they can turn to other players for assistance in real-time if the game is being played online (peer mentoring). In the online context, players can collaborate in real time with other players in a team to tackle game tasks that may be too hard for the individual player (collaboration), and they can negotiate to use another team member's game skills to assist in problem solving, such as being revived from the dead without losing advancement in the game or help another with their own skill set (leadership). What Gee describes in these video games is an engaging, active, and social learning process that provides contrast to the learning environments where often learners are regarded as intellects in isolation and as passive recipients of knowledge. This is clearly counter to the actuality of the commercial world where definitions of reality are a product of consensus (Gee, 2003; Lankshear & Knobel, 2003). In active and social video games, advanced players also come to an understanding of how the game is designed and begin to participate in the game at the level equal to a coproducer, which demonstrates skills of leadership and independent action that employers now ask for (Schwarz & Kay, 2006). Gee (2003) cites many examples of this kind of metalevel understanding, for instance, the gamer who hacked into the game servers in order to edit the game itself. This same gamer modified a game called *Civilisation* and went on to edit the credits of the game to include his own name as a codesigner (Gee, 2003).

That players collaborate to follow paths and stitch their world together meaningfully and construct new meanings makes the networked game environment a powerful model for online learning. Islands of relevant information (challenges or data) are separated in space and time, and there exists not one but many paths to a complete set of meanings. Of course, the danger is that this array of meanings could be experienced as merely encyclopaedic, or worse, chaos. The game environment solves this by establishing a theoretical context (the story), codes of practice (play), feedback, mentoring, and desirable goals (prizes). Translating this to a learning environment, the need is to create for students a robust, informative, and appropriate discipline-specific socialising context within which the unfolding information (fact, theory, practice) becomes meaningful. This is a place where they can make useful decisions to avoid the potential for being lost in a growing network of meanings. Meaning is not something that exists outside a specific embedding context (Lankshear & Knobel, 2003) but is continually being made by the social interaction between the reader and the text, and reader and reader.

The need to contextualise the learning experience underlies Vygotsky's assisted or scaffolded approach to constructivist learning (e.g., 1978) in which the self-discovery of knowledge by students (discovery learning) is guided by instruction (scaffolds) from the teacher (Vygotsky in Riddle & Dabbagh, 1999). Scaffolding is a word chosen because it describes an enabling structure that is by nature flexible and temporary rather than framework that might imply something permanent such as framework of a building. The intent of scaffolding is to provide strategic support appropriate to different levels of the learning path or journey, substantial at the beginning and reducing as participants gain confidence in their own learning. Scaffolding provides students the opportunity to build on and extend their current knowledge; it engages their interest and motivates them to pursue the instructional goal (Salmon, 2002). These contexts and scaffolds are what make up a robust learning path through the knowledge domain. 'A learning path involves following a path made up of certain facts and relationships. The learner actually updates their understanding, their own network of facts and relationships, as they learn the path' (LaBrecque, 1998).

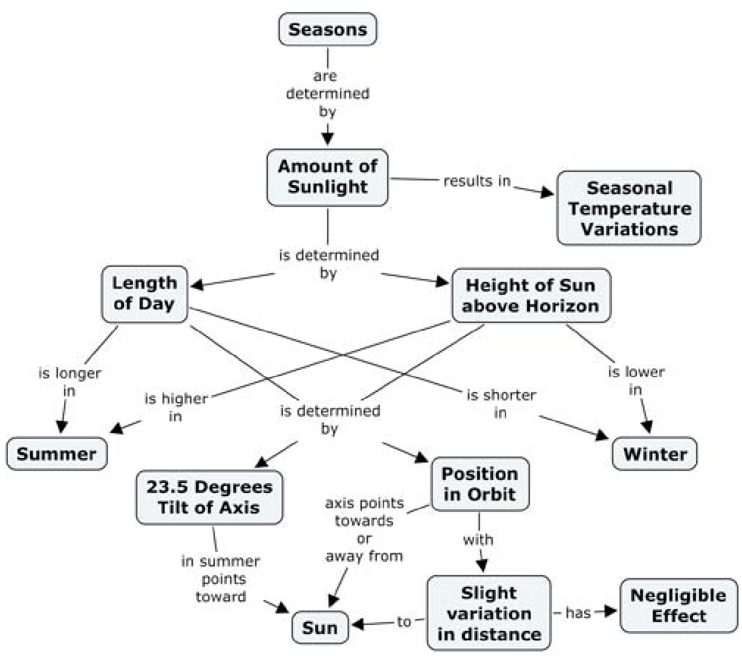
A five-stage scaffolding process in relation to online-moderated asynchronous discussion groups is clearly described by Salmon in *E-tivities* (2002). The first three of the five scaffolding steps in her process are contexutalising and strategic steps. They are about the learners, or participants, as Salmon prefers to call them, getting comfortable, getting to know the learning environment, knowledge domain, and their fellow learners. It is also the step in which students are shown good reasons to take the risk of engaging with others in knowledge construction. Notice that in these steps, the focus is not on the subject matter but on learners/participants and their socialisation within the environment. The steps provide them the keys with which to plan and make decisions. These steps are vital in the success of any learning. 'The penny has dropped!' said one teacher. 'I've been overloading my students with "content" and then talking to myself!' (Salmon, 2002).

Salmon (2002) calls the fourth step in her scaffolding knowledge construction and it is where, in the conferencing model, the participants exchange information and together accomplish a task. Repetition also marks this level. The level provides multiple opportunities or paths to achieve the goal, which is robust and flexible understanding that will stand up in the real world. The fifth step, development, is where the participants reflect on and further develop their knowledge construction skills and look outwards to see what assistance they can offer to others (leadership and mentoring). This scaffolding process designed for moderating discussion groups is another conceptual tool to be used in designing visually mobile paths in a knowledge domain.

TOOLS FOR NEW MEDIA MEANING MANAGEMENT

Making visible the connections between ideas, concepts, and practices of a particular discipline so the writer can see the relationships within the knowledge domain and articulate that domain's place in the real world requires a tool like concept mapping. Studies by Beaver and Luker (1997 in Thickett & Newton, 2006) investigating the efficacy of pamphlet information to inform patients with serious illness showed that text was often written as a kind of substitute for verbal information and was written in a language not easily understood. This added considerably to the discomfort of patients. A similar phenomenon can be seen in many teaching resources online. The text is taken directly from the lecture, and without the lecturer being present to assess the take up by students and to field questions, it is not suitable as a stand-alone learning resource.

Figure 2. Concept map by Novak and Cañas (2006), 'A representation of the knowledge structure required for understanding why we have seasons.' Used with permission from Joseph Novak.



In other studies of communication of information by the medical profession, it has been found that mind (or concept) mapping the vital information improves the retention of data by as much as 10% over that which is written, linear fashion, in a pamphlet (Farrand, Hussain, & Hennessy, 2002, in Thickett & Newton, 2006).

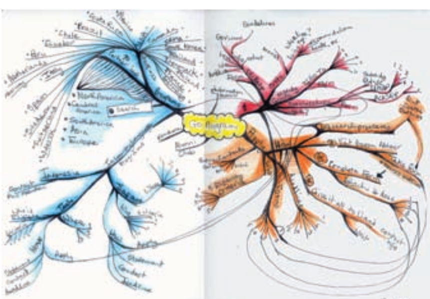
A concept map is a visual exploration of the placement, relationships, and connections between, in the case of a knowledge domain, theory and practice (Figure 2). It is a concept familiar with most academics and has been progressively introduced into the school curriculum since the publication in 1984 of the landmark book *Learning to Learn* by Novak and Gowin.

The advantage of such a relational map is its capacity to show the spread and location of pieces of material in the knowledge domain in association to each other; to demonstrate the currents within the discipline and the flows and counterflows between the islands of content, and to articulate the nature of the relationships that link it all together. It is the articulation of these relationships, locations, and flows that assist in the building of learning paths specific and appropriate to the learning domain. The benefit of the concept map is that all the content can be seen simultaneously. Concept mapping and similar tools assist the discipline expert to clearly see the complex network of facts, relationships, and understanding about the knowledge domain built from their own learning experience. With this map visible, it becomes easier to construct paths for other learners. Like a map, these elements used as an entry in a learning resource invite the student participant to explore and discover.

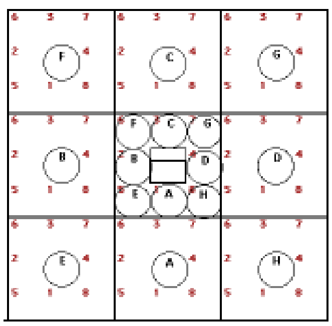
There are many different ways of making a concept map (Figure 3); the method is unimportant, but what matters is that the ideas are presented visually to reveal the contextual relationship between them. In Michalko's Lotus diagram mapping tool (Figure 1b), the information proliferates out from an initial nine squares. Each of the outer squares subsequently becomes the central thought for another set of squares, and so on outwards. Should you be feeling playful, a Chatterbox (Figure 1c) is a mapping tool that successfully circumvents the tendency to think of narratives as a single voice.

There have been many experiments in writing for the open-ended networked medium. Hyptertext novels and choose-your-own-ending adventure books are examples. An encyclopaedia is not a multilineal document but an assemblage.

Figure 3. (a) Concept map (Gaskin, 2006); (b) Lotus diagram after Michalko (1994); (c) Chatterbox (Turner, 2001)



a



b

c

It has no coherent, satisfying embedding of contextual relationships to unfold further levels of meaning for each word simply because words are isolated from each other in an alphabetical list which provides no contextual information. Examples of multilineal writing using the methods suggested in this chapter follow. The examples are a stimulus or starting point for developing individual ideas rather than a completed set of rules and procedures to be followed. The ideas developed below further those already presented (Turner, 1999, 2000, 2005, 2006a, 2006b).

HOW IT IS DONE

The starting point of visual thinking is with the text and its meanings and treating text with visual meaning management devices to enhance that meaning.

Visual Organisation

Step 1: Explore the contents of the relevant area of the discipline with visual organising tools such as concept-mapping, lotus diagrams (Michalko,

Figure 4a. PowerPoint's draw tool is used to create linked text boxes for a concept map

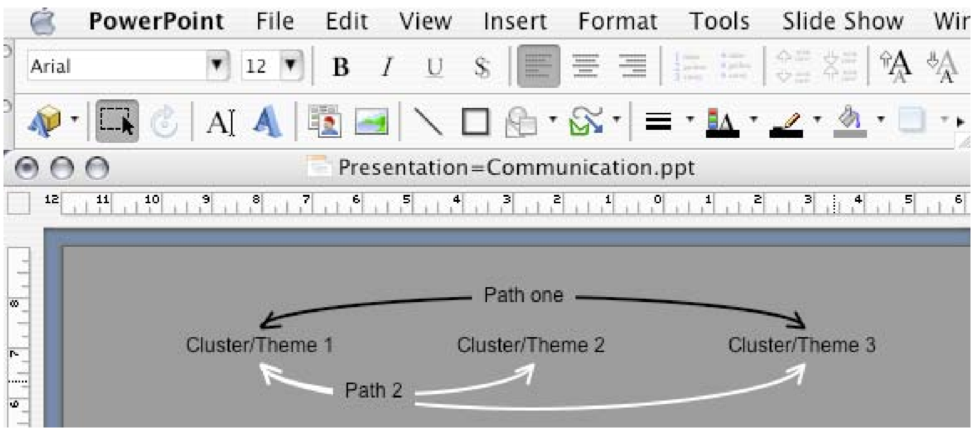
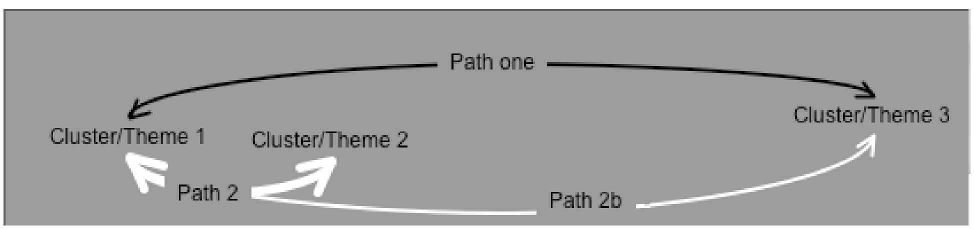


Figure 4b. Connecting arrows 'stick' to the text boxes when the boxes are moved. Notice how the potential understanding of these clusters is changed quite simply by moving two into close proximity and the other further away.



1994), or the humble Chatterbox (Turner, 2001). The purpose of using these tools is to break down the habits of linear thinking and writing. PowerPoint's draw palette and a blank slide is particularly good for this process because it has a full range of tools to visually customise text and graphic elements plus flexible connecting arrows that will stay linked to a box of text no matter where it is moved on screen (Figure 4a, b). If preferred, this first stage can be accomplished easily using moveable yellow stickies on a white board.

Process: Document all ideas for teaching a particular unit of study—facts, activities, theories relationships together with learning objectives—in separate boxes (stickies). Cluster ideas into groups and place the groups in proximity to each other using visual devices to highlight connections, difference, associations, importance, and so forth. Be prepared to keep on adding facts and ideas and to modify or add to the nature of the relationships as the process uncovers them.

With the ideas and facts visually presented in this way, the author-designer can *see* the connections in content (proximity and distance, placement in the space all become meaningful), and begin to *map* the potential paths that can be taken between clusters of content. The author-designer will also see that there are content-centred 'visual themes' emerging from the process. Using visual themes, the content will naturally fall into a number of clusters that, when incorporated in the layout of content on screen, assists the learner to understand the content. For instance, three main clusters of content would lead to a design of the learning object's interface organised in three main areas. The information encoded in such an organisation is 'There are three main areas to study even if there are a dozen different topics.' In contrast, when the content is presented as a list, a hierarchy is implied that can lead the learner to surmise the first thing on the list is most important which in turn leads to the conveyed meaning that there is only a single path of meaning-making through the content (Dervin, 1999).

Translating

Step 2: Translate the concept map of information into networked pathways. The term translation implies a change of form or state in which the new form has a 'meaning equivalent to the original' (MSEncarta in Word 2004 for Mac) and is a useful way to conceptualise the move to multilineal design. Do not resort to writing sentences and paragraphs of text in a word processor to make an essay or paper out of these clusters of content. If there is no multipath authoring software available (such as Dreamweaver), use a word processor but use it in a different way with tables (see below). The task is to translate the 'intention and meaning' of the concept map to the table and follow the paths that open up in the material in the process of moving outwards from the centre. Each screen of content for each cluster is sorted into its structural components, severely edited to eliminate padding words and to pull out important meanings immediately and expressed where possible in clear, active, and descriptive terms.

Process: Tables are the key to nonlinear design using either Dreamweaver or equivalent HTML software or a word processor like MS Word. Open a new Word document from Page Setup, select Landscape alignment, save as Web page, and call it index.htm (or home.htm). Insert a 9x9 cell table. Select the middle nine cells of the table and merge them. In this merged centre cell, insert a new 9x9 table and merge the centre nine cells of this nested table. This is a Michalko diagram. Put the subject of the whole learning object as a descriptive name in the centre cell (e.g., Emedia: Teaching and Learning). Insert descriptive tags of the main clusters of content in the surrounding cells. The outside table may shrink away to nothing as the nested table is filled with content but do not delete as it comes into play on the next levels in the following steps. Select each cluster title and make it a hyperlink (e.g., Insert/Hyperlink/critical.htm)

The initial translation of the concept map into an authoring program (in this case, Dreamweaver) yields this simplified diagram (Figure 5). Its focus is strongly administrative or strategic in nature, providing an overview of the domain, showing there are multiple ways the content can be entered, proposing provocative questions and pointing out potential paths. Note that there are four ways to move into the content, the four nodes of the diagram, the numerals which suggest a guided path, the questions on the left and right, and the navigation bar.

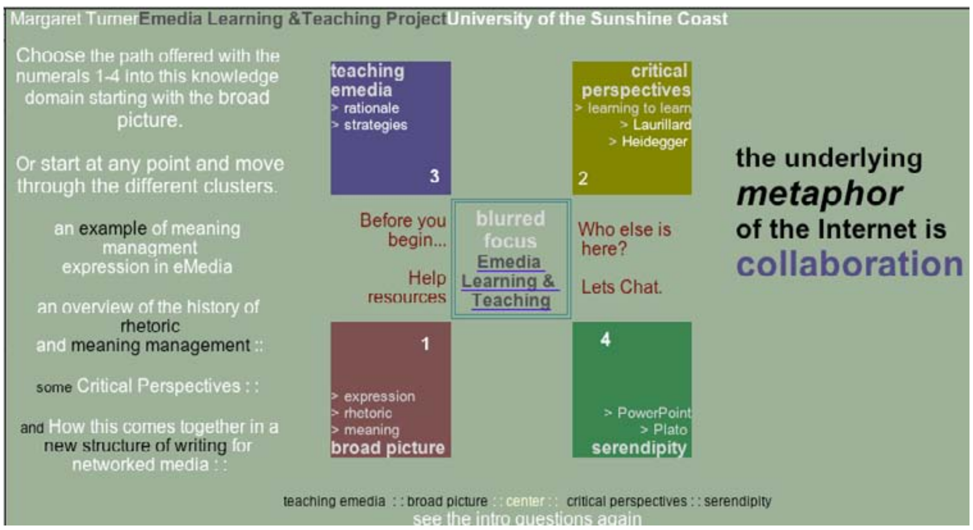
Step 3: Follow the content paths. Select one of the higher order clusters from the entry page (Figure 5). Trace the movement that arises out of the content, seeking the sparks to motivate students to learn. Tease out the content to provide as many triggers or point of departure as possible. It is helpful if the designer is familiar with tables in these software programs, to be able to diminish some parts of the diagram and expand others—see Figure 6. In this way, the reader's eye is guided to the focus of the moment.

Process: Make sufficient copies of the first document (Figure 5) to represent each cluster of content—in this case, four. Save as a Web page, calling each by the name of its cluster. Have all open at once to facilitate moving between them. Enter the detail of the next level of refinement into the table cells surrounding the cluster name. Hyperlink text to documents that will follow.

Step 4: Focus on the path or journey or experience. The core of the learning node remains visible in the background while the paths open over the top of it. This is predominantly still a management or overview level of the knowledge domain.

Process: Make copies of each of the second level cluster documents (save as Web page out of Word), as many as the hyperlinks require. Move into the outer table to further project the detail of the third level of analysis in each cluster. In Figure 6, the Teaching EMedia cluster opens to Strategies, which shows the many strategy learning paths: Learning community, Projects, Assessment. As this happens, the areas of content that are not key

Figure 5. An overview of the subject content taken from a concept map and displayed on screen using a table. This screen of content is contextual and strategic in nature, getting to know the environment, getting comfortable.



to the cluster diminish and the area of interest expands. Write provocative sentences or questions that invite perusal, or make explicit instructions that give a participant the direct understanding that they must take a path. Link these teasers or instructions to the next in a series of documents in which the answers unfold and explore broader territory. (See Figures 8 and 9 for examples of the kinds of content paths that might proceed from the nodes in this step.)

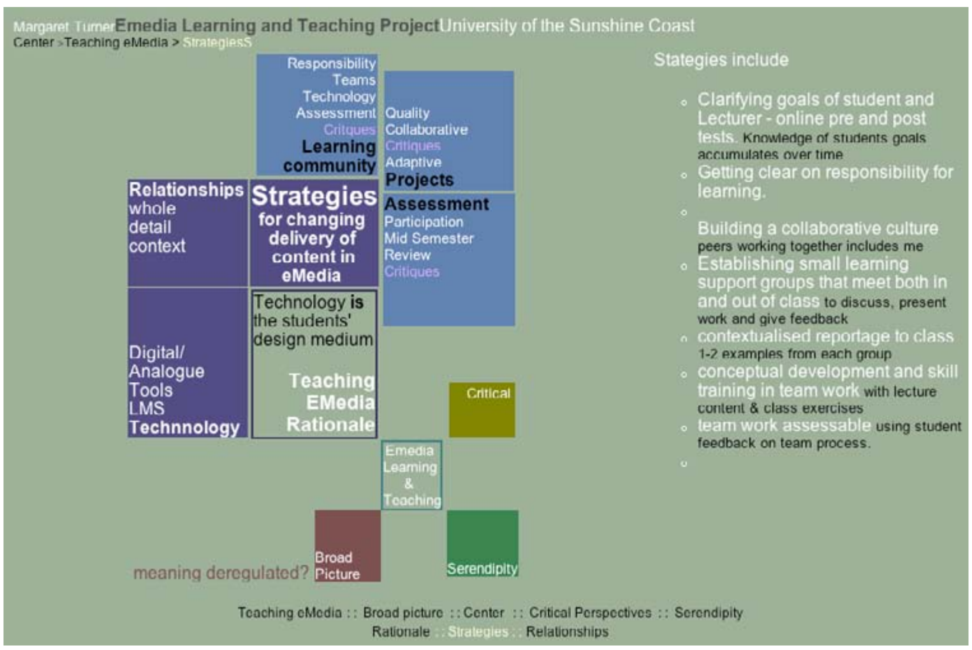
In Figure 6, the 'map' of the overall content is still available (overview, location in the knowledge domain) but reduced in intensity to focus on the relevant content cluster. This has been achieved by scaling up one cluster and increasing the number of nodes of information in the cluster and, at the same time, reducing the size and quantity of text in other areas. This provides room for more mapped detail of content in the learning node while sufficient contextualising information is left on screen for students to choose another path should they wish. The included figures represent the beginning of a multilineal document.

Designing Learning Paths

The examples in Figures 7, 8, and 9 show content translated into an actual onscreen learning tool, a reflection tool, in trial at this university. It is structured so that 'a player can make mistakes and attempt a problem many times until successful' (Gee, 2003). It would open in a separate window over the top of the strategic levels of the environment (Figures 5 and 6) so that at any time the participant can return to the main area and take up another path to learning. The example is a concept test to be taken by the student on entry to a second level course to ascertain their levels of knowledge of discipline-specific terms, deepen that knowledge, and put design understanding into practice.

Notice that the tool is based on the use of text, and placement and colour play major parts in guiding the participant's eye to choose a path. Two choices of learning path are offered. One is to go directly to the questions on the left that will immediately engage students in testing their

Figure 6. Following the paths of unfolding content in concept map clusters



design skills. A second option is to look at the key concept terms on the right and revise knowledge before attempting the questions. The invitation is issued with informal, active, or conversational language. In this example, both questions and statements are used to engage the participant. In these static images, the pathway indicators that rely on movement and which give students clues to the journey cannot be demonstrated.

CONSIDERING A MULTIMEDIA RHETORIC

It takes a scope larger than this chapter to fully explain this approach to multilineal writing; however, the following attributes of multimedia comprise the beginning of a description, after Channing (1856), of a 'body of rules derived from experience and observation, extending to all communication by language [networked and multimedia] and designed to make it efficient [at communicating].'

Attributes of Multimedia

Movement: Movement is the key new opportunity of networked media. In this case, movement is into and out of and between, *not* animation, but movement. Movement models the process of learning, as in the connecting over time, building relationships between here and there, arriving and coming back again with what has been discovered. Movement is the unfolding paths through the knowledge domain that the learner follows.

Text: Text, particularly at the tertiary level, retains importance even while it needs to be conceived and used in different ways to accommodate the qualities of multimedia. Nevertheless, text conveys meaning quickly and efficiently. The

Figure 7. An invitation to reflect on prior learning. The statements on the right are key design concepts that lead to questions about the meaning of discipline-specific terminology (Figure 8a). The questions on the left lead students to opportunities to put into practice their understanding of the key concepts (Figure 8b).

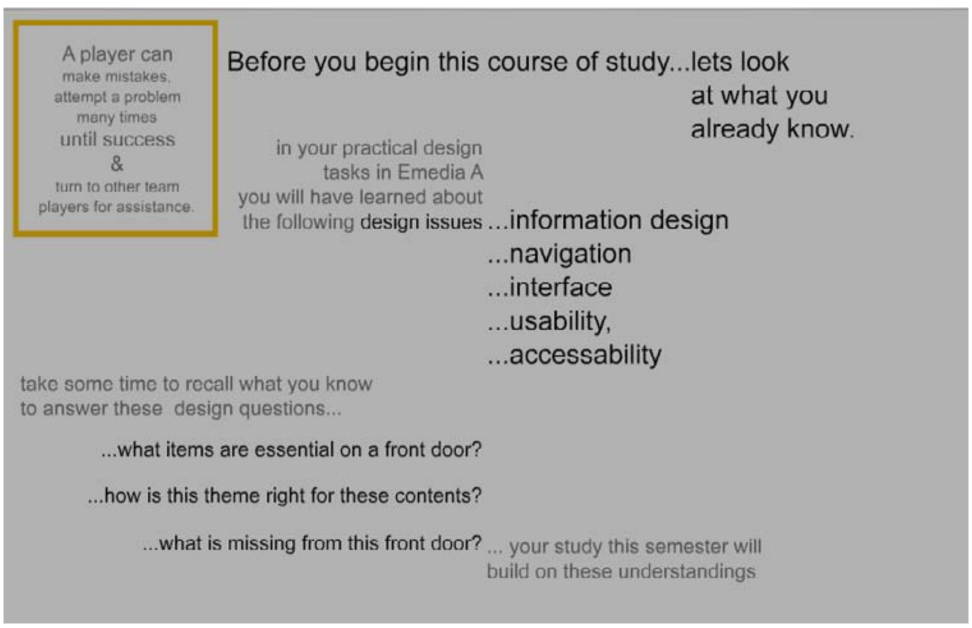


Figure 8a. A set of linked statements is revealed that test students' knowledge and leads to further discussion of the term and its uses.

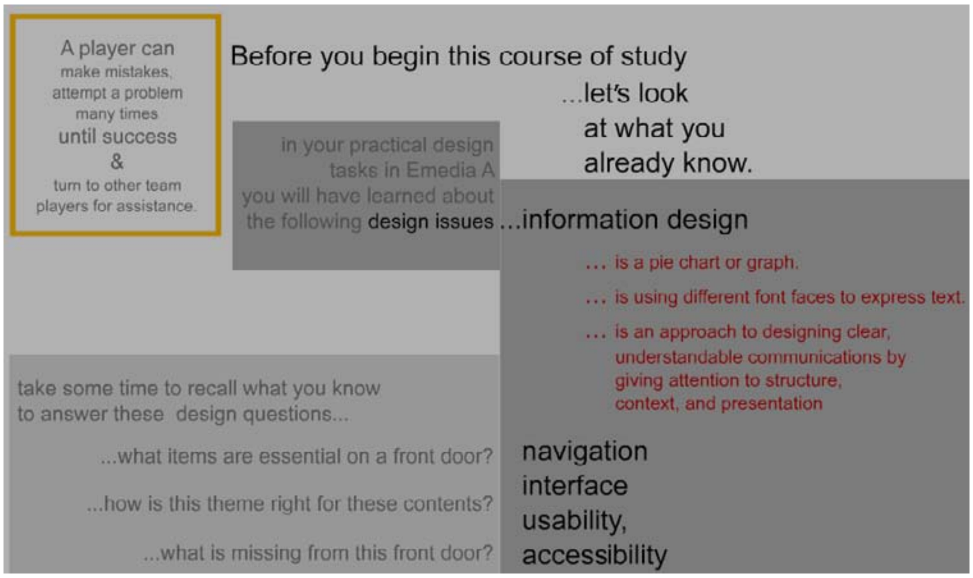


Figure 8b. Drilling into the responses to one of the statements reveals an answer that gives more information, not just a 'yes' or 'no.' Notice that local links are greyed out but still available.

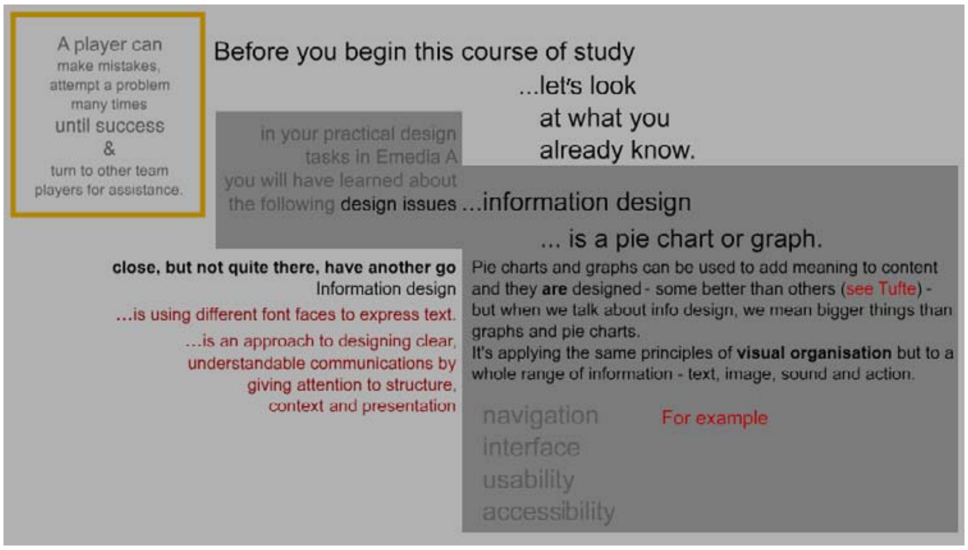
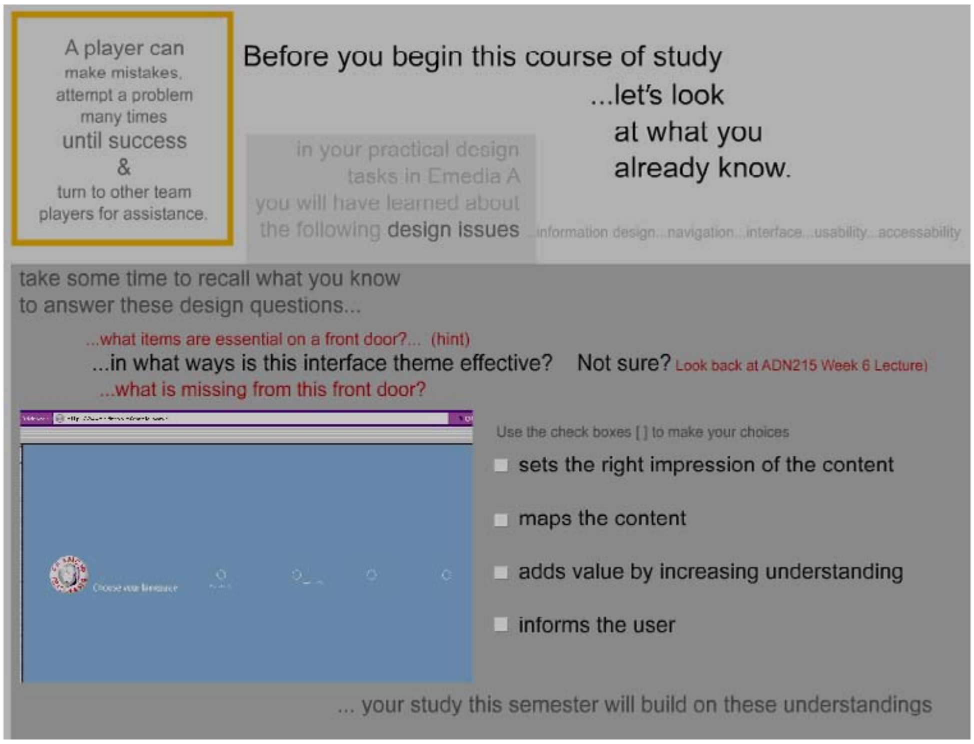


Figure 9. An example from the design questions posed on the left of the initial state of this learning node (Figure 7). It gives students an opportunity to practice design knowledge.



problem with a picture that 'paints a thousand words' is that it is unclear which thousand words are indicated. Remember, text needs to be active and statements need to be direct and brief. Use less formal language that is inclusive and student centred.

Colour: Colour is used to identify the themes or clusters in content and extended to colour-coding the paths. Use transparent colour in order to prevent it overwhelming content (90% alpha in PowerPoint). Overlaying transparent colour as the different clusters are linked adds more colour and thus prominence to those items that are key or more important. Where paths and different types of content intermix, the transparent colour will also mix and provide an intermediate tone. The resultant colours can be used to identify key clusters of information and their related paths in the learning object.

Layout: Visualising the content in clusters using tables assists the understanding of relationships between a student's prior conceptions, the concepts under study, and the wider world. The map of the content in relationship should guide the design of the learning objects interface. For instance, three clusters of content would yield an interface composition that is based on three.

Media: Do not merely illustrate text after the event. In the process of writing the content, use cell phones to create sound (commentary) the moment you think of it, take lots of photographs of process (instances that add up to a whole) and text (SMS, e-mail) as the idea is thought through, rather than using anything from some database.

CONCLUSION

This chapter has introduced to teachers some emerging issues in creating online learning, particularly in relation to the ways in which networked media is different to print media. It proposed that these differences have the potential to change the way meaning is communicated. Moving through the historical and contemporary debates on expression and communication of ideas, the chapter introduces the concept of managing meaning visually. It is not new, simply a new way of identifying the role of rhetoric in daily life. Meaning has always been designed or managed using visual clues or rhetorical devices such as punctuation. Classic rhetoric for meaning management evolved substantially for the purposes of mass publication on the broadcast, one-to-many business model. These are no longer sufficient to deal with the expanded demands of networked multimedia where the relationship between author and reader is flatter and more reciprocal. Unlike a book with linear sequential paths to meaning, networked media is characterised by individual content nodes separated in time and space, in relationships that are not predicted by proximity or order. Where as the book is static and predictable, networked media is mobile, dynamic, and reciprocal, and these resources require new devices in managing meaning. Chief among these is managing the connections across separate nodes on a network—or learning pathways—and the case of video games was used to illustrate a model of pathmaking through content. This chapter further proposed strategies and tools for rethinking the way learning content is written to help teachers accommodate and leverage the new medium's differences. These suggested strategies lead to the consideration of visual tools and a four-step procedure for the development of multipath documents. Finally, the chapter considered attributes of multimedia which may lead to a provisional networked multimedia rhetoric.

Out of the endeavours of all those who undertake the adventure, a new rhetoric or grammar of writing will emerge, a grammar that expands the existing conventions of print to encompass movement, sound, image, and colour. It probably will not take 100 years to coalesce, as did the book, but we need to take the time now to think it through in order that the meaning and understanding of the relationships between data and process in specific knowledge domains are not distorted.

REFERENCES

Adams, A. (1999). *Gorgias*. Retreived April 8, 2008, from http://personal.ecu.edu/mccartyr/ancient/athens/Gorgias.htm

Bransford, J.D., Brown, A.L., & Cocking, R.R. (1999). (Eds.). How people learn: Brain, mind, experience, and school [Electronic version]. Washington, DC: National Academy of Sciences, National Academy Press.

Burton, G. (2007). *Silva rhetoricae*. Brigham Young University. Retrieved April 8, 2008, from rhetoric.byu.edu

Channing, E.T. (1856). *Some definitions of rhetoric* [Electronic version].

Danton, R. (1999, July 21). Brought to book: Gutenberg galaxy meets Gate's universe. *Australian Higher Education*, p. 38.

Dervin, B. (1999). Something new, something old, something R\radical? From chaos, order, and sense-making: A proposed theory for information design. In R. Jacobson (Ed.), *Information design*. MIT Press.

DiMaggio, P.J., & Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(1983), 147-160.

Downes, S. (2003). Designing learning objects. *Australian flexible learning framework.* Retrieved April 8, 2008, from http://community.flexiblelearning.net.au/GlobalPerspectives/content/article_4077.htm

Gee, J.P. (2003). *What video games have to teach us about learning and literacy*. New York: PalGrave MacMillan.

Fowler, H.W. (1908). *The King's English* (2nd ed.) [Electronic Version]. Oxford: Clarendon Press.

Gaskin, L. (2006). *Project 1 concept map* (ADN216). Electronic Media Studies, University of the Sunshine Coast.

LaBrecque, D. (1998). *The physics of learning: Do students obey the laws of physics?* Retrieved April 8, 2008, from http://icn2.umeche.maine.edu/instruments/PHYSLRNR.html

Lankshear, C., & Knobel, M. (2003). *New literacies: Changing knowledge and class room learning.* UK: Open University Press.

Laurillard, D. (2002). *Rethinking university teaching: A conversational framework for the effective use of learning technologies* (2nd ed.). London/New York: Routledge/Falmer.

McDonell, T.B. (2003). *The effects of text presentation: Linear and hypertext on English language learners* (ITForum paper). School of Education, New York University. Retrieved April 8, 2008, from http://it.coe.uga.edu/itforum/paper76/paper76.html

Michalko, M. (1994). *Thinkpak*. Ten Speed Press. Retrieved April 8, 2008, from http://members.optusnet.com.au/charles57/Creative/Techniques/lotus.htm

Novak, J.D., & Cañas, A.J. (2006) *The theory underlying concept maps and how to construct them* (Tech. Rep.). IHMC. Retrieved April 8, 2008, from http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf

Novak, J.D., & Gowin, D.B. (1984). *Learning how to learn*. New York: Cambridge University Press.

Planeaux, C. (1999). The Republic *by Plato: Written 360 B.C.E* (B. Jowett, Trans.). Retrieved April 8, 2008, from http://plato.evansville.edu/texts/jowett/republic39.htm

Riddle, E.M., & Dabbagh, N. (1999). *Lev Vygotsky's social development theory.* Retrieved April 8, 2008, from http://chd.gse.gmu.edu/immersion/knowledgebase/theorists/constructivism/vygotsky.htm

Salmon, G. (2002). *E-tivities: The key to active online learning.* London: Kogan Page.

Schwarz, E., & Kay, K. (Eds.). (2006). The case for twenty-first century learning. *New Directions for Youth Development*, *110*. Jossey-Bass. Retrieved April 8, 2008, from http://www.josseybass.com/WileyCDA/WileyTitle/productCd-0787988278.html

Sofia, Z. (2000). Container technologies. *Hypatia, 15.2*. JHU Press. Retrieved April 8, 2008, from http://muse.jhu.edu/journals/hypatia/v015/15.2sofia.html?

Thickett, E., Newton, J.T. (2006) Using written material to support recall of orthodontic information: A comparison of three methods. *The Angle Orthodontist*, *76*(2), pp. 243–250.

Tufte, E.R. (1983). *The visual display of quantitative information*. Cheshire, CT: Graphics Press.

Turner, M. (1999). Fundamental Web design principals? In *Proceedings of Ausweb99.* Retrieved April 8, 2008, from http://ausweb.scu.edu.au/aw99/papers/turner/

Turner, M. (2000). Of mice and men: Interface as map. In *Proceedings of Ausweb2k*. Retrieved April 8, 2008, from http://ausweb.scu.edu.au/aw2k/papers/turner/index.html

Turner, M.E. (2001). Chatterbox and hyperspace: A child's game as a tool for multimedia authoring. *Ausweb01k*. Retrieved April 8, 2008, from http://ausweb.scu.edu.au/aw01/papers/refereed/turner/

Turner, M.E. (2005). Online teaching: Designing lively conversation. In *Proceedings of Effective Teaching and Learning.* Griffith University.

Turner, M.E. (2006a). Invite, engage & play. *Express, OLT 2005 Beyond Delivery Conference*. Retrieved April 8, 2008, from https://olt.qut.edu.au/udf/olt2005/

Turner, M.E. (2006b). Multi-path and networked: Possible futures for academic writing. *ASCILITE05*. Retrieved April 8, 2008, from http://www.ascilite.org.au/conferences/brisbane05/proceedings.shtml

Tziamalis, N., & Lambrou, N. (2002). *The history of Bauhaus*. Retrieved April 8, 2008, from http://www.red-grass.com/articles/history-of-art-and-design/typography-in-bauhaus

Wiley, D.A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D.A. Wiley (Ed.), *The instructional use of learning objects: Online version*. Retrieved April 8, 2008, from http://reusability.org/read/chapters/wiley.doc

KEY TERMS

Expression: Expression of some kind, image, text, or sound is needed for concepts to be communicated.

Learning Paths: Scaffolded journeys through a subject domain (similar to multiple narrative).

Meaning Management: Regards the representation of information for presentation using in this case visual devices such as punctuation, grammar, and spelling.

Multipath Characteristic of Networked Media: Many options exist to a certain resource, each with its own coherent rationale.

Networked Media: Characterized by individual nodes or pages of content separated in time and space in relationships that are not predicted by proximity or order.

Rhetoric: The body of rules, methods, and means derived from experiences that make efficient communication at another time and/or space possible (Fowler, 1908).

Chapter XXI
Modification of Learning Objects for NESB Students

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ABSTRACT

Due to the increasingly diverse student population in multicultural nations such as Australia, the U.S., Canada, and the UK, educators are faced with the challenge of how to best meet the needs of students with limited English proficiency without 'watering down' the curriculum. The use of educational digital resources is one way of enhancing non-English speaking background (NESB) students' academic skills and understandings, but without explicit English as a second language (ESL) support integrated into these resources, the benefits for NESB students are limited. This chapter documents a study of the content and format of a number of learning objects designed by The Le@arning Federation in an attempt to explore how specific learning objects can be modified to address the language needs of NESB students and unlock the value of their content. Design guidelines for ESL adaptation of digital learning content are provided based on current research and second language acquisition (SLA) principles.

NESB STUDENTS IN THE MAINSTREAM CLASSROOM

Australia is a multicultural nation with a large migrant population. In 2005–2006 alone, there were over 111,000 permanent arrivals, of which 68% came from a non-English speaking country (DIMIA, Immigration Update, 2005–2006). Over 20% of immigrants are school aged children and young adults. Upon arrival to Australia, NESB immigrant and refugee students receive an intensive English course for a few weeks, and then they are placed in mainstream classrooms where they have to attend regular classes alongside their Australian peers. Immigrant students, indigenous Australian students, and second phase NESB students comprise 25% of the total P–12 student population in Australia. This large-scale presence of ESL students in mainstream schools is the result of the world 'demographic explosion' and has been experienced in all the developed English-speaking countries (i.e., the USA, Canada, and the UK) along with the challenges it brings (for a discussion on mainstreaming ESL students in Australia, the UK, and Canada, see Mohan, Leung, & Davison, 2001).

In general, NESB students are taught and assessed the same way as native Australian students. Thus, in the mainstream classroom, NESB students face a tripartite task of tremendous difficulty: they have to learn English in order to communicate and interact with others, they have to learn subject content (e.g., Math, Science, SOSE, etc.) *in* English, and they have to develop metalinguistic knowledge *about* English (e.g., how the English language system works, how to use it appropriately, etc.). Most NESB students find themselves overwhelmed by the amount of technical vocabulary and the complexity of grammatical structures that appear in their textbooks, while their inability to fully understand spoken English in a natural speed, leads to partial, if any, understanding of spoken instructions by their teachers. As a result of their low proficiency level, NESB students find themselves unable to participate in class, share ideas or opinions, or demonstrate knowledge (Miller, 2000). Along with diminished learning outcomes, NESB students show lack of motivation for learning which often leads to behavioural problems and maladjustment.

Undoubtedly, NESB students' general academic success at school is incumbent upon the development of their linguistic skills. For example, in mathematics, it was found that students with limited English proficiency were more likely to fail finding a solution to problems stated in English, their second language, despite the fact that English was the language used for instruction and for all the textbooks, readings, and word problems (Bernardo & Calleja, 2005). In science education, all students have to master the specific academic language to discuss predictions, observations, hypotheses, natural phenomena, and so forth (Laplante, 1997). Mastering the language of science is even more difficult for NESB students. Even if they understand the scientific concepts and are able to express them in their first language (L1), they will still struggle to express their understanding in their second language (L2) for at least 5–8 years after immersion in an English education program (Case, 2002). The challenges NESB students face are compounded by mainstream teachers' practices, many of whom were found to engage in 'benevolent conspiracy' in which they avoid asking NESB students higher level questions in order to save them from embarrassment, but consequently they deprive them of real learning opportunities and allow them to engage only in lower order thinking (Verplaetse, 1998), thus creating in many cases a 'two-tiered' system of education with 'challenging curriculum' for native speakers and 'mediocrity for the rest' (August, Hakuta, & Pompa, 1994).

Given the increasingly diverse student population in Australian schools and other equally multicultural 'melting pots' (e.g., the U.S., Canada, and the UK), the challenge faced by educators is how to best meet the needs of students with limited English proficiency without 'watering down' the curriculum. Having to teach a group of students at different reading and writing levels, and from different language backgrounds, can be an overwhelming task for the mainstream classroom teacher. Computer technology is one ally teachers can enlist to help NESB learners succeed in the mainstream classroom as it provides an excellent selection of learning tools that are 'highly adaptable to the individual needs of both ESL students and teachers' and meet the special pedagogical needs of new English speakers (Kurshan, Isler, & Blackburn, 1997).

While there is a plethora of CALL (computer assisted language learning) software specifically designed to teach English language skills (grammar, vocabulary, reading comprehension, pronunciation, listening, etc.) to ESL students, these are not the subject of this chapter. The purpose of this chapter is to look at ICT-based learning resources that are already in use in mainstream classrooms and establish clear guidelines on how to modify and adapt their content in order to make their content more accessible to NESB students and more helpful for ESL language development. Without well-structured support, NESB students in the mainstream classroom are unable to fully benefit from such resources. For NESB students, being able to use the same educational resources as the rest of the students in the class means greater confidence in themselves, seeing themselves able to do the kind of tasks native speakers can do, having access to the same information and content instruction as the rest of the class, and being able to become more autonomous and independent learners. The next section of this chapter will present an example of content modification and adaptation for a large set of educational digital resources, namely learning objects (LOs), that are currently in use in mainstream classrooms across Australia and New Zealand.

LEARNING OBJECTS BY THE LE@RNING FEDERATION

There is no single universally accepted definition of learning objects (for a detailed discussion of the term, see McGreal, 2004; Wiley, 2000, 2001). For the purposes of this chapter, only digital, reusable, stand-alone resources designed to support student learning will be considered. Currently, there is a multitude of such LOs designed to cover a variety of educational levels (from P–12 to tertiary and vocational education) and curricular areas (from science and mathematics to literacy and languages other than English—LOTE). Most of them are stored in learning object repositories (LORs) around the world, along with other digital resources for teachers and learners such as lesson plans, lecture notes, and student projects (for a comprehensive list of LORs, see Scott, 2003). One of the key issues concerning the literature on LOs is their instructional design and the extent to which they have adopted a sound pedagogical framework in their design (Arnold, 2004; Boyle, 2003; Boyle & Cook, 2001; Bradley & Boyle, 2004; Ip & Morrison, 2001; Oliver, 2001). In the P–12 sector, LOs have been particularly scrutinised in terms of their instructional design and their effectiveness for learning, as learners at this level are less independent and self-directed than postsecondary students. Haughey and Muirhead (2005a) stress the importance of designing LOs for P–12 that move away from transmission style models of learning and more towards constructivist and inquiry based models (p. 5). A good example of LOs designed to reflect teachers' current pedagogical approaches to learning and in accordance to a constructivist theoretical framework are the LOs designed by The Le@rning Federation (TLF) in Australia.

Since 2001, The Le@rning Federation has developed 4,500 digital LOs targeting the main key learning areas (KLAs) of the Australian and New Zealand curriculum (such as mathematics and numeracy, science, literacy, studies of Australia, LOTE, arts design and technology, business and enterprise) and in 2007 secured adequate funding to develop another 4,000 LOs. The TLF LOs are 'chunks of digital material—for example, graphics, text, audio, animation, interactive tools—specifically designed to engage and motivate student learning' (official TLF Web site). Atkins (2003) describes the key challenges to designing and developing LOs for school children and explains how TLF adopted a constructivist approach, inquiry processes, and critical pedagogy in their LOs. Atkins also talks about the principles of the educational soundness specification undertaken by TLF (Atkins, 2003). The first of those principles is *learner focus* which 'recognizes that all students, no matter what their profile, must be able to engage with the learning resources' (Atkins, 2003, p. 4). So, the LOs developed by TLF were designed with sound pedagogy in mind and were developed to engage *all* learners regardless of their linguistic or ethnic background.

Over the past few years, TLF has done numerous school trials and evaluations of their LOs in various school settings across Australia (Chapuis, 2003; Clarke, 2004; Clarke & Bowe, 2006; Freebody, 2006; Gronn, Clarke, & Lewis, 2006). In general, students reported that LOs were not only fun to use and interesting but also allowed them to work at their own pace and revisit and repeat activities in a safe learning environment. This feature of the LOs can be most helpful to NESB learners who need self-paced learning and the opportunity to revisit resources in order to accommodate for their deficient linguistic ability. However, this feature alone is not sufficient to ensure that the LO content will be accessible to NESB students. By and large, the needs of NESB students studying in mainstream classrooms have not been considered by LO content developers. In a trial of TLF LO content with ESL students in the Western Metropolitan Region of Melbourne, teachers reported that they had to provide initial tuition in the library to ESL students and allow extra time on the computer to help them engage fully with the LOs (Kensington Primary School video clip, TLF Web site). In another trial of LOs developed by the Department of Education Tasmania and used by a number of schools in Victoria and Tasmania, teachers reported that NESB students found the quantity of text in some LOs very challenging, while lack of specific cultural knowledge led to considerable difficulties engaging with specific LOs (Robertson & Fluck, 2004). The results of these trials indicate that there is a need for explicit ESL support for NESB students and that the ability to overcome their limited language proficiency and engage fully with online learning content cannot be left entirely to incidental, implicit, or inductive processes that arise from the repetitive use of the LOs and self-paced learning (Lo Bianco, 1998; Mohan, 2001).

In an effort to address the needs of NESB learners with regards to online learning and especially the use of LOs, the author of this chapter undertook an audit of the TLF LOs to assess the suitability of their content for NESB learners and propose modifications that would make them more accessible for learners of low levels of English proficiency. The TLF LOs were chosen for this study because they were designed with a pedagogical framework and a specific set of educational principles in mind; they have been tried and evaluated extensively, and they were designed to be used by *all* learners in mainstream classrooms. Furthermore, compared to other LORs (such as Curriculum Online and CELEBRATE), the TLF LOR was found to be the most comprehensive as it contains 'the most complete set of objects covering the greatest variety of subjects available designed for the K–12 sector' (Haughey & Muirhead, 2005a, p. 10).

THE STUDY

One hundred thirteen TLF LO titles and every individual LO under each title were reviewed:

- 43 titles of Studies of Australia LOs for years P–10,
- 66 titles of Science LOs for years P–10,
- 1 title of Arts, Design & Technology for years 7–10, and
- 3 titles of Maths for years 4–9)
  (for a complete list of the LO titles and their corresponding year levels, see Appendix A).

In total, 381 individual LOs under the selected 113 titles were reviewed representing 8.5% of the total number of TLF LOs at the time of the study. The TLF LOs have been previously evaluated in terms of their design and have been assessed on a battery of learning and multimedia design criteria (see Haughey & Muirhead, 2005a, 2005b). This study focused exclusively on the language content of the different LOs and their overall suitability for use by NESB students. Each of the 381 LOs was reviewed, and specific recommendations for ESL modification and support were made. In the next section, the linguistic analysis performed and the results of the analysis are explained.

LINGUISTIC ANALYSIS OF LO CONTENT

Methods

The linguistic analysis targeted two areas: lexis and grammar. The lexical analysis looked at the use of technical vocabulary, collocations, and lexical phrases, phrasal verbs, adjectives, compound adjectives, prepositional phrases, and adverbial phrases in each LO. A study of the vocabulary used in each LO was expected to provide important information about the suitability of each LO for ESL learners and possible challenges that ESL students may encounter. Initially, the criteria used for the lexical analysis were based on the general frequency of use of the different words using the British National Corpus (BNC, a 100-million-word electronic databank of present-day spoken and written English, see Leech, Rayson, & Wilson, 2001), and on the complexity of longer lexical strings such as collocations and lexical phrases using the acquisition orders of implicational scaling research on the development of ESL lexical knowledge (see Gitsaki, 1999). However, due to the multimodal format of the LO content, the criteria originally used were found to be inadequate for the purposes of this study, and a more holistic evaluation of the use of lexis in the individual LOs was deemed necessary. For example, certain technical vocabulary items, such as ‘hemisphere,’ ‘axis,’ ‘greenhouse,’ ‘hydrogen,’ ‘to melt,’ ‘to heat,’ ‘atomic,’ ‘toxic,’ were initially judged as challenging for ESL learners as they appeared to be low on the frequency of use list according to the BNC (i.e., 13 or less occurrences per million words). However, a more holistic approach revealed that such words are commonly used in a science context such as the science LOs reviewed in this study. Furthermore, the use of animations, visuals, and explanations in the LOs provided enough contextual information for such technical vocabulary to be potentially understood by ESL students despite their low frequency of use in general English. On the other hand, the verb ‘to reckon’ has twice as many occurrences per million words as the technical vocabulary listed above (e.g., ‘hemisphere,’ ‘axis,’ ‘greenhouse,’ ‘hydrogen,’ ‘to melt,’ ‘to heat,’ ‘atomic,’ ‘toxic’), and it is frequently used in Australian English, but it is highly unlikely that newly arrived ESL students will be familiar with it, as its use is highly informal and somewhat colloquial and, as such, less likely to be taught to ESL learners abroad.

Along with the use of vocabulary, this study also looked at the use of grammar in each LO. The grammatical analysis considered the use of tense, passive voice, reported speech, comparisons, conditionals, modals, degree complements, the genitive case, the subjunctive, regular/irregular plurals, relative, and other embedded clauses. These structures are dealt with in every ESL grammar textbook (e.g., Allsop, 1983; Larsen-Freeman, 1997; Murphy, 1994), as they are deemed necessary for English language acquisition and challenging for ESL learners. For example, even a morphologically simple structure like the plural form, which is mastered by native English children by the age of 3, can be challenging for ESL learners who may not reach the stage of mastery even after 5 years of L2 immersion (see Jia, 2003). Judgements on the complexity of these structures were based on acquisition orders research (e.g., accessibility hierarchy of relative clauses, morpheme acquisition orders) (see Gass & Selinker, 2001) and the overall length of the sentences (i.e., the longer the sentence the more complex it is; see Gunning, 2003). As with the lexical analysis, a holistic evaluation of the use of grammatical structures was found to be necessary, due to the contextual and multimodal support embedded in each LO.

In summary, the linguistic analysis of the LOs attempted to answer the following questions:

1. What is the overall level of lexical and grammatical complexity of the language in the LOs? What are the potential linguistic challenges for ESL students?
2. Are there enough contextual clues and explanations and/or visuals/animations to aid ESL students' comprehension of concepts?
3. What problems are ESL students likely to encounter in each LO?

Results

The linguistic analysis of the LOs revealed that the use of vocabulary and grammar differed considerably across the reviewed LOs. By and large, LOs were found to belong in three categories. The first category included LOs designed for younger learners (P–3). The content of these LOs was found to be rather simple as it consisted mainly of short and clear instructions and a short scenario often accompanied by audio, text, and visuals (e.g., *Day and Night, Weather, Soil, Mixing Colours, The Night of the Bilby, Neighbourhood Charter*). The small number of key vocabulary items was adequately explained in the script and largely supported visually in the LOs. In some of these LOs, there were structures that were more challenging for ESL students (e.g., the use of conditionals and comparisons in *Make the Rules*), but their repetition throughout the LO and the visual input (e.g., animations) were found useful for helping NESB students decipher their use. Modification recommendations for this group of LOs were minimal as research has shown that such LOs with their listening and visual input would most certainly help young NESB learners improve their listening comprehension skills and their vocabulary knowledge (Verdugo & Belmonte, 2007).

The second category comprised LOs designed for older students but with a relatively low level of linguistic complexity (e.g., *Sunscreens, Chemical Reactions, Additive Colour, Subtractive Colour, Air Pressure, Making Music, Optics and Images, Steady Ships*). These LOs contained concepts appropriate for students in higher year levels, but the linguistic complexity of the LO content was low. By and large, this group of LOs engaged students in activities where they had to conduct an experiment or run a simulation with minimal language content comprising largely of technical vocabulary and basic sentences. Most of the LOs in this category were science LOs. As science concepts 'require little prior cultural knowledge' (Becker, 2001, p. 74), these LOs were not anticipated to cause difficulties to ESL students provided that the key vocabulary was adequately explained and/or illustrated (see guidelines on providing vocabulary support through glosses below).

Finally, a considerable number of LOs for the higher grades were found to be too complex in terms of the vocabulary and the grammatical structures used (e.g., *Wind Farm, GM Foods, Peter Dalton, Norman Dean, Fiona Chiu, The Colour of Water, Bacteria Zoo*). Most of these LOs contained large amounts of text with challenging vocabulary, complex grammatical structures, and insufficient contextual clues to aid ESL students' understanding. The majority of the Studies of Australia LOs belonged in this category. In addition to the language content of these LOs, the extensive reading and 'cultural background' they require can be 'obstacles to ESL students' success' (Becker, 2001, p. 74). Therefore, the LOs in this category were anticipated to cause major problems to students with limited linguistic ability and as such they were judged to be unsuitable for use with NESB learners unless adequately modified.

RECOMMENDATIONS

Based on the results of the linguistic analysis and in accordance with research and current literature on LO and CALL software design, and second language acquisition, recommendations were made for the provision of ESL support. These recommendations covered three different areas:

- The modification of content,
- The scaffolding of existing activities, and
- The design of additional extension ESL activities for each LO.

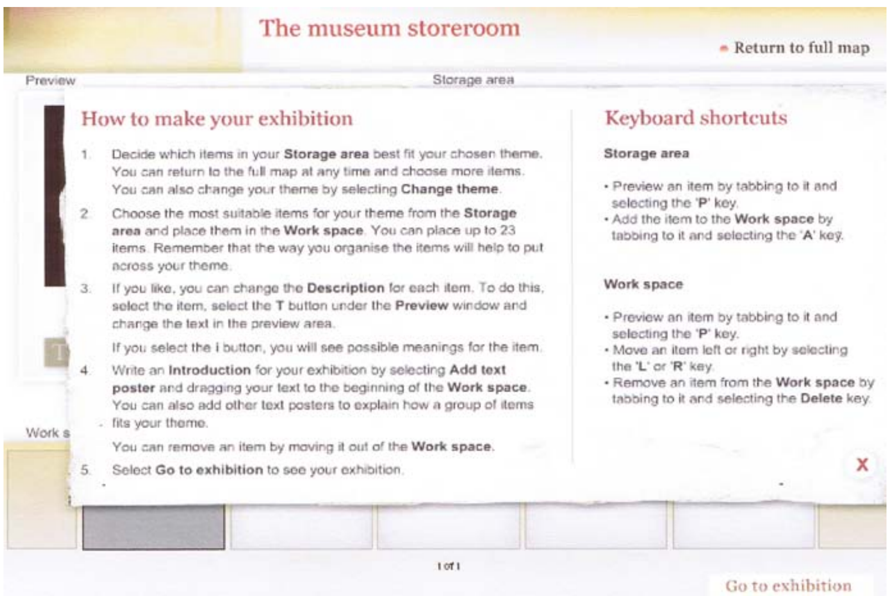
The proposed recommendations took under consideration the size of each LO keeping the addition of extension activities and audiovisual material to a minimum, thus ensuring that the portability, accessibility, and usability of the LOs would not be affected. These recommendations are discussed in detail below, as they constitute the basis for the proposed general guidelines for the design of LOs suitable for use with NESB students in mainstream classrooms.

MODIFICATION OF CONTENT

Instructions

The instructions used in the LOs were mostly succinct and clear. In some cases, where the instructions used phrasal verbs, the verbs were substituted for single verbs (e.g., 'find' instead of 'look for') making the instructions shorter, clearer, and more direct. In some LOs, instructions were long and rather complicated. These would have to be simplified. For example, in *Logic Gates*, one set of instructions reads: '*Wire this circuit so that either the loud sound detector (which is mounted on a window to detect glass breaking) or the door switch will activate the siren when the activate switch is turned on. When the activate switch is off, the alarm's warning light, which reads "Alarm*

Figure 1. The journey of the Hong Hai: Design a museum exhibition (source: TLF L648 v1.0.0)



not activated," must be on. The activate switch will need two connections.' These instructions could be simplified as follows: '*In this circuit the siren is on when the loud sound detector is on OR the door switch is on AND the activate switch is also on. When the activate switch is off, the warning light must be on. You will need two connections for the activate switch*.'

There were some instances of instructions that comprised a rather long list of steps explaining to the student what they had to do (see Figure 1).

These instructions would overwhelm ESL learners, as they would not only have to read the full set of steps but also remember each step in order to do the required activity. It was recommended that such instruction screens be divided into several smaller instruction screens with each screen giving only one step and appearing after the student had completed the previous step or when they would click an icon. Having the instructions appear physically integrated in the main LO content page rather than on a separate page will also help reduce the split-attention effect which 'in turn might be expected to reduce working memory load, freeing resources for schema acquisition and automation' (Kalyuga, Chandler, & Sweller, 1998).

Reading Texts

With regards to the modification of reading texts included in the LOs, the following guidelines were proposed:

- Reading texts should be kept short, and they should not scroll down to several screens, as having the whole text on one screen means that students can easily use strategies such as skimming and scanning to locate information, two very important reading skills for ESL learners (Harmer, 2004, p. 69). Making the reading text more 'scannable' means keeping its length to a minimum, expressing one key idea per paragraph, highlighting keywords, using meaningful headings to guide the reader and bulleted lists where possible (for a discussion on the readability of online text, see Nielsen, 2000).
- The use of relative and other embedded clauses should be kept to a minimum, as their use can negatively affect the readability of the text. Such language structures make sentences longer and complex, and they can confuse and distract learners with low English proficiency. For example, studies have shown that relative clauses which refer to nouns in the subject and direct object positions are early acquired by ESL students, and as such, they are easily 'accessed,' while relative clauses that are used as indirect object, object of preposition, object of comparison, or possessive are only later and in some cases never acquired (Lightbown & Spada, 1999). In the *Design Chair*, the script reads '*We design products to suit the people who use them and the environment where they will be used*.' In this example the relative clauses refer to the direct objects so they should be easy to understand. However, having two relative clauses in one sentence increases its length and could negatively affect its readability. Another sentence reads '*This is the classroom the chair will be used in*.' This is a much shorter sentence, but it is harder for ESL students to understand as the relative clause belongs to the lower end of the accessibility hierarchy (object of preposition). Later in the script, students read '*The chair needs to be sturdy, but not too heavy to move and stack, to avoid people hurting their backs*.' Examples like these illustrate how the use of embedded clauses can increase the length and consequently the complexity of a sentence and subsequently decrease its readability. To remedy this, sentences can be broken into shorter and simpler ones or rephrased to increase their accessibility (e.g., '*The chairs will be used*

in this classroom' instead of '*This is the classroom the chairs will be used in*').

- Colloquialisms and the use of phrasal verbs are frequent in informal everyday speech; however, their use in reading texts should be kept to a minimum. Students who have just migrated to an English-speaking country will most likely be unfamiliar with local colloquialisms and having to read (or listen to) text that is loaded with colloquial language use will demotivate them and reduce whatever little confidence they may have in using English. Phrasal verbs also cause problems to ESL students. For example, in *Patrick Brennan: The Legend of Ned Kelly*, words such as *bush ranger*, *outback*, and *reckon*, which appear frequently in Australian speech, would be unfamiliar to most migrant students, and they will need to be explained. With regards to phrasal verbs, in most cases, their meaning can be easily deciphered from the meaning of their individual lexical components (e.g., the meaning of 'to run sth over' is easily understood if you know the meaning of 'run' and the meaning of 'over'; similarly 'to look at sth' is also easy to understand), but there is a large number of phrasal verbs used in the LOs that are semantically opaque (e.g., 'to run sth down,' 'to run on sth,' 'to look sth/sb up,' etc.), and as such, they will confuse ESL students and lower their reading speed and their comprehension ability. Support for colloquialisms and phrasal verbs will need to be provided.

SCAFFOLDING OF EXISTING ACTIVITIES

In this section, recommendations are made on how to design and provide much needed scaffolding for ESL students in LOs that contain challenging language. Most of the recommendations are specific to individual LOs or activity types (e.g., see below recommendations for Reading, Writing, and Listening scaffolding activities), while others (e.g., Glosses) would suit all LOs. The recommended scaffolding activities are to be designed and incorporated in the LOs, which would also mean a rise in design costs. Making the scaffolding activities optional (i.e., students can choose whether they want to work with the LO *with* or *without* the scaffolding), would also allow the native English speakers to work with the LO without wasting time accessing information that they already know. However, according to Gibbons (2002), 'the "language-rich diet" of ESL teaching is of benefit to all students: it supports all children to use language in ways that are new and critical to academic learning' (p. 138). So, the following scaffolding activities may actually be of benefit to English native speakers too.

Reading

A considerable number of LOs require students to read a number of different texts in order to collect information for an article, a Web site, a report or some other writing activity (e.g., *Science Reporter, Fiona Chiu: Chinese Family Tree, Frog Pond Habitat, Chemical Science, Fair Test*). Some of the reading texts are authentic (e.g., unedited newspaper articles or book excerpts) while others are lengthy and contain a lot of technical vocabulary (e.g., *Samual Cooper: Putting the Rabble to Work, Nhu Minh: Multiculturalism in Australia, The Golden Age of Cricket, Heroes of the Air, Dorothy Griffin: Great Australian Women*). In order to help ESL students cope with such reading tasks, the following scaffolding strategies based on second language acquisition theories (e.g., schema theory, cognitive load theory, etc.) and their effect on reading comprehension (see Graesser & Nakamura, 1982) need to be employed:

- When students have to read text that consists of multiple paragraphs, it is important to provide them with a summary of the main points of the text in simple and clear language. Access to this summary can be used as a pre- and/or postreading activity. As prediction is a major factor in reading (Harmer, 2004, p. 70), using the summary as a prereading activity will allow ESL students to get an idea of what the text is about, thus aiding their comprehension of the text and speeding up their reading. As a postreading activity, the summary will help students consolidate their comprehension of the text and clear up any confusion that may have resulted from unfamiliar vocabulary and complex grammatical structures in the text.

- A more interactive way of providing students with the main points of a reading text is to have them answer simple multiple choice or true/false comprehension questions based on the text. Again, students can preview the questions before reading the text and then attempt to answer the questions after reading the text. This type of task helps ESL students activate prior knowledge and develop their inferencing skills (Harmer, 2004).
- Providing students with a concept map or a graphic organizer is another pre- or postreading strategy that can help students obtain a visual overview of the concepts appearing in a text and how they are connected and it can lead to increased knowledge retention (Nesbit & Adesope, 2006).
- Where the text follows a particular genre (e.g., a newspaper article, an argumentative essay, a recipe), it would be beneficial to ESL students to have the different sections of the text highlighted and each section titled (e.g., introduction, main body, conclusion, etc.). This is particularly helpful when the reading task is followed by a writing activity where the students have to produce a piece of writing that adheres to the same structure (for example, in *Fair Test* after students read e-mails, they have to respond to them with the results of their experiment; also in *CarTown* after students read information in newspapers, they have to prepare a newspaper ad). Explicit teaching of the formal aspects of text (e.g., the different parts of a specific genre) has been strongly supported by research and advocated by language practitioners (for a detailed discussion, see Gibbons, 2002).

Listening

In some LOs designed for high school students, authentic videotaped interviews with scientists were used. Each video is accompanied by an edited transcript (i.e., fillers and unfinished sentences which are frequent strategies in spoken English were removed). Recent research on the use of subtitles and transcripts in ESL listening tasks has found that ESL students considered the use of subtitles more useful than the edited transcript (Grgurovic & Hegelheimer, 2007). Thus, it would be helpful to NESB students if they could watch the videos with subtitles instead of having the full edited transcript on the screen. This way, they would be able to directly connect body language and facial expressions to language use and be exposed to the use of native speaker oral language devices (such as fillers, pauses, and false starts).

Writing

A number of the reviewed LOs involved students in writing tasks. Some of the writing tasks were simple and did not require any scaffolding (e.g., in *Homelessness*, *Fish Stocks*, and *Sunday Trading*, students have to compose a Web page with sentences and pictures that they collect from a number of different texts with little or no editing). Other writing tasks require students to produce their own text and provide little, if any, support or feedback (e.g., in *Science Reporter*, students have to write a report based on interviews without any support; in *The Journey of the Hong Hai*, students have to create a museum exhibition and add their own captions to each exhibit). These writing tasks could be scaffolded to support ESL students. The following recommendations are based on scaffolding principles for ESL writing (see Gibbons, 2002):

- In some LOs, students have to carry out experiments and write down their predictions and observations (e.g., *Chemical Science*). In order to write simple sentences such as predictions and observations, ESL students would need to be provided either with a model sentence as an example, or a 'shell' that they could fill in with the specific vocabulary items, or a set of phrases to choose from and construct their own sentences. Another example is *The Futurist* where students have to write a set of recommendations. To assist them in this task, the LO could provide them with examples of specific language structures used for recommendations (e.g., recommend + that clause, recommend/suggest + gerund, recommend/suggest + should, recommend +object + to infinitive, etc.). Students could then use these examples as models for writing their own sentences.
- In LOs where students have to produce a printable report (e.g., in the *Science Reporter*), they should again be provided with a 'shell' where the different sections of the report are clearly labeled and are linked to information screens telling students what should be written in each section. Students should also be given example phrases and a list of conjunctions and other linking devices that they could use to link their ideas and report the information. To further simplify the writing task, students could be given a group of sentences that they would have to put in the right order to construct their report. Modeling the text type they are required to produce or reconstructing a text are ESL scaffolding activities used in student preparation courses for independent writing (Derewianka, 1990).
- Other writing tasks require students to write notes (e.g., *GM Foods*). Note taking is not an easy task for students with low vocabulary and language acquisition skills (Honnert & Bozan, 2005; Wilson, 1999). Having key utterances in the text highlighted would help students sort out what information is important to go in their notebook.

Glosses

One of the most widely used scaffolding strategies in language software is providing students with glosses. The use of glosses has been found to be beneficial to L2 reading online and vocabulary acquisition (Chun, 2001; Lomicka, 1998; Yoshii, 2006). In the TLF LOs examined in this study, there was very little use of glosses with only some technical vocabulary and key concepts in some LOs hyperlinked to a definition/explanation. In CALL, software glossaries are quite often bilingual, allowing students to link L2 words to L1 concepts and translations. Bilingual glossaries are beneficial for students at the early stages of second language acquisition when the L1 conceptual links are stronger than the L2 conceptual links. As learners progress to higher levels of proficiency, direct links of L2 words to concepts are possible (Kroll & Sunderman, 2003, p. 114). In the reviewed LOs, providing bilingual glossaries would not be feasible as NESB students come from a number of different L1 backgrounds. Even though L1 glosses in ESL have been found to be particularly effective for long term vocabulary retention, glosses in general, L1 or L2, have been shown to be highly effective for incidental vocabulary learning (Yoshii, 2006). Based on the above, the following recommendations would allow ESL students to greatly benefit from this reference resource:

- For ESL students, glossing would need to be much more extensive, as NESB learners will be unfamiliar with a far larger number of vocabulary items than students who are native speakers of English. It would include not only technical vocabulary but also collocations, idioms, colloquialisms, low frequency vocabulary items, academic vocabulary, as well as high-frequency words that may be used with a different meaning than usual (e.g., the meaning of *great* is different in ‘We are *great* friends’ and ‘She is my *great* aunt’).
- Each glossary item would need to be explained in simple language using short sentences and high frequency vocabulary. An audio file would provide students with the standard English pronunciation of the word, while an illustration or even a simple animation or video clip of the lexical item where ever possible would provide students with additional visual input about the vocabulary item. Providing students with the pronunciation of new vocabulary items has been found to aid L2 word learning and long-term vocabulary knowledge (Cheung, 1996), while L2 glosses that contained both text and pictures or video clips were found to be much more effective than L2 glosses that offered only definitions (Al-Seghayer, 2001; Yoshii, 2006). However, the pictorial input should also be simple, clear, and direct as ‘rich’ images and videos that contain more information than is needed were found to ‘clutter’ students’ memory and affect their vocabulary retention (Chun & Plass, 1996; Jones, 2004) and even have a negative effect on reading comprehension, especially for students with lower levels of proficiency (Ariew & Ercetin, 2004).
- Students should be given the option to read the definition, listen to the pronunciation, or see a picture or animation of the glossed word. While access to full glossing may promote a deeper level of text comprehension (Lomicka, 1998), when reading a hypermedia text, students were found to prefer word definitions to other types of annotations, such as pronunciation and graphics (Ercetin, 2003). Furthermore, having the students choose what information they want to access makes the glossary an interactive resource and allows them to choose the modality of the input that best suits their different learning styles (Kettanurak, Ramamulthy, & Haseman, 2001).
- Access to glossing should be not only through hyperlinked words but also through a link to the whole glossary list that students could access and browse at any time and even print out. Being able to access the glossary at any time and select the type of information they want to view provides students with a sense of control, enhances their independence, reassures them that help is available at any time should they need it, and satisfies the ‘just-in-time learning’ and ‘just-enough information’ instructional principles (Novak & Patterson, 1998).

Feedback

The TLF LOs provided immediate feedback to the students throughout the different tasks and activities. However, the writing tasks where students have to produce text from scratch do not give any feedback. Providing explicit corrective feedback to ESL students is important for their linguistic development (see Han, 2001; Swain, 1995). In writing tasks where students have to produce sentences or a piece of writing in English, giving adequate feedback to the learner when an ungrammatical sentence is formed would be highly beneficial (Ellis, Loewen, & Erlam, 2006; Nagata, 1996). One major obstacle in designing a system for the provision of online intelligent feedback is the unpredictability of the errors that ESL students will make when attempting to produce the target language. It has been suggested that the theory of lexical functional grammar (LFG) could be used by software designers to create an error recognition system and to provide intelligent feedback to L2 learners (Reuer, 2003). To simplify this task even further, feedback could be provided for a small number of grammar error types that studies have shown to be particularly 'grievous,' such as word order, verb tense, word morphology, it-deletion in cleft constructions, relative clauses, and subject-verb agreement (Hinkel, 2004). Feedback screens should contain a concise description of the error and constructive guidance in a positive tone (Schulze, 2003).

EXTENSION ACTIVITIES

Additional extension ESL activities for each LO are recommended, as explicit instruction in L2 vocabulary and grammar improves learners' receptive and productive skills and expands their lexical and syntactic repertoires necessary for academic success (Hinkel, 2004). These activities should be designed to be part of the LO, but they should be optional so that students who are native speakers do not have to go through them, unless they choose to.

Grammar Activities

Even when ESL students can do the activities in the LOs and they appear to understand what the text is about, it does not mean that they have acquired the syntactic system of the target language (Chapelle, 1998). Usually semantic comprehension can be accomplished through the recognition of isolated vocabulary items or nonlinguistic clues like pictures and animations which are in abundance in the reviewed LOs. By helping ESL students process linguistic input both semantically and syntactically, *input* can become *intake*, that is, 'comprehended language that holds the potential for developing the learners' linguistic system' (Chapelle, 1998, p. 22). To aid NESB students' syntactic processing, extension activities targeting specific grammatical structures have to be provided. Certain language structures should be identified within each LO and chosen to be further explained and practiced. If NESB learners can receive explanation and practice for one grammatical structure per LO, through the use of the different LOs over time, they will acquire a good basis on English grammar. Research has also shown that practicing grammar through computer-based activities can be extremely beneficial for ESL students, even more than teacher-instructed grammar (Nutta, 1998; Torlakovic & Deuco, 2004). Certain grammar structures would need to be highlighted in the text (e.g., comparisons in *Wind Farm* and *Air Pressure*, superlatives in *Colossal Fossils: The Dig*, the use of past tense and present perfect in *Medical Emergency at Lonely Creek*, the use of past tense and simple present in *Heroes of the Air*, irregular plural and singular forms in *Eyeball Challenge*, the use of prefixes and suffixes to signify negation in *Patrick Brennan: The Legend of Ned Kelly*, etc.). Highlighting target structures in a text makes them perceptually salient and can be useful for enhancing listening and reading skills as well as productive skills (Collentine, 1997). A short and simple explanation of what the structure is and how it is used (e.g., how to form and use comparatives or superlatives) with examples of use from the script would be sufficient. Students should then be given opportunities to produce the structure and receive feedback. Providing students with explicit feedback and metalinguistic explanations has been found to be beneficial for developing explicit and implicit grammatical knowledge (Ellis et al., 2006). Activities to help them use the target structure can range from simple recognition tasks (e.g., identifying and highlighting the target structure in a text), to drill and practice exercises (e.g., doing a blank filling activity or unscrambling sentences that contain the target structure, etc.), to more open-ended tasks (e.g., having to produce new sentences from scratch) which would also require an intelligent level of feedback. These activities vary in their level of difficulty and having students select the level of difficulty they want or automatically and systematically progress from low level tasks to high level tasks will enhance their motivation and self-confidence (see Torlakovic & Deuco, 2004).

Vocabulary Activities

Vocabulary training through computer-based exercises has been found to benefit ESL students by accelerating their lexical access and word recognition skills (Fukkink, Hulstijn, & Simis, 2005). NESB students could benefit from simple and quick vocabulary activities such as matching pictures and words (spoken or written), spelling games, filling in missing letters in a word, and so forth. Such activities are popular with ESL students, as they require less mental effort and they would help students review key vocabulary at the end of their work with the LO content (Ma & Kelly, 2006). Other activities focusing on vocabulary production (e.g., creating a word puzzle or using the target word in a new sentence) will also aid students' vocabulary acquisition (Webb, 2005).

CONCLUSION

Even though research on the effectiveness of technology in language education is limited in many respects (e.g., there are not enough studies on secondary and primary school settings, while only certain aspects of second language learning have been investigated—mostly grammar and vocabulary—the available studies to date show a pattern of positive effects (Hartley, 2007; Zhao, 2003). This study aimed to examine a set of LOs designed for the mainstream classroom in order to assess their suitability for use by NESB students. The LOs reviewed in this chapter engage students in top-down processes necessitating attendance to meaning first. However, the low language proficiency of NESB learners may result in partial understandings, confusion, and even disengagement. Based on the reviewed LOs, a number of recommendations were compiled in order to modify the LOs and to help NESB students process input from a bottom-up perspective, as computer environments and multimedia lend themselves to such processing strategies. These recommendations, which resulted from the LO reviews and were based on second language acquisition research, could be further generalised to form the foundations of a set of guidelines that can be used in the future for designing LOs that would sensitive to the linguistic needs of NESB students. The following four sets of guidelines for LO modification and adaptation is a first attempt to summarise and group the recommendations included in this chapter in a format that will be easy to remember (SOAR) and hopefully apply:

- **S**implification and saliency of language input. Simplification, elaboration, and added redundancy are common strategies for modifying language input for ESL learners (Larsen-Freeman & Long, 1991) and increasing the saliency of linguistic features (Chapelle, 1998, 2003). LO instructions need to be clear and worded in simple language. Reading texts need to be short and have main ideas and keywords highlighted. Language needs to be free of complex syntactic structures as much as possible, and the use of language structures needs to be systematic throughout the LO.
- **O**utput opportunities. Students should be given ample opportunities to produce valuable 'comprehensible output' (Swain, 1985), rather than engage in mindless language use that receives no feedback. Giving ESL students the opportunity to correct their output through the provision of intelligent

feedback will enhance purposeful language production and create the necessary conditions that will facilitate and enhance their language acquisition.

- **A**ids for semantic and syntactic processing. ESL students should be given access to multimodal vocabulary glosses to help them accelerate their lexical acquisition and increase their reading comprehension. Help with syntactic processing should also be provided in the form of short explanatory screens, targeting a small set of high frequency language structures and grammar practice exercises.
- **R**einforcement of knowledge through repetition and reiteration. Providing ESL students with the opportunity to review newly acquired vocabulary and grammar through regular recycling activities within and across LOs will facilitate their long term retention of new knowledge. Also, allowing ESL students to print out grammatical explanations, vocabulary lists, and definitions as well as their own written output will help them review this information at a later stage and increase the possibility of commitment into long term memory.

These guidelines have the potential to modify LO content and make it accessible to NESB learners helping them to SOAR not only in their language development and subject matter knowledge but also in their motivation and attitude towards learning in a mainstream classroom. Increased accessibility of LO content will enhance NESB student-computer interaction (Cheng-Choo, 2004), which is a key factor in L2 acquisition according to interactionist SLA theory (Long, 1996). Although the guidelines described in this chapter are based on a study of the linguistic content of LOs designed for mainstream students, future research studies could investigate the affordances of online instructional materials that enhance linguistic input in digital resources designed specifically for primary and secondary NESB students.

REFERENCES

Allsop, J. (1983). *Cassel's students' English grammar.* East Sussex: Cassell Ltd.

Al-Seghayer, K. (2001). The effect of multimedia annotation modes on L2 vocabulary acquisition: A comparative study. *Language Learning and Technology, 5*(1), 202–232.

Ariew, R., & Ercetin, G. (2004). Exploring the potential of hypermedia annotations for second language reading. *Computer Assisted Language Learning, 17*(2), 237–259.

Arnold, S. (2004, December 2–3). Teaching with learning objects: Towards excellence in pedagogy for mathematics classrooms. In B. Tadich, S. Tobias, C. Brew, B. Beatty, & P. Sullivan (Eds.), *Towards excellence in mathematics: 2004 MAV Annual Conference*, Monash University, Clayton (pp. 1–12). Brunswick Vic: Mathematics Association of Victoria

Atkins, S. (2003). *Achieving educational soundness in the digital age.* Melbourne: The Le@rning Federation. Retrieved April 8, 2008, from http://www.thelearningfederation.edu.au

August, D., Hakuta, K., & Pompa, D. (1994). *For all students: Limited English proficient students and goals 2000.* Washington, DC: National Clearinghouse for Bilingual Education.

Becker, H. (2001). *Teaching ESL K–12: Views from the classroom.* Ontario, Canada: Heinle & Heinle.

Bernardo, A.B.I., & Calleja, M. (2005). The effects of stating problems in bilingual students' first and second languages on solving mathematical word problems. *Journal of Genetic Psychology, 166*(1), 117–129.

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educations Technology, 19*(1), 46–58.

Boyle, T., & Cook, J. (2001, December 9–12). Towards a pedagogically sound basis for learning object portability and re-use. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the crossroads: Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE)* (pp. 101–109). Melbourne: Biomedical Multimedia Unit, The University of Melbourne.

Bradley, C., & Boyle, T. (2004). The design, development, and use of multimedia learning objects. *Journal of Educational Multimedia and Hypermedia, 13*(4), 371–390.

Case, R.E. (2002). The intersection of language, education, and content: Science instruction for ESL students. *The Clearing House, 76*(2), 71–76.

Chapelle, C. (1998). Multimedia CALL: Lessons to be learned from research on instructed SLA. *Language Learning and Technology, 2*(1), 21–39.

Chapelle, C. (2003). *English language learning and technology.* Amsterdam: John Benjamins.

Chapuis, L. (2003). *Report on a pedagogical trial of learning objects in ACT schools.* Melbourne: The Le@rning Federation. Retrieved April 8, 2008, from http://www.thelearningfederation.edu.au

Cheng-Choo, K. (2004, November 24–25). The challenge of developing engaging interactive tertiary online language materials based on instructional design and learning principles. In K. Deller-Evans & P. Zeegers (Eds.), *Refereed proceedings of the 2003 Biannual Language and Academic Skills in Higher Education Conference* (pp. 149–159). Adelaide: Student Learning Centre, Flinders University.

Cheung, H. (1996). Nonword span as a unique predictor of second-language vocabulary learning. *Developmental Psychology, 32*(5), 867–874.

Chun, D.M. (2001). L2 reading on the Web: Strategies for accessing information in hypermedia. *Computer-Assisted Language Learning, 14*(5), 367–404.

Chun, D.M., & Plass, J.L. (1996). Effects of multimedia annotations on vocabulary acquisition. *The Modern Language Journal, 80*(2), 183–198.

Clarke, O. (2004, November 28–December 2). *Using digital content in authentic curriculum P–10 contexts: What do teachers have to say?* Paper presented at the Meeting of the Australian Association for Research in Education Conference, Melbourne, Australia.

Clarke, O., & Bowe, L. (2006). *The Le@rning Federation and the Victorian Department of Education and Training trial of online curriculum content with ESL students.* Melbourne: The Learning Federation. Retrieved April 8, 2008, from http://www.thelearningfederation.edu.au/

Collentine, J. (1997). Cognitive principles and CALL grammar instruction: A mind-centered, input approach. *CALICO Journal, 15*(1), 1–18.

Derewianka, B. (1990). *Exploring how texts work*. Portsmouth, NH: Heinemann.

DIMIA: *Immigration update, 2005–2006*. Research and Statistics Section. Department of Immigration and Multicultural Affairs. Retrieved April 8, 2008, from http://www.immi.gov.au/media/publications/pdf/Update_June06.pdf

Ellis, R., Loewen, S., & Erlam, R. (2006). Implicit and explicit corrective feedback and the acquisition of L2 grammar. *Studies in Second Language Acquisition, 28*(2), 339–368.

Ercetin, G. (2003). Exploring ESL learners' use of hypermedia reading glosses. *CALICO Journal, 20*(2), 261–283.

Freebody, P. (2006). *Early-stage use of the Le@rning Federation's learning objects in schools.* Melbourne: The Learning Federation. Retrieved April 8, 2008, from http://www.thelearningfederation.edu.au

Fukkink, R.G., Hulstijn, J., & Simis, A. (2005). Does training in second language word recognition skills affect reading comprehension? An experimental study. *The Modern Language Journal, 89*(1), 54–75.

Gass, S.M., & Selinker, L. (2001). *Second language acquisition: An introductory course*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Gibbons, P. (2002). *Scaffolding language, scaffolding learning: Teaching second language learners in the mainstream classroom*. Portsmouth, NH: Heinemann.

Gitsaki, C. (1999). *Second language lexical acquisition: A study of the development of collocational knowledge*. Bethesda, MD: International Scholars Publications.

Graesser, A.C., & Nakamura, G.V. (1982). The impact of a schema on comprehension and memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 59–109). New York: Academic Press.

Grgurovic, M., & Hegelheimer, V. (2007). Help options and multimedia listening: Students' use of subtitles and the transcript. *Language Learning and Technology, 11*(1), 45–66.

Gronn, D., Clarke, O., & Lewis, G. (2006). Using The Learning Federation's learning objects in the classroom. *Australian Primary Mathematics Classroom, 11*(2), 4–7.

Gunning, T.G. (2003). The role of readability in today's classrooms. *Topics in Language Disorders, 23*(3), 175–190.

Han, Z. (2001). Integrating corrective feedback into communicative language teaching. *Academic Exchange Quarterly, 5*(3), 12–18.

Harmer, J. (2004). *How to teach English: An introduction to the practice of English language teaching.* Essex: Longman.

Hartley, J. (2007). Teaching, learning and new technology: A review for teachers. *British Journal of Educational Technology, 38*(1), 42–62.

Haughey, M., & Muirhead, B. (2005a). Evaluating learning objects for schools. *E-Journal of Instructional Science and Technology, 8*(1).

Haughey, M., & Muirhead, B. (2005b). The pedagogical and multimedia designs for learning objects for schools. *Australasian Journal of Educational Technology, 21*(4), 470–490.

Hinkel, E. (2004). *Teaching academic ESL writing: Practical techniques in vocabulary and grammar.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Honnert, A.M., & Bozan, S.E. (2005). Summary frames: Language acquisition for special education and ELL (English language learners) students. *Science Activities, 42*(2), 19–30.

Ip, A., & Morrison, I. (2001, December 9–12). Learning objects in different pedagogical paradigms. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the Crossroads: Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE)* (pp. 101–109). Melbourne: Biomedical Multimedia Unit, The University of Melbourne.

Jia, G. (2003). The acquisition of the English plural morpheme by native Mandarin Chinese-speaking children. *Journal of Speech, Language, and Hearing Research, 46*(6), 1297–1312.

Jones, L. (2004). Testing L2 vocabulary recognition and recall using pictorial and written test items. *Language Learning and Technology, 8*(3), 122–143.

Kalyuga, S., Chandler, P., & Sweller, J. (1998). Levels of expertise and instructional design. *Human Factors, 40*(1), 1–17.

Kettanurak, V., Ramamurthy, K., & Haseman, W.D. (2001). User attitude as a mediator of learning performance improvement in an interactive multimedia environment: An empirical investigation of the degree of interactivity and learning styles. *International Journal of Human-Computer Studies, 54*(4), 541–583.

Kroll, J.F., & Sunderman, G. (2003). Cognitive processes in second language learners and bilinguals: The development of lexical and conceptual representations. In C.J. Doughty & M.H. Long (Eds.), *The handbook of SLA* (pp. 104–129). Malden, MA: Blackwell Publishing.

Kurshan, B., Isler, E., & Blackburn, J. (1997). ESL (English as a second language) electronic classroom. *Multimedia Schools, 4*(2), 46–49.

Laplante, B. (1997). Teaching science to language minority students in elementary classrooms. *NYSABE Journal, 12*, 62–83.

Larsen-Freeman, D. (1997). *Grammar dimensions.* Boston: Heinle & Heinle.

Larsen-Freeman, D., & Long, M. (1991). *An introduction to second language acquisition research.* London: Longman.

Leech, G., Rayson, P., & Wilson, A. (2001). *Word frequencies of written and spoken English: Based on the British national corpus.* London: Longman.

Lightbown, P., & Spada, N. (1999). *How languages are learned.* Oxford: Oxford University Press.

Lo Bianco, J. (1998). ESL: Is it migrant literacy? Is it history? *Australian Language Matters, 6*(2), 1, 6–7.

Lomicka, L.L. (1998). 'To gloss or not to gloss': An investigation og reading comprehension online. *Language Learning and Technology, 1*(2), 41–50.

Long, M. (1996). The role of the linguistic environment in second language acquisition. In W.C. Ritchie & T.K. Batia (Eds.), *Handbook of second language acquisition* (pp. 413–468). San Diego: Academic Press.

Ma, Q., & Kelly, P. (2006). Computer assisted vocabulary learning: Design and evaluation. *Computer-Assisted Language Learning, 19*(1), 15–45.

McGreal, R. (2004). Learning objects: A practical definition. *International Journal of Instructional Technology and Distance Learning, 1*(9).

Miller, J.M. (2000). Language use, identity, and social interaction: Migrant students in Australia. *Research on Language and Social Interaction, 33*(1), 69–100.

Mohan, B. (2001). The second language as a medium of learning. In B. Mohan, C. Leung, & C. Davison (Eds.), *English as a second language in the mainstream: Teaching, learning and identity.* Essex: Pearson Education Limited.

Mohan, B., Leung, C., & Davison, C. (2001). *English as a second language in the mainstream: Teaching, learning and identity.* Essex: Pearson Education Limited.

Murphy, R. (1994). *English grammar in use.* Cambridge: Cambridge University Press.

Nagata, N. (1996). Computer vs. workbook instruction in second language acquisition. *CALICO Journal, 14*(1), 53–75.

Nesbit, J.C., & Adesope, O.O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research, 76*(3), 413–439.

Nielsen, J. (2000). *Designing Web usability: The practice of simplicity.* Indianapolis: New Riders Publishing.

Novak, G.M. & Patterson, E.T. (1998, May). Just-in-time teaching: Active learner pedagogy with WWW. Paper presented at IASTED International Conference on Computers and Advanced Technology in Education, Cancun, Mexico.

Nutta, J. (1998). Is computer-based grammar instruction as effective as teacher-directed grammar instruction for teaching L2 structures? *CALICO Journal, 16*(1), 49–62.

Oliver, R. (2001, December 9–12). Learning objects: Supporting flexible delivery of online learning. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the Crossroads: Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE)* (pp. 101–109). Melbourne: Biomedical Multimedia Unit, The University of Melbourne.

Robertson, M., & Fluck, A. (2004, November 28–December 2). *What makes a good learning object?* Paper presented at the Meeting of the Australian Association for Research in Education Conference, Melbourne, Australia.

Reuer, V. (2003). Error recognition and feedback with lexical functional grammar. *CALICO Journal*, *20*(3), 497–512.

Schulze, M. (2003). Grammatical errors and feedback: Some theoretical insights. *CALICO Journal, 20*(3), 437–450.

Scott, S. (2003). Learning objects: Curriculum resources for the 21st century. *Access*, *17*(4), 14–15.

Swain, M. (1985). Communicative competence: Some roles of comprehensible input and comprehensible output in its development. In S.M. Gass & C.G. Madden (Eds.), *Input in second language acquisition* (pp. 235–253). Rowley, MA: Newbury House Publishers.

Swain, M. (1995). Three functions of output in second language learning. In G. Cook & B. Seidlhofer (Eds.), *Principle and practice in applied linguistics.* Oxford: Oxford University Press.

Torlakovic, E., & Deugo, D. (2004). Application of a CALL system in the acquisition of adverbs in English. *Computer Assisted Language Learning, 17*(2), 203–235.

Verdugo, D.R., & Belmonte, I.A. (2007). Using digital stories to improve listening comprehension with Spanish young learners of English. *Language Learning and Technology, 11*(1), 87–101.

Verplaetse, L.S. (1998). How content teachers interact with English language learners. *TESOL Journal, 7*(5), 24–28.

Webb, S. (2005). Receptive and productive vocabulary learning: The effects of reading and writing on vocabulary learning. *Studies in Second Language Acquisition, 27*(1), 33–52.

Wiley, D.A. (2000). *Learning objects: Difficulties and opportunities.* Retrieved April 8, 2008, from http://wiley.ed.usu.edu/docs/lo_do.pdf

Wiley, D.A. (2001). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. Wiley (Ed.), *The instructional use of learning objects* (Online version, chap. 1). Retrieved April 8, 2008, from http://www.reusability.org/read/

Wilson, K. (1999). Note-taking in the academic writing process of non-native speaker students: Is it important as a process or a product? *Journal of College Reading and Learning, 29*(2), 166.

Yoshii, M. (2006). L1 and L2 glosses: Their effects on incidental vocabulary learning. *Language Learning and Technology, 10*(3), 85–101.

Zhao, Y. (2003). Recent developments in technology and language learning: A literature review and meta-analysis. *CALICO Journal*, *21*(1), 7–27.

KEY TERMS

CALL (Computer Assisted Language Learning): Software designed specifically for teaching English language skills to ESL students.

English As a Second Language (ESL) Students: Learning English while living in an English-speaking country.

L1 (First Language/Mother Tongue): The language NESB students speak at home.

L2 (Second Language): The language NESB students speak at school.

Learning Objects (LOs): Educational digital resources targeting specific areas of the curriculum (e.g., Math, Science, LOTE).

Learning Object Repository (LOR): A collection of LOs accessible electronically.

Non-English Speaking Background (NESB) Students: Students whose first language is not English. Migrant children, refugees, indigenous Australians, and second generation ethnic minority Australians are usually from a non-English speaking background.

APPENDIX A

Table 1. The Le@rning Federation learning objects reviewed in this study

Learning Object Title	**Year Level***	**Curricular Area**
Playground Rules	P–2	Studies of Australia
What's your job	P–2	Studies of Australia
The night of the Bilby	P–4	Studies of Australia
Make the rules	P–4	Studies of Australia
Island life	P–6	Studies of Australia
Job match	1–6	Studies of Australia
Neighbourhood charter	3–4	Studies of Australia
Water matters	3–6	Studies of Australia
Group membership	3–6	Studies of Australia
Take a vote	3–6	Studies of Australia
Community enterprise	3–8	Studies of Australia
Kangaroo	5–8	Studies of Australia
Balancing the Options	5–8	Studies of Australia
Cartown	5–8	Studies of Australia
Your rubbish pile	5–10	Studies of Australia
The futurist	7–10	Studies of Australia
Homelessness	7–10	Studies of Australia
Wind Farm	7–10	Studies of Australia
Know your rights	7–10	Studies of Australia
Changing Faces	7–10	Studies of Australia
GM foods	7–10	Studies of Australia
Sunday trading	7–10	Studies of Australia
Fish stocks	7–10	Studies of Australia
Golden fleece	P–2	Studies of Australia
National Parks	P–2	Studies of Australia
The Cobb & Co coach	P–2	Studies of Australia
The Enterprise	3–6	Studies of Australia
Gold Rush	3–6	Studies of Australia
Citizen's Arch	3–6	Studies of Australia
Heroes of the Air	3–6	Studies of Australia
The journey of the Hong Hai	3–7	Studies of Australia
New homes	5–6	Studies of Australia
The first golden age of cricket	5–6	Studies of Australia
Medical Emergency at Lonely Creek	5–6	Studies of Australia
Beth Murray: The people behind the Snowy Mountains Scheme	7–8	Studies of Australia
Fiona Chiu: Chinese Family Tree	7–8	Studies of Australia
Nhu Minh: Multiculturalism in Australia	7–8	Studies of Australia
Samual Cooper: Putting the rabble to work	7–8	Studies of Australia
Dorothy Griffin: Great Australian Women	7–8	Studies of Australia

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Table 1. The Le@rning Federation learning objects reviewed in this study (continued)

Learning Object Title	Year Level*	Curricular Area
Patrick Brennan: The legend of Ned Kelly	7–8	Studies of Australia
Peter Dalton: Enlistment and the call to war	9–10	Studies of Australia
Norman Dean: Great Depression	9–10	Studies of Australia
Mervyn Bishop	9–10	Studies of Australia
Water	P–2	Science
Day and night	P–2	Science
Weather	P–2	Science
Soil	P–2	Science
Mixing colors	P–2	Science
Light and Shadows	P–2	Science
Under the Earth	P–2	Science
Land Use	P–2	Science
Garden Detective	P–2	Science
Water use	P–2	Science
Food chains	P–2	Science
Let's make it go	P–1	Science
Animal search	1–2	Science
Human body	3–4	Science
Plant life	3–4	Science
Human impact	3–4	Science
Surviving in a habitat	3–4	Science
Energy from the sun	3–5	Science
Sound: Thunderstorm	3–6	Science
Steady ships	3–6	Science
Sound	3–6	Science
Mystery substances	3–6	Science
Frog pond habitat	3–9	Science
Jet force	4–6	Science
Energy efficient house	4–6	Science
Light and reflection	5–6	Science
Create a creature	5–6	Science
Chemical science	5–6	Science
Making music	5–6	Science
Matter and evaporation	5–6	Science
Optics and images	5–6	Science
Colossal fossils: the dig	5–6	Science
Pulleys	5–8	Science
Eyeball challenge	5–8	Science
Air pressure	5–8	Science
Bacteria zoo	5–8	Science
Fair test	5–8	Science
Additive color	5–8	Science

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Table 1. The Le@rning Federation learning objects reviewed in this study (continued)

Learning Object Title	Year Level*	Curricular Area
Subtractive color	5–8	Science
Meet a scientist	5–9	Science
Shaping the land	5–10	Science
Wild ride	6–7	Science
Sports shoes	6–7	Science
Lunar cycles	7–8	Science
The elements	7–8	Science
Earth rotation	7–8	Science
Plastics	7–8	Science
Travel back in time	7–9	Science
The colour of water	7–10	Science
Science reporter	7–10	Science
Accelerate	7–10	Science
Optics and prisms	8–10	Science
UV index	9–10	Science
Sunscreens	9–10	Science
Chemical reactions	9–10	Science
Exploring atoms: Atom structure	9–10	Science
Glide	9–10	Science
Isotopes and Radiation	9–10	Science
Nuclear Power	9–10	Science
Wind Power	9–10	Science
Speed and Distance	9–10	Science
Speed and direction	9–10	Science
Vision and lenses	9–10	Science
Logic gates	9–10	Science
Optics and refraction	9–10	Science
Seeing with sound	9–10	Science
Directional Design	7–10	Arts, Design & Technology
Squirt	4–8	Mathematics
Circus Towers	7–9	Mathematics
Lifting Loads	8–9	Mathematics

** Note: a wide range of year levels per title indicates multiple LOs under the same title with each LO aiming at a specific year level.*

Chapter XXII
Learning Objects, Learning Tasks, and Handhelds

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ABSTRACT

The main idea behind learning objects is that they are to exist as digital resources separated from the learning task in which they are used. This allows a learning object to be reused with different learning tasks. However, not all learning objects operate in similar ways, neither are all learning tasks the same, and this exposes the problem that current recommendations from literature fail to link learning objects and their reuse in varied learning tasks. In this chapter, we explore definitions of learning objects and learning tasks. We also suggest that appropriate matches would lead to more effective pedagogical applications that can be used as set of recommendations for designers of learning objects and teachers who plan learning tasks and select learning objects for student learning activities. In addition, we discuss applications of learning objects delivered by emerging technologies which may change how digital resources are accessed and used by students in and out of classrooms.

LEARNING OBJECTS

Initially, the idea behind learning objects was that the curriculum content of a course could be broken down into small, reusable instructional components and each addressed a specific learning objective. These components could be tagged with metadata descriptors and deposited in digital libraries for subsequent machine-defined reuse into larger structures such as lessons and courses (see Cisco Systems, 2001; E-learning Competency Center, 2003; IMS Global Learning Consortium, 2002; L'Allier, 1998; Wiley, 2000). These early ideas largely emerged from a partnership between information technology and traditional instructional design communities who believed that information could be packaged into learning objects, and that when the learning objects were arranged according to a set of rules in a particular sequence, learning would result (Jonassen & Churchill, 2004). More recently, learning objects have been viewed as a promising strategy to support technology-based learning especially in the design, management, and reuse of educationally useful resources (Churchill, 2006). Learning objects emerged within a variety of frameworks for understanding the design of student-centered learning such as constructivist learning environments (Jonassen, 1999), problem solving (Jonassen, 2000), engaged learning (Dwyer, Ringstaff, & Sandholtz, 1985-1998), problem-based learning (Savery & Duffy, 1995), rich environments for active learning (Grabinger, 1996), technology-based learning environments (Vosniadou, De Corte, & Mandl, 1995), interactive learning environments (Harper & Hedberg, 1997), collaborative knowledge building (Bereiter & Scardamalia, 2003), 3D virtual world explorations in Quest Atlantis (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005), situated learning (Brown, Collins, & Duguid, 1989), and WebQuests (Dodge, 1995). Common to these frameworks, students must engage and interact with a task where knowledge is created and applied and the learning object is critical to this outcome.

Learning objects can be described as interactive, multimedia curriculum resources purposely designed to achieve learning outcomes (Le@rning Federation, 2007). Alternatively, learning objects can be described in more general terms as a representation designed to afford use in different educational contexts (Churchill, in press a). Learning objects can be distinguished from a *digital resources* which refer to pertinent multimedia resources that can be woven into learning objects, sequences, or activities. Digital resources normally refer to images, movie clips, and audio files sourced from diverse collections of cultural and scientific institutions. If learning objects are to be uniquely effective, they must replace, supplant, or advance other forms of representation and thus contribute to a "disruptive pedagogy" in which the digital representation replaces all previous representations (Hedberg, 2006). The concept of disruptive pedagogies suggests that to result in effective learning, digital resources should represent ideas in ways that are difficult if not impossible with previous nondigital forms. In this context, learning objects utilize representation capabilities of contemporary technologies and merge these into a set of educationally useful displays of data, concepts, and ideas. The definition should be considered together with the intended uses of educationally relevant material that they display: presentation, practice, simulation, conceptual models, information, and contextual representation objects (see Table 1). The traditional approach to computer-based learning is not rejected by this classification but incorporated in the classification primarily under the presentation objects category. Presentation objects can be combined with practice objects into larger structures that resemble computer-based instructional modules.

Usually, learning objects reside in digital repositories, ready to be retrieved and utilized by those involved in generating educational activities (e.g., teachers and students). These representations address: key concepts from disciplines, in visual and often interactive ways (conceptual models); information (information objects) and situated data (contextual representation objects) that can be useful in the context of developing discipline-specific thinking, a culture of practice, a spirit of inquiry, theoretical knowledge, and information; presentation of small, instructional sequences and demonstrations that deliver encapsulated descriptions and illustration of some aspects of subject matter (presentation objects); provide opportunity for practice (practice objects); and simulations

Table 1. Types of learning objects (from Churchill, in press a)

Learning Object Type	*Explanation*	*Simple Example*
• Presentation object	• Direct instruction or presentation resources designed with the intention to transmit specific subject matter	• A presentation or an instructional sequence on classification of triangles
• Practice object	• Drill and practice with feedback, educational game, or representation that allows practice and learning of certain procedures	• Quiz question requiring a learner to use representation of a protractor to measure angles and answer a question regarding ration between base and height of the right-angled triangle
• Simulation object	• Representation of some real-life system or process	• Simulation of a compass allowing learner to draw a geometric shape (e.g., equilateral triangle)
• Conceptual model	• Representation of a key concept or related concepts of subject matter	• Representation that allows manipulation of parameters of a triangle, which in turn changes displayed modalities such as visual representation of a triangle, and numerical values of sizes of its angles and sides, and displays a graph showing changes in relationship between sides or angles
• Information object	• Organized display of educationally useful information where the organized form assists in understanding	• Representations that allow learners to change angles and sizes of a triangle and, based on configuration, to obtain information such as the type of triangle illustrated, a picture showing it in real-life, and a short description of its properties
• Contextual representation	• Data displayed as it emerges from represented authentic scenario	• Representations that show real-life examples of triangle (e.g., roof of a building) and allow a learner to use representation of a tool (e.g., tape measure) to collect data about dimensions of these triangles.

of key equipment, tools, and processes from a discipline to support the development of a deeper understanding of artifacts used in a culture of practice (simulation objects). Some of the learning objects from the classification can be combined with other objects into direct instruction products supporting traditional pedagogies (e.g., computer-based tutorials). Other learning objects are more appropriate in the context of contemporary pedagogical approaches as resources to be deployed in learning tasks designed by teachers. Through all these forms, representation and interaction are key attributes which also explains why they are also sometimes called manipulatives.

LEARNING TASKS

For any learning object to be meaningfully and effectively used in learning, there is a need for student to engage in a learning task where the learning objects support and manipulate a recognizable context. The suitably designed task might include an ill-structured, dynamic, and authentic challenge that requires students to solve problems, conduct inquiries, work with information and data, collaborate, and deliver products and presentations. Students would be expected to apply emerging understanding through strategic decisions, as well as engage in metathinking about their solution strategy, and reflect on its success in achieving the goal. Such a task, as more specifically defined by the literature, might take the task form of troubleshooting, strategic performance analysis, case study, design challenge, or resolving a dilemma (for more detailed classification of problem types, see Jonassen, 2000). Some examples of tasks designed to engage students in learning might include:

1. Create an aerial map of an area surrounding and including the school
2. Develop a digital story to promote an artistic creation
3. Write a proposal for a suitable water treatment technology to overcome a water shortage problem
4. Plan a menu for foreign visitors
5. Design a model to demonstrate how friction plays an important role in motion
6. Create a visual representation (e.g., mind map) that illustrates the rise and fall of Napoleon Bonaparte
7. Maintain a blog the describes the benefits of living in a particular country
8. Develop a presentation about 21st-century artifacts that will no longer be useful in the year 3000

Table 2. Learning tasks as the basis for high quality design

	Rules	*Incidents*	*Strategies*	*Roles*
Description of the design focus	The learning task requires learners to apply standard procedures and rules in the solution. Learners meaningfully and reflectively apply procedures and processes.	The learning activity is focused around learners' exposure and participation in authentic and realistic events or incidents. The learning activities require learners to reflect and take decisions based on their responses to events.	Learning is focused around the strategies employed to achieve the task goals. Often, the strategy options are generated as part of the solution. Often, tasks have time and performance constraints.	The learning is achieved through learners' participation as a player and participant in a setting that models a real world issue. Learners negotiate, apply judgments, experience subrogation, and employ multiple perspectives.
Jonassen (2000) problem design types	Logical problems Algorithmic problems Story problems Rule-using problems	Scenarios* Decision making Case study tasks	Troubleshooting Diagnosis solution problems Strategic performance tasks Design tasks	Dilemmas Social dilemmas*

**Not included in the classification by Jonassen*

9. Collect and organize material to support an argument for or against nuclear power (from Churchill, 2006)

A task provides a focus for students to engage in a goal-directed set of subtasks (or actions). A goal, for example, may be to design a multimedia presentation, build a physical model, or otherwise give public life to an idea. By engaging with the task, students should be led to experience a flow-through transformative cycle of "information and data-knowledge-application and innovation." In this cycle, learning is a part of the process of adaptability to the conditions of the task; that is, learning is voluntary and directed as an applied strategy towards achieving a particular goal. Through this cycle, properties of resources and products emerging from involvement in the task, as well as interactions with others, penetrate into and change students' knowledge. Appropriate resources include learning objects that contain representations that support task completion.

Problem-based learning challenges can be considered in four categories according to the underlying concept that the learner is addressing. Thus, the learner might be practicing the use of *rules* or standard processes to achieve a solution; the learner might explore a *incident* or scenario and argue for a particular course of action; the task might include a new design so the focus is upon the *strategy* through which it is achieved; and the situation might require the analysis of different perspectives and hence the challenge is seen in terms of a particular *role* that the student might take (Hedberg, 2002). This classification was developed from Jonassen (2000) who suggests a range of problem types each of which has a specific design approach. Table 2 presents this classification of learning task in more detail.

CASE STUDY OF A LEARNING OBJECT USE WITHIN A LEARNING TASK

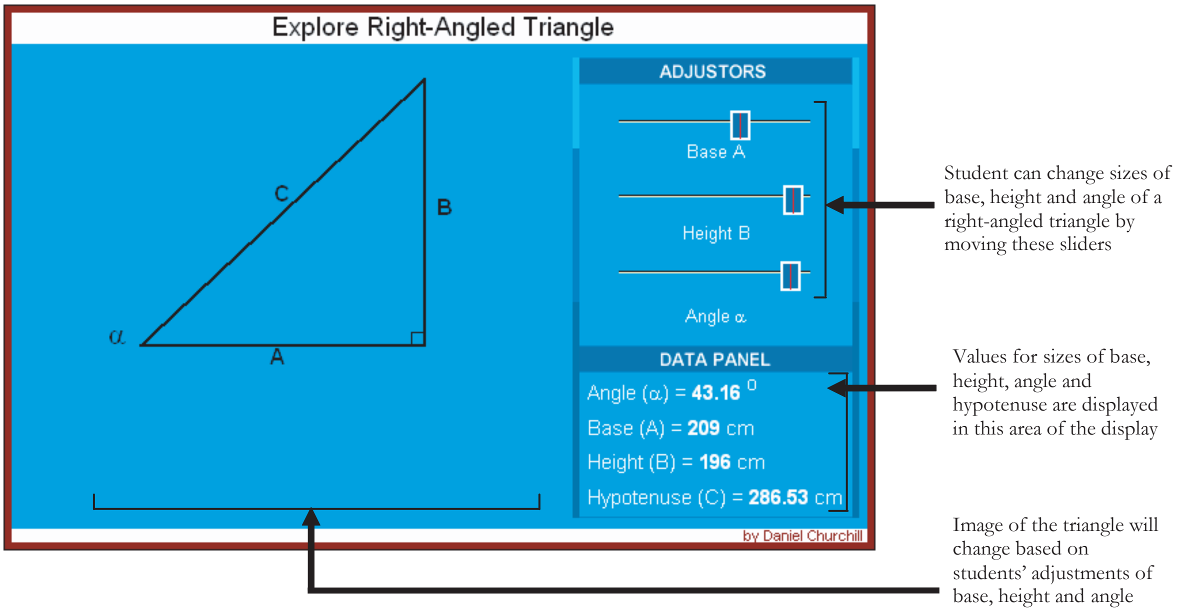
An example of a learning object is illustrated in the Figure 1. This learning object is a conceptual model learning object entitled "Explore Right-angled Triangle." This learning object could possibly be used in variety of learning tasks enabling students to develop mathematical concepts such as the Pythagorean Theorem, similar triangles, or trigonometric rules.

By repositioning a set of sliders, students manipulate values for base, height, and angle of a triangle, and then examine changes in value of hypotenuse. This allows students to keep the angle constant while changing sides of the triangle and examining the ratio that exists between the sides. The changes are represented:

1. Numerically as numbers relating to the sides and angles of the triangle, and
2. Visually as a dynamic drawing of a triangle.

The role of a teacher is to design learning tasks that will require students to work with material and produce a portfolio of artifacts that demonstrate their learning achievements. Once a learning task is planned, suitable resources (including learning objects) to enable student learning are often supplied. The learning object in Figure 1 was used by a group of school students who were presented with a problem to identify the height of objects in their school environment such as school buildings, lamp posts, and trees (Churchill, 2005). This challenge was part of a learning task that involved students in designing a small scale model of their "new school" environment. The students needed to work in small teams and obtain measurements of different objects in

Figure 1. "Exploring Right-angled Triangle" learning object



their environment in order to construct a model to an appropriate scale. Although they were able to simply use tape measure to measure parameters, this was not possible with vertical objects such as trees. Divided into small groups, they were given a tape measure to measure the distance from a group member to the object (e.g., a tree) and an inclinometer to measure the angle of elevation from the group member to the top of the object. The groups were also provided with a digital camera to collect evidence of their data collection, which they needed for subsequent presentation of their solutions and approaches.

The students were provided, among other resources, with the learning object from Figure 2. Prior to going into the field, the students explored this learning object via computer. They were told that it would later be helpful during their field work. Their initial exploration of a learning object was supported by a set of questions and graphical organizers which directed them to approach this inquiry in an appropriate way: for example, to collect some values in a table, to compare different rows and columns in search of patterns and build some preliminary generalizations about concepts represented by learning object. Once the students moved outside of the classroom to collect measurements of objects, some handheld devices (PDAs) with the learning object were made available for them to use as reference tools while they interpreted the situation and explored possible solutions. The solution to the problems is based on the ratio of the base and height of a triangle that remains constant for any size of right-angled triangle with the same angle of elevation. Groups of students were encouraged to discuss and share their problem-solving approaches. Once groups arrived at their solutions, a representative of each group was required to present their solution to the rest of the class. The presentation contained a proposed solution to the problem, an approach to the solution based on the learning object and digital photos they collected of objects that they measured in their problem-solving task.

Several weeks later, the students were asked to estimate the values of a ratio of sides of a right-angled triangle with given sizes of an angle provided to them. They were also asked to recall their experience with the learning object and to explore whether this recall would help them in their estimation. Interesting patterns were observed as the students employed auxiliary means to help them in this estimation. Some students sketched triangles on paper. Others used their pens, rulers, and other objects as arms of a constructed angle. Some students used their fingers as arms of an angle in attempting to reconstruct elements of the learning object in the air in front of their eyes. These behaviors indicate that some form of interaction between mental structures (cognitive residues from previous activity and interaction with the learning object) and physical objects (auxiliary means) was occurring. Aspects of an activity involving the learning object were reconstructed as a cognitive resource in a similar way to the way children learn to work with numbers. Vygotsky (1962) observed that when learning to count or perform simple addition or subtraction, young children are likely to use their own fingers as auxiliary means. Children will later begin to hide their hands behind their backs and keep using their fingers to aid the process; the auxiliary means disappears from the visual field but remains physically present. Slowly, children will stop using their fingers or other auxiliary means and the process will become more internal. Auxiliary means do not disappear, however, through internalization of an external activity they begin to operate purely in the mind; that is, they take form of internal psychological mediator.

MATCHING LEARNING OBJECTS WITH LEARNING TASKS

For Foo, Ho, and Hedberg (2005), learning task design should be the central task for the teacher when designing learning activities that engage students. Based on a study of several teachers, these authors suggest that the key indicator of successful technology-based task design is the level of student engagement generated, and task design is dependent upon teacher interpretation and translation of the concept to be learned and their perception of how technology might facilitate it. Thus, the main pedagogical advantage for learning objects is how they enable and support students working on learning tasks. For example, Boud and Prosser (2002) suggest four major areas need to be addressed in the design of a high-quality learning environment:

1. How does the learning task support learner engagement? The reasons for the learner wishing to become involved with the learning tasks and the way the tasks require them to reflect or employ their previous interests and understandings.
2. How does this learning task acknowledge the learning context? In the case of learning objects, there are unique characteristics. Learners can be in a real context, and assessment can be made to employ real world skills.
3. How does the learning task seek to challenge learners? Novices need supportive structures, experts require information to fill in the missing blanks in an existing knowledge structure, too much ambiguity can turn a novice student away, too little and they become bored. Novices might need support to extend the information provided as part of a problem-solving scenario.
4. How does the learning task provide practice? As with most effective learning contexts, the

Table 3. Matching a learning object to a learning task

Type of Task / Type of LO	*Rule focused*	*Incident focused*	*Strategy focused*	*Role focused*
Presentation object	Instruction how to execute certain algorithm (e.g., calculate area of a triangle)*	Presentation slides instructing issues to consider when making a decision in relation to an event or incident (e.g., what to do if driver refuses to produce his or her license)	Description of the strategy and procedure to be used in solving a problem (e.g., how to troubleshoot faulty computer)	Instruction how to act in a situation requiring an answer to controversial question (e.g., what to do if a student with special needs fails to submit an assignment)
Practice object	Practice item that allows a learner to repeatedly practice application of a rule (e.g., calculate circumference of a circle with given diameter)	Practice requiring action based on some emerging event or incident (e.g., select a medication for a patient based on symptoms presented)	Practice that allows a learner to dismantle and assemble certain system and explore its components (e.g., dismantling and assembling a water pump)	Practice that requires a learner to interact with a virtual character and negotiate solution (e.g., negotiating court case settlement)
Simulation object	Simple simulation that requires logical action based on imposed rule without understanding of underlining principles (e.g., turn on a TV and change channels)	Simulation of some decision making process (e.g., scan a patient's hand and decide whether to repeat the scan)	A simulation of a measuring instrument or a tool used in troubleshooting (e.g., digital multimeter instrument)	A simulation of a social entity that allow a learner to act in a variety of scenarios emerging form the situation (e.g., managing classroom behavior)
Conceptual model	Representation that enables a learner to construct internal model of a rule to be used in solution of algorithmic problem (e.g., representation of how to divide two numbers)	Conceptual model that allows a learner to explore if-than or cause-and-effect scenario (e.g., effect of spread of birth flue on markets in Asia)	Representation of a concept which guides an expert in diagnosing a problem and proposing solution (e.g., concept of Ohm's Law)	Representation of value system held by an expert that supports his or her judgment (e.g., value system of a movie produces who produced a controversial film)
Information object	Illustrated story problem (e.g., James has to go to airport to meet his father. How long it would take him to get there based of given parameters)	Interactive table of some useful information or a flow graph of decision making process (e.g., trigonometric table)	Information with description of items (e.g., items required for interior design of an apartment)	Organized collection of articles (e.g., newspaper clips allowing a learner to explore them, for example, by navigating along a time)
Contextual representation	Simple real-life scenario that provides few variables which can be captured and used in the rule to solve a problem (e.g., click on a vehicle to capture how fast it is going)	Realistic scenario that provides data which is used to make a decision (e.g., collecting water quality indicators form the lake)	Representation that allows collection of data from a realistic scenario which shape strategy applied in solving a problem (e.g., collecting performance data from a faulty engine)	A scenario that allow a learner to collect views of different people affected by the situation (e.g., collecting views about war in Iraq)

** These are suggested rather than absolute possibilities* matches between assessment, learning tasks, and the transfer tasks might align and model performance. Feedback must be consistent for learning.

These four criteria might be applied to the evaluation of a good learning object for an educational task. The object must be engaging, provide authentic context, facilitate the sequence of learning, and provide appropriate practice and feedback along the way. In the example above and those which follow, these elements can be readily identified. In addition, the technology chosen must obviously enable the learning task to ensure appropriate learning environments and strategies are created. To actively engage learners, the learning task should include several strategies such as:

1. Active engagement with the tools and the task; participation in groups; frequent interaction and feedback; and connectedness to real world contexts (Roschelle, Pea, Hoadley, Gordin, & Means, 2001)
2. Going beyond the amplification of cognition and to assist with a reorganization of mental functioning (Pea, 1985)
3. Focusing on knowledge building rather than knowledge reproduction (Scardamalia & Bereiter, 1996)

Learning objects can achieve these strategies through their interactivity, their requirement to generate a response from a specific set of factors or variables, not simply recall a previously given answer. As with good game design, the context presented to the learner should be an interesting challenge, not simply a repetition of previous demonstrated responses.

Obviously, understanding the affordances of the learning object and how it might be used within the learning activity is the key skill set for the teacher. Norman (1988) defines affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (p. 9), while for Barnes (2000), a teacher's use of new technology in teaching and learning is carried out with a belief that this technology will afford learning in some way. Understanding how different types of learning objects support different types of learning tasks can provide useful heuristics for selecting learning objects from repositories and the Internet more generally. In addition, the framework might also be useful for designers of learning objects in suggesting learning objects that might be usefully developed. The guideline is represented in Table 3.

APPLICATION OF LEARNING OBJECTS VIA HANDHELD DEVICES

Handheld devices for the delivery of learning objects can obviously become critical and important for learning in authentic contexts. A key advantage of handheld technology is portability which enables students to have access to learning objects anytime and anywhere as required by the demands of a learning task (e.g., during field-based inquiries, during an experiment in a laboratory, or a class trip to a museum). Conceptual models and information objects appear to be the best match for this kind of technology application (Churchill, in press b). A handheld device today is not only a small portable piece of technology; it is equipped with computer capabilities, wireless network connectivity, mobile telephony, a camera, and a variety of other hardware and software extensions. These devices are referred to variously as PDAs) Pocket PCs, "smartphones" (Keegan, 2004), "wearables" (Sharples, 2000), "communicators," or "mobile multimedia machines" (Attewell, 2005). For Attewell (2005), as the number of such devices available globally increases, this technology will become "digital life" for many individuals. This tool potentially creates a spectrum of educational opportunities and a new type of student-technology partnership in learning. Handheld devices may assist learners "to access internet resources and run experiments in the field, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world" (Sharples, Corlett, & Westmancott, 2002, p. 222). For Luchini, Quintana, and Soloway (2004), the key benefit of handheld device technology is that it is a powerful personal device that "provides access to tools and information within the context of learning activities" (p. 135).

For Klopfer and Squire (2005), use of handheld devices in teaching and learning depends largely on understanding of the educational affordances of this technology. Churchill and Churchill (in press) suggest five potential areas of educational affordances of handheld devices:

1. *Multimedia-access tool:* a variety of multimedia resources can be delivered using this technology such as e-books, Web pages, presentations, interactive resources, audio files, and video segments. These resources can be accessed anytime, anywhere (by connecting to the Internet using GPRS or wireless network connections), from the memory of the device or storage card if the resources were previously downloaded, or through synchronization of the device with a computer. But merely moving resources from a computer to a handheld device might not lead to effective learning.
2. *Connectivity tool:* handheld devices empower students to connect to each other, facilitators, and experts in the field; exchange ideas and files; collaboratively build understanding; manage activities; negotiate roles in their projects; and so forth. Connection might be established synchronously and asynchronously over mobile telephony and wireless networks that support voice and multimedia data transmission.
3. *Capture tool:* handheld technology is equipped with capture capabilities that include capture of video and still photographs. Students might, for example, photograph and videotape machines and people during their industry visits, or photograph diagrams from a book or catalogue. The capture affordance also includes audio capture. For example, students might interview experts and capture their own audio notes, or capture characteristic sounds of a faulty engine. There is a possibility for specially designed extensions and consoles to be attached to a handheld device and used to capture, store, and process other kinds of data such as recording global positioning of certain air pollution sources. The devices also enable connectivity to share geographical positioning (Lim, Hedberg, & Chatterjea, 2004)
4. *Representational tool:* handheld technology can be used by students to create representations which demonstrate their thinking and understanding such as, mind maps, captured, created, or edited images. The literature often refers to these representation tools as "mind tools" or "cognitive tools" (Jonassen & Carr, 2000; Jonassen & Reeves, 1996). Patten, Sánches, and Tangney (2006) noted that such tools exist for handheld device applications when they reviewed microworld functionality, which allows students to build models. Lately, there has been an emergence of a number of representational tools for handheld device delivery (e.g., Mind Manager, Inspiration); these tools are worthy of attention for their student-centered learning potential without the constraints of the classroom.
5. *Analytical tool:* a mobile-enabled handheld device might be used as an analytical tool to aid students' tasks. For example, these might include standard, scientific, and graphic calculators or specially designed analytical

tools such as digital probes for scientific data collection. Current small footprint technology is employing data collection and analysis tools.

Literature suggests that other affordances of handheld technology should include portability and individual assistance (Clyde, 2004; Kazi, 2005; Klopfer & Squire, 2005; Sharples et al., 2002). One more affordance of handheld technology in the literature is its use as an administrative tool by teachers (Ray, 2002). Equally, students might also find handheld devices to be effective administration tools to help them manage their day-to-day activities, e.g., calendars, task managers, or contacts (Patten et al., 2006).

Of particular interest are the multimedia presentational capabilities of this technology and the possibilities for design and delivery on learning objects to students anywhere. If appropriately designed for the context, learning objects can be effectively delivered to a variety of learning environments. However, the key problem of this technology for delivery of learning objects is limited size of display and to a lesser extent the screen brightness in high light environments. The current typical dimension of a screen area of a handheld device is about 3.5 inches (9 cm) with a resolution of 320 by 240 pixels. Further development in this technology may involve a possible reduction in physical size of screen area. For example, the new models of O2, Dipod, and HP mobile-enabled handheld devices have a screen size of about 2.7 inches (7 cm). Recent studies have pointed to potential limitations of such screen sizes for effective presentation of information. Albers and Kim (2001) highlight three specific issues that affect user access to information via handheld devices: (a) users' reading of text of a handheld computer screen is more difficult than on paper, (b) presenting graphical information is limited in the size and complexity of image, and (c) challenges for interactivity are increased due to the lack of keyboard and mouse, and also the screen size limits space for interactive elements to be displayed. Elsewhere, the same authors (Albers & Kim, 2001) suggest that information design for handhelds must be informed by a new understanding of small screen usability and the "limited real estate." Thus, optimizing it remains the primary concern for information designers. Rettig (2002) proposed one other useful practical recommendation for design of information for small screens when he suggested that designers should storyboard their prototypes on small pieces of paper that reassemble the physical size of a screen of a handheld device. Overall, from the literature on design of information for a small screen, we identified the following useful recommendations for design of learning objects for small screens (Albers & Kim, 2001; Bradley, Haynes, & Boyle, 2006; Jones, Buchanan, & Thimbleby, 2003; Jones, Marsden, Mohd-Nasir, Boone, & Buchanan, 1999; Kim & Albers, 2001; Lee & Bahn, 2005):

1. Text needs to be kept short and formatted in a way that provides metaknowledge about information.
2. Images should be reduced in size but not beyond the point of becoming meaningless.
3. Learning objects should be designed for a full screen presentation.
4. Greater use of other modalities (in particular visuals) and interactivity over text should be employed as means of maximizing amount of educationally useful information presented on a single screen.

Bradley et al. (2006) conducted two case studies to explore design and delivery of learning objects via handheld devices. During the design stage, they understood that text legibility and the nature of interaction represented limitations on design possibilities for available display area. One strategy chosen to partially overcome this limitation was to design learning objects for full-screen presentation rather than for presentation in a browser window. When presented in a browser window, top and bottom parts of the screen are occupied by the standard controls, and this reduces available display area. When designing learning objects for students to use on handheld devices, Bradley et al. concluded that although user interactivity does not appear to be affected, screen size continues to present design challenge. They recommend greater use of audio over text to compensate for the limited text display. Although this study represents an important step towards better understanding of design of educational material, its key limitation rests on how they defined learning objects, which was "small, self-contained resources that focus on one learning objective." This appears to be limited view and not entirely useful when reviewing the complex range and disagreement that exists in the literature on learning objects.

Recently, we conducted a study to further explore learning object design to manage the challenge of the small display area of handheld device technology (Churchill & Hedberg, in press). This study led to a number of useful ideas for the design of learning objects for delivery via handheld technology, and the results also provided additional ideas for new strategies for interaction with resources delivered via this type of technology. In addition to creating further research opportunities, these ideas might be useful to other designers of learning objects for delivery via handheld technologies and to people involved in planning their use by students. The following ideas flow from this study:

1. *Design for full-screen presentation:* Throughout the study, all the participants indicated preference for full-screen presentation of information when accessing it via handheld device. Full-screen presentation of learning object increases amount of available space and this appears to create an improved user experience.
2. *Design for landscape presentation:* Typically, a screen of a handheld device is presented in portrait layout. Participants in the study were unanimous that presentation of learning objects in a landscape position was preferred. The landscape presentation also offered more flexibility for design.
3. *Minimize scrolling:* The study participants agreed with the literature and suggested that scrolling should be avoided or at least minimized.
4. *Design for short contacts and task centeredness:* Learning objects should be designed in a way that provides for learning task-centered information in a single action on a small screen.
5. *Design for one step interaction:* The design goal for a learning object should be to provide through visualization and interactivity all necessary information with a single display that fits in the screen of the handheld device. Single interactions, such as changing a position of a slider, should result in immediate updates on the screen presented in way that is perceptually and immediately noticeable by a learner in response to an action.
6. *Provide zooming facility* when appropriate to enlarge display beyond the physical limits of the screen. Allow a user to zoom and drag the entire screen in any direction to access hidden areas of the display beyond the physical limits of the screen.
7. *Design movable, collapsible, overlapping, semitransparent interactive panels:* Providing hints to other windows of information becomes critical to understanding information when multiple windows can afford limited cues such as a close box.

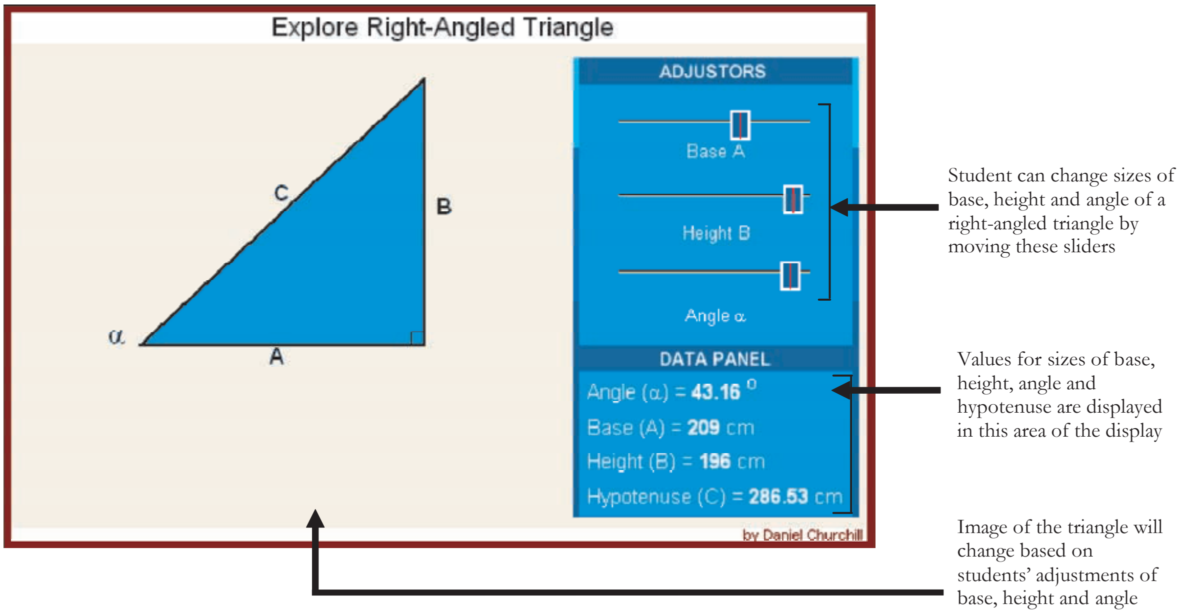
AN EXAMPLE OF LEARNING OBJECT DESIGN FOR A SMALL DISPLAY

Figure 2 shows an example of a learning object that was redesigned for application via handheld devices (Churchill & Hedberg, in press). This learning object is an interactive and visual representation of a concept of mechanical transfer of power through a pulleys system. It allows students to manipulate a number of parameters and observe the impact of the configuration on the pulleys system. In order to realize the full educational potential of this learning object, a teacher needs to create a task within which students will be engaged in inquiry and exploration of underlining relationships embedded in the learning object. Uncovering these relationships should lead to deeper understanding of the key concepts represented by the learning object. This deep understanding might, in the longer term, be supported by perceptual impressions and individuals' cognitive ability to recreate interaction in the mind through imagination.

A student could reposition the two sliders in order to change values of the load to be lifted and the effort to be exerted to lift this load, or vice versa. We experimented with a small group of students using this learning object via handheld device in an attempt to explore more effective design of this learning object. We began the experiment by using a standard feature of the Pocket PC Flash Player that supports magnification of the display beyond the physical limits of the screen. If the stylus pen is held against the screen for a few seconds, an option that allows magnifying is activated. The magnified display then becomes moveable. However, from casual demonstration and trials with the students, this possibility was not sufficiently explicit and was not employed by the average user. Thus, in design, it is more appropriate to make this function more explicit via an interactive element on the main screen interface. To enable this redesign, the new interface of the learning object included a button that would simply magnify the display to a larger size ("2X" button seen in the Figure 2). This button also activated the feature that permits a student to drag the entire screen in any direction to access hidden areas of the display beyond the physical limits of the screen. From further experiment with students, we understood that this redesign was not optimal. The students did not always recognize the function, so in a third redesign, the button that previously magnified the screen activated a moveable square that acted as a magnifying glass. The participating students were able to move the magnifying glass rectangle to different areas of the display and to preview a magnification of background of the area covered by it. In this new approach, the students were able to see the whole display and, at the same time, have access to magnification of the required information. Although this design resulted in enthusiastic endorsement from the students, it solved only a limitation of the visual display but not aspects of the interactivity, such as the case when a student finds the sliders to be too small for effective manipulation. Interacting with the sliders inside of the magnifying rectangle was not possible, and if the students wanted to reposition them, they had to close magnifying rectangle, reposition the sliders, then open the magnifying rectangle and move it until the desired magnified part of the display becomes visible. This design worked against our proposed principle of "one step interaction," as the students were unable to see clearly and immediately the impact of their change of parameters.

Our final design allowed the participating students to click on a button to magnify displayed learning objects beyond the limits of the physical screen while at the same time displaying a small thumbnail view of the whole display in the top-left corner (see Figure 3). This thumbnail served as a navigation area that contains another smaller

Figure 2. "Pulley System" learning object



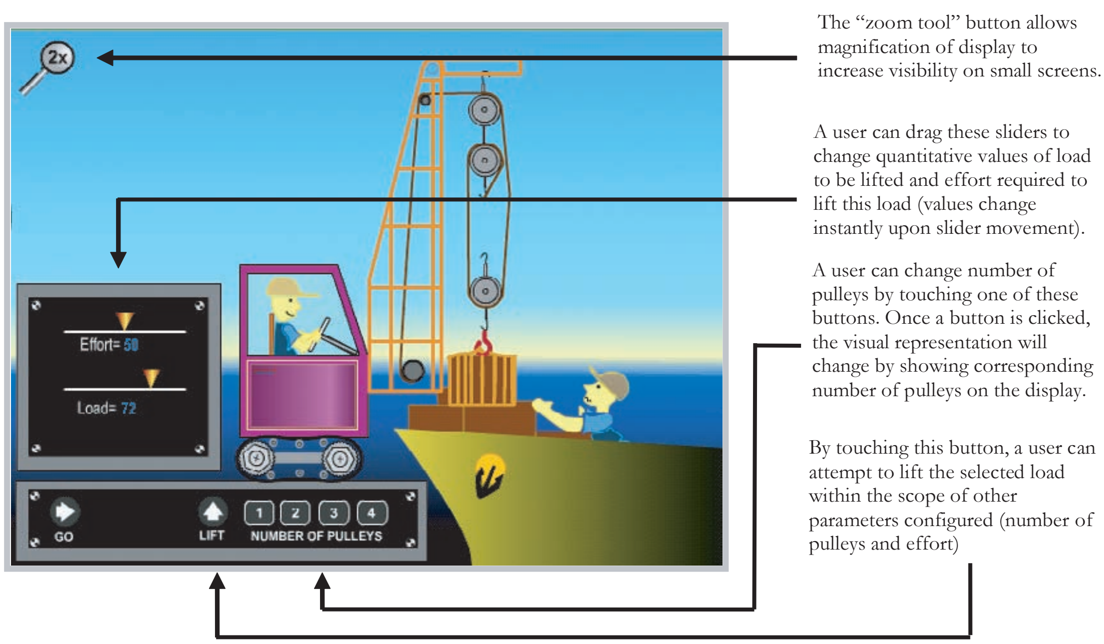
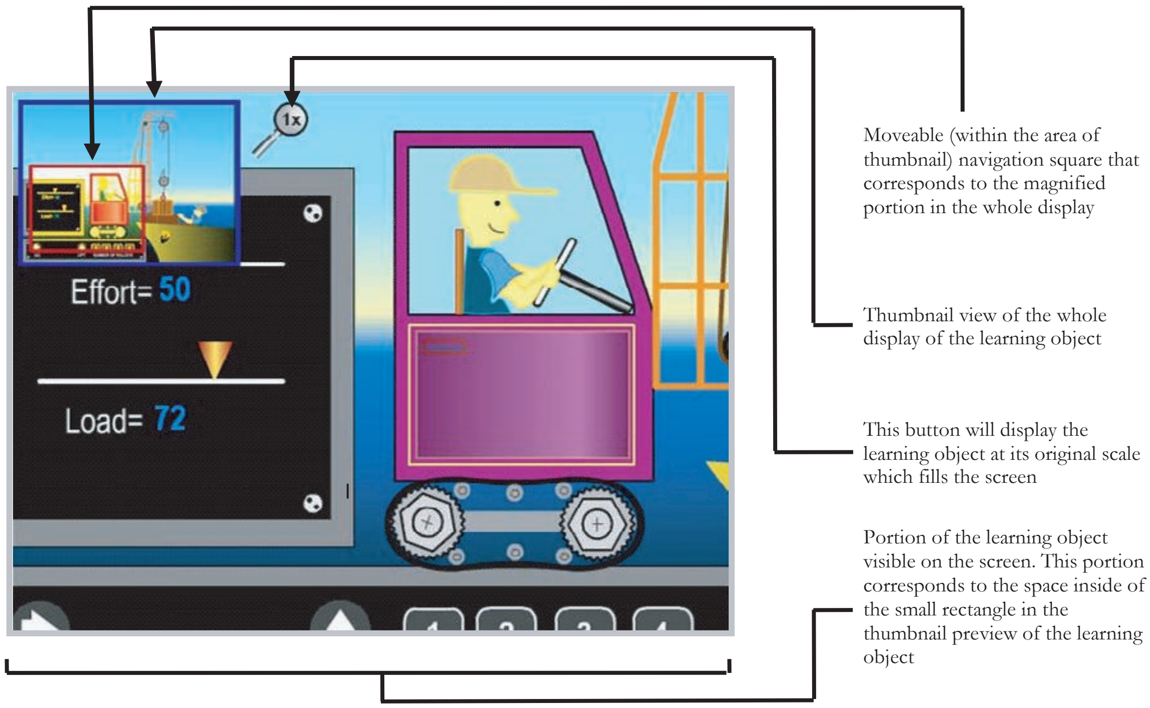


Figure 3. Navigable thumbnail preview of the screen that allows focus on magnified areas



movable rectangle. Moving the rectangle within the thumbnail would result in repositioning of the magnified display. This final approach was selected as most favorable by the participating students, and accordingly, based on this case study, we propose it as a suitable design. With introduction of new Windows Mobile 5 operating system for handheld devices, a similar feature has been built into the presentation display of PowerPoint Mobile. This is in fact an endorsement to design this fourth approach.

CONCLUSION

In this chapter, we have explored the complexities of learning object and task design and the importance of the teacher selecting the most appropriate match to ensure student engagement and the representation of idea and concepts in a way that requires the technology's interactivity and presence in the learning environment. We have sought to move the discussion into a matrix of issues that relate to the function of the learning object and the underlying goals inherent in the task. We realize that even though the issues considered here are only portions of the possible options, based on the studies we have explored and conducted, they are critical to effective applications of the technology in the first instance. Future explorations will need to add the layers of complexities often required in the decision making of the learning object designers to produce practical products. For instance, the inherent strategy embedded in learning objects that are popular with learners is often game-like and seeks to provide practice, feedback, and challenge in ways that are currently rather simple. However, the developments in technology, its miniaturization, and wireless connectivity all offer possibilities that not only can be student driven, but also challenge the nature and relevance of many of our current classroom-bound learning tasks.

REFERENCES

Albers, M., & Kim, L. (2001). Information design for the small-screen interface: An overview of Web design issues for personal digital assistants. *Technical Communications, 49*(1), 45–60.

Attewell, J. (2005). *Mobile technologies for learning.* London: Learning and Skills Development Agency.

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *ETR&D, 53*(1), 86–107.

Barnes, S. (2000). What does electronic conferencing afford distance education? *Distance Education, 21*(2), 236–247.

Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. In E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merriënboer (Eds.), *Powerful learning environments: Unravelling basic components and dimensions.* Oxford, UK: Elsevier Science. Retrieved April 8, 2008, from http://ikit.org/fulltext/inresslearning.pdf

Boud, D., & Prosser, M. (2002). Key principles for high quality student learning in higher education: A framework for evaluation. *Educational Media International, 39*(3), 237–245.

Bradley, C., Haynes, R., & Boyle, T. (2006). *Design for multimedia mlearning.* Retrieved April 8, 2008, from http://newsletter.alt.ac.uk/e_article000552781.cfm

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Research, 18*(1), 32–42.

Churchill, D. (2005). Beyond learning objects: From tools in the world to capacity in the mind. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2005* (pp. 2777–2783). Chesapeake, VA: AACE.

Churchill, D. (2006). Student-centered learning design: Key components, technology roles and frameworks for integration. *Synergy, 4*(1), 18–28.

Churchill, D. (in press a). Towards a useful classification of learning objects. *ETR&D.*

Churchill, D. (in press b). Learning objects for educational applications via PDA technology. *Journal of Interactive Learning Research.*

Churchill, D., & Churchill, N. (in press). Educational affordances of PDAs: A study of a teacher's exploration of this technology. *Computers & Education.*

Churchill, D., & Hedberg, J. G. (in press). Learning object design considerations for small-screen handheld devices. *Computers & Education.*

Cisco Systems. (2001). *Reusable learning object strategy: Designing information and learning objects through concept, fact, procedure, process, and principle template.* San Jose, CA: Cisco Systems, Inc.

Clyde, L. A. (2004). M-learning. *Teacher Librarian, 32*(1), 45–46.

Divaharan, S., & Wong, P. (2003). Student-centered learning: Microlessons. In S. C. Tan (Ed.), *Teaching and learning with technology: An Asia-pacific perspective* (pp. 182–198). Singapore: Prentice Hall.

Dodge, B. (1995). *Some thoughts about WebQuests.* Retrieved April 8, 2008, from http://webquest.sdsu.edu/about_webquests.html

Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1985–1998). *Apple Classroom of Tomorrow.* Cupertino, CA: Apple Computer Inc. Retrieved April 8, 2008, from http://www.apple.com/education/k12/leadership/acot/library.html

E-learning Competency Center. (2003). *Explanation on learning objects.* Retrieved April 8, 2008, from http://www.ecc.org.sg/loc/ecplain.htm

Foo, S. Y., Ho, J., & Hedberg, J. (2005). Teachers' understanding of technology affordances and their impact on the design of engaging learning experiences. *Educational Media International, 42*(4), 297–316.

Grabinger, R. S. (1996). Rich environments for active learning. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 665–692). New York: Macmillan.

Harper, B., & Hedberg, J. (1997). *Creating motivating interactive learning environments: A constructivist view.* Paper presented at the ASCILITE 97. Retrieved April 8, 2008, from http://www.ascilite.org.au/conferences/perth97/papers/Harper/Harper.html

Hedberg, J. (2002). Ensuring high quality thinking and scaffolding learning in an online world. In A Williamson, C. Gunn, A. Young, & T. Cleer (Eds.), *Winds of change in the sea of learning: Charting the course of digital education*: *Proceedings of 19th Annual Conference of the Australasian society for Computers in Learning in Tertiary Education* (pp. 261–270). Auckland, New Zealand: UniTech. Retrieved April 8, 2008, from http://www.ascilite.org.au/conferences/auckland02/proceedings/papers/166.pdf

Hedberg, J.G. (2006). E-learning futures? Speculations for a time yet to come. *Studies in Continuing Education, 28*(2), 173–185.

IMS Global Learning Consortium. (2002). *Learning resource meta–data specification.* Retrieved April 8, 2008, from http://www.imsglobal.org/metadata/

Jonassen, D. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (vol. 2, pp. 215–239). Hillsdale, NJ: Lawrence Erlbaum Associates.

Jonassen, D. (2000). Towards design theory of problem solving. *ETR&D, 48*(4), 63–85.

Jonassen, D. H., & Carr, C. (2000). Mindtools: Affording multiple knowledge representations in learning. In S. P. Lajoie (Eds.), *Computers as cognitive tools* (pp. 165–196). Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, D., & Churchill, D. (2004). Is there a learning orientation in learning objects? *International Journal on E-Learning, 3*(2), 32–41.

Jonassen, D. A., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In. D. H. Jonassen (Eds.), *Handbook of research for educational communication and technology* (pp. 693–719). New York: Simon & Schuster Macmillan.

Jones, M., Buchanan, G., & Thimbleby, H. (2003). Improving Web search on small screen devices. *Interacting with Computers, 15*, 479–495.

Jones, M., Marsden, G., Mohd-Nasir, N., Boone, K., & Buchanan, G. (1999). *Improving Web interaction on small displays.* Retrieved April 8, 2008, from http://www.cs.waikato.ac.nz/~mattj/web8.pdf .

Kazi, S. A. (2005, May 30–June 1). *Vocatest: An intelligent tutoring systems for vocabulary using mlearning approach*. Paper to be presented at the Redesigning Pedagogy: Research, Policy, Practice Conference, Singapore.

Keegan, D. (2004, 28–30 November). *Mobile learning: The next generation of learning.* Paper presented at the 18th Asian Association of Open Universities Annual Conference, Shanghai, China.

Klopfer, E., & Squire, K. (2005). *Environmental detectives: The development of an augmented reality platform for environmental simulations.* Retrieved April 8, 2008, from http://website.education.wisc.edu/kdsquire/manuscripts/ETRD-handheld-Draft.doc

L'Allier, J. J. (1998). *NETg's precision skilling: The linking of occupational skills descriptors to training interventions.* Retrieved April 8, 2008, from http://www.netg.com/research/pskillpaper.htm

Le@rning Federation. (2007). *The Le@rning Federation Schools Online Curriculum Content Initiative.* Retrieved April 8, 2008, from http://www.thelearningfederation.edu.au/node2

Lim, K., Hedberg, J. G., & Chatterjea, K. (2004, June 21–26). Pictures in place: How teenagers use multimedia messaging to negotiate, construct, and share meaning about geographical tasks. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of ED-MEDIA 2004 World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Lugano, Switzerland (pp. 1179–1186). Norfolk, VA: Association for the Advancement of Computing in Education (AACE).

Luchini, K., Quintana, C., & Soloway, E. (2004). Design guidelines for learner-centered handheld tools. *CHI, 6*(1), 135–141.

Norman, D. A. (1988). *The psychology of everyday things.* New York: Basic Books.

Patten, B., Sánches, I. A., & Tangney, B. (2006). Designing collaborative, constructivist and contextual applications for handheld devices. *Computers & Education, 46*, 294–308.

Pea, R. D. (1985). Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychology, 20*(4), 167–182.

Ray, B. (2002). PDAs in the classroom: Integration strategies for K–12 educators. *International Journal of Educational Technology, 3*(1). Retrieved April 8, 2008, from http://www.ao.uiuc.edu/ijet/v3n1/ray/index.html

Roschelle, J., Pea, R., Hoadley, C., Gordin, D., & Means, B. (2001). Changing how and what children learn in school with collaborative technologies [Special issue on children and computer technology]. *The Future of Children, 10*(2), 76–101.

Savery, J. R., & Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology, 35*(5), 31–38.

Scardamalia, M., & Bereiter, C. (1996). Engaging students in a knowledge society. *Educational Leadership, 54*(3), 6–10.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education, 34,* 177–193.

Sharples, M., Corlett, D., & Westmancott, O. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing, 6*, 220–234.

Vosniadou, S., De Corte, E., & Mandl, H. (1995). *Technology-based learning environments.* Heidelberg: Springer-Verlag.

Vygotsky, S. L. (1962). *Thoughts and language*. Cambrige, MA: The MIT Press

Wiley, D. A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. A. Wiley (Ed.), *The instructional use of learning objects.* Retrieved April 8, 2008, from http://reusability.org/read/chapters/wiley.doc

KEY TERMS

Conceptual Model: A particular kind of learning object that displays a representation of a key concept or related concepts of subject matter.

Contextual Representation: A particular kind of learning object that displays data as they emerge from represented authentic scenario.

Handled Devices: Small, handheld technology that nowadays often includes mobile telephone and computer functionalities.

Information Object: A particular kind of learning object that displays educationally useful information where the organized form assists in understanding.

Learning Design: A student-centered plan for implementation of learning tasks and use of learning objects with students.

Learning Task: Engaging student-centered involvements that requires students to make use of learning objects to aid produce a solution to a problem.

Practice Object: A particular kind of learning object that contains drill and practice with feedback and an educational game and allows practice and learning of certain procedures.

Presentation Object: A particular kind of learning object that contains direct instruction or presentation and designed with the intention to transmit specific subject matter.

Simulation Object: A particular kind of learning object that contains representation of some real-life system or process.

Small-Screen Design: Design of learning objects for presentation via small screens of handheld devices.

Chapter XXIII
Technology, Curriculum, and Pedagogy in the Evaluation of an Online Content Program in Australasia[1]

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ABSTRACT

The question addressed in this chapter is: What is the evidence for the effects of online programs of learning objects on motivation and learning? Much of the research available on information and communication technologies (ICTs) generally yields short-term or ambiguous findings, with recommendations that centre on the need for more attention to theorizing and documenting: how ICTs can be located within sequences of curricular learning; the kinds of learning that new ICTs offer (factual, conceptual, application, and transfer); and the ways in which existing pedagogies and uses of ICTs both adapt to and transform one another. This chapter aims to advance discussion of these issues by summarizing ongoing evaluations of a large-scale national program of online learning objects across key curriculum areas, drawing on survey and interview data, and a field experiment in which the effects of exposure to learning objects on learning outcomes in mathematics are documented.

INTRODUCTION AND BACKGROUND

Investment in ICTs by educational systems has grown dramatically over the last decade, as has research evaluating the efficacy of those investments. By way of background to the data summarized later, this section presents a brief, selective summary of this research. (For more extensive coverage, see the British Educational Communications and Technology Agency (BECTA) site; Cox, Abbott, Webb, Blakeley, Beauchamp, & Rhodes, 2003; Freebody, 2005, 2006; Mitchell & Savill-Smith, 2004; Owen, Calnin, & Lambert, 2002; Parr, 2006). We follow this research summary with a brief description of the origins of the national program under examination in the middle sections of this chapter.

Overall, it is striking how many research reports and summaries have signalled their "disappointment" with regard to the ratio between, on the one hand, effort and expenditure, and, on the other, the dissemination, creative use, and efficacy of ICTs in educational settings. Nichol and Watson's (2003, pp. 132-133) conclusion, following extensive examination of the educational uses of ICTs in the UK, gives the flavour:

the role and nature of ICT in schools is problematic, with minimal involvement of ICT across the curriculum in the everyday teaching of pupils … Rarely in the history of education has so much been spent by so many for so long, with so little to show for the blood, sweat and tears expended.

Similarly, Jamieson-Proctor, Burnett, Finger, and Watson (2006, p. 511) concluded their extensive survey of ICT usage in classrooms in Queensland Australia with this:

there is evidence of significant resistance to using ICT to align curriculum with new times and new technologies … current initiatives with ICT are having uneven and less than the desired results system wide.

It is clear that the introduction of materials based on ICTs into classrooms has not, of itself, been shown to have brought about changes that commentators claim are needed for new forms of economic and civil life (e.g., CEO Forum, 2000).

Some studies have focussed on rates of ICT usage in schools. Pittard and Bannister (2005), for example, drew together studies that reported simple rates of uptake of ICTs across a range of curriculum domains in UK. They showed that reported usage is increasing, but that this increase has not been consistent across curriculum domains: There has been increased usage in mathematics and science, but substantially less in English and other arts/humanities-based subjects.

On the question of the outcomes of ICT usage, Pittard and Bannister (2005) sounded three cautionary notes. First, they noted that some promising outcomes may appear only after the passage of some considerable time, but also that, contrariwise, some other effects may in fact disappear. The research is not yet at a point of offering guidance on which kinds of outcomes will be visible over what timeframes. Second, Pittard and Bannister (2005) noted that we might expect differential consequences for learners with varying linguistic, cultural, and socio-economic characteristics. Finally, they posed the puzzle of how we may determine how much of an effect is due to the use of the technology itself, how much to the work of the teacher, and how much to other factors.

Three technology-related features that Pittard and Banister (2005) used to account for the minor gains observed in some studies were:

1. The enhanced presentational capabilities available for lesson and assignment work

(see Abidin & Hartley, 1998; Dori & Barak, 2001);
2. The enhanced range of resources available to support students' and teachers' research; and
3. The immediacy of feedback for self-evaluation (see Marzano, Gaddy, & Dean, 2000).

BECTA reviews, compatible with research from other countries, have also drawn attention to the need for more targeted, carefully designed, longer-term research. Commenting on educational activities and policies in Australia, Ainley, Bourke, Chatfield, Hillman, and Watkins (2000, p. 4) commented

On the basis of current data it is difficult to assess the quality of existing educational content and there is a need for a more sophisticated analysis of the dimensions of quality in practice.

In documenting the views of principals, teachers, pupils, parents, social workers, teacher aides, and students on the educational uses of ICTs, Passey, Rogers, Machell, McHugh, and Allaway (2004) used case study, interview and survey data to present three key findings:

1. ICT use by pupils and teachers led to positive motivational outcomes; a focus on confidence in researching skills and the tackling of complex learning tasks is strongly endorsed (and see Mann, Shakeshaft, Becker & Kottkamp, 1999; Walton & Archer, 2004).
2. Positive motivational outcomes were most frequently found when ICTs were used to support engagement, research, writing and editing, and presentation of work.
3. There were indications that ICT impacted positively upon students' behaviour in school, and had as well some impact on their behaviour out of school. Among the areas of students' motivation positively effected by ICT, the researchers cited perception of class time as more interesting, students' completion of homework, and students' confidence and independence in their learning.

While evaluations of learning object (LO) use are emerging in the literature, the findings to date remain limited. McCormick and Li (2006) reported an evaluation of a project initiated by the European Union involving 500 schools across six countries that examined the effects of LOs on teaching and learning. They found teachers to be generally receptive to LOs, and in some cases enthusiastic about their potential. A recurring recommendation, however,

that of having some element of pedagogy within the LO, is not supported. The fact that teachers use LOs in a variety of contrasting ways means that they are likely to be able to superimpose their own pedagogy on any LO, almost whatever the "designed" pedagogy. (McCormick & Li, 2006, p. 229)

An argument that will be outlined below, however, points to the pedagogically conservative nature of this conclusion. It has been claimed that digital online materials will have the potential to significantly reorganize the relationships among teachers, students, and knowledge (Kress, 2003), and that aiming to produce technologies and materials that simply fit into or even expand the reach of teacher-centred, transmissionist, factual accumulation will fail to capitalize on the potential gift that digital ICTs can offer teachers and students (Jonassen, 2004; Wiley et al., 2004). We discuss this issue in light of our findings in the sections below.

THE LE@RNING FEDERATION INITIATIVE

In 2001, the Australian Ministerial Council on Education, Employment, Training and Youth

Affairs established The Le@rning Federation (henceforth TLF) to:

- Produce a repository of online materials in the following priority curriculum areas: (i) Innovation, enterprise and creativity (years 1-10); (ii) Languages other than English (specifically Chinese, Japanese, and Indonesian across all school year levels); (iii) Literacy for students at risk of not achieving national literacy benchmarks (years 5-9); (iv) Mathematics and numeracy (years 1-10); Science (years 1-6 and 9-10); and (v) Studies of Australia (years 1-10);
- To make these materials available to all schools in Australia and New Zealand;
- To engage students and teachers in innovative learning environments; and
- To equip students to live competently and proactively in an environment increasingly characterised by online communication, learning and work.

LOs are defined in TLF as files or modules of learning material that:

- Represent interactive learning activities that may include texts, and/or graphic, audio, or animated materials;
- Are reusable in multiple settings and for multiple purposes;
- Are usable in classrooms as components of units of work accompanied by digital and nondigital materials; and
- Are accessible from digital repositories, as referenced, located, and accessed by metadata descriptors.

In articulating an approach to educational "soundness" in the production of LOs, TLF drew attention to these principles (Atkins & Jones, 2004, pp. 2-7):

- Learner focus, inclusively addressing the needs of all students;
- Content integrity, ensuring domain-related accuracy, authenticity, and purposefulness;
- Usability with accessible interaction design and sequences; and
- Accessibility to otherwise frequently disadvantaged categories of students.

With regard to the learning framework guiding the development of materials, TLF indicated the following four "soundness criteria":

- Problem-based learning;
- Inquiry-based and investigative learning;
- Authentic, situated contexts for learning; and
- Constructive and tailored feedback.

The Le@rning Federation Web site (www.thelearningfederation.edu.au/default.asp) provides elaborations of these working principles. TLF has developed over 2000 LOs for use in Australian and New Zealand schools. Each new LO is subjected to field trialling in classrooms and feedback from teacher and researcher groups prior to its release. It is important to note that TLF does not accompany any LO with specifications or guidelines for its educational use.

Since TLF commenced the production and dissemination of LOs, there have been changes in classrooms, in the theorisation of ICTs for teaching and learning, and in the attitudes and practices of teachers and students in and out of the classroom. Some aspects of the scene in which the LOs are attempting to make a beneficial difference are evolving rapidly, a situation that calls for continuous evaluation. This is the immediate setting for the evaluation data summarized in sections below. The evaluation was conducted via surveys, site visits, and a field experiment.

SURVEY FINDINGS

In this section, we outline the findings of two surveys completed by teachers and students. Surveys were made available to schools (government, Catholic and independent primary and secondary schools) in all states and territories of Australia and New Zealand for a period of 8 weeks. Teachers and students were asked to complete the surveys online but a paper version was made available if their schools could not access the online version. Responses were received from approximately 3,400 students and 350 teachers located in 200 schools, responding with reference to 200 LOs. The survey for teachers contained questions about their use of LOs, whether or not using the LOs in specific curriculum domains helped to support teaching and learning, and, more specifically, whether or not the LOs had any effect on motivation, depth of learning, higher-order concept acquisition, collaboration with peers, thinking about new ideas, and independence in learning. The student survey contained questions about specific operational elements integrated into the LOs (such as sound, animation, and interactivity) and whether or not the LO was easy to work with and fun.

Findings

Teachers were asked to respond with respect to one LO they had recently used with their classes, and to arrange for their students to respond with respect to the same LO. The distribution of respondents was uneven across the jurisdictional sites. Distributional and response discrepancies, unavoidable in light of the voluntary nature of students' and teachers' participation in the study and their completion of the survey, need to be kept in mind when reflecting on the generalizability of the findings.

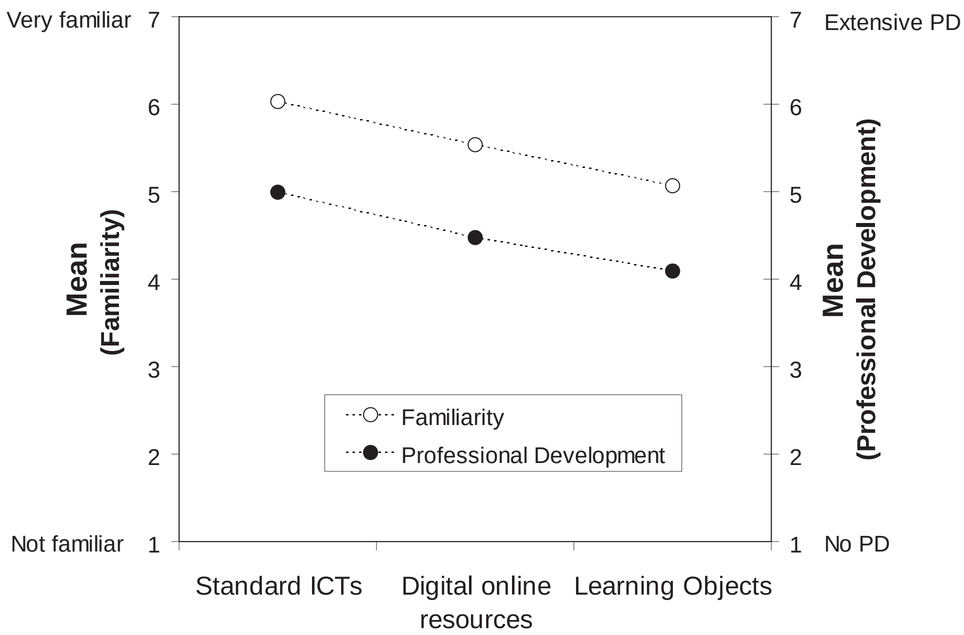
The kinds of schools (according to the reports of the teachers) volunteering survey responses show moderate to high levels of representativeness. Specifically: about three out of four schools are government administered; the large majority (93%) are co-educational institutions; about 80% of schools have less than 25% of the enrolments that have backgrounds that are Indigenous, or characterised by home languages other than English, or in poverty; and schools' enrolments ranged from 25 to 1,000 and schools were more or less evenly distributed across this range.

A number of questions to the teachers concerned their backgrounds and current teaching activities. Female teachers made up 69% of the participating sample; the sample is tending toward high levels of professional experience; this experience has been gained from movement across a number of schools; the large majority of teachers held a 4-year teaching qualification; and about one teacher in six had completed postgraduate studies, the majority of which were undertaken in the form of specialised diplomas (early childhood, special needs education, and so on).

With respect to a question concerning year levels currently taught, all year levels are represented in the sample, but there is a concentration of teachers working between Year 3 and 10 with a peak at the upper primary level. Similarly, with respect to a question concerning their areas of specialisation, most of the core curriculum areas are represented in the sample, with peaks for English, Language, Literacy, and Science. In addition, a substantial number of respondents regarded themselves for the most part as general primary teachers.

As shown in Figure 1, the teachers report relatively high levels, but, respectively, declining, of familiarity with standard ICT applications, digital online resources, and, more, specifically LOs. These levels, however, are higher than would be predicted from the available literature (e.g., Jamieson-Proctor et al., 2006) and would even exceed projections based on European and UK research (e.g., Pittard & Bannister, 2005). Similarly, mod-

Figure 1. Familiarity with and professional development in ICT education (N = 335)



erate to high levels of professional development (PD) are reported by this sample, again less so for PD specifically on LOs. It is likely, therefore, that the sample choosing to respond to this voluntary survey is somewhat more ICT-familiar than others of their colleagues in schools across Australia and New Zealand.

Turning to the LOs that students and teachers reported on and to their use of and access to those LOs, students and teachers responded to a number of questions with particular reference to the LO with which they were working at the time of the response. This gives a snapshot of the LOs in use at that time. Table 1 summarises the number of LOs within each of The Le@rning Federation's curriculum domains. According to the survey responses, LOs in Mathematics and Science are the most heavily used, and in Creativity/Business/Enterprise the least.

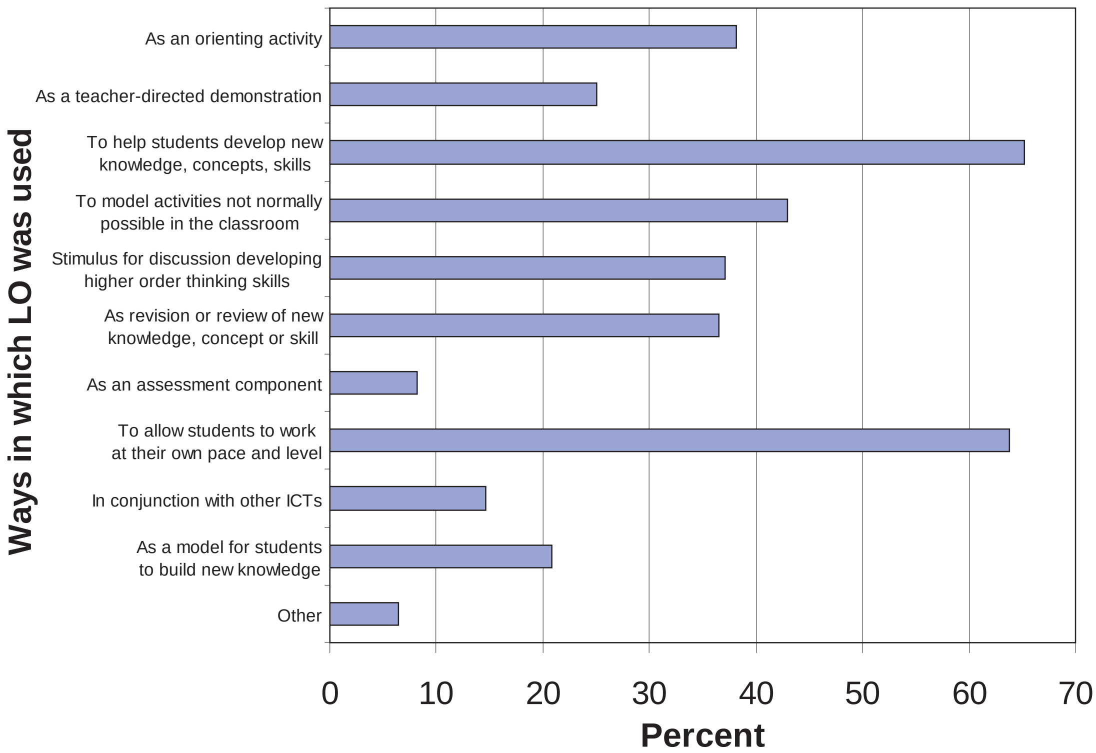
Ongoing debate around the value of LOs has included qualifications about how teachers variously use them. As noted earlier, McCormick and Li (2006) argued that avoiding any pre-emptive pedagogical framing of the LO is crucial to its success, allowing teachers "to superimpose their own pedagogy on any LO" (p. 228). Others, such as Pittard and Bannister (2005), have suggested that it is the pedagogical settings and strategies that can radically modulate the success of a LO. As Wiley et al. (2004, pp. 521) concluded:

Research along these lines would require instructional designers to deploy learning objects in problem-based environments, as opposed to the next, next, next manner in which learning objects are frequently used. ... [The] call for social science research to focus on mediated action would suggest that neither learners working in online

Table 1. Numbers of learning objects nominated by teachers and students as being in use within each curriculum domain

TLF Curriculum Area	Number of LOs	
	Students	**Teachers**
Literacy for Students at Risk	26	20
Mathematics and Numeracy	51	42
Science	38	39
Studies of Australia	26	18
LOTE	18	19
Art, Design & Technology and Business & Enterprise	9	7
TOTAL	**185**	**158**

Figure 2. Ways in which teachers reported using LOs. Note that these percentage figures add up to more than 100 because teachers could indicate more than one response (N = 356).



environments nor the resources they use in those online environments could be studied fruitfully in isolation. Rather than studying learning objects out of context, the unit of analysis must be learners' actual uses of the objects within a learning context.

Both points of view call for some documentation of current usage practices by teachers, albeit with contrasting motivations. Figure 2 summarises teachers' responses to questions about the uses to which the LOs were put in their classrooms.

A number of points evident in Figure 2 are noteworthy. First, these teachers rarely used the LOs as forms or components of assessment activity. This is perhaps not surprising in light of (i) the novelty of LOs in the teaching repertoires of these teachers and their understandable reluctance to use them as assessment items, (ii) the variable nature of the relationship between the LOs and formal school syllabus content, and (iii) the LOs' essentially instructional rather than measurement intent. Second, teachers report frequent use of the LOs for the development of new knowledge, concepts and skills. Teachers for the most part view the LOs as curricular objects, not solely or even principally motivational in nature. It is their cognitive value-adding capacity that motivates their usage in this sample.

Also attracting high levels of response is the opportunity offered by LO usage for allowing students to work at their own pace and level. An ongoing motivation for TLF in this initiative has been focused on students to whom current arrangements for schooling are not well suited. One aspect of that, for some students, is that the movement of interaction and thus knowledge is either too fast or too slow, with materials that are too hard or too easy. LOs allow students thereby not only to have measured exposure to some core knowledge, concepts and skills, but also to achieve a sense of success and progress. The teachers in this sample nominate that issue as critical in their use of the LOs. Finally, analogous to TLF's stated intention to support students not well-suited to current schooling arrangements is its focus on knowledge, concepts and skills conventionally regarded as difficult to teach in standard classroom conditions.

Evaluating the Learning Objects

A series of questions addressed students' evaluations of the LOs on a list of general criteria, as shown in Figure 3. The bars represent mean responses on a 5-point scale. The students responding to these items clearly distinguished between the variables under consideration. Students were strongly positive in their support for the LOs as "easy to work through" and "interesting and fun" to complete (the top two items in Figure 3). Responses were reliably closer to the positive extreme of the scale than were responses to the other items. Students reported marginally positive views of the helpfulness of the LOs in terms of "thinking about new ideas," and, as a group, had no decisive views on the need for help from partners or peers. They did indicate, however, that they did not need help from their teachers to work through the LOs.

As overall judgements, therefore, these respondents offer support for the manageability and interest level of the LOs students had at hand, and offered some support for the ability of the LOs to stimulate thoughts about new ideas.

A series of questions asked students about the helpfulness or otherwise of certain features of the LOs. Students' responses on a 5-point scale are summarised in Figure 4. While all rankings are reliably on the positive side of the neutral point, these students drew particular attention to the opportunity to work at their own pace in the completion of the LO activity. All of the features are consistently nominated as helpful, and, critically, students recognised the particular advantages of the use of LOs compared to ordinary whole-class or small-group work in the classroom

Figure 3. Overall evaluations by students of the LOs on five criteria (N = 3210)

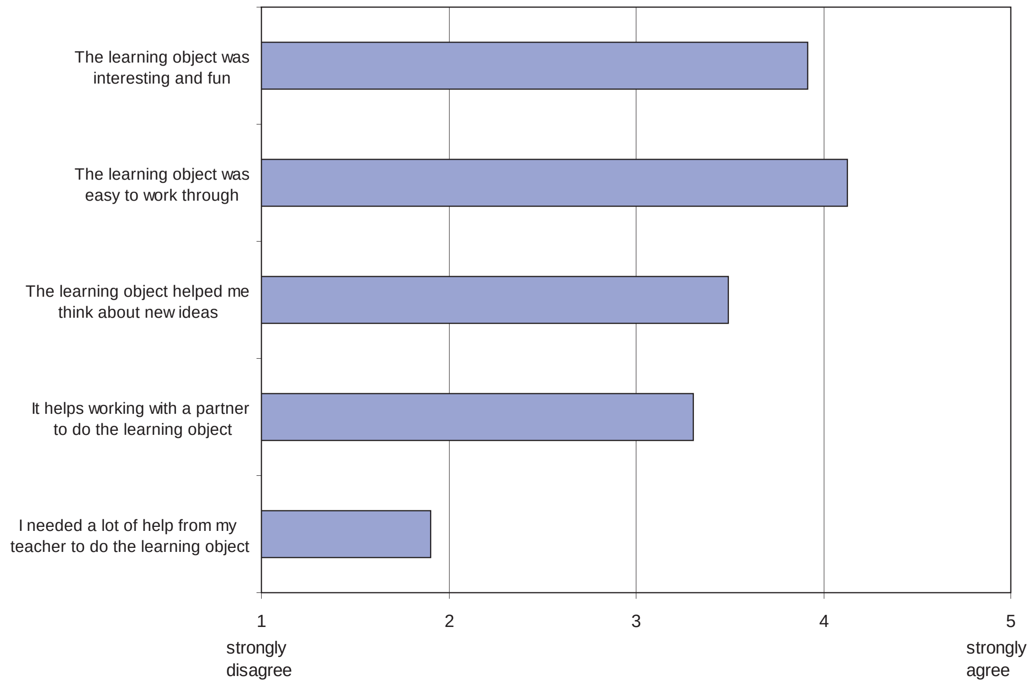


Figure 4. Evaluations of the helpfulness of various features of the LOs by students (N = 3103)

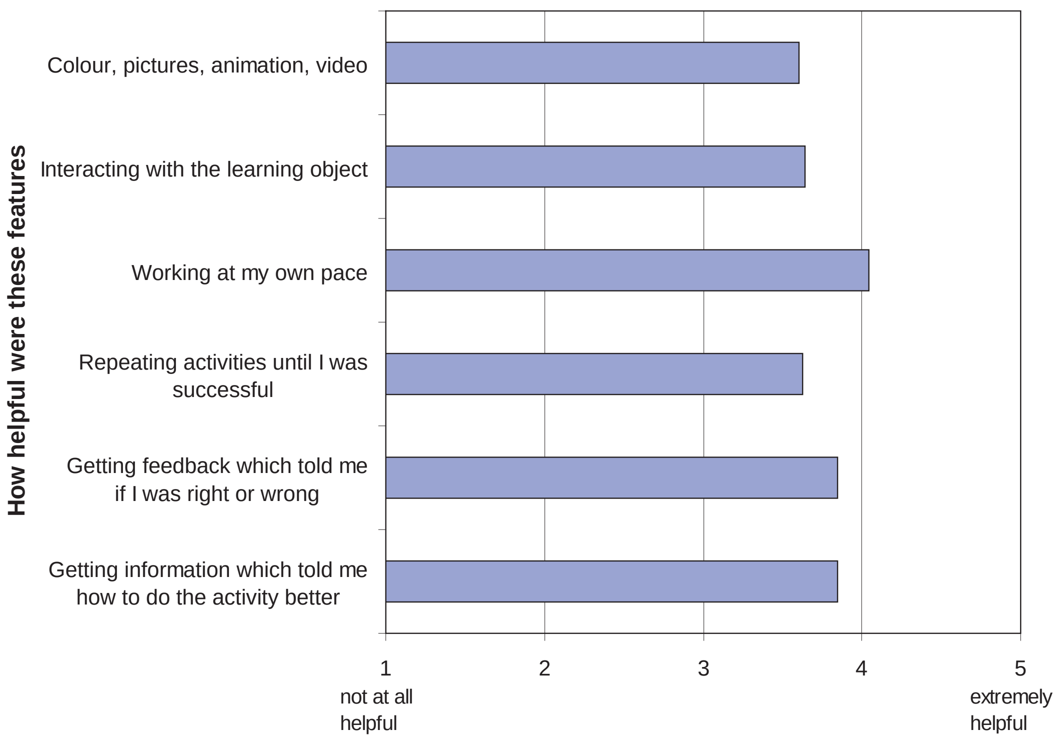
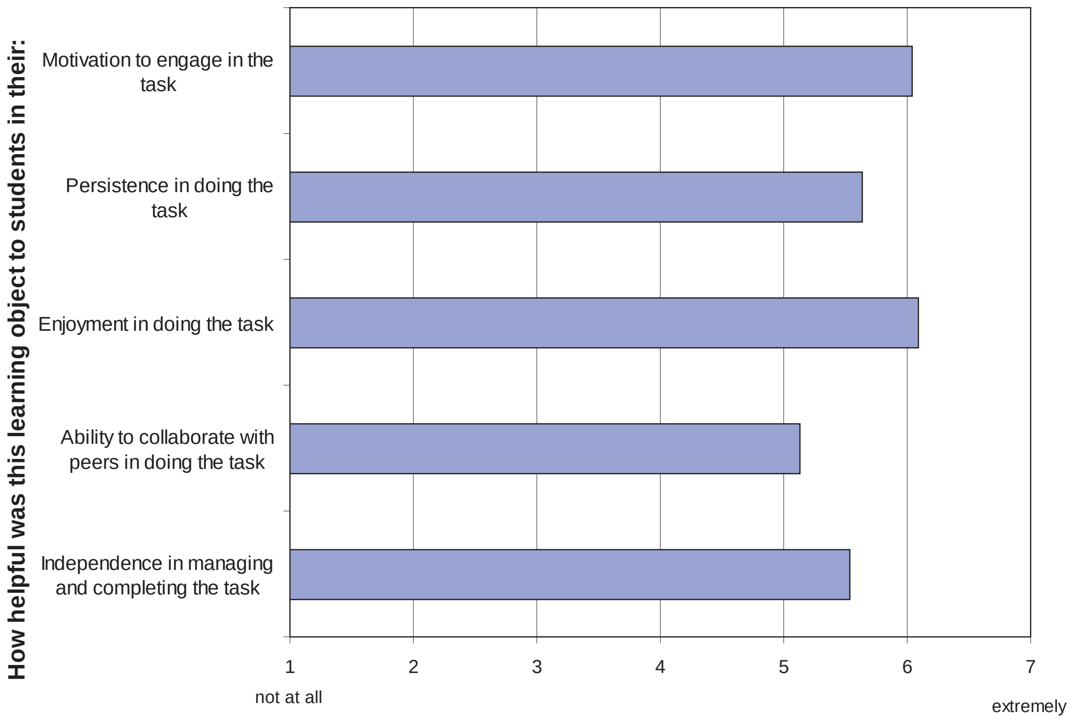


Figure 5. Teachers' perceptions of the motivational outcomes of using the LOs (N = 326)

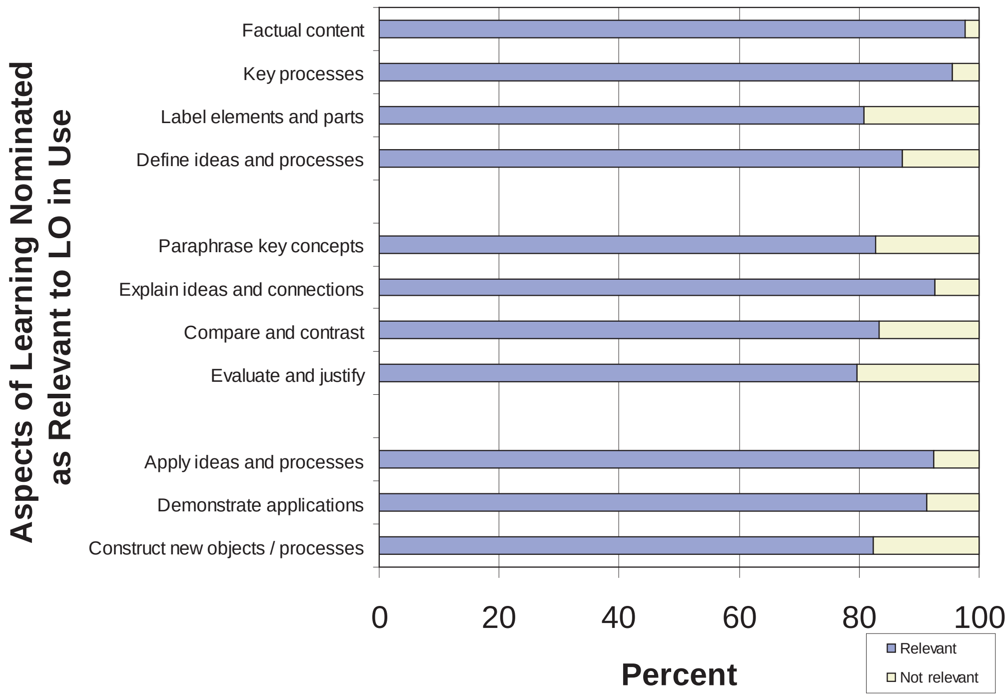


regarding improvement, feedback, and choice of pace, sequence, and interactive content.

Teachers also gauged their perceptions of the motivational effects of the LOs on students, as summarized in Figure 5. All means presented in Figure 5 are substantially and reliably above the neutral midpoint. Differences between these means are not such that any highly differentiated response patterns to the various items are evident; that is, teachers strongly endorsed the helpfulness of the LOs equally on all of the counts offered to them.

For purposes of ongoing development and to contribute to a growing understanding of this area, there is also interest in what particular aspects of learning the teachers believed the LOs enhanced. A series of questions asked about the value of the LOs in helping students learn with respect to different kinds of knowledge and learning. Teachers could nominate the relevance or otherwise of the particular LO in use to a variety of learning types. Figure 6 shows the percent of teachers who nominated each aspect of learning as relevant or not to the LO they were using with their students. There is clearly some minor variation relating to different kinds of learning, but the overall high rates of nominated relevance, taking into account that they reflect responses to a large variety of individual LOs, is striking. The aspects of learning most consistently nominated

Figure 6. Percent of teachers rating the relevance of the LO in use to a variety of types of learning (N = 330)



as relevant are: factual content and key processes; those nominated least often are: evaluating and justifying and the labelling of elements and parts. It needs to be noted, however, that these lowest-rated aspects were nonetheless named as relevant by more than 80% of teachers in the sample.

A summary of teachers' ratings of the features found to be important in these different kinds of learning is presented in Figure 7. Note that on the vertical axis the original variables are named in lower case. In addition, Factor Analysis revealed three reliable factors that directly reflected the conceptually generated variable sets (the factor analytic methods and details of the solution can be found in Freebody, Muspratt, & McRae, 2007) The factor solution is shown in Table 2.

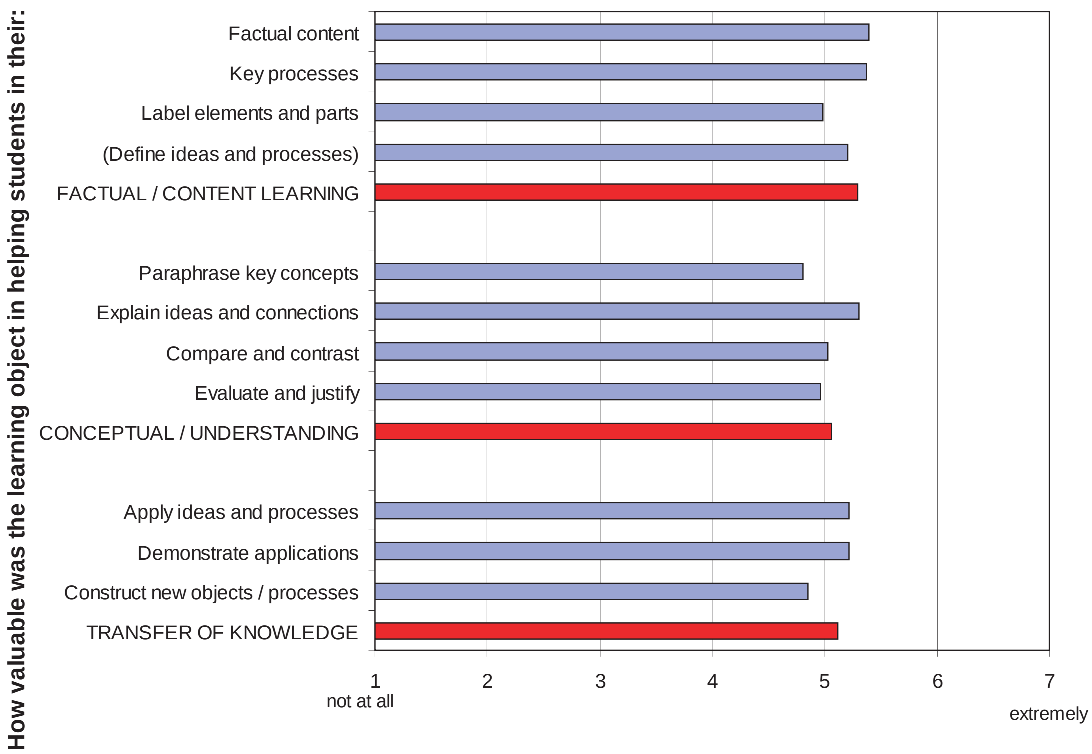
Upper case labels on the vertical axis refer to these three factors. Again, the ratings are substantially above the neutral mid-point for all variables, and the differences in mean ratings are not of sufficient magnitude to be noteworthy. The three composite scores, as shown in Figure 7, have close mean values, indicating strong overall and consistent endorsement of all forms of learning presented in the survey.

In addition, multilevel analyses revealed considerable variation in patterns of responses from the teachers relating to the particular LOs to which they were referring and to the curriculum domains from which the objects were drawn. LOs in common use tended to be rated more highly for their benefits in facilitating factual learning than conceptual understanding and transfer. Further,

Table 2. Loadings for the 3-factor CFA solution

Variable	Factor 1 Loading	Factor 2 Loading	Factor 3 Loading
1	.829	0	0
2	.825	-.068	.116
3	.548	.254	-.066
4	.477	.379	.028
5	-.001	.773	.015
6	-.027	.802	.132
7	0	.819	0
8	-.049	.786	.163
9	-.095	.118	.888
10	0	0	.978
11	.235	.057	.532

Figure 7. Teachers' perceptions of the learning outcomes of using the LOs (N = 351)



both overall and factor-related differences among curriculum domains were found, although at this level of analysis there emerges a distinction that focuses on conceptual understanding. For four of the domains LOs are rated lower on this factor than on the other two.

In summary, teachers and students reacted positively to the use of LOs as settings for enhancing learning and motivation. It is important to recall that these teachers were given no explicit guidance on how, when, where, or why to use LOs with students. It is also significant, in that light, to note substantial variations relating to the curriculum domains in which the LOs are used and to the specific LO in use. Field notes from site visits indicated a wide range of uses to which the LOs were put, but most teachers tended either to use them to introduce and new topic or to revise and practise other relevant lesson work. More specifically, however, researchers observed a wide range of pedagogical strategies surrounding the use of the LOs.

FINDINGS FROM SITE VISITS

Ongoing evaluations of TLF's LO program have also involved visits to over 30 schools across Australia and New Zealand: primary and secondary schools, schools in urban, rural, and remote settings, and schools serving mixtures of mainstream and at-risk students of various kinds. Data have included lesson observations and interviews with principals, teachers, and students. In this section, we summarize factors found to be common among sites in which ICTs, and specifically the LOs, were in productive use.

Committed Leadership

On effective sites the support of the school leadership was generally based on a shared analysis of the ways in which the lives of young people in contemporary societies are rapidly changing. Part of that analysis was a confidence in the capacity of teaching with / through ICTs to improve pedagogy and learning in ways that amounted to a response to these changes.

This responsiveness was sometimes aimed at improving the effectiveness of existing resources. This from a school principal:

There was a lot of technology hardware around. In fact it had been around for a long time. It was a matter of changing expectations about the ways in which it could and should be used.

Some were emphatic about viewing ICTs as tools learning rather than its masters. The work was characterized as pragmatic and aspirational, rather than a driven by technological determinism.

A Champion

The term "champion" here means "advocate," but these colleagues also displayed considerable confidence and technical strength, knew about teachers and teaching, and were motivated to make their ideas work. School leaders made provision for champions to operate at high levels in their schools, in a number of cases as Assistant or Deputy Principals. Such people were often regarded as the objects of poaching, so it was in the interests of schools to find ways to retain them. Concessions were made not only with regard to their conditions of employment but also to the sort of freedoms they enjoyed in implementing their ideas. In most cases these "champions" were seen as either having delivered or being in the process of delivering benefits in return.

A Working Plan

"Going with ICTs" was in almost all cases a conscious and planned decision with regular implementation, review, and refinement. This was evident in schools' operational plans and other documentary sources. The principal at a distance education centre, for instance, outlined the processes of investigating and formally defining directions, but noted:

It's surprising how change is occurring before the need becomes formalised … It will take time, but people will see the results in better teaching and learning. Even in the last two months things have escalated dramatically in the development of online learning materials. We would now have a dozen or more staff active in this regard. It's being driven by the kids' interest.

In other examples, schools developed and used formal professional learning guides, which occupied a key role in operations. Such guides sometimes included an ICT's "capabilities chart," describing not just intentions but also activities. It seemed that such planning activities were evolving rapidly and becoming increasingly foundational to some schools' activities.

Well-Directed and High Quality Resources

It was clear from visits that schools were aiming for better coordination of resources, a higher level of dissemination and accessibility, and more consistent, better quality hardware. In three of the larger schools visited a levy for continuous upgrading was in place, agreed, and, in one case, instigated, by parent bodies. This, from an ICT coordinator:

It was a matter of changing expectations about the ways in which [ICTs hardware] could and should be used. Teachers had laptops as administrative tools for almost a decade, but our next step was to stop the haphazard roll-out of hardware and infrastructure. We developed a 3-year plan to ensure that we had the sorts of things we needed ... We also began to redesign our learning spaces. The general principle was to provide greater access to hardware through a higher level of distribution.

Most, but by no means all of the conventional schools had a high level of technical support. In one case the technical support officer was an active member of the "conceptual" team and was directly involved in the school's initial digital learning project. On another site, however, outside technical support was provided for 2 hours per week. The extreme range observed raises questions about the production of new forms of disadvantage, forms more difficult to specify due to the breadth and depth of their implications for different kinds of learning, creative digital production, and research techniques among students.

A Substantial and Effective Program of Professional Learning

In ICT-effective schools attention was paid to developing the case for the importance of ICTs in both the improvement of learning and the overall effectiveness of the school. The pattern of professional ICT-oriented learning programs offered to teachers varied strongly from site to site. In one case it could be best described as "infusion"—strong peer support coupled with access to consultancy for some staff. At another, defined sessions for staff working in their normal teams had been superseded by voluntary activities. The secondary schools visited tended to have extensive modular programs provided both from within the school and by external agencies. At the distance education school, teams of teachers were constructing new units of material for electronic transmission.

Finally, in most successful cases there was provision to support and skill people with low levels of ICT familiarity. While there was encouragement to up-skill, there seemed no blame directed at people at beginning levels. An important message for teachers and school leaders seems to relate to describing where staff are, accurately, with regard to ICTs and providing experiences and supports that colleagues need and *think* they need, rather than, or perhaps as well as, what other sources or authorities think would be good for teachers.

FIELD STUDY OF OUTCOMES

In this section, we describe a study that aimed to provide empirical evidence on the effectiveness of LOs. A small-scale field experiment was undertaken to test for gains in students' learning as a result of the use of LOs. In the study, the effectiveness of LOs was compared with traditional classroom teaching environments in mathematics.

Methods

Participating in the study were 708 Year 5 and Year 7 students from 41 classrooms in 19 schools located in the Australian Capital Territory, New South Wales, and Queensland. The participating schools included schools serving urban, rural and remote communities, and schools serving communities with large numbers of Indigenous students, large numbers of students from non-English speaking backgrounds, and large numbers of students from low socio-economic backgrounds.

Classrooms were randomly assigned to a "Business-as-Usual" group (a quasicontrol group) or to a Learning Object group (a treatment group). Teachers of the Learning Object group were given a general briefing on the use of LOs. Teachers of both groups were encouraged to teach the topics more or less as they normally would, incorporating whatever additional resources they would normally use; either digital or non-digital. Table 3 shows the distribution of students and classrooms across the two year levels and the two learning conditions. Teachers taught for approximately six weeks on two mathematics topics: basic number operations (Number) and introductory probability (Chance). Both topics are related to the Years 5 and 7 syllabi in the three jurisdictions.

Students in each group completed a pretest at the commencement, and a post-test at the conclusion, of the intervention period. The tests contained items taken from a bank of standardized items (with documented and acceptable levels of reliability and validity), appropriate to each year level and related directly to Number and Chance. Separate analyses were conducted for the Chance and Number components of the tests. There were unequal item numbers for Number and Chance, reflecting unequal availability of standardized items at the two year levels.

There are three features of the data and the design that preclude standard procedures in testing for group differences. First, it was classrooms, not students, that were selected and assigned to one or other of the learning conditions, and thus the treatment variable is a "classroom" variable, not a "student" variable. Multilevel modelling is appropriate for these designs because it takes account of the clustering of students within classrooms.

Table 3. Distribution of students and classrooms across year levels and learning condition

Group	Year Five		Year Seven	
	Number of students	Number of classrooms	Number of students	Number of classrooms
Business-as-Usual	170	9	99	8
Learning Objects	201	11	238	13

Second, with such a small number of Chance items, the assumption of normally distributed data on a continuous scale is not likely to hold. In these situations, it is better to treat the outcome variable as a categorical variable with categories of: no questions correct, one question correct, two correct, and so on. The analysis, a proportional odds analysis, operates on the proportion of students in each category (for a detailed discussion, see Goldstein, 2005). The third feature concerns the number of classrooms in the study. Estimation of parameters in multilevel models is mostly done using maximum or quasi-likelihood methods, but these assume a large number of cases, and the assumption extends to the number of level 2 units (i.e., number of classrooms). According to Hox (2002), however, Markov chain Monte Carlo (MCMC) procedures do better than maximum likelihood in situations where only a small number of level 2 units are available. Thus the data were analysed using *MLwiN* (Rasbash, Steele, Browne, & Prosser, 2005) in which MCMC procedures are available (Browne, 2005).[2]

Findings

The results from the multilevel proportional odds models are depicted graphically in Figures 8 and 9. These results are summarised as follows:

- As expected, there was no effect for treatment on any of the pretests; that is, groups were effectively equivalent on the items prior to the intervention period. In Figures 8 (sections a and c) and 9 (sections a and c), this is depicted by the probabilities for the Learning Object group almost overlapping the probabilities for the Business-as-Usual group.
- There were statistically reliable effects for the Learning Object group for the Years 5 and 7 Chance post-tests; students in Learning Object classrooms scored more correct items than students in Business-as-Usual classrooms. In Figures 9 (sections b and d), this is depicted by the probabilities for the Learning Object group being displaced to the right compared to the probabilities for the Business-as-Usual group.
- There were no effects for the Learning Object group for the Years 5 and 7 Number post-tests. Figure 8 (section b) shows the probabilities for the Learning Object group displaced slightly towards the right, but the effect is not statistically significant.

An issue in outcome-based evaluations such as this is gauging the optimal intervention period. Interventions may be too long or too short, and lead to false-positive or false-negative results. The relatively short period of intervention used in this design took into account the highly constrained nature of the topic focus: The two aspects of Mathematics were covered in some form at the two participating year levels for which some standardised assessment items were available. It is for further research to develop a sense of optimal intervention periods for instructional devices with as short a history as digital LOs. The demonstration of a reliable effect for the Chance items suggests that even six weeks of diverse and "uncontrolled" exposure can have some demonstrable positive effects for some kinds of LOs.

Over the course of the intervention period, observers visited each school and observed lessons of those teachers using the LOs. In general, observers reported, among other things, that the topic of Chance was challenging to teachers and students generally, and many teachers reported that they usually avoided the topic. So from "guild-knowledge," anecdote, and more specifically from observations and explicit statements to observers during the intervention period, it is clear that there is a notion that the topic area of Chance/Probability is regarded as difficult to teach, certainly in comparison to concepts involved in Number. This difficulty seems, from the observations, to relate as much to pedagogy

Figure 8. Estimated probabilities for the number of questions correct for Years 5 and 7 Number pre-tests and post-tests

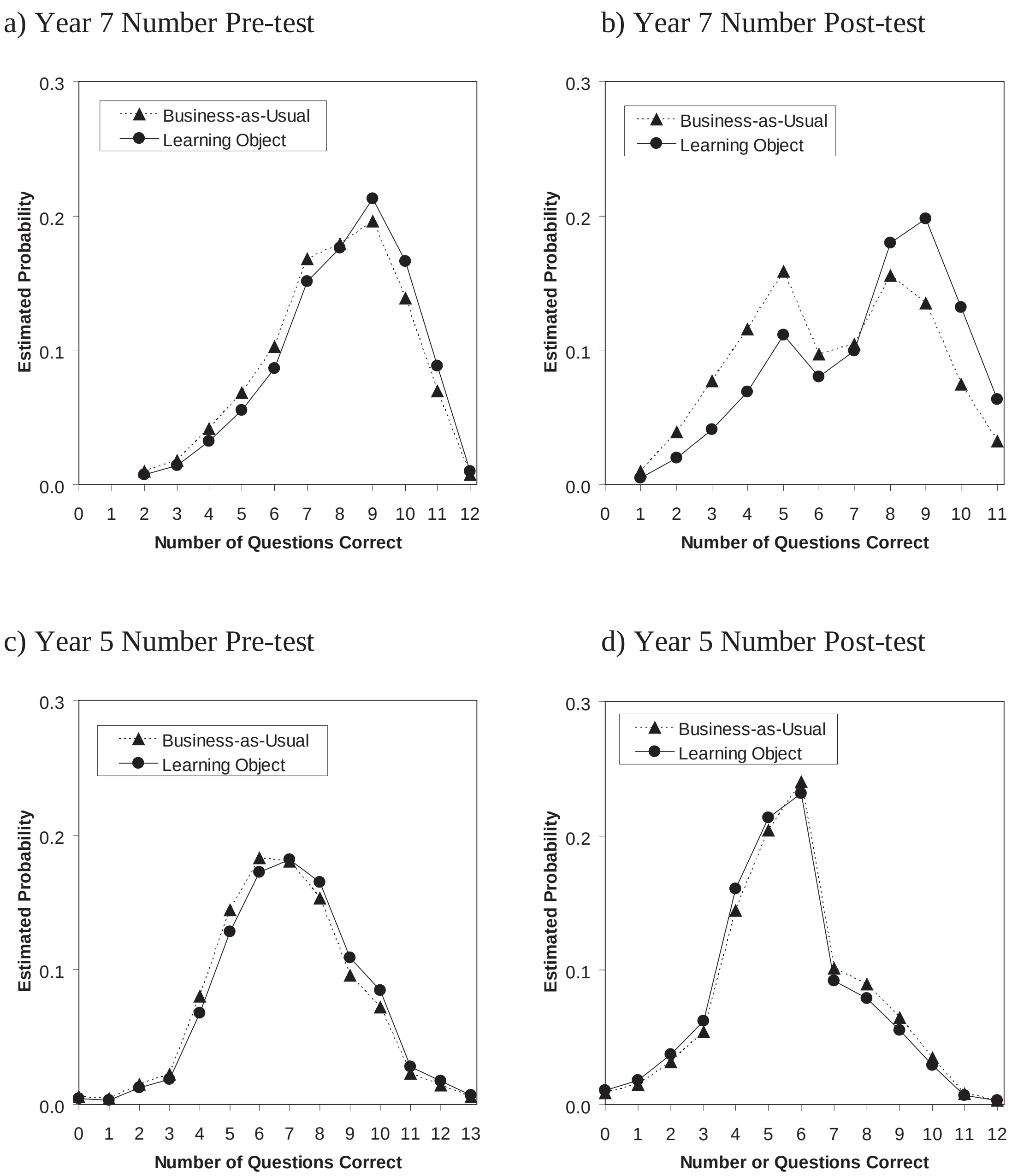
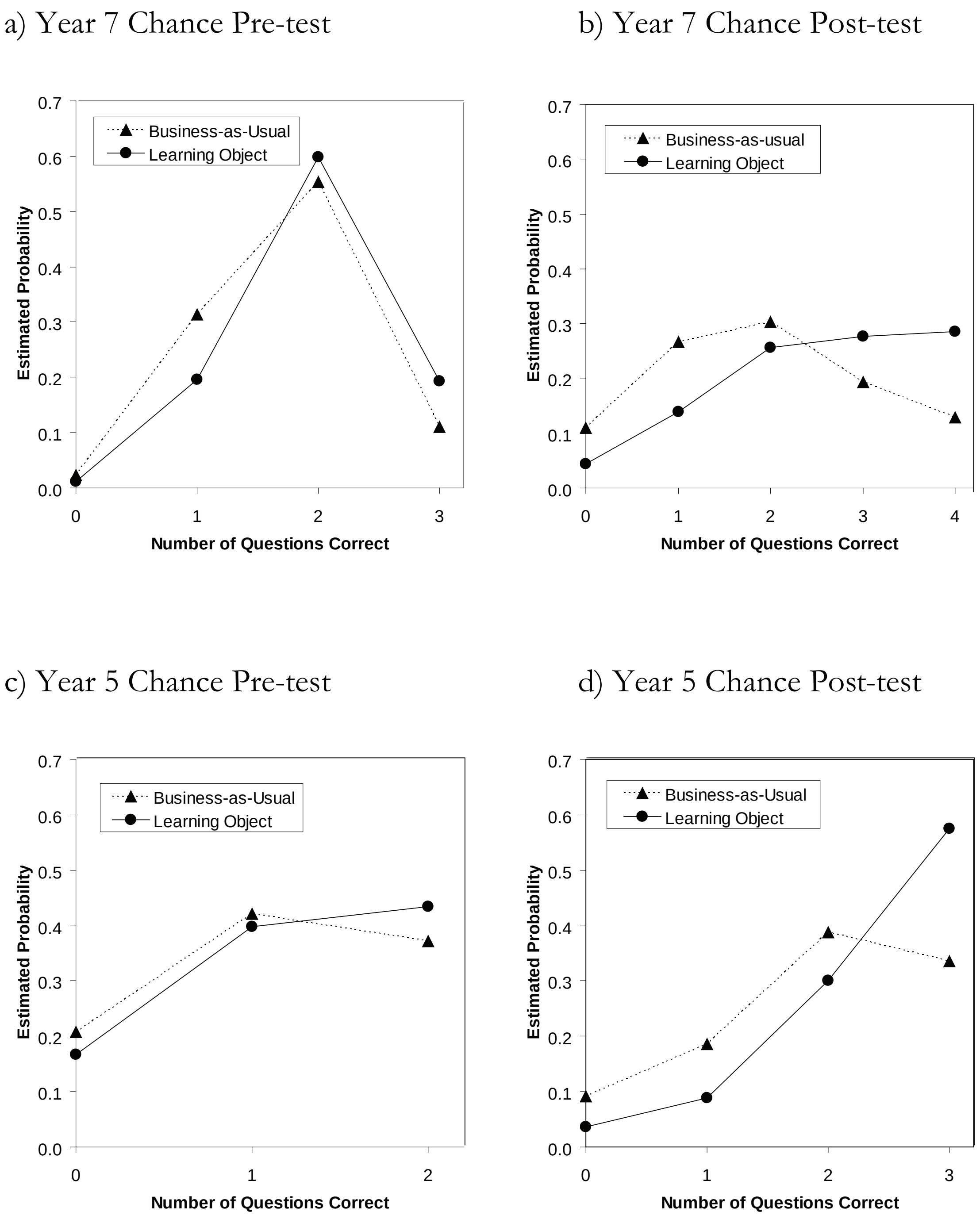


Figure 9. Estimated probabilities for the number of questions correct for Years 5 and 7 Chance pre-tests and post-tests



as to intrinsic conceptual structure: Teachers indicated that scenarios could be constructed in the LOs that would be either impossible or highly time-consuming for them to set up in classrooms. The view was expressed that Number concepts were more straightforward—conceptually, logistically, and pedagogically—to teach well. The speculation arising from the findings, therefore, is that it was this "difficulty" edge that caused the effect to appear more clearly for the Chance items in this intervention. The short time frame and small bank of items prevent any definitive acceptance of this hypothesis, but the indication is that further evaluations, along with "homing in" on optimal periods for different kinds of LOs, should be designed to take into account digital resources that are designed specifically for conceptually difficult, complex, and pedagogically challenging learning tasks.

So the elements of the evaluation converge on positive messages concerning the use of LOs. We documented persistent patterns of positive judgements by users and productive understandings of possibilities for use in a variety of educational circumstances, and found evidence of outcome gains on standardised test items not particularly chosen for their equivalence to the LO materials.

CONCLUSION

Recurring in our discussion have been issues to do with pedagogy and LO use. We found teachers using LOs like textbooks, library resources, and educational child-minders, so the observation of Wiley et al. (2004) ("they are used as glitzy information dumps") is only partly accurate. It is clear that consideration needs to be given to some developing theorization of the tension noted by Boyle (2003, p. 50):

from a software engineering perspective, each learning object should be as cohesive and decoupled as possible. This greatly facilitates re-use and re-purposing. From a pedagogical perspective, however, there is a need to create an overall coherent learning experience. These design challenges may be in conflict.

To support such developing theorization, research agenda in the areas of pedagogy and ICT usage need to document both the immediate and sustained consequences of engagement with online curriculum content for teachers and students. This needs to take account of curriculum domain differences and ecologically valid settings. This is not just a research question relating to student outcomes, notwithstanding their significance. Documentations of student outcomes that set aside the question of pedagogy (as indeed does the field experiment reported above) or that assume pedagogies can be considered either generic and common or too messy or idiosyncratic to contemplate, need from now on to be supplemented by systematic examinations of LOs in use. Only in this way can an appreciation of the potential of LOs in a variety of educational circumstances be systematically developed.

That is, what now needs to be documented, in collaboration with school colleagues and over timeframes that allow establishment phases for LOs in classrooms, is how teachers' and students' perceptions are acted out in sequences of teaching and learning activities, and the nature and extent of changed pedagogies and learning that result from the use of LOs. In their summary of the 51 original submissions to an international symposium on LOs, Duval, Hodgins, Rehak, and Robson (2004, p. 343) observed:

Many groups seem to be grappling with issues that relate to the pedagogically sound use of learning objects. Few papers included clear guidelines or methodologies, or analyzed in any detail what had worked and how or why it worked. It seems as if there is more agreement on the nature and relevance of the questions than on approaches to making progress with answering these questions.

This amounts to a recognition that the outcomes of using LOs are outcomes of enhanced teaching and learning, not automatic outcomes of the intrinsic properties of the LOs themselves. The point of departure now seems to be how to encourage and document the broadest possible range of good practices with LOs while at the same time remaining aware of the retrograde uses to which any promising initiative can be put. To respond with principled answers to these issues also means acknowledging the high stakes of failure for target communities, educational systems, schools, individual teachers, and students.

In his outline of the transformations facing contemporary societies, Kress (2003) has identified four related domains of high-speed change that should preoccupy educators:

- Changes in economic structures and opportunities in an information-driven economy (and see Ball, Maguire, & MacRae, 2000);
- Changes in the forms and modalities of communication, with a move away from the single dominance of written language and a move toward the use of image;
- Changes in social structures and relations of social power, with the reworking of new socio-economic hierarchies; and
- Changes in the technologies of communication, with a move away from the single dominance of paper-texts and toward digital-screen-texts.

The educational distribution of these new forms of communication becomes a system imperative if schools are to retain their currency and connection with the civic and domestic lives of young people and simultaneously with the labour markets that they face after school (Gee, Hull, & Lankshear, 1996). This broader policy setting calls for a programmatic approach to trialling and monitoring the use and efficacy of digital products, one that is rich and multi-faceted enough to rise to challenges that are socio-economic, cultural, and intellectual as well as technological.

To conclude, it is worth recalling Pittard and Bannister's (2005) warnings about how the outcomes of ICT use can be rigorously assessed. In particular, they cautioned against an over-reliance on standardized test gains as the only, or even the leading criterion in pronouncements of success or otherwise for ICT interventions. They drew attention to the potentially growing discrepancy between what these tests assess and two other domains of practice and learning: (i) the special learning affordances of ICTs and (ii) the skills, understandings, and dispositions young people will need to engage with emerging forms of globalized economic, civic, and cultural life—autonomy, discernment, and the establishment and maintenance of new, digitally-based relationships. Evaluating new teaching and learning technologies only in terms of whether or not they can be shown to improve performance on standardised tests that reflect 19^{th} and 20^{th} Century pedagogies, practices, forms of communication, and social organisations is not likely to give reliable guidance on how schools might enhance the development of new kinds of effective citizen-workers. It is also unlikely to enable the equitable distribution of precious communicational and intellectual resources afforded by enhanced digital and online learning settings. The creative understanding and application of knowledge expected of students in "new times" needs to be demonstrated as well by those who assess their learning.

REFERENCES

Abidin, B., & Hartley, J. R. (1998). Developing mathematical problem solving skills. *Journal of Computer Assisted Learning 14*, 278-291.

Ainley, M., Bourke, V., Chatfield, R., Hillman, K., & Watkins, I. (2000). *Computers, laptops and tools.* ACER Research Monograph No. 56. Melbourne, Australia: Australian Council for Educational Research.

Atkins, S., & Jones, D. (2004). *Considerations for learning design*. Melbourne, Australia: The Le@rning Federation. Retrieved March 24, 2008, from http://www.thelearningfederation.edu.au/tlf2/showMe.asp?nodeID=73

Ball, S., Maguire, M., & MacRae, S. (2000). *Choice, pathways and transition post-16: New youth, new economies in the global city*. London: Routledge.

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology, 19*, 46-58.

British Educational Communications and Technology Agency (BECTA). (2005). *Evidence on the progress of ICT in Education*. Coventry, UK: BECTA.

Browne, W. (2005). *MCMC estimation in MLwiN*. Centre for Multilevel Modelling, University of Bristol. Retrieved March 24, 2008, from www.cmm.bristol.ac.uk/MLwiN/download/manuals.shtml

CEO Forum on Education and Technology. (2000). The power of digital learning: Integrating digital content. *The CEO Forum School Technology and Readiness Report*, Year 3. Retrieved March 24, 2008, from http://www.ceoforum.org/downloads/report3.pdf

Cox, M., Abbott, C., Webb, M., Blakeley, B., Beauchamp, T., & Rhodes, V. (2003). *ICT and attainment: A review of the research literature*. ICT in Schools Research and Evaluation Series Number 17, BECTA/DIES, London. Retrieved March 24, 2008, from www.becta.org.uk/page_documents/research/ict_attainment_summary.pdf

Dori, Y. J., & Barak, M. (2001). Virtual and physical molecular modeling: Fostering model perception and spatial understanding. *Educational Technology & Society, 4*, 61-74.

Duval, E., Hodgins, W., Rehak, D., & Robson, R. (2004). Learning objects symposium [Special issue, guest editorial]. *Journal of Educational Multimedia and Hypermedia*, *13*, 331-343.

Freebody, P. (2005). *Does the use of online curriculum content enhance motivation, engagement and learning? The Le@rning Federation trial review*. Report to Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA). Retrieved March 24, 2008, from http://www.thelearningfederation.edu.au/tlf2/showMe.asp?nodeID=67]

Freebody, P. (2006). *Early-stage use of The Le@rning Federation's learning objects in schools: Results of a field review.* Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA). Retrieved March 24, 2008, from http://www.thelearningfederation.edu.au/tlf2/showMe.asp?nodeID=891]

Freebody, P., Muspratt, S., & McRae, D. (2007). *Evaluating The Le@rning Federation's online curriculum content initiative: Summary of findings from surveys, site visits and a field experiment.* Retrieved March 24, 2008, from http://www.thelearningfederation.edu.au/tlf2/showMe.asp?nodeID=891

Gee, J. P., Hull, G., & Lankshear, C. (1996). *The new work order: Behind the language of the new capitalism*. Sydney, Australia: Allen and Unwin.

Goldstein, H. (2003). *Multilevel statistical models* (3rd ed.). London: Arnold.

Hox, J. (2002). *Multilevel analysis: Techniques and applications.* Mahwah, NJ: Lawrence Erlbaum Associates.

Jamieson-Proctor, R. M., Burnett, P. C., Finger, G., & Watson, G. (2006). ICT integration and teachers' confidence in using ICT for teaching and learning in Queensland state schools. *Australasian Journal of Educational Technology, 22*, 511-530.

Jonassen, D. (2004). Model building for conceptual change: Using computers as cognitive tools.

In M. Gregoriadou, A. Rapti, S. Vosniadou, & C. Kynigos (Eds.), *Information and communication technologies in education* (pp. 3-17). Athens, Greece: New Technologies Publications.

Kress, G. (2003). *Literacy in the new media age*. London: Routledge.

Mann, D., Shakeshaft, C., Becker, J., & Kottkamp, R. (1999). *West Virginia story: Achievement gains from a statewide comprehensive instructional technology program*. Retrieved March 24, 2008, from http://www.mff.org/pubs/ME155.pdf

Marzano, R. J., Gaddy, B. B., & Dean, C. (2000). *What works in classroom instruction*. Aurora, CO: Midcontinent Research for Education and Learning.

McCormick, R., & Li, N. (2006). An evaluation of European learning objects in use. *Learning, Media and Technology, 31*(3), 213-231.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Learning and Skills Development Agency.

Nichol, J., & Watson, K. (2003). Special issue devoted to the rhetoric and reality: The present and future of ICT in education. *British Journal of Educational Technology, 34*, 2.

Owen, J. M., Calnin, G. T., & Lambert F. C. (2002). Evaluation of information technology. In J. W. Altschuld & D. D. Kumar (Eds.), *Evaluation of science and technology education at the dawn of a new millennium* (pp. 133-164). New York: Kluwer Academic/Plenum Publishers.

Parr, J. (2006). *Review of the literature on computer-assisted learning*. Auckland. Retrieved March 24, 2008, from www.minedu.govt.nz/print_doc.cfm?layout=document&documentid=5499&fro

Passey, D., Rogers, C. G., Machell, J., McHugh, G., & Allaway, D. (2003). *The motivational effect of ICT on pupils: Emerging findings*. London: UK Department for Education and Skills.

Pittard, V., & Bannister, P. (2005). *Understanding the impact of ICT*. London: BECTA.

Rasbash, J., Steele, F., Browne, W., & Prosser, B. (2005). *A user's guide to MLwiN* (Version 2). Centre for Multilevel Modelling, University of Bristol. Retrieved March 24, 2008, from www.cmm.bristol.ac.uk/MLwiN/download/manuals.shtml

Walton, M. N., & Archer, A. (2004). The Web and information literacy: Scaffolding the use of Web sources in a project-based curriculum. *British Journal of Educational Technology, 35*, 173-186.

Wiley, D., Waters, S., Dawson, D., Lambert, B., Barclay, M., Wade, D., et al. (2004). Overcoming the limitations of learning objects. *Journal of Educational Multimedia and Hypermedia, 13*, 507-521.

KEY TERMS

Field Experiment: A trialling of an intervention that is designed to keep most variables constant except the intervention in question within the constraints of the allocation of schools and classrooms into conditions, rather than the random allocation of students, and the reliance on 'standard practice' in a contrast group, rather than a strict 'control group'.

Learning: Taken here to involve the understanding and management of factual content, the understanding and use of concepts, and the application of content and concepts to new settings.

Learning Object: Files or modules of learning material that represent interactive learning activities that may include texts, and/or graphic, audio or animated materials, and that are reusable in multiple settings and for multiple purposes.

Motivation: Taken here to comprise persistence, engagement, and enjoyment.

Multilevel Modelling: A set of procedures for partitioning variance at different levels of unit formation (e.g., students within classrooms within schools).

Online Content: Referring here to digital materials accessible from digital repositories, as referenced, located, and accessed by metadata descriptors.

Pedagogy: Taken here to involve curriculum materials, teacher-student interaction, and assessment activities.

ENDNOTES

1 The data reported in parts of this chapter were collected as part of a grant provided by The Curriculum Corporation. Some sections of this chapter contain data reported more fully in Freebody, Muspratt, and McRae (2007) and Freebody (2006).

2 At each year level, four groups of multilevel proportional odds analyses were run: Chance pretest, Chance post-test, Number pretest, and Number post-test. Each group comprised three analyses: (1) A single-level analysis to establish base-line estimates; (2) A multilevel analysis with "Classroom" as a random factor to determine whether or not there was variation at the classroom level; and (3) The treatment variable (Business-as-Usual vs. Learning Object) was added to the model to determine whether or not students in Learning Object classrooms performed better than students in Business-as-Usual classrooms. For a more complete description of the models, see Freebody, Muspratt, and McRae (2007).

Chapter XXIV
Effective Use of Learning Objects in Class Environments

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ABSTRACT

This chapter provides a model to analyse the effectiveness and efficiency of Learning Objects being used in primary and secondary schools by considering their place within that educational environment, paying particular attention to the manner in which they, like any resource, can aid or occlude productive interactions between teachers and students. It draws from a study of Australian and New Zealand schools that piloted the first release of Learning Objects from the Le@rning Federation. The chapter considers the place of Learning Objects within the overall systemic school environment, and in this environment, examines the individual classroom as the combination of tensions between the teacher's needs, the students' needs, and the potential available within the existing infrastructure. Within this framework, the chapter discusses the ways in which these three components interact during teacher selection of Learning Objects, students' accession of Learning Objects in the classroom, and the use of the Learning Objects by students. It concludes by suggesting how students' construction of knowledge can be enhanced through merging the capabilities of the resource with the needs of students and teachers.

INTRODUCTION

The Le@rning Federation began in 2001 as a collaboration between the state, territory, and federal governments of Australia and New Zealand. At the time of writing, it has placed 5,000 digital learning resources online, including a wide range of Learning Objects relevant to Literacy, Numeracy, Science, Studies of Australia, Languages other than English, and Innovation, Enterprise, and Creativity. The scale of government commitment meant that the first round of Learning Objects made available to teachers on the Internet during 2003 were a critical testing ground for this technology. At the same time, extensive guidelines were put in place to ensure that all offerings would be accessible, usable, and have educational integrity with a learner focus, as outlined in the specifications for developers (The Learning Federation, 2002, 2006). Underlying this project was a definition of a Learning Object as

- One or more files or "chunks" of material, which might consist of graphics, text, audio, animation, calculator or interactive notebook, designed to be used as a standalone learning experience
- Reusable—a single learning object may be used in multiple contexts for multiple purposes such as across curriculum areas, year levels, different locales, and cultures
- Usable as a component of a topic or unit of work alongside other digital and nondigital resources and tools
- Accessible from the World Wide Web and is referenced, located, and accessed by its metadata descriptors
- A product that can be identified, stored, and tracked using a content or learning management system (Lake, Phillips, Lowe, Cummings, Schibeci, & Miller, 2004, p. 1).

BACKGROUND

Duval, Hodgins, Rahak, and Robson (2004) noted that "few papers [about Learning Objects] included clear guidelines or methodologies, or analysed in any detail what had worked and how or why it worked" (p. 338). This chapter will consolidate the results of an Australasian study into the impact, application and effectiveness of Learning Objects developed for primary and secondary classroom teaching and learning (Lake et al., 2004; Schibeci, Lake, Phillips, Lowe, Cummings, & Miller, 2006).

The study arose from the early stages of a major government initiative to develop online digital content, and involved case studies of 20 classrooms in 14 schools in Australia and New Zealand.

The four main data collection activities were student observation, student interviews, student surveys, and teacher interviews and observation.

Researchers visited schools in pairs. They spent between 1 and 5 hours in each classroom. Students were observed using the learning object and then about half (based on parental permission) were interviewed. Teachers were also interviewed during or after the lesson. Surveys were administered to students and teachers. In several cases the teacher selected students according to characteristics they felt made them of special interest (for example, cultural background, non-English-speaking background, ADHD, reading or mathematics difficulties). The researchers made no representations in this area. Researchers observed students using a learning object in the context of a normal lesson and did not provide assistance unless students had significant difficulties getting the learning object to operate and directly requested assistance from the researcher. All classroom activity was tape-recorded and transcribed for later analysis.

Semistructured interviews used questions that were developed from the generic evaluation questions and reduced in number refined through use in the classroom during a prepilot study. A second set of student interview questions involving role playing was developed for early-years students. Students were interviewed at their computer or in an adjacent area. Where two students shared a computer, they were interviewed together. Interviews took between 5 and 20 minutes. All interviews were recorded and transcribed for later analysis.

A stand-alone student survey was designed as a two-page questionnaire based on Likert-type statements relating to the generic evaluation questions. It was trialed and refined during the pre-pilot study. The survey consisted of two parts: a common section about general learning object usability, and one with questions specific to the learning area (Science, Literacy, or Numeracy). Responses were obtained from 134 students in six participating classrooms

Semistructured class teacher interviews of 30 to 60 minutes based on generic evaluation questions developed through the Program Logic approach probed issues specific to the way in which learning objects augmented accepted pedagogical approaches within the relevant learning area. However, teachers were encouraged to provide any feedback they felt was important. All interviews were recorded and transcribed for later analysis.

A teacher questionnaire was distributed to one teacher in each of the 10 post-pilot schools selected by The Le@rning Federation for this study, and was used as an exploratory tool, and as a stimulus for discussion.

Qualitative data comprised of 84 documents, consisting of over 55,000 lines interview transcripts from student and teacher interviews, and field notes were analysed using the NUD*IST computer program. A node tree of expected response themes was developed from the generic questions and expanded by issues that emerged from the data. A set of additional "free" nodes was created from unrelated themes and field notes. Data was coded by two research assistants. Initially each assistant worked in collaboration with a member of the research team to increase reliability. Coding was also reviewed independently by other members of the research team.

Responses from student surveys were analysed using the RUMM computer implementation (Andrich, Sheridan, & Luo, 2002) of the Rasch Extended Logistical Model (Andrich, 1988). The RUMM software package uses the Rasch latent trait measurement model, and is suited for cumulative scales. Researchers employed this form of analysis to ascertain the relationship between different features of the learning experience and determine the relative importance of each factor in creating a useful learning experience.

MODELLING THE EDUCATIONAL ENVIRONMENT

It is critical when a new program is implemented, that stakeholders share an understanding of how the program is intended to operate and what it is trying to achieve. Most programs, including this one, produce formal documents describing the program. However, many stakeholders and evaluators also benefit from a process that develops clear and agreed understandings of the program, or program logic. One of the most useful program logic analyses is provided by Funnell (1997, p. 5):

In simple terms, a program logic is a program's theory of action. It is a theory about the causal links among the various components of a program: its resources and activities, its outputs, its short-term impacts and long-term outcomes. Like any other theory, it is testable and should be tested. Making a program's theory of action explicit is *the first step towards testing its validity. Program analysis is the process of identifying and making explicit the logic of a program.*

An iterative program logic analysis was conducted with the Field Review Reference Group to explore understandings and assumptions about the nature of the Learning Object model and the pilot Field Review. This included:

- Clarifying the evaluation aims
- Providing the evaluation team with background information
- Identifying documents and data sources
- Identifying underlying assumptions
- Identifying who should be involved in the evaluation
- Assisting the evaluation team in selecting the best opportunities for data collection within the time and budget constraints.

This program logic analysis identified factors required for the success of the initiative and led to the development of four broad research questions which reflect the concerns of Duval et al. (2004) that there should be more "recognition that the important aspects of learning objects are how they are implemented and used, not how they are defined" (p. 339).

1. How useful are the Learning Objects for teachers?
2. How useful are the Learning Objects for students?
3. How does Learning Object design interact with: geography, structures within the school and classroom, socio-economic status, and student diversity to affect the ways in which teachers and students use Learning Objects?
4. What factors, including school and system level issues, impact on the wider adoption of Learning Objects?

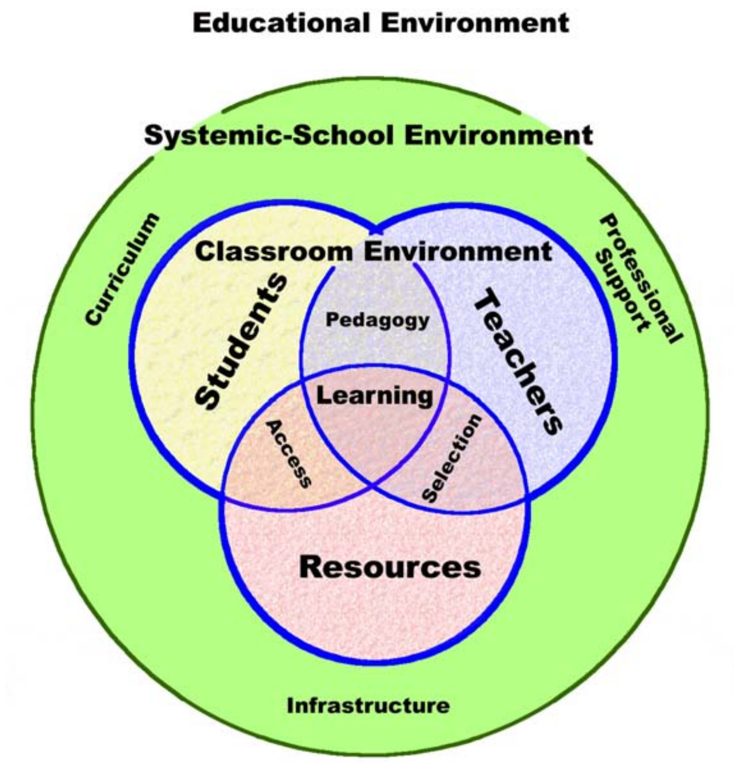
These questions formed the primary focus of the study (see Lake et al., 2004 for a more detailed description of the program logic analysis). Schaffer and Douglas (2004) observed that model components join to create environments and systems and used this to develop a model for metadata storage. Similarly Bouzeghoub, Defude, Duitama, and LeCocq (2006) arranged metadata using the domain, the learner and the object as interacting classes. Fresen (2007) formulated a taxonomy of factors which affect the quality of a Learning Object that include the teacher, the student, the pedagogy, the instructional design, and factors relating to technology and the institution.

The educational environment model described here (Figure 1) was derived initially from the program logic analysis and then further refined from evidence collected in this study. In the program logic hierarchy, school- and system-level support was an overarching factor influencing success, and well-designed Learning Objects were a prerequisite. Two subsequent factors in the program logic were the selection and subsequent use of Learning Objects by teachers. In Figure 1, this is illustrated in the intersection of Teachers and Resources labelled *Selection*. Similarly, the next two factors in the program logic hierarchy concern enjoying and learning from Learning Objects—the intersection of Students and Resources labelled *Access*. The final binary intersection in the model—*Pedagogy*, the interaction of teachers with students—did not arise from the programme logic, but was an important factor arising from the data.

This chapter argues that these points of intersection are the most important areas for promoting learning, and for learning to be maximized, these three components of the classroom environment need to be brought as close together as possible, thus expanding the intersections.

The larger circle in Figure 1 represents the environment of the school and its respective educational system. Together, the classroom environment and the school/system environ-

Figure 1. Model of the educational environment indicating the ways that students, teachers and resources interact with each other and within the larger school/ system environment



ment make up the educational environment. The school/system environment impacts on the classroom in three ways: through the *curriculum*; through *professional support* and development of teachers; and through provision of appropriate *infrastructure*. In the context of this research, the infrastructure is primarily ICT-based, enabling students and teachers to access the Learning Objects appropriately.

TENSIONS WITHIN THE SYSTEMIC-SCHOOL ENVIRONMENT

The classroom environment is shown in the centre of Figure 1, with three main components: Students, Teachers and Resources. Learning Objects are one of the resources that teachers may choose to embed within their teaching programmes. This model posits that the classroom environment exists within a broader school and system-level environment, and there are three primary mechanisms through which the classroom environment interacts with the broader educational environment:

- The relevance of the *curriculum* to students and its coherence;
- The provision of appropriate *infrastructure*; and
- The *professional support* and development of teachers.

Resources and Infrastructure

Using the dominant constructivist pedagogical approach, resources are the tools that teachers use to develop activities where students are able to construct their experiences into a pattern of belief. Learning Objects are one type of resource for providing experiences to help scaffold knowledge. Wiley, Waters, Dawson, Lambert, Barclay, and Wade (2004) cautioned against Learning Objects that fail to scaffold knowledge, but simply seek to deposit knowledge into the mind of the user while an analysis of the ARIADNE project (Põldoja, Leinonen, Väljataga, Ellonen, & Priha, 2006) estimated only 1.4% of objects were based on constructivist principles. At the same time, Baruque and Melo (2004) demonstrated how Learning Objects can be enhance behaviourist, cognitivist, and various constructivist pedagogical approaches.

The ability of the teacher and student to access the Learning Objects depends both on the technical infrastructure and the skills of the individual teacher or student. This study found a wide variety of computing facilities, technical support, and policies for using technology within schools. There was also a wide range of teacher competence and confidence with using the available technology and the Learning Objects. Without appropriate facilities and both technical and operational support, uptake of the Learning Object model is uncertain and is likely to be limited.

The Learning Objects surveyed were not supported by all operating systems. The researchers understand the pragmatism of that decision, and would expect that for Learning Objects to continue to be useful, periodic updates will continue to be required as operating systems change and develop.

McRae (2001, p. 16) reported that "effective whole school planning is critical to the successful implementation of ICTs." For Learning Objects to be effective in schools, all parts of the school community need to be aware of, and support, the initiative. In particular, effective IT support. Widespread use of Learning Objects will require re-examination of IT policies and procedures in some schools, where download limits are imposed to reduce costs, and Internet access can be revoked as a component of behaviour management policies. It will also require Internet use to be viewed as a core activity, rather than a recreational or reward activity.

Learning Objects provide a means to bridge geographical barriers facing students. The equitable provision of quality resources for students in rural and remote regions continues to be a challenge for educational authorities (Lake, Faragher, Lenoy, Sellwood, Archer, & Anderson, 2006) and Learning Objects will undoubtedly continue to be an important part of the solution. The rapid rise in access to broadband Internet services in schools will mean that in the near future Learning Objects will be available to students in the remotest parts of Australia. However, access is not yet uniform and some schools found bandwidth to be an issue, particularly when teachers attempted to have all students in a class access a Learning Object from a remote site rather than downloading it to a local server in advance. Despite these limitations, the Learning Objects already enable many remote students to undertake activities in the same way as their metropolitan counterparts decreasing the educational divide (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006), assuming that their teachers are able to make the best use of them.

Teachers and Professional Support

Teachers promote learning, but how they achieve this depends on the particular mix of the beliefs, knowledge, and skills that they bring to the task. Teachers in this study felt more professional support including the identification of time management issues and strategies to address them, was needed to maximize their use of Learning Objects for effective student learning. Professional development of teachers in selecting, structuring, implementing, and monitoring the use of Learning Objects must be a priority if their full potential is to be achieved in the classroom.

Teachers in this study sought a range of support:

- Guidance in identifying Learning Objects containing appropriate and accurate content relevant to their syllabus materials;
- Advice on techniques for presenting the Learning Object, in particular, suitable introductions and conclusions to the session;
- Advice on class management techniques suitable for lessons incorporating Learning Objects;
- advice on how and where specific Learning Objects fitted into the local syllabus; and
- Advice on how to integrate strategies used in the Learning Objects into their own teaching practice.

Teachers almost universally felt that professional development should be brief, focussed, and integrated into ongoing professional support rather than once-off professional development sessions. One means to achieve ongoing professional support is online communities of practice (see Cummings & Aquilina, 2004; Phillips, 2002, chaps. 1, 2) which can enable:

- Conversations among peers about techniques to adapt generic Learning Objects for specific themes;
- Debates with peers and the wider academic community about the role of the curriculum, and the part that ICT can play in its development;
- Conversations with peers about how to identify and use Learning Objects that will meet special needs of specific students;
- Sharing worksheets and other materials that can be used by students while they are interacting with the Learning Objects; and
- Discussion about how to assess learning achieved through using Learning Objects.

This conclusion is in agreement with Muirhead and Haughey (2003, p. iii) who recommended

The Le@rning Federation should take immediate steps to expand its current mandate to develop communities of practice among learners and instructors involved with the content development initiative.

A second alternative is for the Learning Objects to contain associated information providing teachers with explicit guidance about the ways in which a particular Learning Object may be best utilized, either through release notes or by being embedded within the Learning Object.

Coupled with either option is the need for others within schools to be familiar with the requirements for successful use of Learning Objects. This includes professional development for both technical support personnel and administrators, as part of a whole-school approach.

Students and Curriculum

The classroom, real or virtual, does not exist without students who may be there to learn, but who are also individuals that bring their own experience, needs, motivations, and aspirations. What a student is required to learn is dependent on the mix of sociological, administrative, cultural, economic, and historical factors that shaped his or her curriculum. The particular suite of Learning Objects that were the basis of this study were required to be relevant to the curricula of New Zealand and eight Australian states and territories.

Based on thorough research (McRae, 2001), the Le@rning Federation specified that Learning Objects should be designed specifically from a constructivist perspective where:

The objects should contribute to the learning of the user. They are not meant to be assessment experiences or revision experiences or drill and practice experiences. They are meant to contribute to the understanding of concepts and processes and the development of skills. This does not mean that assessment, revision or drill and practice cannot be exhibited through interaction with the learning objects but this is not the primary focus.(Atkins, 2003, p. 1)

THE CLASSROOM ENVIRONMENT

The model developed in this study views classrooms composed of three factors that interact with each other, as discussed subsequently, but are also in tension with the broader systemic school environment (Figure 1). Individual resources like the Learning Objects must operate within the infrastructure of the school. Teachers are dependent on the professional support that they receive from within the system, and students work within a curriculum setting that is imposed in large part from outside the classroom. The Learning Objects were analysed from each of these perspectives.

The Resource Perspective

The use of the Learning Object as a resource within the classroom environment was dependent on three aspects of the available infrastructure: the available hardware, the available enabling software (such as *Flash* readers), and the policies that determined how they could be used within the classroom.

It is often difficult for those enmeshed in the world of computer technology, usually in large well connected establishments to appreciate that the end-user of Learning Objects, particularly in the primary school setting, frequently qualified before the impact of the technology was felt. She (normally) has a small number of professional development days each year that are devoted, in the main, to keeping abreast of administrative and curriculum changes. Furthermore, her students are likely to have faster, more capable machines at home than those in the school. For example, machines in several schools lacked soundcards reducing the pedagogical utility of many Learning Objects. Finally, most primary schools and many of the secondary schools visited, had no dedicated technician, relying instead on the goodwill of an enthusiastic but not IT-trained teacher to keep the system operating.

The same teachers find it difficult to keep abreast of software trends. While most were accustomed to *Word* and *Powerpoint*, and were able to download digital images from the Internet, many teachers were intimidated by the need to download unfamiliar software packages, like *Flash* readers, where they were not directly obtainable from the official educational authority Web site. Similarly, a familiarity with the point and click simplicity of the Internet made them unprepared for system specific requirements beyond those commonly used for Internet searches, such as requirements to obtain and use passwords or navigate tables of metadata to locate learning objects of an appropriate level for their students' needs. Automatic timed log outs within the delivery systems also prevented some early childhood teachers from setting up the classroom in advance for young students unable to complete these tasks themselves.

School policy was also found to conflict with the successful use of Learning Objects. These policies created the impression that authorities considered computers as an optional motivational tool rather than an integral part of the teaching program. Policies preventing students accessing inappropriate Internet material or reducing Internet download costs led to some schools disabling sound cards or prohibiting earphones. One school blocked downloads of video, audio, and *Flash* files. Another introduced a "bank balance" of download time meaning that some students had used their allowance prior to the class.

The Teacher Perspective

Teachers are the second interacting component of the classroom environment in the model. Despite the obvious importance of the teacher controlling the learning process within the classroom environment, this human factor can be overlooked in Learning Object design (MacLaren, 2004). Overall, teachers in this study expressed enthusiasm about the potential of Learning Objects to introduce a wider variety of learning activities into the classroom particularly activities that were otherwise dangerous or beyond the scope of existing school infrastructure or budgets such as science experiments needing chemicals or materials perceived as hazardous. Teachers also felt that simulations could increase the viability of conducting science experiments that would normally require days or weeks to complete.

However, teachers do not form a homogeneous group. A range of factors affect each teacher's comfort and confidence in using Learning Objects, including their available time to plan, and their familiarity with the curriculum, their students, and the systems and facilities in their school. The teacher's expertise, both in ICT and in discipline areas, is also important in relation to how it interacts with the teacher's pedagogical approach. Technological attitudes, skills, and knowledge are necessary for teachers to organise and guide students using Learning Objects (Ilomäki, Lakkala, & Paavola, 2006)

A wide range in disciplinary literacy was evident amongst the teachers included in this study. This is particularly prominent at the primary level where teachers are generalists, but the majority of Learning Objects were science objects more suited to specialist science classes. Teachers often lack disciplinary confidence and may be only one step ahead of their students (McComas, 2000). Even in high schools there can be no assurance that teachers are specialists within their teaching area (Harris, Jensz, & Baldwin, 2005) especially within rural and remote schools. Within this systemic environment some teachers were using Learning Objects as props to support their lack of depth in the discipline being taught. At the other extreme, others were modifying Learning Objects to provide students with learning experiences that meshed with highly developed, meticulously constructed content programmes.

Teachers' beliefs about teaching, and their consequent pedagogical approaches, affect how they structure lessons and evaluate student learning thus influencing the way they use Learning Objects (Bain & McNaught, 2006). Consequently, there is no ideal Learning Object which will suit all teachers, and resource providers need to provide variety.

Learning Objects could be considered to have the following three possible roles for the teacher:

- Support the teacher to teach in the manner that they are used to;
- Motivate the teacher to provide more enriching experiences for their students; and
- Enable the teacher to discover more enriching teaching methodologies.

These issues, which are broadly congruent with McRae (2001 pp. 92-94), indicate that Learning Object designs must be attractive enough for teachers to choose them (as described in a subsequent section), but should also act as motivators for professional development.

While a number of teachers observed in this study had relatively high interest in ICT and relatively strong computing literacy, it can be expected that the majority of teachers have limited confidence and expertise (Department of Education, Science, and Training, 2001).

The Student Perspective

The case study approach used in this study enabled the investigation of how students of different abilities and backgrounds used Learning Objects.

Almost all students were observed to gain benefit from their use of the Learning Objects, regardless of background. The amount of benefit derived from them depended less on the students' backgrounds and more on other factors including how the design of the Learning Objects permitted them to engage, how the Learning Objects were embedded in lessons, and the teacher expectations and how they matched the general needs of the group and the specific needs of individual users.

Teachers strongly valued the ability of Learning Objects to provide students with new and stimulating ways to learn. Students demonstrated an enthusiasm when using Learning Objects that was not always apparent in their approach to other classroom activities. Bright colours and simple graphics within the user interface engaged particularly the younger students. Humour, particularly through quirky animated characters, was especially appreciated. As also reported by Kay and Knaak (2007), sound and animation incorporated into the multimedia attributes of the Learning Objects, particularly when linked to interactivity, strongly correlated with this engagement. Students found navigation simple where they used the familiar conventions of the Internet and, with some exceptions, they completed tasks using the media well to assist their learning.

McRae argues that Learning Objects need to de-emphasize written text and emphasize the visual.

> *Digital learning can make visual representations of knowledge (through static or moving images and animation) readily accessible. It can "show," model and explicate in ways that verbal … communication alone cannot.* (McRae, 2001, p. 56)

School students are growing up in a culture where multimedia stimulation is commonplace, unlike the situation when their teachers were young. Therein lies a gulf in education that Learning Objects can bridge. The challenge for Learning Objects is to recognise and exploit this paradigm shift whose pace and parameters are set in other fields particularly entertainment through videogames and the Internet. Students, as experts in the new paradigm, are discerning and demanding when it comes to good communication.

Students did not like reading large sections of text and were less inclined to make appropriate use of Learning Objects containing text-heavy instruction pages. Students generally skipped instructions and experimented instead for one or more of the following reasons:

- A preference to experiment rather than work sequentially;
- A lack of patience when reading lengthy instructions;
- A lack of literacy skills to read confusing instructions;
- A preference for using their time "doing" rather than reading; and
- A perception that the font sizes were too small.

Sound and graphics can provide an alternative to text-based information which afford students with reading difficulties another way of learning. Students enjoy graphics and wherever it does not compromise the learning purpose, graphics should be used in place of text. The graphics need not be realistic, they can be more accessible when they are not (for example when depicting physiological functions). However, students experienced difficulties and frustration when graphics were not clear or factually reliable. Icons were preferred over text for labelling buttons, and colour was important, especially for younger students. The entire suite of offerings for younger students was well received for that reason. Older students focused more on content rather than graphic presentation.

While the need for creative and engaging use of graphics and multimedia and a de-emphasis of textual components was common throughout the student sample, Learning Objects were found to possess features that are of specific importance to specific groups. Not surprisingly these features were often predictable from the broader educational research literature. For example, Learning Object design needs to accommodate our understanding of educational psychology, recognising the different needs of different aged students. So, young students require and prefer simple cartoon-like graphics with fewer distractions, while older students demand greater complexity and more control over different aspects of the interface. Other important elements of Learning Object design identified by teachers are listed below.

Multimodal Content**:** Learning Objects also enabled teachers to accommodate the differing learning styles of individual students. Visual learners were provided with new and stimulating ways to learn whereas aural elements assisted other students. Some Learning Objects enabled students to experience abstract mathematical concepts in a concrete fashion by allowing them to visually manipulate and observe variables. Effectively, this mimicked the processes considered critical in situated learning (Ovens & Smith, 2006).

Opportunities for Collaboration: for lower-achieving students anonymous feedback is a potential advantage. The vast majority of these students, however, expressed a preference for working in pairs on a computer to gain peer feedback and support, and when working in pairs, teachers observed that they persisted longer than in other activities, reflecting the findings of Põldoja et al. (2006) and Baker, Gersten, and Lee (2002) from their review of the literature surrounding at-risk students in mathematics. Wiley et al. (2004) argue that collaboration is necessary to negotiate meaning, and providing opportunity for collaboration is therefore a requirement of high quality Learning Objects.

Flexibility for Gender: some gender differences were observed. For example a Learning Object about braking distance of vehicles allowed students to investigate using a risk avoidance approach (initially applying the brakes almost immediately and then progressively extending the distance), or a risk acceptance approach (initially applying the brakes almost at the point of impact and then progressively decreasing the distance). Unsurprisingly, given the pan-global stereotype (see, for example, *Mueller, 2004),* the majority of female students were engaged by the former and the majority of males by the latter. Nonetheless, the effectiveness of this means of engagement needs to be balanced by considerations of the ethics of appealing to stereotypes like this in educational material.

Literacy Assistance: teachers reported that students from non-English speaking backgrounds were able to use the Learning Objects as easily as other students, making use of nontextual elements. Students were able to navigate around Learning Objects using visual clues and intuitive logic. Teachers valued sound files to mirror screen text that could be toggled on for students with weak literacy skills. Unfortunately, many Learning Objects assumed that literacy reflected age and so Learning Objects designed for older students often lacked this useful facility.

Cultural Appropriateness: the Learning Objects also provided specific cultural advantages. Shame has long been recognised as a major issue in Indigenous and Pacific cultures. Students from *Pacifica* backgrounds were found to engage positively with Learning Objects that allowed them to test and modify their answers in response to immediate computer-generated feedback, ensuring that the answer displayed to the teacher would not be subject to the shame of rejection by the teacher.

Not only did Learning Objects provide a nonjudgemental environment, they enabled alternative ways to succeed. Students could tackle activities involving experiment and strategy with fewer barriers from text and facts. They were also able to produce high quality work in cases where writing or drawing on paper proved time-consuming and difficult.

INTERACTIONS IN THE ENVIRONMENT

Maximization of the Learning Objects' potential lies in increasing the overlap of the three components of the classroom environment in the model (teachers, students and resources, i.e., Learning Objects) because it is when these are all trying to do the same thing that learning is most likely to occur. The Le@rning Federation (2002) specifications stress the importance of maximising these interactions by promoting accepted pedagogies including constructivism, individual progression, multiple intelligences, collaborative learning and scaffolding of knowledge. Learning Objects offer unique possibilities for teachers to utilise these pedagogies in ways appropriate to their situation.

Selection: Teachers and Resources

The selection process is often where teachers interact with the Learning Objects for the first time during the preparation of their teaching program. Reasons for teachers' selection of learning resources within their programmes are complex. In this study, teachers who had been able to find the resources quickly and reliably selected them according to the ease with which they could embed them within their program, and the match that they saw between the demands of the Learning Objects and the nature of their students. Pegler (2005) described levels of engagement during the selection process where users rejected, browsed, selectively engaged, actively engaged, or augmented the material on offer.

Like the teachers in Li, Nesbit, and Richards' (2006) study, teachers in our study were concerned with making the content of the Learning Objects meaningful to students by integrating them into their teaching and learning programs rather than planning their programs around the Learning Objects. In keeping with this, teachers indicated they wanted large banks of Learning Objects to choose from for specific parts of the curriculum. Like the teachers in McCormick and Li's (2006) study, they expected it to be as easy as using Google and other common search engines to sort through, preview and download with additional content that could extend and support their discipline knowledge to bolster their confidence in the classroom. They also wanted the design and interface of the Learning Objects to be sufficiently flexible to accommodate the specific contexts being used within the programme, in much the same manner as "skins" allow users to customize the appearance of mobile phones without changing the basic control mechanisms or functions. This was partially to embed them within their programme, but also to increase their reusability where other teachers may have used the same resources. The tendency for teachers to select and structure their use of resources to increase relevance for their students reflects the requirements of the outcome-based curriculum with which they work where:

> *outcomes developed at the state or large-system level ought to be written to enable the specifics of curriculum and pedagogy to reflect a diversity of people and practices, and students to demonstrate their achievement of the outcomes in a variety of ways.* (Willis & Kissane, 1995, p.15)

Teachers also wanted contextual information about how Learning Objects could be used and how other teachers had used them. While mechanisms for peer review of ICT-based learning resources have been proposed in the tertiary sector (McNaught, Phillips, Rossiter, & Winn 2000; Taylor & Richardson, 2001), such mechanisms have not matured, nor have they been applied to the schools sector.

Teachers were keenly aware of the needs and capabilities of their specific classes when selecting Learning Objects. However, the metadata recommending age bands for each Learning Object was disputed by many teachers. In rejecting the metadata, some teachers selected Learning Objects on the sophistication of their graphic interface rather than their cognitive demands creating the potential for a mismatch between student and resource.

Because of their multimedia components, it is sometimes difficult for teachers to assess how Learning Objects make demands on students' literacy, memory and cognitive abilities. A mismatch in any area will result in a less successful learning experience, so selection, task-setting, and monitoring the use of Learning Objects needs to be done thoughtfully. Peer support and professional development have a role to play in enhancing the way in which teachers employ Learning Objects (Baker et al., 2002).

Teachers also appreciated the potential for Learning Objects to demonstrate sensory experiences outside the range of resources and activities that are normally available for their students, such as functions of the human body or plant systems. Many of the Learning Objects fulfilled this potential, but others which provided material and activities within the repertoire of most classrooms and teachers were still used even though students and teachers indicated a preference for real experience. This may reflect the limitations being placed on teachers preparation time, their budgets for materials, and the ethical and safety requirements of the systemic-school environment where switching on the computer is a simpler option. Interestingly, although Nurmi and Jaakkola (2006) observed no significant improvement in mathematics or language learning using Learning Objects, in science there was evidence that the use of Learning Objects while students explored and explained new scientific concepts, coupled with opportunities to corroborate and elaborate on this new understanding by use of real materials did promote significantly superior learning. They suggested that, in science at least, the Learning Objects could promote the development of sound mental models without the constraints imposed by motor coordination when using real materials.

Other strengths of Learning Objects identified by teachers were their potential to:

- Cater for a range of cognitive abilities;
- Match students' cognitive capabilities;
- Assist in providing links between concepts and contexts;
- Provide scaffolding and reinforcement.
- Allow for individual progression and record that progress electronically; and
- Provide new opportunities for collaborative learning.

Access: Students and Resources

The second interaction between the three components of the classroom environment highlighted in Figure 1 occurs during the access process where students first interact with the Learning Object. Li, Nesbit, and Richards (2006) collected user evaluations of Learning Objects they accessed from the eduSource Canada repository using nine criteria: content quality, alignment to learning goals, feedback, motivation, presentation, usability, accessibility, and reusability.

Our study revealed many of the same features. Students in general appreciated their novelty and found many of them interesting, engaging and motivating. Teachers reported instances of increased levels of concentration, enthusiasm and successful learning when students used the Learning Objects. There was evidence that students from a range of abilities achieved success using Learning Objects. The objects engaged students resistant to traditional classroom approaches or those with low levels of academic performance. Disruptive students were observed participating actively in lessons and withdrawn students were observed in purposeful investigations.

The motivation of students was primarily dependent on the way in which the student perceived that the objects recognised their needs and style. Students were motivated using Learning Objects when they were:

- Challenged;
- Able to explore;
- Given control; and
- Provided with useful feedback.

Students desired discrete activities with clear goals against which they could gauge their success. They were not content with "talking books" that proceeded in a linear fashion to a predetermined endpoint without providing them with decision-making opportunities.

Students expressed a strong preference for Learning Objects that were quick to launch and gave them rapid access to clear screen actions which they could initiate through intuitive commands. They preferred Learning Objects that created their own personalities from the skilful and creative use of multimedia. In particular, humour provided by animation or through sound effects was well received. Visual detail, such as that provided in video-clips rather than simple animation, was not seen as a positive when conflicting elements made it difficult to interpret or when the intricacies of the events displayed distracted from the primary focus.

The user interface is the entry point and provides the tools for navigation and interaction. While some Learning Objects had very simple interfaces, others were relatively complex and provided a number of pathways. However, complexity need not detract from effectiveness when the challenge within the Learning Object encourages students to stretch themselves and learn from feedback. Learning Objects providing a number of levels of information that students could access when needed worked well. Most students used Learning Objects intuitively, in an exploratory fashion, in the same way that they use computer games. Unfortunately, the design of some Learning Objects did not easily accommodate this approach, imposing more rigid pathways and relying on detailed instructions at the beginning.

As in Gunn, Woodgate, and O'Grady's (2005) study, it was important that students' interactions resulted in immediate, meaningful and context-relevant on-screen responses. Year 10 students were not satisfied with simple text responses affirming their choices of chemical reagents whereas Year 1 students missed the point of the Learning Object when the inappropriate selection of clothes for a yacht-racing lizard did not cause him subsequent physical harm. But all students from Year 3 to Year 11 were highly engaged and on task when their choices of diet and physiological processes brought relevant consequences for the cartoon character whose purpose was to demonstrate the processes of digestion.

Students appreciated being able to regulate the pace of their learning. They were able to take time to investigate concepts they found difficult in class or to repeat activities as they chose. The ability to engage with a self-contained, self-paced task was valuable for certain students who did not accommodate easily to the fixed-period lessons common in most schools. Students also enjoyed selecting their own multiplication problems or setting the variables in science experiments.

In general, while students were not particularly concerned about being given control over the screen layout, they were most motivated when provided with:

- Choices of levels at which they could operate, so they could start with simpler examples and work towards those with more variables, or more variation within the available variables.
- Choices of assistance levels. On-screen hints were a distraction for students working comfortably with the materials, however they were sometimes essential for students working alone. Nonetheless, almost all students in the study, regardless of ability, preferred to work collaboratively with a friend.

- Immediate feedback in the form of visibly changed conditions on the screen.
- Multiple sources of feedback. However, it was observed that students given graphic and numerical data to work with often overlooked the numerical information.

Comfort and familiarity with multimedia elements and conventions influenced how well Learning Objects were used. Not all students understood how to follow text links to "Help" and were more likely to follow graphical cues. Students, especially the literacy-challenged, liked the use of sound to alert, add effect and provide assistance. They responded with varied success to visual complexity so that some helpful features of Learning Objects were overlooked by students until they were pointed out by the teacher.

Pedagogy: Students and Teachers

The third interaction between the three components of the classroom environment from Figure 1 is where teachers and students interact through the pedagogy operating within the classroom.

The taxonomy of Brickell, Kanuth, Freeman, Latshaw, and Larson (2006) distinguishing various levels of interaction between students and the Learning Object resource from fundamental (e.g., images) through combined closed (e.g., videos), generative (e.g., quizzes) to generative instructional (e.g., objects providing feedback) requires more expansion at the upper end if the potential of Learning Objects is to be achieved. Ilomäki et al. (2006) provide an insight into some of the higher level tasks that can be promoted through the use of learning objects including: activating prior knowledge, providing multiple representations of concepts, supporting conceptual change, enabling the visualisation of abstract concepts, simplification of complexity, provision of models and guidance in their use, and support for collaboration.

Various other documents have discussed the impact of pedagogical philosophy on Learning Object design (Atkins, 2003; McRae, 2001; Muirhead & Haughey, 2003), and other authors have discussed the role of pedagogical philosophy in ICT-based learning (Kennedy & McNaught, 1997; Phillips, 1997; Reeves & Hedberg, 2002).

Participating teachers diverged widely in how they finally embedded the Learning Objects into lessons. Some teachers spent time leading into the Learning Object and set clear tasks to be achieved. Others selected Learning Objects thematically related to recent class work but little preparation or integration was evident. Approaches included:

- Using a single Learning Object as the focus of a lesson or lesson series;
- Using a number of Learning Objects as resources for a lesson or lesson series; and
- Using a Learning Object as one of a number of activities within a lesson.

Learning was most effective in environments where teachers provided additional guidance and scaffolding, and where students were able to apply it within Learning Objects. Where the Learning Objects were an integral part of a wider project or series of lessons there was evidence of intended or actual follow-up. In classrooms where little preparation or integration within the wider programme was evident, it appeared that follow-up was unlikely.

The study found four important ways in which Learning Object design influenced its pedagogical value. They parallel the decisions teachers must take when planning a learning experience: the accuracy and depth of the syllabus content, how to fore-ground the learning purpose, the means by which students can proceed through the learning experience, and the choice of an authentic learning context to couch their learning experience.

The content accuracy and integrity of Learning Objects are important, particularly where teachers use the Learning Object as pivotal teaching resources (Kay & Knaack, 2007). Potential concerns for learning are where the Learning Object provides:

- unclear and insufficient information. This is sometimes unavoidable when teachers use the same Learning Object for different purposes. For example, a secondary teacher of a gifted and talented class based a lesson on the normal distribution of results provided by a random number generator within a simulation's algorithm. A primary teacher reviewing the same Learning Object felt the uncertainty created by the random number generator would distract her class.
- an inaccurate representation of important disciplinary concepts. This may occur when visual impact is added by multimedia developers, especially when using cartoon animation, after content accuracy has been checked by content experts. Critical input from content experts, familiar with both the canon of the discipline and the common alternative conceptions that students may possess about it, throughout the entire lifecycle of resource development would avoid this vital deficiency.
- no immediate feedback to confirm or reject student choices resulting in misconceptions being propagated. The study noted examples of scientific misconceptions being fostered, simply because, in the absence of feedback or additional contradictory information, the students imposed an inappropriate mental model that built on prior misconceptions.

Students rely on the learning purpose being transparent and central to the activity that they are undertaking with the Learning Object. This transparency can be enhanced by the use of contextualised information, hints and timely feedback which were all observed to be valuable in directing and affirming student input and understanding. Teachers have a role in monitoring whether students are aware of elements within Learning Objects that provide this.

As with any educational activity, it is essential that motivation is not treated as a goal in its own right, but that success is linked to learning rather than the completion of the activity. Where the challenge of a Learning Object is inextricably linked to the teaching purpose, including the consequences (feedback) navigation, scoring and all other parts of the action, students learn *through* "playing the game." However, where the gaming components are not aligned with the learning aims, then students will circumvent the learning activities in order to finish the game quickly. Again, the lesson content and teacher expectations frame how Learning Objects are used.

Integrity can also be compromised where there is a mismatch between the literacy and other conceptual demands in the Learning Objects. For example, where the literacy demands of the instructions exceed the capacity of the students, then students may guess and succeed without engaging with the learning purpose. To be effective, it is important that Learning Objects are designed so that students can only succeed by demonstrating and applying the intended learning. It is not always easy for teachers to detect this when selecting Learning Objects but by observing how students use them, appropriate questions and help can be provided.

While the learning purpose should be determined by the teacher and supported by the Learning Object, it does not mean that the user should be bound to traverse the Learning Object in a predetermined manner. Some Learning Objects maintained a clever balance between text and graphical information. While they did not appear to impose structure on students, they provided a highly structured learning environment where their success relied upon the way in which students were immediately engaged in making choices, and gained necessary context-specific information through feedback on their input throughout the activity. Where feedback arrived at the point of need, and in segments small enough for students to assimilate them, the students incorporated them into the next stage of their interaction. This design mimics Boud and Feletti's (1997) Problem-Based Learning approach where students are provided with an initial scenario and need to make decisions. The complexity of the situation builds as they attain more information depending on the decisions that are made at each stage. As opposed to linear activities where students resisted more than one exposure, students voluntarily kept exploring these nonlinear activities in order to master them fully. This would appear to be a sound approach to encourage authentic learning.

INTEGRATION: LEARNING @ THE CORE

The educational environment model in Figure 1 suggests that effective learning arises where the three factors: Students, Teachers and Resources intersect. McCormick and Li (2006, p. 227) regretted how Learning Object design often "assumes that the pedagogy resides within the Learning Object rather than in the interaction of the way teachers fit it into their own pedagogy" effectively decontextualising the Learning Object from its use.

Recognition of the importance of the educational context implies that learning takes place when both students and teachers are at ease with the Learning Objects, there is a shared understanding of the learning purpose and the way the Learning Object is to be used and that the Learning Object fulfils the teacher's need to address the curriculum and the students' need to construct meaning and receive appropriate support and feedback during that process. As long ago as 1995, Peters (cited in Schaffer & Douglas, 2004, p.15) recognised that "objects … will be more like *experiences* than they will be like *things*, much more like *programs* than *documents*, and readers will have unique experiences with these objects."

Students believed that their learning benefited from the introduction of Learning Objects. Learning Object design can accommodate the key elements which satisfy students' needs: challenge, student control, freedom to explore, capacity for collaboration and timely instructions, and feedback on input. The more these elements are satisfied the better is the learning. Learning Objects, therefore, need to exploit their ability to provide students with novel content and learning situations that draw from situated learning opportunities beyond the classroom.

In this study teachers believed their teaching had benefited from using the Learning Objects. Some teachers found that Learning Objects presented new ways for them to view the curriculum or led them to appreciate a wider variety of learning perspectives or prompted them to reconsider their assumptions about teaching and learning. At the same time, a teacher's life is crowded and the value of Learning Objects and their ability to fit into pre-existing programmes and teaching styles must be immediately clear as resources are most valuable when they can be readily matched to curriculum and integrated into learning programmes. As more Learning Objects are produced, this match will be easier. Learning Objects which are rich enough to have multiple uses are particularly valuable.

FUTURE TRENDS FOR SUCCESSFUL LEARNING OBJECTS

There is a need to develop a variety of Learning Objects and assist teachers to choose the Learning Objects that would best suit their needs. The current offerings are a useful start, but a larger corpus of materials, easily accessible, will make them more appealing to both teachers and students.

A synthesis of the results of this study has led to the development of a set of characteristics of a successful Learning Object. These are summarised in Table 1.

Table 1. Characteristics of successful learning objects

Generic	Exploration by students is encouraged.
	Learning Objects are rich enough to allow use on multiple occasions.
	Students are motivated to undertake multiple attempts.
	Gaming techniques, such as rewards and consequences which are relevant to the learning purpose, are used.
	Where appropriate, levels of difficulty are incorporated to provide activities suitable to students of varying academic and literacy levels.
	Instructions are provided when they are needed rather than only in advance.
	A statement of the learning purpose is accessible throughout the Learning Object.
	Learning activities challenge students and are suitably complex while maintaining a simple user interface and reducing literacy demands.
	Timely feedback is provided to students, preferably in multimedia format.
	Students can modify earlier results on the basis of additional experience, or can demonstrate understanding at any time.
	Mechanisms to scaffold student learning are incorporated.
	Students are able to transfer their work to printers or other applications such as *Word* and *Excel*.
Text and graphics	Text-intensive instructions are avoided, especially on initial screens of a Learning Object.
	Graphics, animation and voice support are used in preference to, or in conjunction with, text.
	The amount of text on each screen is limited to six lines or less.
	The need for students to enter their own information is carefully considered and only used where it adds to the learning purpose.
Sound	Sound is available wherever possible, both for information and effect, and to minimise literacy demands.
	Sound can be toggled on and off.
Animation and video	Video clips are distinct and easily interpreted by students.
	Animation is used in preference to video when focus on important features is enhanced by it.

CONCLUSION

Learning Objects remain one resource amongst many that are available to teachers, and may not always be the most appropriate for the task. This study reconfirms previous findings suggesting that teachers' beliefs about teaching and learning influence their choice and use of resources. In practice, the study found that while teachers were eager to exploit new the opportunities offered by Learning Objects, some teachers replicated simple, meaningful real-world activities with Learning Object simulations. Yet both students and teachers repeatedly expressed a preference to perform activities using real materials rather than through computer simulations. This apparent anomaly needs investigation if Learning Objects are to expand, rather than contract, students' experiences in the world around them.

Pivotal to the successful implementation of Learning Objects in primary and secondary classrooms are the teachers':

- ability to access and select appropriate resources using the infrastructure available within the school
- confidence in selecting appropriate Learning Objects to satisfy curriculum outcomes.
- competence to incorporate Learning Objects into meaningful teaching programmes where they can promote student learning in the most effective way
- capacity to adapt Learning Objects to satisfy the individual needs of their diverse classes
- monitoring and evaluation of learning while students are using Learning Objects.

The refinement of design standards for Learning Objects will never make a significant impact on any of these factors. In each instance, the provision of suitable, ongoing professional support within the context of the systemic-school environment will be required. The design of Learning Objects is ultimately not simply a technical issue, but raises many issues related directly to the learning process and environment.

REFERENCES

Andrich, D. (1988). A general form of Rasch's extended logistic model for partial credit scoring. *Applied Measurement in Education, 1*, 363-378.

Andrich, D., Sheridan, B., & Luo, G. (2002). *RUMM 2020: A Windows interactive program for analysing data with Rasch unidimensional models for measurement.* Perth, Australia: Murdoch University.

Atkins, S. (2003). *Achieving educational soundness in the digital age*. Melbourne, Australia: The Le@rning Federation.

Bain, J. D., & McNaught, C. (2006). How academics use technology in teaching and learning: Understanding the relationship between beliefs and practice. *Journal of Computer Assisted Learning, 22*, 99-113.

Baker, S., Gersten, R., & Lee, D. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal, 103*, 51-75.

Baruque, L., & Melo, R. (2004). Learning theory and instructional design using learning objects. *Journal of Educational Multimedia and Hypermedia*, *13*, 343-370.

Boud, D., & Feletti, G. (1997). *The challenge of problem based learning.* London: Kogan Page.

Bouzeghoub, A., Defude, B., Duitama, J., & LeCocq, C. (2006). A knowledge-based approach to describe and adapt learning objects. *International Journal on E-Learning, 5*, 95-102.

Brickell, J., Kanuth, M., Freeman, V., Latshaw, S., & Larson, C. (2006). Learning objects: Resources for instruction. *Clinical Laboratory Science, 19,* 184-187.

Cummings, R., & Aquilina, H. (2004). *Evaluation study of the quality teacher program: 2001–2003 summary report*. Perth, Australia: Department of Education and Training.

Department of Education, Science and Training. (2001). *Raising the standards: A proposal for the development of an ICT competency framework for teachers.* Retrieved March 25, 2008, from www.dest.gov.au/schools/publications.

Duval, E., Hodgins, W., Rehak, D., & Robson, R. (2004). Learning symposium special issue: Guest editorial. *Journal of Educational Multimedia and Hypermedia*, *13*, 331-342.

Fresen, J. (2007). A taxonomy of factors to promote quality Web-supported learning. *International Journal on E-Learning, 6*, 351-362.

Funnell, S. (1997). Program logic: An adaptable tool for designing and evaluating programs. *Evaluation News and Comment*, *6*, 5-17.

Gunn, C., Woodgate, S., & O'Grady (2005). Repurposing learning objects: A sustainable alternative? *Alt-J., 13,* 189-200.

Harris, K., Jensz, F., & Baldwin, G. (2005). *Who's teaching science?* Melbourne, Australia: University of Melbourne, Centre for the Study of Higher Education.

Ilomaki, L., Lakkala, M., & Paavola, S. (2006). Case studies of learning objects used in school settings. *Learning Media and Technology, 31,* 249-267.

Kay, R., & Knaack, L. (2007). Evaluating the learning in learning objects. *Open Learning, 22,* 5-28.

Kennedy, D.M., & McNaught, C. (1997) Design elements for interactive multimedia. *Australian Journal of Educational Technology, 13*(1), 1-22.

Lake, D., Faragher, R., Lenoy, M., Sellwood, J., Archer, L., & Anderson, N. (2006). What makes a good teacher? They have respect for our culture - report from SiMERR Queensland**.** *In T. Lyons (Ed.), Science, ICT and mathematics education in rural and regional Australia volume 3 case studies* (pp. 123-147). Armidale, NSW: University of New England.

Lake, D., Phillips, R., Lowe, K., Cummings, R., Schibeci, R., & Miller, E. (2004). *Report of field review stage 1: The Le@rning federation pilot field review.* Melbourne, Australia: The Learning Federation. Retrieved March 25, 2008, from http://www.thelearningfederation.edu.au/repo/cms2/tlf/published/8620/tlfwa_report_final.pdf

The Le@rning Federation. (2002). Educational soundness specification. Retrieved March 25, 2008, from http://www.thelearningfederation.edu.au

The Le@rning Federation. (2006). TLF specifications. Retrieved March 25, 2008, from http://www.thelearningfederation.edu.au

Li, J., Nesbit, J., & Richards, G. (2006). Evaluating learning objects across boundaries: The semantics of localization. *Journal of Distance Education Technologies, 4,* 17-30.

Lyons, T., Cooksey, R., Panizzon, D., Parnell, A., & Pegg, J. (2006). *Science, ICT and mathematics education in rural and regional Australia: The SiMERR national survey.* Armidale, NSW: University of New England, National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia.

MacLaren, I. (2004). New trends in Web-based learning: Objects, repositories and learner engagement. *European Journal of Engineering Education*, *29,* 65-71.

McComas, W. F. (Ed.). (2000). *The nature of science in science education: Rationales and strategies*. Boston, MA: Kluwer Academic Publishers.

McCormick, R., & Li, N. (2006). An evaluation of European learning objects in use. *Learning, Media and Technology*, *31*, 213-231.

McNaught, C., Phillips, R., Rossiter, D., & Winn, J. (2000). *Developing a framework for a useable and useful inventory of computer-facilitated learning and support materials in Australian universities.* Canberra, Australia: Department of Educaton, Training and Youth Affairs.

McRae, D. (2001). *What to make and why: Principles for the design and development of online curriculum content.* Prepared for the Curriculum Corporation, Armidale, NSW: University of New England.

Mueller, S. (2004). Gender gaps in potential for entrepreneurship across countries and cultures. *Journal of Developmental Entrepreneurship, 9,* 199-221.

Muirhead, B., & Haughey, M. (2003). *An assessment of the learning objects, models and frameworks developed by The Le@rning federation schools online curriculum content initiative*. Melbourne, Victoria: The Le@rning Federation.

Nurmi, S., & Jaakkola, T. (2006). Effectiveness of learning objects in various instructional settings. *Learning Media and Technology, 31,* 233-247.

Ovens, A., & Smith, W. (2006). Skill: Making sense of a complex concept. *Journal of Physical Education New Zealand, 39*, 72-84.

Pegler, C. (2005). Objects and issues- a Sunday supplement view of continuing professional development in higher education. *Open Learning, 20*, 51-64.

Phillips, R. A. (1997). *The developer's handbook to interactive multimedia – a practical guide for educational applications*. London: Kogan Page.

Phillips, R. A. (2002). *Learning-centred evaluation of computer-facilitated learning projects in higher education: Outcomes of a CUTSD staff development grant* (Staff development in evaluation of technology-based teaching development projects: An action inquiry approach). Canberra, Australia: Committee for University Teaching and Staff Development, Commonwealth of Australia.

Põldoja, H., Leinonen, T., Väljataga, T., Ellonen, A., & Priha, M. (2006). Progressive inquiry learning object templates. *International Journal on E-Learning, 5,* 103-111.

Reeves, T. C., & Hedberg, J. G. (2002). *Interactive learning systems evaluation*. Englewood Cliffs, NJ: Educational Technology Press.

Schaffer, S., & Douglas, I. (2004). Integrating knowledge, performance and learning objects. *Quarterly Review of Distance Education, 5,* 11-19.

Schibeci, R., Lake D., Phillips, R., Lowe, K., Cummings, R., & Miller, E. (2008). Evaluating the use of learning objects in Australian and New Zealand schools. *Computers & Education. 50*(1), 271-283.

Taylor, P. G., & Richardson, A. (2001). *Validating scholarship in university teaching: Constructing a national scheme for external peer review of ICT-based teaching and learning resources.* Retrieved March 25, 2008, from http://www.dest.gov.au/archive/highered/eippubs/eip01_3/01_3.pdf

Wiley, D., Waters, S., Dawson, D., Lambert, B., Barclay, M., & Wade, D. (2004). Overcoming the limitations of learning objects. *Journal of Educational Multimedia and Hypermedia, 13,* 507-521.

Willis, S., & Kissane, B. (1995). *Outcome-based education: A review of the literature***.** Perth, Australia: Education Department of Western Australia.

KEY TERMS

Access (Student and Resource): Access in the sense used in this chapter is not simply how the student brings up the relevant Learning Object onto his or her screen. A Learning Object is accessible when students can easily locate the Object, are engaged by what they observe, can work through the learning opportunities it presents, and, through its use, achieve some desirable learning objective. This process has components, including the hardware, software, connectivity, and regulations within the educational system that provide the student with the physical access to the learning potential of the object. However, accessibility must also recognise the developmental nature of education, for example in the literacy or manipulative loads that are required of students if they are to learn from the Object. Finally, there is an important social equity component of access where the Learning Object must be usable by all targeted students in ways that recognise, for example, individual student's culture, gender and special needs.

Pedagogy (Teacher and Student): Pedagogy has been used in this chapter to include all aspects of the ways in which teachers create learning environments in the classroom through an appropriate alignment of instructional strategies and styles of the teacher and the Learning Object. As such pedagogical concerns include all the choices that affect how the students can manipulate the learning materials to construct and reconstruct their conceptions in the classroom. In this manner it will include the social aspects of the learning purpose as conceived by the teacher and the students, and the way in which the resource either facilitates or hinders that purpose. While the social construction of learning is at the heart of the pedagogy, it cannot be seen in isolation. Also important is the manner in which the learning context is developed and directed. The context is the environment in which learning occurs and a learning environment is created around the resource by the programming of the teacher and the reactions of the students. The pedagogy will also include a component where the physical and cognitive skills of the students are recognised by the way that the teacher and the resource draw on them to facilitate the learning outcome.

Selection (Teacher and Resource): Selection in the sense used in this chapter is more than a teacher picking a lesson activity. It is a complex sequence of choices where the teacher must locate a source of Learning Objects, evaluate the range of available Objects for the intended purpose, and then decide on the viability of integrating that Object into a multifaceted teaching programme. Each step of this selection process implies evaluative judgement. In involves an evaluation of the physical availability of necessary software and hardware, as well as passwords and permission to download onto the system infrastructure. Selection involves reflective judgements by the teachers of their own intellectual skills in areas like Internet searching and understanding the presentation of metadata. It also involves an emotional response from the teacher that may be dependent on subject or computer literacy, available time, a sense of empowerment—or disempowerment, and a host of personal factors.

Chapter XXV
A European Evaluation of the Promises of LOs

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ABSTRACT

Most studies on reusable digital learning materials, Learning Objects (LOs), relate to their use in universities. Few empirical studies exist to explore the impact of LOs on pedagogy, especially in schools. This chapter provides evidence from an evaluation of the use of LOs in schools. The evidence is from an EU-funded project Context E-Learning with Broadband Technologies, involving 500 schools in six countries across Europe, to examine the impact of LOs on pedagogy. It brought together producers and users to try out technically and pedagogically sound ways of producing, making available through a portal, and using LOs. This chapter reports data from both quantitative and qualitative studies conducted during 2004, including: online surveys (of all the teachers involved), routine data from the portal, semi-structured interviews in 40 schools in all six countries, experimental studies in one of these countries, and 13 classroom case studies in four of the countries.

INTRODUCTION

This chapter will examine the major promises that learning objects (LOs) offer to teachers through the experience of a major European project, *Context E-Learning with Broadband Technologies* (CELEBRATE). LOs have been seen to offer a way of exploiting the new educational technologies, including those based on the Web and on virtual learning environments (VLE). One difference that it is claimed LOs bring to the new educational technologies is their potential for re-use in a variety of circumstances and thus that they have flexibility and interoperability. This marks them out from more purpose-built resources. Despite this apparently special nature, the most accepted definition of a LO is rather general: any entity, digital or nondigital that can be used or re-used or referenced during technology supported learning.[a] In this chapter we will examine the major features that have been attributed to LOs and, through the data from the evaluation of the CELEBRATE project, see to what extent some of the promises they offer can be fulfilled.

CELEBRATE was an Information Societies Technology Programme project funded by the European Commission over 30 months: June 2002 until November 2004.[b] It involved 23 participants from 11 countries, including commercial producers of learning materials, multimedia specialists, ministries of education, software and network companies, university academics and schools, and associated local authorities. Its objectives were to create and use a critical mass of material for a new generation of learning environments, and this material was distributed and used in schools in six countries: England, Finland, France, Hungary, Israel, and Norway. The LOs were made available via a Demonstration Portal to selected schools across Europe that were involved in existing broadband pilots in order to further stimulate the development of LOs by teachers themselves. CELEBRATE took the idea of an "exchange" and applied it to the school sector through a brokerage system. The CELEBRATE Brokerage System, which was a way of connecting initially four repositories of LOs and allowing users to search for and retrieve a LO on that system, provided a working model for how both schools and commercial publishers could develop and make available media-rich LOs both separately and in partnership. Precisely because all the elements of production, distribution, and use of LOs were involved, this was considered a feasibility study, and all that could be achieved by way of use of LOs by teachers was in the form of a pilot lasting a relatively short period of time (a maximum of four months). The data that forms the basis of this chapter were derived from an evaluation carried out by three of the universities involved (see Chapter XXVII for an account of the evaluation methodology).

The literature on LOs is largely based on technical aspects or on speculations about the benefits to producers and users of LOs, and much of this within the higher education sector. There are few empirical studies (e.g., Littlejohn, Jung & Broumley, 2003), and so this evaluation provided unique empirical evidence against which to judge the promises that pre-occupy the literature on LOs, extending it to include user experience (teachers). The evaluation revealed a positive view of LOs by school teachers, but a number of problems related to some of the major promises of LOs. The promises examined in this chapter relate to each of the phases of production, distribution and use (re-use) of LOs, and through this address the issues of:

- Interoperability, that is, that they can be used in different technical environments (Campbell, 2003; Koper, 2003);
- Reusability, that is, that though they might have been designed by one person with a particular learning context in mind, they can be used by another in a different context and in different combinations of LOs without making any changes to content (use "as is") (Lambe, 2002);

- Modification, that is, that they can be modified in some way to make them appropriate to the "new" situation of use;
- Adaptability, that is, that the re-use, and any modification, will enable the LO to be adapted to the particular learners in question.

In addition there are some specific issues relating to providing LOs at an international level, where the language, culture, and educational systems vary considerably; a particular consequence of the CELEBRATE project.

THE PROMISES

These promises flow from the desire to make LOs interoperable, reusable, modifiable, and adaptable. Any consideration of these features of LOs cannot be applied to just an individual LO, they must be seen within a system of producing, distributing, and use of LOs (assuming that use might involve modification, and always adaptability). For example, a LO can only be reusable if it is distributed to others and, however informal this may be, there needs to be some "system" to do this. We will therefore examine the promises of LOs under each of the headings that include the aspects of a system and the LOs.[c]

Production of LOs

There is a concern that LOs have been based on the instructional paradigm prevalent in training (e.g., Rahak & Mason, 2003; Wiley et al., 2003), which reflects the individualised instruction of the 1970s and uses an information processing view of learning (examples of this view are Dodds & Fletcher, 2003; Merrill, 2001). Those who criticise electronic material based on such "outdated" views of learning, look to the development of LOs that are based on contemporary constructivist views. However, just what is meant by these views is less clear. Orrill (2001), for example, takes the discussion of constructivism into the area of situated cognition, whereas others see it as moving on from behaviouristic and information processing theories to what is usually referred to as "cognitive constructivism" (Baruque & Melo, 2003). [d] In all this debate there is an underlying view on the part of some that we could move on from "drill and practice" type material to LOs that incorporate or facilitate constructivist learning through appropriate pedagogy. This desire to base the construction of LOs on contemporary views of learning is one of the first elements of their production. However, the literature on LOs has less to say on how this should come about. The CELEBRATE project enabled us to examine some of the problems for those involved in the production, including commercial and education ministry organisations, as well as academics advising them on learning issues.

At a more basic level of the production of LOs, the desire for reusability assumes that in some ways there is an "LO economy," where either teachers share their own LOs and/or providers (commercial or ministry funded) create repositories that allow access to all, or to authorised, users. There are those who give accounts of production of LOs quite devoid of such considerations, for example, Bradley and Boyle (2003), thus undermining the basis of one of the use of LOs. Such repositories imply an economy based on mutual gain (in the case of a teacher system) or on the usual commercial basis; but these are quite different kinds of economy, and the literature has again little to say to guide us. Many commercial organisations are likely to want to create a repository of LOs and, through some "pay as you go" or subscription scheme, allow users (teachers and their students) access to them. Ministries of education (or other public bodies) are likely to want open access, but they have to work out how to fund or stimulate the production of the LOs. In the case of the CELEBRATE project there was the hope to allow access not just to one repository, but to "connect up" several, including commercial ones.

Those establishing repositories need to know what is worth providing, so that they can match what they produce to the needs of users. This is complex as there needs to be an element of innovation and "market" leading, as well as responding. Those who build the systems that deliver the LOs tend not to build them around data collection such that they could respond to users' requirements, and as a consequence reliance is put on special one-off evaluations, such as the one we conducted.[e]

Distributing LOs

This is mainly an issue for producers who are giving access to LOs outside of a closed system (e.g., a VLE). They must allow users to gain access to a Web site to search for LOs and to either download them to a local machine or network, or to run them in the Web site or a VLE environment. As noted above, this implies reusability, which has two elements. First, the LOs need to be *technically* interoperable, so that they can operate in whatever environment required (machine, specific software, system, or learning platform). This is particularly so when distributing large numbers of LOs, or at least making them available across whole education systems or even to international audiences. Such interoperability is provided through standards and metadata specifications (e.g., to define the structure, form, type; ISO, 2003). These are largely driven by those who create the systems to host and "deliver" LOs, and in some cases who would like the technology to construct the learning interactions, rather than allow human intervention. Although this interoperability is functional when the LOs are distributed, the definition of metadata, and the compliance with the required standards are actually part of the production.

Use of LOs

When we consider LOs being used, we are in fact considering "reuse," and hence their promise of being reusable. Following on from the above discussion, the second element of reusability is that the LO is *pedagogically interoperable* (or pedagogically reusable) and here the core issue is flexibility, in this context pedagogic flexibility. A teacher reusing an LO will want to make sure that it can fit in with her pedagogy and to combine it with other LOs or learning activities that are different from, either the original situation for which the LO was produced, or different from any use that has been envisaged or tried previously. Advocates of LOs therefore emphasise the need to make them decontextualised, but that conflicts with the desire to produce LOs that encapsulate constructivist views of learning. In addition many content producers may prefer to "bake in" the context (Koper, 2003). There is therefore a tension between the desire to keep the LO independent of context of use and the desire to encapsulate some element of pedagogy (constructivist or otherwise).

At one end of the spectrum, it is possible to move away from the idea of a LO and think of "assets," such as a picture or item information in text form. At the other end would be a whole course that combines many LOs in a structured way and with a particular pedagogy. Some envisage a number of small modularised LOs that can be easily combined (Hodgins, 2002). This is therefore a discussion of "size" (implying the amount of study time or range of content covered, rather than digital space occupied; in kilobytes), granularity, and the degree of integration of LOs, features for which there is no absolute specification.

Finally a consequence of having an "economy," and being able to distribute and reuse LOs, presumes that issues of intellectual property rights (IPR) have been agreed. A commercial economy presumes that payment by the user covers these rights, but for the mutual sharing economy, this is less clear. Contributing to a repository may permit use of other LOs or some form of Creative Commons copyright system may protect contributors.[f] As we will show, IPR issues are not straightforward.

Modifying LOs

Part of the answer to the ease of reuse is that the LOs can be modified. The theory is that the user, usually thought of as the "teacher," will adapt the LO to his or her circumstances. There are several features that have been used to enable this modification. In the context of a project like CELEBRATE, it is useful to replace the language (or chose a particular language), and this can be enabled by a more general provisions of modification through separating content and structure. This requires careful design of the LO and is possible when a particular engine or template is used in that design. The use of templates as LOs is a way in which the teacher can easily "modify" what amounts to a "contentless" LO (or at least one of range of content); for example, a template to present pictures with associated text and a zoom facility, or one for a crossword, where clues can be linked to a pattern of words.

Any modification of a LO implies that it is in a form to allow change. A template does this by definition and will have to have an associated construction process. For other types of LOs it is necessary that the original program code is available to users and that they have the programming skills to use it. If users are ordinary teachers, or indeed learners, access to the software necessary and the skills to use it are unlikely.

By and large all these elements of modification are driven by a pedagogical necessity, however, the *means* to enable it are by and large technical.

Adapting LOs

Adaptability is a similar idea to modifiability, though here the focus is on the learners and the degree to which they can select or be guided through LOs (or a collection of them) to suit their needs. Here the concern is pedagogical, with the focus on the learner rather than teacher. Traditional computer-assisted learning had as its aim the tailoring of electronic material to the responses of learners but, as McCormick (2003) argues, this was a forlorn hope and one that the more sophisticated educational technology has not solved. A more radical view of learning underlying adaptability would be to allow the learners to carry out the adaptability to suit their requirements. Whether this is in the "interests" of LO producers, with a concern to maximise the "added value" of their LOs, is not clear, again something little discussed in the educational technology literature.

Inter-Related Promises

Looking back over this discussion of the four "promises," which, in effect, can be seen as characteristics of LOs, it is evident that we have different types of issues and different levels of concern. Thus *reusability* is the prime characteristic, and this is enabled by *technical interoperability* and *pedagogical flexibility*. The latter is not just a function of the pedagogical design of the LO, but is also related to the way this interacts with the context of use, whether that be a classroom or purely electronic environment. The re-usability is also enhanced by the possibility of *modifiability*, which itself is a technical issue in terms of how it is achieved. It may be possible to argue the same about *adaptability*, however, the prime focus is on the pedagogical design of the LO (though this is implemented by technical means).

EVALUATION EVIDENCE

This section of the chapter will examine the CELEBRATE evaluation evidence in relation to the issues outlined above. This evaluation used large-scale surveys, interviews with producers and users (mainly teachers), experimental studies of the use of particular LOs, and classroom case studies in most of the countries of the project trial phase. This involved coordinating and standardising as much as was feasible the qualitative data collection, providing a rich source of data.[g] Around 400 teachers used the system over a sixth-month period, from late 2003. Here we will outline the findings, following the headings examined in the last section: production, distribution, modifiability and adaptability. Although reusability was a permeating characteristic in the section on "promises," the evidence has some quite specific things to say about it and so it is added as separate topic here.

Production

LOs were produced in large numbers (over 1400) covering a range of subjects, though those dealing with science were the most common (see Figure 1). The importance of having enough LOs in total, and in each subject, is essential to ensure a "critical mass," both to give teachers choice and to enable them to put together LOs in some sequence. Although English predominated, there were LOs in all the languages of the schools involved (Figure 2), apart from Hebrew, where it was rather belatedly that a producer could be found to create the LOs.[h] A total of 770 teachers registered in the system from more than six countries: Finland (42%), Hungary (14%), Israel (14%), Norway (13%), and France (12%). There were very few teachers from England; they made up only 4% of the total participants.[i] For those teachers where the number of LOs in their own language was small (e.g., French), this was a problem as our survey evidence indicates. Most teachers wanted LOs in their own language, but French teachers indicated the least satisfaction with the number in French and were least happy with using those in a foreign language (17% were happy using LOs in a foreign language compared with the average of 40% across all countries).

Evidence on the implementation of constructivist principles was less positive as the spread of

Figure 1. The proportions of learning objects produced, by subject

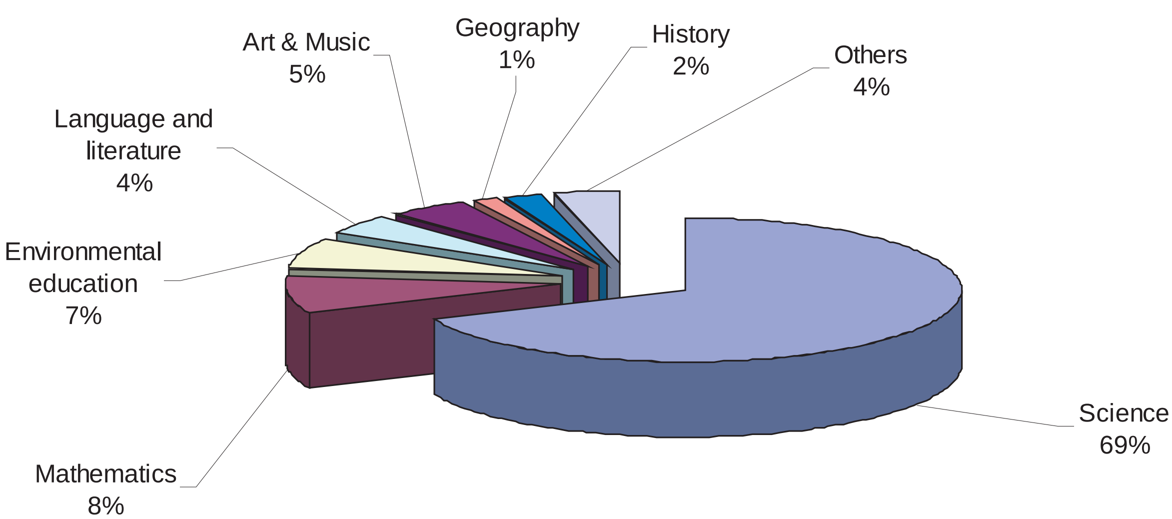
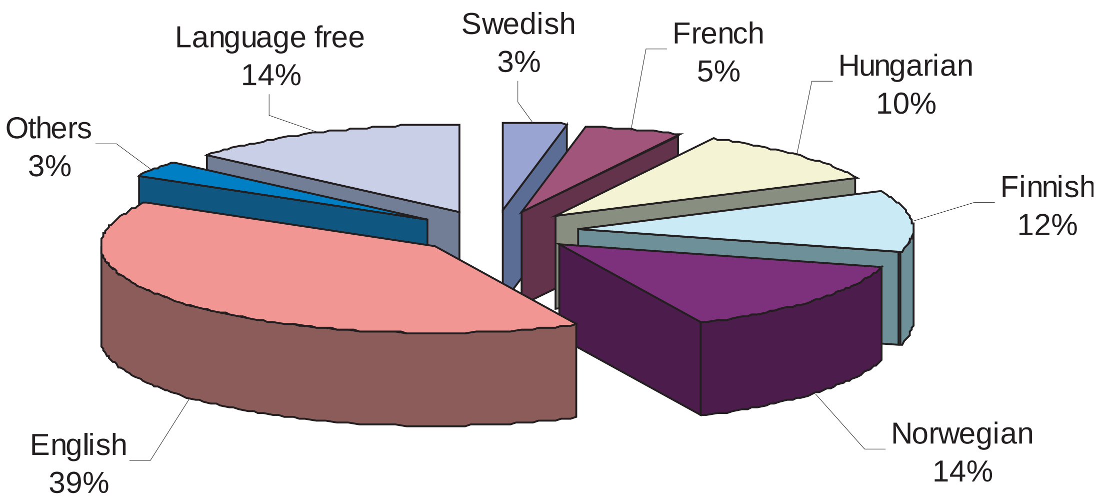
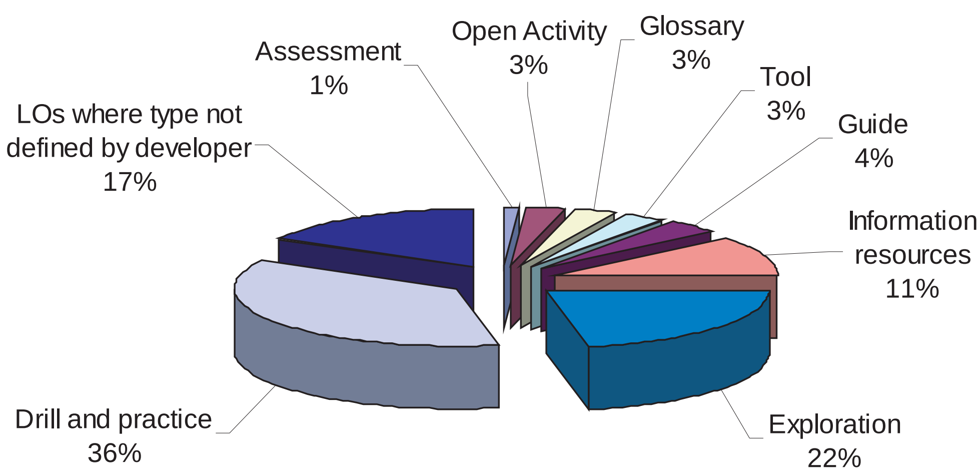


Figure 2. The proportions of learning objects produced, by language



LO types produced indicates (Figure 3), where despite the intentions the major type was "drill and practice" (where "type" had been entered into the metadata). There were two sets of problems in relation to these data. First, some producers did not classify "type" in the metadata (as Figure 3 indicates), and this reflected a general difficulty they had with the metadata entry process. Second, the metadata categories were not reliably used: some producers tried to maximise the attractive-

Figure 3. The proportion of learning objects, by type



ness of their LOs by specifying more than one "type," and sometimes in a conflicting manner (e.g., categorising it as both "drill and practice" and "exploration").

But there was a more fundamental problem, which reflected the ideas on pedagogy that producers had, and the difficulty for them to create LOs based on constructivist principles. The CELEBRATE team spent some time discussing issues of pedagogy and the academics produced a variety of models to help producers (e.g., problem-based learning).[j] But it was evident from interviews that these were too complex and laborious for them, and in any case might have required a large LO or collection of LOs to implement a model. Some attempt was made to give pedagogic *principles*, though it was evident that there is an education task for producers.[k]

The CELEBRATE project assumed that the LOs would be created by a variety of producers as part of their repositories of material, and that teachers across Europe would have access to them. It was technically possible to link up repositories (through the Brokerage system), and to define metadata standards for interoperability implemented this at the system level; but it proved more difficult than was thought (and the Brokerage system was not operational within the main project), as the technical issues across several repositories were not trivial.

Distribution

Although technical interoperability largely worked at the Brokerage system level, as noted above, interviews in schools revealed there were many local technical problems not related to the kind of issues in the specifications of metadata (which are geared to producers and repositories). The main causes of technical difficulties concerned the local ICT infrastructure. For example: the school network and general Internet connection speeds caused problems, rather than the LOs or Demonstration Portal themselves; teachers in Norwegian schools using the Linux operating system had difficulties in accessing LOs; particular plug-ins need to run LOs were not available locally (*Flash*, *Media Player*, etc.); some Finnish students had limited ICT access rights and could not download LOs to a hard disk. These issues indicate that technical interoperability is not simply overcome at the points of distribution in the Portal and Brokerage systems, but also has to exist at the points of use.

When searching teachers used "topic" as the main criterion and this resulted in either nothing being found (i.e., the producers did not use the topic label entered by the teacher) or too many for a teacher to handle. Teachers appeared to expect the system search engine to resemble *Google*! Consequently, they often resorted to browsing subject areas. Other elements of metadata (e.g., LO type) were unhelpful for searching. This undermines the detailed metadata specification for issues other than technical interoperability, and casts doubt on the wisdom of trying to capture, for example, pedagogic elements.[l]

The Portal,[m] which offered access to the LOs and provided other services, was used to store the LOs while the Brokerage system was being constructed. It operated using the "shopping basket" metaphor to retrieve the LOs teachers searched for and then selected. They could "store" them in the basket to allow later use by themselves or students. However, if they needed to select LOs for different student classes, they could not keep them separate and they requested a folder structure (which was later added) that they could draw upon in class or direct students to use. Thus the Portal, which had been designed initially as a LO search facility, was being used by teachers as a primitive Virtual Learning Environment, an unexpected outcome. (At this time few CELEBRATE teachers had experience of these and the experience across Europe was not positive (Vuorikari, 2003); the Portal offered an easy route in to the use of VLEs.)

Reusability

Any "use" of LOs by CELEBRATE teachers is effectively "reuse," and here we consider what we know about the use they made of them. It turns out not to be such an easy question to answer! We can tell from the system information if teachers select them in their "basket" (see Table 1 for the top 10 selections), but not if they used them with students. (When we specifically asked them to say if they used particular LOs they had selected, on average 30% were used.) In most countries the

Table 1. The 10 most popular LOs selected

No. of teachers selected	Title	Content provider	Language[a]	Subject	Type	Age range
44	Open Questions	Heureka[b]	Finnish	Mathematics Computer science, Science	N/A	12-
29	BurgerWriter	National Board of Education, Finland	Finnish English Swedish	Language	Drill and practice	9-13
28	A parabola	Sulinet	English Hungarian	Mathematics	Drill and practice	12-18
27	Kertolaskuharjoitus: taivas putoaa!	National Board of Education, Finland	Finnish English	Mathematics	Drill and practice	8-13
27	Bioenergy	Norwegian Board of Education	English	Biology Chemistry	Exploration	12-16
26	Desimaalilukujen pyöristys: maisema muuttuu	National Board of Education, Finland	English Finnish	Mathematics	Drill and practice	8-13
24	The orchestra	Indire	English	Music	N/A	6-11
24	Flying with prepositions	National Board of Education, Finland	English Finnish Swedish	Language	Drill and practice	9-15
21	Greenhouse effect	Norwegian Board of Education	English	Chemistry Natural Science Physical Science	Exploration	10-16
21	Kulman arviointia ja mittaamista	eWSOY/OPIT	Finnish	Biology	Drill and practice	9-12

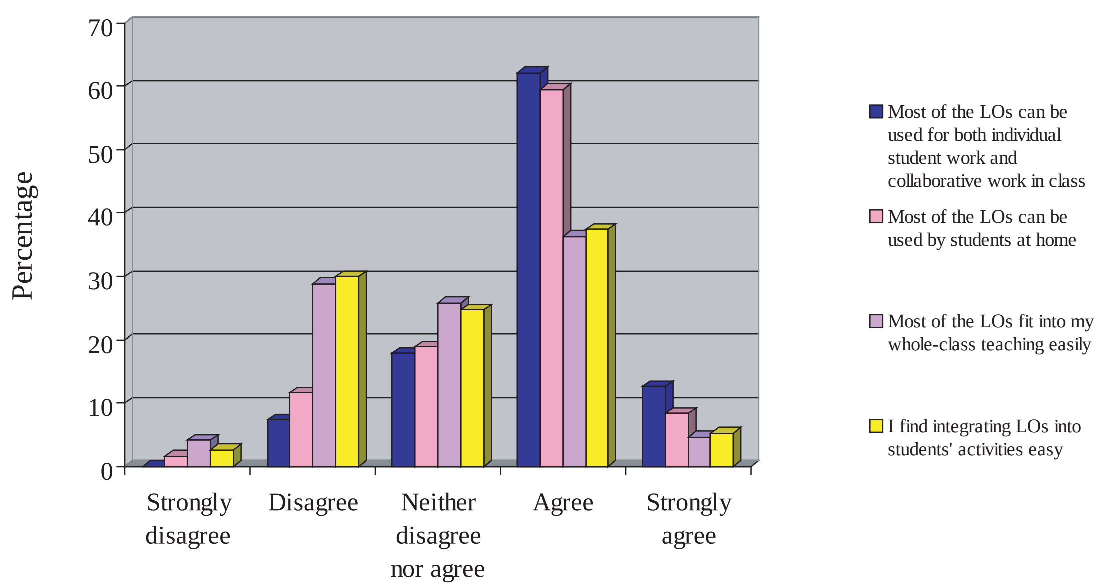
[a] *Note that where more than one language is indicated, the number of teachers who select them are combined.*
[b] *The Finnish Science centre.*

teachers selected 70-90% of all those available from a provider in their language, the exception being the French teachers (reflecting the poorer numbers and range available). The selections in Table 1 reflect in part the bias to Finnish teachers in the user population and show that, despite the concern for constructivist learning discussed earlier, teachers are happy to use “drill and practice” LOs as well as “exploration” ones. Obtaining a general figure for usage is not meaningful as the time period of the project and the number of users (around 400) were limited; thus some LOs were not used at all. Despite the difficulties of obtaining a figure of “use,” teachers views on the usefulness were positive, with over 70% saying they were useful for their teaching.

We have already noted that the language of the LO was an issue and, even where teachers can use a LO in say English (e.g., Finnish teachers), they are unlikely to use them with their students. Interestingly the match of the LOs to the local curriculum was much less of a problem than language. Teachers from those countries with a centralised curriculum (Hungary and France) were happier with the match, whereas those with a decentralised one (Finland and Norway) were less so. Cultural differences were not seen as a problem. Thus, as a European enterprise, there are some problems for such international repositories or networks of repositories in relation to both language and to a lesser extent the coverage of local curricula.

The nontechnical aspects of reusability, namely those related to pedagogy, are much more significant than the technical ones noted above and, as we discussed earlier, we consider these in terms of flexibility. The survey data revealed that most teachers felt LOs helped with their teaching, but the evidence on flexibility was less positive. Figure 4 shows that the LOs could be used in different kinds of activities (individual, whole-class teaching and homework), and indeed in case studies

Figure 4. Teachers' views on the use of LOs for different activities



of classrooms we observed teachers using the same LO in quite different ways. But there were difficulties in fitting them into their teaching and student activities, with sizable groups being unhappy (around 30%). Again, the cases studies indicated that teachers with general experience of ICT in their classrooms were able to fit LOs into their teaching (Ilomäki, Lakkala, & Paavola, 2006).[n] Interviews in schools supported this:

Integrating a learning object into a lesson is fairly simple for teachers who are used to using ICT. However, they tried to make sure, as far as possible, that these activities replaced book-based activities, rather than simply being an add-on extra. This required a great deal of time and effort at the beginning, especially as some LOs are more interesting and relevant than others. (France Interview Studies)

As Ilomäki et al. (2006) note, this supports Lim and Barnes (2002), who argue that the necessary attitude, skills, and knowledge are needed to: identify the cognitive opportunities and limitations of LOs, plan and organise activities to take up their affordances, and address their limitations.[o] In these cases, the teaching and learning activities related to each other in a flexible and meaningful way. Less experienced teachers had problems in organizing the process; their activities did not form a cohesive whole.

A simple example from the French case studies illustrates the issues. A teacher was using an information resource LO on the water cycle, where students could chose any point on the water cycle and see an explanation (often animated) of each stage of the cycle. In theory the students could vary the pace and sequence of their study of the LO. However, as this teacher was inexperienced, she gave students a sequence of written questions that they had to answer, which not only required working sequentially through the stages, but were so low level that the student had only to copy down the information in the LO explanations. Thus, what little affordances this LO had for some form of student control and in offering some thinking (e.g., relating different parts of the cycle), these were not taken up by the teacher. No doubt more use of this particular LO would enable her to start to exploit its affordances. Another example from one of the Finnish classroom studies (using a LO dealing with senses and the brain), gives a contrasting problem. The teacher had set students an open research task, which the students themselves defined, yet the supporting LOs were tightly focused around functions, construction and terminology of the eye, ear, brain, and so forth, and it proved difficult for the students to easily complete a more exploratory task. This focus was a reflection of the specific learning objectives of the LO compared to that of the teacher, but shows how limited LOs, will limit the teacher's pedagogy.

At a more prosaic level of flexibility, the use of LOs in teaching requires access to ICT facilities, and gaining such access requires time and effort, sometimes causing difficulties; none of these unfamiliar in research on ICT-based teaching and learning. For example, the Finnish report indicated a common problem:

one teacher mentioned having had problems in reserving the computer facilities due to the coinciding of another teacher's class. Another teacher saw it as a problem that when changing classrooms they needed to leave teaching material in their own classroom that was rather far from the computer facilities. A few teachers commented on the school facilities: that there should be more computers and there is a demand for a wide-screen television projector. (Finland Interview Studies)

An experimental study of simulation LOs illustrated how the effectiveness of the use of LOs was very much dependant upon their context of use (Nurmi & Jaakkola, 2006). When studying the use of a LO that provided simulations of electric circuits, they were able to show that in comparing three conditions (the simulation LO used on its own; the LO used along with actual wires and bulbs, and so forth; the wires and bulbs used on their own without the LO), the one involving the LO along with actual practical work with wires and bulbs was the most effective, particularly in enabling students to understand current flow models (notoriously difficult to teach). Central to the success of this condition was the affordances of the LO and understanding that the pedagogy as does not reside solely within the LO, but in the context of use. Teachers with ICT experience develop their skills at seeing how to combine the affordances of the LO along with suitable pedagogy to make best use of it.

Another important pedagogic point, developed from the case studies and interviews, was the way LOs could be combined, not in a tightly structured pedagogy but one in which they were used as a basis for a *resource-based learning* approach. An example of this was a teacher who had selected a number of LOs in the Portal "basket" and then asked students to work through them in any sequence that they felt suited them. But, before moving on to another LO, students had to check with her. This resource-based learning approach, with discrete resources (LOs) linked either by teachers guiding students as they work in the classroom, or by students themselves through the choices they make related to their perceived needs, gives another kind of slant on the use of LOs. This does not necessarily require them to be carefully sequenced and linked. Indeed, there was one classroom case study that revealed how some of the notions of LO use could be stood on their heads. A class of senior students were studying multiple intelligences as part of a psychology course and the teacher asked them to analyse a set of LOs to see which intelligence(s) each of them supported (Ilomäki et al., 2006). This imaginative use of LOs could not be easily predicted by anyone providing such LOs!

Finally in these considerations on pedagogy, the literature on LOs, drawing mainly from the training tradition and that of educational technology, seems to have a vision of learning objects being largely used in a virtual environment (McCormick, 2003). Thus an instructional designer can construct the integrated teaching sequence from individual LOs. It is this integrated whole that content providers might see themselves offering to teachers, although within the project, some had to breakdown complex LOs to their modular elements to produce a series of LOs. The CELEBRATE project did not use an integrated approach, based on teachers operating in an exclusively virtual environment, even though some of the lessons were spent exclusively working on the computer. By and large teachers embedded work in a virtual environment into ordinary classroom activities; what is usually referred to as *blended learning*. It seems that, although there will be an increase in virtual working, this blended approach is likely to dominate for some time, and the literature would do well to address this issue, particularly when dealing with the school sector (for an example see Chapter XXIII).

Modifiability

There clearly was a desire on the part of teachers to be able to modify LOs, as was evident in the school interviews:

More often the teachers have made such applications in which LOs designed for older students have been used with younger ones. One lower-level comprehensive teacher contemplated that there are many LOs that would be more applicable to lower-level comprehensive school if small changes were made. Upper level comprehensive teachers also felt that there is room for further improvement in the LOs, for they considered many of the LOs too easy and limited with regard to their content. (Finland Interview Studies)

Modification of LOs did not occur within the CELEBRATE project, except that some ministries translated English language LOs and had the provider modify them. For "users" to do this proved to be problematic. LOs were made available in a form for use, that is, so that teachers and students could "play" the LO. Making it available in a form where the programming code is accessible was not standard practice, and in any case the programming requirements and time to modify LOs were not possible for teachers. We already had evidence that time was an issue in the (re)use of LOs, and few teachers would be able to invest in this additional task. There was some evidence that templates were welcome, but few were available (e.g., crosswords and "picture showing" templates), and they required teachers to learn to use an authoring tool. Most teachers had not used the template (12% had not even heard of them!).

Even where these problems of modification could be overcome, it was evident from interviews that commercial producers wanted to protect their intellectual property rights, and were not in general keen on allowing access to take place (there are also often third-party rights that complicated the problem). Ministries were differently disposed, though the examples we found were of them creating teams of media developers and teachers working together using ideas from existing LOs, rather than modifying them.

Adaptability

Although we have already given some examples of learners with some control over their learning, in general this was modest. They seldom chose an LO, but some LOs allowed students to define pace and gave them variations in the route through them. Where teachers set up a resource-based learning approach, with LOs as a set of resources, then pupils had some control over which LOs they used, though under the control of the teacher. There are growing movements of concern for learning to learn,[p] and it is evident that student autonomy is at the heart of this (Black et al., 2006). In the light of this, it beholds LO developers to consider how students might be involved in the process of using LOs. There was much interest in this idea among teachers and some developers, though this was usually in the context of students using templates. For example, teachers in the UK who were shown a crossword template, thought that it would be ideal for use by students, where they could construct a crossword on a topic they had been learning, to improve and demonstrate their understanding.

CONCLUSION

First it is worth reflecting on what is being evaluated. Our concern has not been with individual LOs, as whether one is effective or fulfils the promises of LOs in general is only part of the story. Rather it is more productive to see LOs as part of a system. In any case even individual LO evaluation would be better collected as "routine data" as part of any delivery system. Can the promise of LOs be fulfilled? The evidence from the CELEBRATE project shows a mixed picture. In terms of being able to produce LOs based on constructivist learning principles, there is much to learn, particularly in trying to educate commercial producers. Technical interoperability is certainly possible at the general system level, though there are likely always to be local problems. Where technical help is available locally, this is probably not a serious problem, but otherwise there may have to be a level of standardisation at the local level that would be difficult to produce at a country level, let alone internationally. "Pedagogic interoperability" is more complex. First it requires that affordances are built into the LO to enable a teacher to create a supporting pedagogy that will encourage constructivist learning (and this is of course a production issue). Second, it requires that the teachers are experienced enough to both recognise affordances (and their absence) and to be able to utilise them. This then leads into the reusability promise, which will be fulfilled if these two conditions exist. It is evident that teachers welcomed LOs, thought that they could be flexibly used and, with affordances and teacher experience, they could be fitted into teachers' pedagogy. It is evident that even the most apparently "nonconstructivist" LO (e.g., drill and practice) could be used as *part* of constructivist pedagogy, if the teacher has the skill of use and the repertoire of approaches in her teaching. Although the general point about building on affordances applies to both a virtual and a blended approach (such as used in this project), it is not evident that a "nonconstructivist" LO could be as easily accommodated in a purely virtual learning environment, and this may have implications for future research in VLEs.

A common model of LO combination is in a structured sequence, but it was evident that another fruitful approach was through resource-based learning, where the learner might be given more control. This could in turn feed into the development of learner autonomy, a growing concern in Europe. The CELEBRATE project had little to say about the promise of modifiability or indeed adaptability, as there was little room for this within the LOs provided, and the examples of their use we were able to observe. As just noted, adaptability was evident in some modest ways and resource-based learning seems to be the context to see this most powerfully.

REFERENCES

Anderson, J., & McCormick, R. (2006). Pedagogic quality - supporting the next UK generation of e-learning. In U-D. Ehlers & J. M. Pawlowski (Eds.), *Handbook on quality and standardisation in e-learning* (pp. 407-421). Berlin, Germany: Springer.

Baruque, L. B., & Melo, R. N. (2003, June). Learning theory and instructional design using learning object. In E. Duval, W. Hodgins, D. Rehak, & R. Robson (Eds.), *Learning objects 2003 symposium: Lessons learned, questions asked* (pp. 5-12). ED-MEDIA 2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Honolulu, Hawaii, USA. Retrieved March 25, 2008, from http://www.aace.org/conf/edmedia/LO2003Symposium.pdf

Black, P., McCormick, R., James, M., & Pedder, D. (2006). Learning how to learn and assessment for learning: A theoretical inquiry. *Research Papers in Education*, *21*(2), 119-132.

Bradley, C., & Boyle, T. (2003). The development and deployment of multimedia learning objects. In E. Duval, W. Hodgins, D. Rehak, & R. Robson (Eds.), *Learning objects 2003 symposium: Lessons learned, questions asked* (pp. 13-19). ED-MEDIA 2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Honolulu, Hawaii, USA, 24 June 2003. Retrieved March 25, 2008, from http://www.aace.org/conf/edmedia/LO2003Symposium.pdf

Campbell, L. (2003). Engaging with the learning object economy. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 35-45). London: Routledge.

Dodds, P., & Fletcher, J. D. (2003, June 24). Opportunities for new "Smart" learning environments enabled by next generation Web capabilities. In E. Duval, W. Hodgins, D. Rehak, & R. Robson (Eds.), *Learning objects 2003 symposium: Lessons learned, questions asked* (pp. 20-25). ED-MEDIA 2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Honolulu, Hawaii, USA. Retrieved March 25, 2008, from http://www.aace.org/conf/edmedia/LO2003Symposium.pdf

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Hodgins, H.W. (2002). The future of learning objects. In D. A. Wiley (Ed.), *The instructional use of learning objects*. Retrieved March 25, 2008, from http://reusability.org/read/chapters/hodgins.doc

Ilomäki, L., Lakkala, M., & Paavola, S. (2006). Learning objects in authentic pedagogical settings. *Learning, Media & Technology, 31*(3), 249-267.

ISO. (2003). *Business plan for JTC1/SC36* (Standards for information technology for learning, education, and training). Retrieved March 25, 2008, from http://jtc1sc36.org/doc/36N0651.pdf

Koper, R. (2003). Combining reusable learning resources and services with pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 46-59). London: Routledge.

Lambe, P. (2002). *The autism of knowledge management*. Retrieved March 25, 2008, from http://www.greenchameleon.com/gc/article_detail/the_autism_of_knowledge_management/

Lim, C. P., & Barnes, S. (2002). Those who can, teach - the pivotal role of the teacher in the information and communication technologies (ICT) learning environment. *Journal of Educational Media, 27*, 19-40.

Littlejohn, A., Jung, I., & Broumley, L. (2003). A comparison of issues in the reuse of resources in schools and colleges. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 212-220). London: Kogen Page.

McCormick, R. (2003, September). *Keeping the pedagogy out of learning objects*. Paper presented in the 10th Biennial Conference of European Association for Research in Learning and Instruction (EARLI), Padova, Italy.

McCormick, R., & Li, N. (2006). An evaluation of European learning objects in use. *Learning, Media & Technology*, *31*(3), 213-231.

McGreal, R. (2004). Learning objects: A practical definition. *International Journal of Instructional Technology and Distance Learning*, *1*(9), 21-31.

Merrill, M. D. (2001). Knowledge objects and mental models. In D. A. Wiley (Ed.), *The instructional use of learning objects*. Retrieved March 25, 2008, from http://www.reusability.org/read/

Nurmi, S., & Jaakkola, T. (2006). Effectiveness of learning objects in various instructional settings. *Learning, Media & Technology*, *31*(3), 233-247.

Orrill, C. H. (2001). Learning objects to support inquiry-based online learning. In D. A. Wiley (Ed.), *The instructional use of learning objects*. Retrieved March 25, 2008, from http://www.reusability.org/read/

Rehak, D. R., & Mason, R. (2003). Keeping the learning in learning objects. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 20-34). London: Kogan Page.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, *27*(2), 4-13.

Vuorikari, R. (2003). *Virtual learning environments for European schools: A survey and commentary*. Brussels: EUN Consortium. Retrieved March 25, 2008, from http://insight.eun.org/eun.org2/eun/en/Insight_Policy/content.cfm?ov=19414&lang=en

Wiley, D., Padron, S., Lambert, B., Dawson, D., Nelson, L., Barclay, M., et al. (2003, June). Using O2 to overcome learning objects limitations. In E. Duval, W. Hodgins, D. Rehak, & R. Robson (Eds.), *Learning objects 2003 symposium: Lessons learned*, *questions asked* (pp. 61-67). ED-MEDIA 2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Honolulu, Hawaii, USA. Retrieved March 25, 2008, from http://www.aace.org/conf/edmedia/LO2003Symposium.pdf

KEY TERMS

Adaptability: The condition for a learning object that will adapt to the learners needs.

Brokerage System: A system for connecting several repositories of learning objects such that they can be searched for and accessed by users through a portal.

Constructivist Learning Principles: Learning that sees learners constructing their own knowledge, and in so doing exercising their agency.

Granularity: The "size" of a learning object, seen in terms of student hours, extent of topic(s) covered, or degree of integration of material.

Interoperability: The condition for a learning object to operate in any technical environment.

Learning Object: Any entity, digital or non-digital, that can be used, re-used, or referenced during technology-supported learning.

Metadata: Data used to describe a learning object in ways that a computer or computer system can read and work with.

Modifiability: The condition for a learning object that a teacher can alter some of its features to suit his or her situation.

Repository: A store of learning objects that can be accessed by users.

Reusability: The condition for a learning object to be used by any teacher in any context.

Routine Data: Data that is collected automatically by a learning object distribution system.

ENDNOTES

[a] This is part of an IEEE standard: http://ltsc.ieee.org/wg12/ (accessed 13 August, 2007). See McGreal (2004) for a range of definitions.

[b] Details are given at http://celebrate.eun.org/eun.org2/eun/en/index_celebrate.cfm (accessed 13 August, 2007).

[c] See Nurmi and Jaakkola (2006) for an account of the problems and criticisms of some approaches to these features of LOs.

[d] This latter view sees learning as individuals constructing knowledge, in contrast "social constructivism" that is concerned with the social process associated with knowledge construction, a view that is nearer to a situated view, which sees such construction as associated with context. There is, however, a plethora of views, theories and schools, interestingly brought under two metaphors by Sfard (1998).

[e] This issue is examined in Chapter XXVII, where the methodology is discussed.

[f] http://creativecommons.org/ (accessed 13 August, 2007)

[g] The full evaluation report can be found at: http://celebrate.eun.org/eun.org2/eun/en/Celebrate_Deliverables/entry_page.cfm?id_area=494 (accessed 13 August, 2007). For published studies of some of the data, see McCormick and Li (2006), Ilomäki et al. (2006), and Nurmi and Jaakkola (2006).

[h] There were also interesting interface problems for presenting the Demonstration Portal in Hebrew.

[i] Of the number registered, 370 actually looked at or used LOs, and the proportions for each country were: Finland 54%, France 7%, Hungary 13%, Israel 3%, Norway 20%, and England 1% (there were 2% from other unspecified countries).

[j] A paper on pedagogical models (*Final Report on Pedagogical Models (D2.2)*) is available at: http://celebrate.eun.org/eun.org2/eun/en/Celebrate_Deliverables/en-

try_page.cfm?id_area=494 (accessed 13 August, 2007).

[k] This approach of defining pedagogic principles was adopted for digital material (not necessarily LOs) in the UK; see Anderson and McCormick (2006).

[l] It may be that those who wish to have the computer system assemble LOs for particular learning activities want this, but if humans find it difficult to think in these terms, it seems unlikely that machines will do it with much sophistication.

[m] http://demoportal.eun.org/celebrate_dp/index.cfm (accessed 13 August, 2007; password required)

[n] All the case studies (*Learning objects in classroom settings*) are available at http://celebrate.eun.org/eun.org2/eun/en/Celebrate_Deliverables/entry_page.cfm?id_area=494 (accessed 13 August, 2007).

[o] An affordance was originally coined by Gibson (1979) and refers to the opportunity that an environment offers to the learner, such that they can act in a way that takes advantage of what the environment offers. In this situation the LO represents the "environment."

[p] An edition of *The Curriculum Journal* (18, 2) is dedicated to considering learning to learn across Europe, in the context of the European Council Lisbon agreement requiring indicators of students' learning to learn "ability."

Chapter XXVI
Instructional Effectiveness of Learning Objects

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ABSTRACT

There has been a clear lack of rigorous empirical evidence on the effectiveness of learning objects (LOs) in education. This chapter reports the results of four experimental studies that investigated the effectiveness of drill-and-practice and simulation-type LOs in comparison to more traditional teaching methods. Results suggest that a simulation LO that works as a tool to support students' exploration process can be especially helpful to students' inquiry learning, but drill-and-practice LOs are less effective than traditional teaching methods in procedural learning. Findings also strongly suggest that we should not see LOs and traditional methods as rivals but as being complementary to one another. The authors hope that the results can inform teachers, instructional designers, and content producers as to what aspects they should consider when designing and implementing LOs in different educational contexts.

INTRODUCTION

High expectations have always been placed on new learning technologies, and the worldwide enthusiasm now directed at learning objects (LOs) presents no exception. Over the last few years, vast amounts of resources have been dedicated to the development, use, and standardization of LOs and LO repositories, in both the public and private sectors (e.g., McCormick & Li, 2006; Rehak, 2006). Several books (e.g., Littlejohn, 2003; Spector, Orchazda, van Schaak, & Wiley, 2005; Wiley, 2002a), special issues of journals, (e.g., *Educational Technology*, 2006; *Journal of Educational Multimedia and Hypermedia*, 2004; *Learning, Media and Technology*, 2006), and symposia (Duval, Hodgins, Rehak, & Robson, 2003; Visser & Amirault, 2002) have been devoted to LOs. Some authors, from educators (e.g., Gibbons, Nelson, & Richards, 2002; Urdan & Weggen, 2000) to corporate leaders (Hodgins, 2006) believe that the LO approach offers the potential to transform education and enables it to reach a new level. Wiley (2002b) goes even further, claiming that technological innovations such as the LO approach can result in a paradigm shift in the way people learn and the ways in which educational materials are designed, developed, and delivered to the learners.

Even though there is no consensus about the definition (McGreal, 2004), learning objects (LOs) are generally understood to be digital learning resources that can be shared and accessed through the Internet and reused in multiple teaching and learning contexts. The core idea behind the LO approach is to make educational materials broadly accessible, searchable, and reusable beyond their original contexts (Nurmi & Jaakkola, 2006). Although sharing and reusing of digital and non-digital instructional materials has been a goal of different educational practices for a long time (e.g., Collis & Strijker, 2002; Parrish, 2004), reuse has been difficult with traditional digital resources, since they have been designed with one target audience or context in mind. LOs, in contrast, are specifically designed for reuse, flexibility, and interoperability (McGee & Katz, 2005). This is the true beauty of LOs—they can be used by different people, for different purposes, and in different contexts (Bennett & McGee, 2005). In an ideal situation, little if any customization would be required to reuse LOs in a new environment (Richards, 2002). In these situations, a teacher could pick and choose from among the available LOs, simply aggregating them into the new entity. This requires that LOs have no tight contextual dependencies because contextual dependencies limit possible audiences. However, in most cases the original design context of an LO and its contexts for reuse do not correspond, and the LO must be contextualised. This contextualisation is vital, because without a context, an LO (like any learning resource) has very little educational value (Parrish, 2004). LOs can be contextualised by being embedded within various instructional activities (Nurmi & Jaakkola, 2006).

Besides their flexibility, LOs can offer other advantages over traditional teaching methods. For instance, due to their illustrative power, simulation type LOs are generally considered to be very effective tools for learning many complex phenomena. They can provide a safe and customizable learning environment in which students can perform experiments virtually by manipulating variables, observing the outcomes, and receiving feedback for their actions (de Jong, 2006). In contrast to a traditional laboratory working, a simulation can reveal processes or abstract laws that are invisible in natural systems and may provide support for perceptual understanding of concepts that might be otherwise too abstract and difficult to comprehend (Goldstone & Son, 2005). Furthermore, a simulation can reduce the cognitive demands of physical laboratory experiments by providing students with a "cleaned-up," idealized version of the complex and messy real world, while still retaining a necessary level of theoretical authenticity (Hennessy, Deaney, & Ruthven, 2006). The major criticism of the use of simulation LOs has been that when using simulations, students are asked to learn in fundamentally different way than that of scientists in an authentic environment (Steinberg, 2000). The other concern has been that a simulation may oversimplify complex systems.

The benefits that other types of LOs can provide for learning in comparison to traditional teaching methods are less obvious. For instance, a majority of the available LOs are very simple drill-and-practice applications (McCormick, Jaakkola, & Nurmi, 2008). The main aim of a drill-and-practice LO is to transmit the content from the LO to the learner, who passively receives and acquires the prescribed knowledge and reproduces it when required (Nurmi & Jaakkola, 2006). A good example of this kind of knowledge transmission is Microsoft Office online training (see http://office.microsoft.com/training), which provides short training courses on using Office programs. The structure of the courses consist of an initial overview section, followed by a presentation of content knowledge, a self-practice section, and finally a series of test-yourself questionnaires intended to measure the learner's level of understanding of the content and skills that the program teaches. Although this kind of LO format may be effective in training narrow skills according to a learner's specific learning needs, such LOs have limited potential to encourage deeper-level understanding and to develop student-centred knowledge construction processes. Ilomäki, Lakkala, and Paavola (2006) investigated the role of LOs in authentic classroom settings and found that LOs can provide new possibilities for innovative, student-centred pedagogies and for instructional solutions that encourage students' active inquiry and knowledge construction, but that for this to be effective, the LO must enable the teacher to create a supporting pedagogy. A drill-and-practice type of LO whose content and pedagogy were narrow focused promoted only the use of fact-oriented knowledge transmission and prevented teachers from applying more sophisticated, student-centred pedagogies. By contrast, an exploration-oriented LO promoted student-centred inquiry and supported various innovative pedagogies.

Even though the above findings emphasize the importance of students' playing an active role in learning, this does not necessarily mean that educational systems in which students play an active role will always result in "good" learning outcomes and systems in which students play a passive role will result in "poor" outcomes. Rather, it is the instructional context that defines the value of a learning resource. For instance, Swaak, de Jong, and van Joolingen (2004) investigated the effects of computer simulation environment in comparison to a hypertext environment on the acquisition of definitional and intuitive knowledge, and found out that the hypertext group performed better on the definitional knowledge test. Here, the computer simulation was regarded as an environment that supported active inquiry on the part of students, whereas the hypertext was considered to be a passive, expository environment. Swaak et al. (2004) conclude that simulations are to be considered only when clear benefits of active discovery are expected. However, research indicates that, even in such situations, overall, students have substantial problems with the inquiry processes (see de Jong, 2006, for examples of difficulties in inquiry learning). Therefore, successful inquiry often requires accurate instructional support and appropriate pedagogies. Yet providing students with accurate instruction can be challenging (see de Jong & van Joolingen, 1998, for a review). In general, weaker students seem to benefit from structured instruction, whereas instruction that is too tightly structured may hamper the performance of more skilled students, who require more control and freedom in the process of learning (Vermunt & Verloop, 1999).

According to above findings, there is some indication that LOs can provide some advantages over traditional teaching methods, but both LO type and instructional approach need to meet the needs of the particular learning situation at hand. However, in practice there is still a rather limited understanding of the instructional value and effectiveness of LOs in education because the ongoing LO debate is mainly theoretical and technological (Butson, 2003; Collis & Strijker, 2004; Kay & Knaack, 2007; Nurmi & Jaakkola, 2006). Duval et al. (2003), after reviewing the papers submitted for the Learning Objects Symposium of the 2003 ED-MEDIA conference, were concerned about the fact that there had been insufficient focus on what works and why it works. In a recent review of LO literature, Kay (2007) found only 2 articles out of 58 that examined the impact of LOs on learning. Without empirical evidence on the impact that LOs have on learning and analysis of the instructional aspects of LO implementation, we are at the risk of having our digital repositories filled with easy-to-find LOs that we do not know how to use meaningfully in the classroom (e.g., Agostinho, Bennett, Lockyer, & Harper, 2004; Kay & Knaack, 2007; Richards, 2002).

AIM OF CHAPTER

This chapter reports and discusses the results of four experimental studies that investigated the effectiveness of drill-and-practice type learning objects in comparison to more traditional paper-and-pencil activities in procedural learning context, and the effectiveness of simulation-type learning objects in comparison to laboratory activities in inquiry learning context. Three of the four studies were conducted as a part of Context E-Learning with Broadband Technologies (CELEBRATE, http://celebrate.eun.org), a large-scale European R&D project that developed, shared, and used a large number of LOs in European schools (McCormick et al., 2008), and the fourth study follows up the same line of research. All the LOs used in our studies were originally designed for different learning contexts. The LOs were first searched and selected from the CELEBRATE Demonstration Portal, they were then aggregated

Table 1. Experimental design in four studies

<table>
<tr><th></th><th>Topic / required learning skills</th><th>Age</th><th>Control condition</th><th colspan="2">Experimental condition</th></tr>
<tr><td>Study I (N = 35)</td><td>Mathematics (fractions)/ Procedural learning</td><td>10</td><td>Paper-and-pencil tasks with expository instruction</td><td colspan="2">Drill-and-practice LOs with expository instruction</td></tr>
<tr><td>Study II (N = 37)</td><td>Finnish language (grammar)/ Procedural learning</td><td>11</td><td>Paper-and-pencil tasks with expository instruction</td><td colspan="2">Drill-and-practice LOs with expository instruction</td></tr>
<tr><td>Study III (N = 64)</td><td>Science (Electricity)/ Inquiry learning</td><td>10-11</td><td>Laboratory kit with implicit instruction</td><td>Simulation LO with implicit instruction</td><td>Simulation-laboratory combination with implicit instruction</td></tr>
<tr><td rowspan="2">Study IV (N = 51)</td><td rowspan="2">Science (Electricity)/ Inquiry learning</td><td rowspan="2">11-12</td><td>Simulation LO with implicit instruction</td><td colspan="2">Simulation-laboratory combination with implicit instruction</td></tr>
<tr><td>Simulation LO with explicit instruction</td><td colspan="2">Simulation-laboratory combination with explicit instruction</td></tr>
</table>

Note: Procedural learning = learning of facts and rules, and how to perform certain activities (Anderson, 1983). Inquiry learning = learning approach that mimics authentic scientific inquiry; it involves a process of actively exploring some realistic phenomena or part of the natural world in a way that leads to asking questions, generating testable hypotheses, making discoveries, and rigorously testing and evaluating the plausibility of those discoveries in the search for new understanding (de Jong, 2006). Expository instruction = students learn by rehearsing (Mayer, 2002). Implicit instruction = students receive instructions for the inquiry process (e.g., regarding the procedure itself) but not about the inquiry process (e.g., a description of the rationale behind the procedure) (Veermans, de Jong, & van Joolingen, 2006). Explicit instruction = students receive both instructions for the inquiry process and information about the inquiry process (Veermans et al., 2006). See study descriptions for additional details.

inside the local learning content management system (LCMS) to form a new LO entity, and finally were used by the students online with a Web browser.

The experimental designs of the four studies are summarized in the Table 1. The topic of Study I was fractions and the topic of Study II was grammar. Content mastery in these studies required procedural learning skills. In Study I, students needed first to understand the concept of fractions, then to convert fractions to mixed numbers, and finally to do simple calculations with fractions. In Study II, students had to learn specific grammatical rules and to be able to use them in a correct context. In studies I and II, students in the control condition used traditional paper-and-pencil materials, whereas the students in the experimental condition used drill-and-practice LOs. Students in both conditions received expository instruction. The topic of Studies III and IV was electricity. Content mastery in these studies required inquiry learning skills. The main focus was on acquiring a qualitative understanding of series and parallel circuits by exploring the complex rules that cover electric circuits. In Study III, students in the control condition used traditional laboratory equipment, whereas students in the experimental condition 1 used simulation LO, and students in the experimental condition 2 used both laboratory equipment and simulation LO. Students in all conditions received identical implicit instruction. In Study IV, students in the control condition used simulation LO, whereas students in the experimental condition used both laboratory equipment and simulation LO. Half of the students in both conditions received implicit instruction, whereas the other half received explicit instruction.

The procedure for each study followed the same pattern. In the first session, students were given a pretest. In order to ensure that different learning conditions within each study had the same spread of achievement—that is, that students in all learning conditions were equal at the baseline—students were first classified according to their pretest scores and were then placed evenly into learning conditions. The actual intervention phase, in which students worked in different learning conditions, took place one week after the pretest and lasted two hours. A post-test was administered to students one day after the intervention. The pretest-post-test design with control and experimental conditions allowed us to evaluate the effectiveness of LOs and to examine whether there are differences in learning outcomes between LO and traditional environments.

In this context, the research questions investigated in this chapter are:

1. Are there differences in the learning outcomes of students who study with LOs as compared to those who study with more traditional learning materials (Studies I-III)?
2. Are there differences in learning outcomes when studying with drill-and-practice LOs as compared to paper-and-pencil assignments in procedural learning context (Studies I-II), or when studying with simulation LO as compared to laboratory activities in inquiry learning context (Study III)?
3. Does LO type have different impact for students who have varying levels of prior knowledge (all studies)?
4. Would it be better to combine LO and traditional activities than to use them separately (Studies III-IV)?
5. Does instructional support play a role in students' learning outcomes when studying with LOs alone or with LOs and traditional materials together (Study IV)?

The results can provide valuable information for teachers, instructional designers, and content producers as to what aspects they should consider when designing and implementing LOs in different educational contexts.

Details of the studies—including study topic, procedure, mediums, and instruction—are given in the following sections.

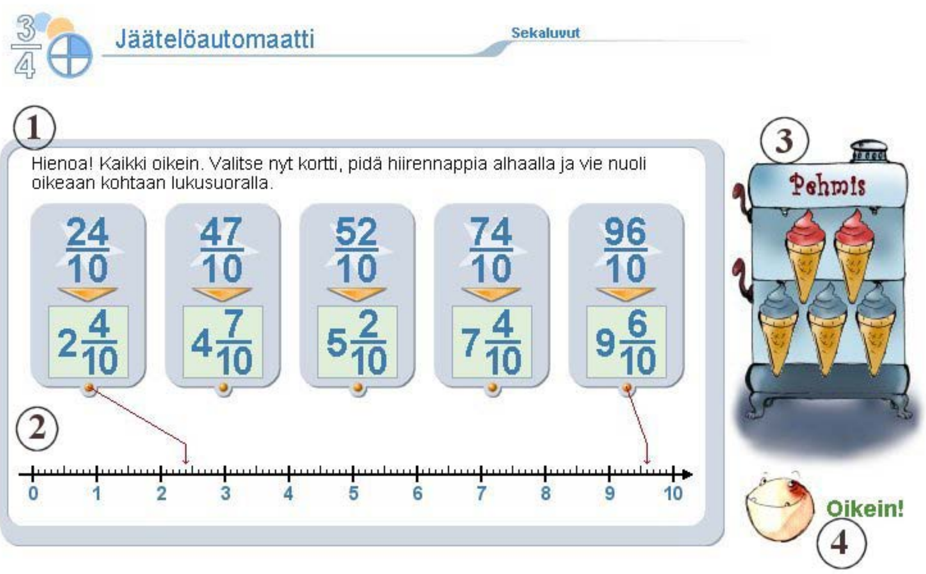
EXPERIMENTAL STUDIES

Study I. Mathematics: Fractions and Mixed Numbers (Procedural Learning)

The first study was conducted with 35 10-year-old (fourth grade) Finnish elementary school students. A subject knowledge test that measured students' understanding of fractions and mixed numbers was administered before and after the intervention phase. The intervention phase consisted of two 1-hour sessions. The teacher started both sessions in both conditions with an introductory instruction in which he presented the content to the students. After the introduction, students solved content assignments individually. Students were taught by the same teacher for both conditions, in order to control the possible effect that differing teaching styles might have. To ensure that the conditions were comparable, the assignments used in both conditions were carefully chosen to cover the same topics.

1. In the *Drill-and-Practice Learning Object* condition (n = 19), students worked in the computer laboratory with LOs (three LOs per session). The LOs covered fractions and mixed numbers and were principally

Figure 1. Example of one of the drill-and-practice LOs used in the study I (Sanoma WSOY, 2003). The aim of the LO is to practice translating fractions to mixed numbers and to relate them to the continuum.



Note: (1) Introduction and usage guidelines for the learner as to what to do next; (2) the interactive working area where the learner needs first to convert fractions to mixed numbers and then to mark the mixed numbers on the continuum with arrows; (3) illustration of learner progression within LO; (4) simple feedback (right or wrong) with face image and text.

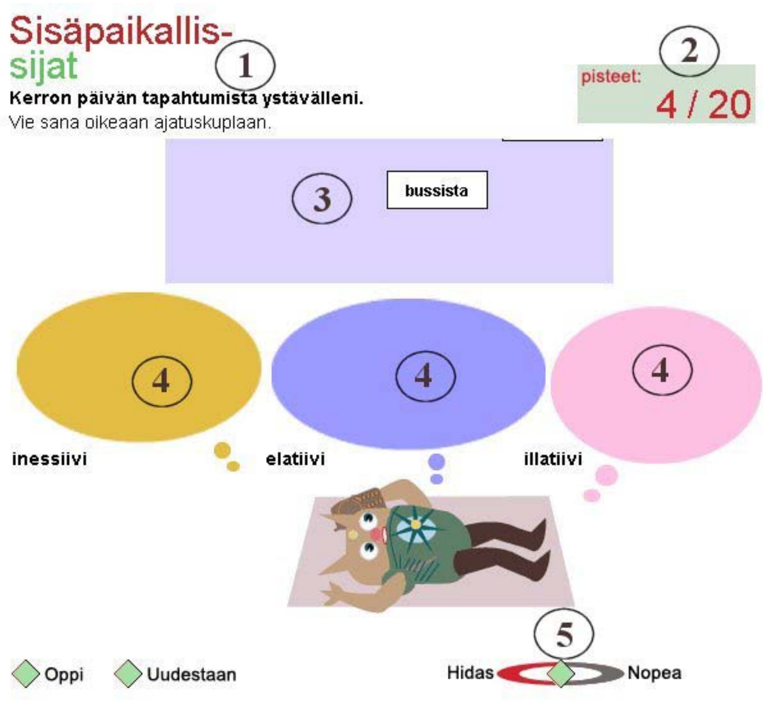
quite simple "game like" drill-and-practice programs that provided instant feedback for students' input/answers (see Figure 1). Even though the students could proceed at their own pace, the order of the LOs was predetermined. There was no direct teaching and no teacher-controlled tasks during and after the working phase. The LOs provided very simple feedback, indicating only whether an answer had been correct or incorrect.

2. In the *Traditional Paper-and-Pencil* condition (n = 16), students worked in a normal classroom. Here students individually completed different paper-and-pencil tasks concerning fractions and mixed numbers. Students were allowed to seek help from the teacher during the working phase (although they were not encouraged to do so), and at the end of the lessons, the students marked their work using answers provided to the class by the teacher.

Study II. Finnish Language: Cases/Grammar (Procedural Learning)

The content of study II was Finnish grammar, more specifically noun cases. Cases are a vital part of the Finnish language and are considered to be very difficult to learn. The participants in the study were 37 11-year-old (fifth grade) stu-

Figure 2. One of the drill-and-practice LOs used in the study II (Sanoma WSOY, 2003) This LO is meant for practicing recognition of Finnish language cases.



Note. (1) Introduction and guidelines as to how to work with the LO; (2) learner's score (current points/maximum points); (3) downward-scrolling words; (4) three case categories to which the learner had to drag the scrolling words from above; (5) difficulty of the LOs (slide button for controlling the speed of the scrolling words).

dents from average Finnish elementary schools. A subject knowledge test that measured students' understanding of cases was administered before and after the intervention phase. The intervention phase itself consisted of two 1-hour sessions. The lessons in both conditions started with a teacher-led introduction that included collective sentence completion during which the teacher asked students to propose which cases fit in particular contexts. After the introduction, students solved content assignments individually. Again, in this study, students were taught by one teacher and the assignments that were used in both conditions were carefully chosen to cover the same topics.

1. In the *Drill-and-Practice Learning Object* condition (n = 19), students worked individually in the computer laboratory with LOs containing case identification tasks. There were five LOs for both sessions. Even though the students could proceed at their own pace, the order of the LOs was predetermined. The LOs were again simple drill-and-practice games or drag-and-drop applications that gave instant feedback or scores for each student action (see Figure 2). As in study I, there was no direct teaching and no teacher-controlled tasks during and after the working phase, the only feedback came from LOs.
2. In the *Traditional Paper-and-Pencil* condition (n = 18), students worked in a normal classroom. Here students were individually assigned to solve case identification tasks, which were to be completed in paper-and-pencil format. As in Study I students were allowed to seek help from the teacher during the working phase (although they were not encouraged to do so), and at the end of the lessons, the students marked their work using answers provided to the class by the teacher.

Study III. Science: Electricity and Simple DC Circuits (Inquiry Learning)

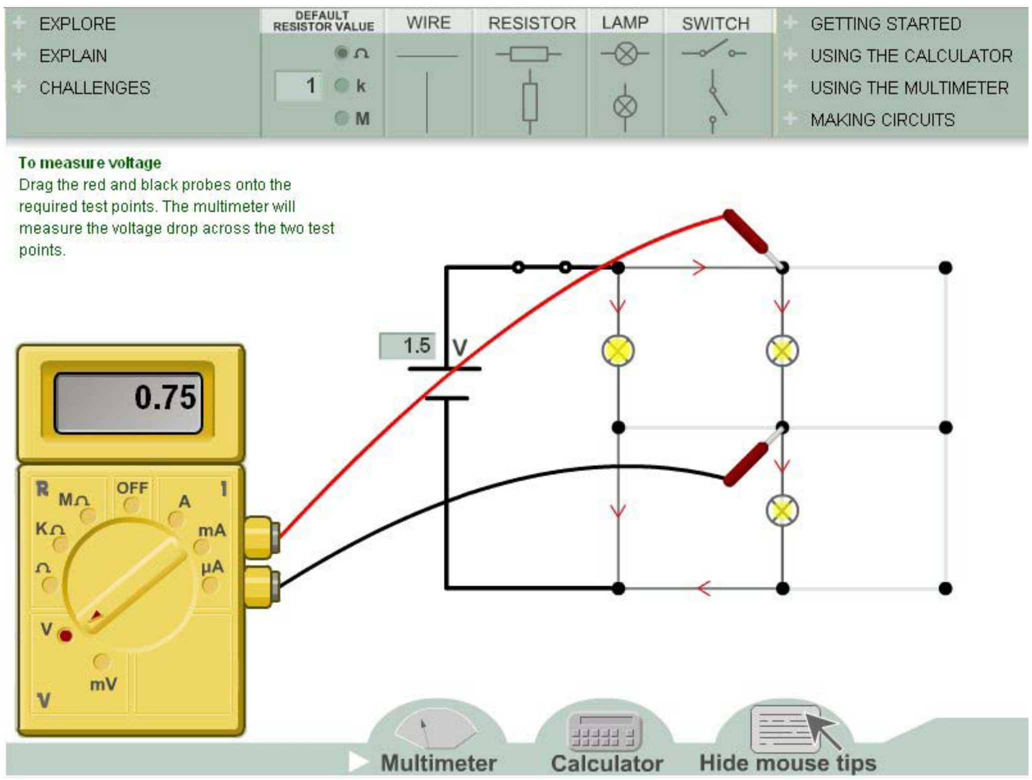
The participants in study III were 66 fourth and fifth grade students (10-11 years old) from an average Finnish elementary school. The topic of the study was electricity. Previous research has shown that gaining an understanding of electricity seems to be challenging for students at all school levels (e.g., Lee & Law, 2001; McDermott & Shaffer, 1992). A subject knowledge test that measured students' understanding of series and parallel circuits was administered to students before and after the actual intervention phase. The intervention phase consisted of one 2-hour session. In the beginning of the intervention, students in each condition received a 15-minute introduction to the subject of electricity. After the introduction, instruction was given in specially designed worksheets that asked students to construct various circuits and to conduct various electrical measurements. Students had to make notes about their observations and then write down their answers on the worksheet. There were 12 worksheets in total (of varying levels of difficulty), and each worksheet consisted of one main topic. The students' progression through the worksheets was tightly controlled by the teacher, but there was no direct teaching and students had to solve worksheets on their own. As a student had completed a worksheet, the student had to ask the teacher to check her/his answer, and the student could proceed into the next worksheet only when the previous worksheet was completed correctly. In order to ensure that the conditions were treated equally, the circuits and circuit elements in the worksheets were always presented both in realistic and schematic form. The teacher remained consistent for each learning condition.

1. The *Simulation LO* condition (n = 22[1]) was located in a computer laboratory in which students solved the worksheet assignments

with an online simulation LO, the "Electricity Exploration Tool" (EET; Digital Brain, 2003), as shown in Figure 3. The EET is a Flash application that is used online with a Web browser. With the EET, students are able to construct various DC circuits easily by dragging wires, bulbs and resistors into desired points in the circuits with simple mouse moves. After constructing the circuit or making a certain configuration with the circuit, students can observe the effects of their actions and get instant feedback (e.g., they can see how the current flows within the circuit and if the bulbs are lit; they can conduct different electric measurements with a multimeter by dragging its probes onto the required testing points). The EET may also facilitate students' inquiry process by eliminating extraneous features (e.g., surface level appearance of circuit elements) and difficulties (e.g., poor connection with real wires) while retaining its validity.

2. Students assigned to the *Traditional Laboratory* condition (n = 22) solved worksheet assignments in a normal classroom with laboratory equipment kits that included real batteries, bulbs, wires, switches, and a multimeter.

Figure 3. Electricity exploration tool (EET; Digital Brain, 2003) used in the study III and IV. EET is an easy-to-use simulation LO for constructing simple DC circuits, observing circuit functionalities, and conducting electrical measurements



3. Students in the *Simulation-Laboratory Combination* condition (n = 22) worked in a computer laboratory. Here students used the EET and the real circuits together. Students were first asked to complete the assignment using the EET and then, after succeeding with the simulation, to repeat the assignment with the laboratory equipment kit (which was equivalent to the Traditional Laboratory condition) that was located next to the computer.

Study IV. Science: Electricity and Simple DC Circuits (Inquiry Learning)

The study was conducted with 50 fifth and sixth grade students (11-12 years old) from one average urban Finnish elementary school. The topic, tests, and durations were identical to those in Study III. The Electricity Exploration tool (EET) described in Study III was used in every condition. In addition to comparing the simulation-laboratory combination condition to the simulation LO condition, this study also investigated the effects of instruction in the conditions. Thus, this study had 2 x 2 factorial design (Combination vs. Simulation LO x Implicit instruction vs. Explicit instruction).

1. In the *Implicit Simulation LO* condition (n = 12), students used the EET and received implicit instruction via worksheets. Implicit means that students received instructions for the inquiry process (e.g., for the procedure) but were not given information on the nature of the inquiry process (e.g., on the rationale behind the procedure). The worksheets with implicit instructions were identical to the worksheets in Study III.
2. In the *Explicit Simulation LO* condition (n = 14), students also used the EET, but here they received explicit instruction in the worksheets. This means that students obtained both instructions for and information about the inquiry process; that is, in addition to the procedural knowledge that they were given (i.e., what to do next), they were given hints as to what to concentrate on as central issues during their working and instructed to compare different configurations of the circuit.
3. In the *Implicit Combination* condition (n = 12), students received implicit instruction. Here students were first asked to complete the assignment using the EET; then, after succeeding with the EET, they were asked to repeat the assignment with the real batteries, wires, and bulbs that were located right next to the computer.
4. In the *Explicit Combination* condition (n = 12), students used both the EET and the laboratory equipment kit and received explicit instruction.

RESULTS

We will start the examination of the effect of different learning conditions on students' learning outcomes by comparing students' subject knowledge post-test scores between different conditions within our four studies. Analysis of covariance (ANCOVA), with a subject knowledge pretest as a covariate, was used to investigate post-test differences. For studies III and IV, which investigated more than two conditions, Fisher's Protected Least Significant Difference (PLSD) test was used for pairwise comparisons (pairwise comparisons are not conducted unless the overall F-ratio is statistically significant). The results of the four studies are presented in Table 2. There were no statistical differences ($p > .05$) in procedural learning between the drill-and-practice LO and paper-and-pencil conditions in studies I and II. In study III, the students working in the simulation-laboratory combination condition outperformed the students working in the traditional laboratory condition and the students in the simulation LO condition in inquiry learning. It seems that the students with low prior knowledge benefited particularly strongly from the combination condition. There were no differences between simulation LO condition and laboratory condition. In Study IV, the students who studied in the combination condition also outperformed the students from the simulation LO condition in inquiry learning. However, contrary to Study IV, the students with high prior knowledge seemed to get the most out of the combination condition. In Study IV, there were no differences between the students who received implicit instruction and the students who received explicit instruction. Furthermore, there was no interaction between media (Combination vs. Simulation LO) and instruction (Implicit vs. Explicit) in study IV.

There were many similarities in the designs of our four studies. On the whole, Studies I, II, and III compared the effectiveness of LO conditions to traditional conditions; Studies I and II investigated more specifically the effectiveness of drill-and-practice-type LOs in comparison to traditional paper-and-pencil tasks in procedural learning context; and Studies III and IV evaluated the effectiveness of the simulation-laboratory combination in comparison to the simulation LO environment in inquiry learning context. Therefore, instead of focusing only on the results of individual studies, it is more beneficial to investigate the impact of identical parameters across the studies simultaneously: by combining the results from individual studies we increase the sample size, which allows us to make firmer conclusions and detect more easily statistical differences at $p < .05$ (p-value is a direct function of sample size). The combined (average) results of identical parameters across the studies are shown in Table 3 with significant average p-values **highlighted**. We will begin by interpreting the results from the first row of the table and will continue to the final row. From the rightmost column on row 1 we can see that overall, there are no differences in learning outcomes between the LO and the traditional conditions ($p > .05$). This also applies to the outcomes of students who had different prior knowledge levels (rows 2 and 3). However, the more detailed investigation in row 4 reveals that the students using paper-and-pencil tasks (the traditional condition) outperformed the students using drill-and-practice LOs in procedural learning, but that the paper-and-pencil condition had no specific effect for students who had low prior knowledge vs. those who had high prior knowledge (rows 5 and 6). In row 13 of Table 3, we can see that students in the combination condition outperformed the students in the simulation LO condition in inquiry learning, a fact which was already evident in the results of Table 2. This effect is apparent among both low and high prior knowledge students (rows 14 and 15).

Thus far we have found that paper-and-pencil tasks were more effective than drill-and-practice learning objects in procedural learning context, and that the combined simulation-laboratory activities were more effective than laboratory and simulation LO activities alone in inquiry learning context. An interesting additional question, which we will address next, is that of how much more effective the paper-and-pencil and combination conditions were. In other words, what is the magnitude of the effect these two conditions have on students' learning outcomes? However, since all four of our studies measured students' posttest performances on a unique scale, it would be difficult to compare "raw" scores from different studies. Fortunately, any difference between two populations that is presented on a unique scale can be transformed and expressed in standard deviation units, which allow us to view the mean differences on an identical scale. The mean difference expressed in standard deviation units is called standardized mean difference effect size. As a general rule of thumb, Jacob Cohen, one of the most influential educational statisticians and

Table 2. Comparison of estimated marginal post-test means (post-test scores adjusted by pre-test scores) between different learning conditions in four studies

	Mean (S.E.)	ANCOVA	Fisher's PLSD
Study I, Math/Procedural learning (N = 35)			
Paper-and-pencil (n = 16)	7.02 (.39)	F (1, 34) = 3.777, p = .061	
Drill-and-practice LO (n = 19)	6.00 (.36)		
High prior knowledge			
Paper-and-pencil (n = 8)	7.76 (.53)	F (1, 18) = 1.394, p = .253	
Drill-and-practice LO (n = 11)	6.94 (.45)		
Low-prior knowledge			
Paper-and-pencil (n = 8)	6.09 (.57)	F (1, 15) = .2.165, p = .163	
Drill-and-practice LO (n = 8)	4.91 (.57)		
Study II, Language/Procedural learning (N = 37)			
Paper-and-pencil (n = 18)	11.80 (1.37)	F (1, 36) = .894, p = .341	
Drill-and-practice LO (n = 19)	9.99 (1.33)		
High-prior knowledge			
Paper-and-pencil (n = 8)	17.63 (2.57)	F (1, 15) = 2.385, p = .147	
Drill-and-practice LO (n = 8)	12.01 (2.57)		
Low-prior knowledge			
Paper-and-pencil (n = 10)	7.19 (1.28)	F (1,20) = .522, p = .479	
Drill-and-practice LO (n = 11)	8.47 (1.22)		
Study III, Science/Inquiry learning (N = 64)			
Laboratory (n = 22)	11.43 (.62)		Sim vs. Lab p = .088
Simulation LO (n = 20)	12.99 (.65)	F (2,61) = 10.247, p < .001	Comb vs. Lab p < .001
Combination (n = 22)	15.35 (.62)		Comb vs. Sim p = .011
High prior knowledge			
Laboratory (n = 11)	13.26 (.97)		
Simulation LO (n = 11)	15.48 (.98)	F (2,31) = 3.118, p = .059	
Combination (n = 12)	16.61 (.94)		
Low prior knowledge			
Laboratory (n = 11)	9.07 (.72)		Sim vs. Lab p = .311
Simulation LO (n = 9)	10.18 (.79)	F (2, 27) = 13.693, p < .001	Comb vs. Lab p < .001
Combination (n =10)	14.21 (.74)		Comb vs. Sim p = .002
Study IV, Science/Inquiry learning (N = 51)			
Simulation LO (n = 26)	13.44 (.61)	F (1,50) = 4.820, p = .033	
Combination (n = 25)	15.36 (.63)		
High prior knowledge			
Simulation LO (n = 12)	15.44 (.86)	F (1,24) = 6.828, p = .017	
Combination (n = 13)	18.55 (.81)		
Low prior knowledge			

continued on following page

Table 2. Comparison of estimated marginal post-test means (post-test scores adjusted by pre-test scores) between different learning conditions in four studies (continued)

	Mean (S.E.)	ANCOVA	Fisher's PLSD
Simulation LO (n = 14)	11.41 (.83)	F (1, 25) = .591, p = .451	
Combination (n = 12)	12.35 (.90)		
Explicit instruction (n = 27)	14.88 (.60)	F (1, 50) = 1.162, p = .287	
Implicit instruction (n = 24)	13.93 (.64)		
High prior knowledge			
Explicit instruction (n = 14)	17.13 (.78)	F (1,24) = .444, p = .821	
Implicit instruction (n = 11)	16.86 (.88)		
Low prior knowledge			
Explicit instruction (n = 13)	12.79 (.87)	F (1, 25) = .2.208, p = .152	
Implicit instruction (n = 13)	10.97 (.86)		

Note. S.E. = standard error of the mean. Fisher's PLSD = Fisher's Protected Least Significant Difference test for pairwise comparisons (pairwise comparisons are not conducted unless the overall F-ratio is statistically significant).

effect size pioneers, suggested that a standardized mean difference effect size (ES) of .20 should be interpreted as small, .50 as medium, and .80 as large; however, he reminded us that these boundaries should not be taken literally without consideration of the context (Cohen, 1988). With Cohen's suggestions, we can interpret from the Table 3 (row 4) to mean that the average difference between the means of the traditional paper-and-pencil condition and the drill-and-practice LO condition in procedural learning is of medium size (ES = .47) in favour of the former. In similar fashion, the margin by which the students in the combination condition outperformed the students in the traditional laboratory condition in inquiry learning is large (ES = 1.33, row 10; see also Table 2), and the mean difference between the combination condition and the simulation LO condition in inquiry learning is close to being large as well (ES = .70, row 13).

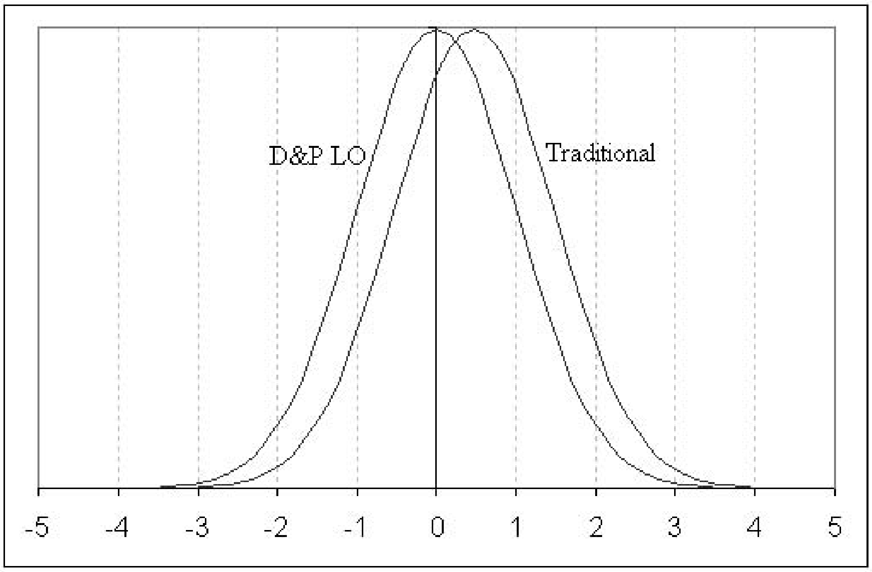
Since the standardized mean difference effect size (ES) is exactly equivalent to the "Z-score" of a standard normal distribution, another useful, and perhaps more concrete, way to interpret the magnitude of the effect is to consider the percentage of overlap between the scores (or distributions) of two conditions. Using this logic, an ES of .47 means that 68% of the students using paper-and-pencil tasks did better in procedural learning context than 50% of the students who used drill-and-practice LOs. Figure 4 provides an illustration to help the reader to understand what this means. An ES of 1.33 between the simulation-laboratory combination condition and the traditional laboratory condition means that 91% of the students studying electricity with the simulation LO and the laboratory kit together (i.e., the combination condition) did better in the inquiry learning post-test than 50% of the students who used the laboratory kit only. An ES of .70 between the combination condition and the

Table 3. Average impact of identical learning conditions across the studies on students' learning outcomes. Significant averages are highlighted

	Procedural learning		Inquiry learning		
	Study I (Math)	Study II (Lang)	Study III (Sci I)	Study IV (Sci II)	AVERAGE
1. LO vs. Traditional (N = 114)	p = .06, ES = -.64	p = .34, ES = -.31	p = .09, ES = .53		p = .51, ES = -.23 ±.37
2. Low (N = 57)	p = .16, ES = -.70	p = .48, ES = .30	p = .31, ES = .45		p = .85, ES = -.16 ±.53
3. High (N = 57)	p = .25, ES = -.53	p = .15, ES = -.73	p = .12, ES = .66		p = .54, ES = -.47 ±.54
4. D&P LO vs. Paper-and-pencil (N = 72)	p = .06, ES = -.64	p = .34, ES = -.31			**p = .04**, ES = -.47 ±.47
5. Low (N = 37)	p = .16; ES = -.70	p = .48, ES = .30			p = .63, ES = -.12 ±.66
6. High (N = 35)	p = .25; ES = -.53	p = .15, ES = -.73			p = .07, ES = -.62 ±.69
7. Simulation LO vs. Laboratory (N = 42)			p = .09, ES = .53		
8. Low (N = 20)			p = .31, ES = .45		
9. High (N = 22)			p = .12, ES = .66,		
10. Combination vs. Laboratory (N = 44)			**p < .001**, ES = 1.33		
11. Low (N = 21)			**p < .001**, ES = 2.10		
12. High (N = 23)			**p = .02**, ES = .99		
13. Combination vs. Simulation LO (N = 93)			p = .01, ES = .80	p = .03, ES = .61	**p = .001**, ES = .70 ±.42
14. Low (N = 45)			p = .002, ES = 1.64	p = .45, ES = .29	**p = .006**, ES = .85 ±.63
15. High (N = 48)			p = .41, ES = .33	p = .02, ES = 1.02	**p = .02**, ES = .69 ±.59

LO = condition in which students worked only with LO(s) (Study I & II Drill-and-practice LO; Study III Simulation LO). Traditional = condition in which students used traditional learning methods (Study I & II Paper-and-pencil tasks; Study III Laboratory kit). D & P LO = condition in which students worked with Drill-and-practice LOs (Studies I & 2). Paper-and-pencil = traditional condition where students used Paper-and-pencil tasks (Studies I & II). Simulation LO = condition in which students worked with the simulation LO (Study III). Laboratory = traditional condition in which students worked with a laboratory kit (Study III). Combination = condition in which students worked with both the simulation LO and a laboratory kit (Studies III & IV). Low = students who had low prior knowledge, High = students who had high prior knowledge; the division was based on the median split of pre-test scores. ES = standardized mean difference effect size (ES) with Hedges' (1981) bias correction. In other words, the mean difference expressed in standard deviation units. The basic formula to calculate ES is to first subtract the mean of $group_y$ from the mean of $group_x$ and then to divide this difference by the square root of pooled variance of these two groups (see Rosenthal, 1984, for details and formulas). AVERAGE = Averaged results from individual studies with identical parameters. Average p-values have been calculated via Stouffer method through following steps: (a) transform each two-tailed "p" into one-tailed "p," (b) transform one-tailed "p" into a standard normal deviation Z-score (note that signs of Z-score should indicate the direction of an effect), (c) add Z-scores together, (d) divide sum of Z's by the square root of the number of studies, (e) transform the new Z statistic first back into one-tailed probability, (f) and finally into two-tailed probability (see Rosenthal, 1984, for details). Average ES is an average effect size from individual studies when each ES is weighted by degrees of freedom (N-2) of each comparison. ± = 95% confidence interval for the ES.

Figure 4. Average percentage of overlap in post-test scores between the traditional paper-and-pencil condition and the drill-and-practice LO condition; 68% of the students in the paper-and-pencil condition succeeded better than 50% of the students in the drill-and-practice LO condition (ES = .47). Numbers in the continuum are standard deviation units .



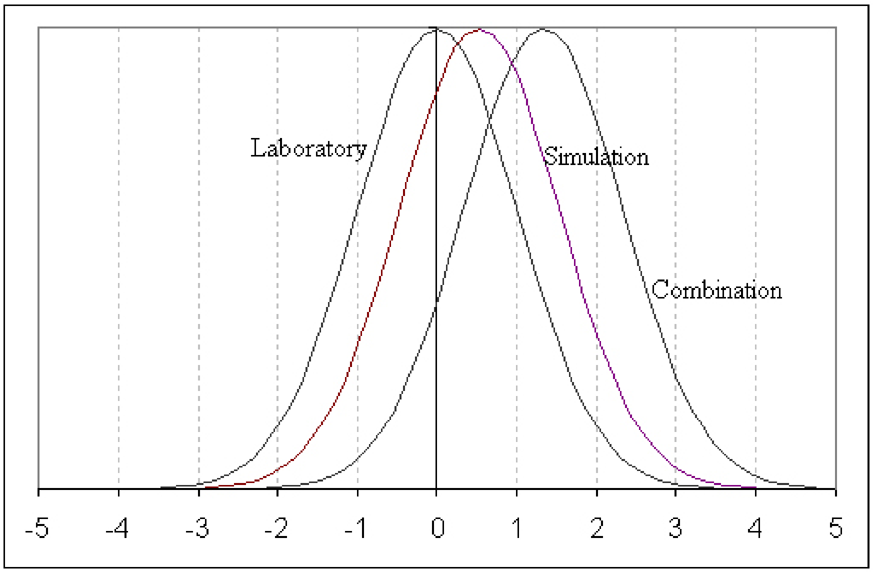
simulation LO condition means that 76% of the students in the former condition did better than 50% of the students in the latter condition. Figure 5 demonstrates these differences.

DISCUSSION

The main aim of this chapter was to investigate the effectiveness of drill-and-practice type learning objects in comparison to more traditional paper-and-pencil activities in procedural learning context, and the effectiveness of simulation-type learning objects in comparison to laboratory activities in inquiry learning context. The combined results from studies I & II showed that students using traditional paper-and-pencil tasks outperformed the students working with drill-and-practice LOs. This result indicates that using drill-and-practice LOs to replicate traditional teaching activities—that is, stressing knowledge transmission—does not seem to be fruitful in procedural learning. However, it should be kept in mind that in addition to the medium, the instructional support was slightly different in the LO condition as compared to the traditional condition in studies I & II. In the traditional condition, students were allowed to seek help from the teacher during the working phase, and at the end of the lessons, the tasks were collectively checked, whereas in the LO condition students received no support from the teacher and only elementary feedback from the LO itself.

In Study III, there were no statistical differences in learning outcomes between the traditional laboratory condition and the simulation LO condition. This indicates that simply replacing physical materials (here real bulbs and wires) with virtual

Figure 5. Average percentage of overlap in post-test scores between laboratory, simulation LO, and simulation-laboratory combination conditions; 70% of the students in the simulation LO condition did better in the post-test than 50% of the students in the traditional laboratory condition (ES = .53) (statistically non-significant); 91% of the students in the combination condition outperformed 50% of the students in the laboratory condition (ES = 1.33), and 76% of these students also performed better than 50% of the students in the simulation condition (ES = .70). Numbers in the continuum are standard deviation units.



materials (electricity simulation LO) does not affect inquiry learning outcomes when other aspects of the condition are kept constant, as also found by Triona and Klahr (2003). However, the performance of students working in the simulation-laboratory combination condition was superior to that of students in the traditional laboratory condition only, and they also outperformed the students in the simulation LO condition in studies III & IV. The combination environment seemed to be especially beneficial for students who had low prior knowledge, but the students with high prior knowledge also did better in the combination condition than in the two other conditions. The fact that the combination learning environment was superior as compared to simulation and laboratory-only environments suggests that we should not consider LOs and traditional methods as rivals but rather as complementary to one another. It appears that simulation and laboratory activities both have unique characteristics that are needed to promote deeper understanding in inquiry learning.

One plausible explanation as to why the combination condition was superior to the laboratory and simulation only conditions is that the simulation LO may have helped students to understand the concepts and theoretical principles of electricity better than the laboratory condition did because it revealed certain properties of DC circuits (e.g., current flow) that were invisible to the students who worked with real wires and bulbs (the laboratory kit). Moreover, an interactive LO such as the Electricity Exploration Tool that was used in Study III and IV can be especially effective in inquiry learning because such an LO requires students to make explicit their implicit reasoning and allows them to visualise the consequences of that reasoning. As a consequence, students discover the properties of the underlying model (e.g., Ohm's law). However, even though the simulation was able to provide students with a clear, informative and interactive learning environment, it was also important for students to obtain experience with real circuits. One explanation is that as the simulation was only semi-realistic in representing circuits on a diagrammatic level, the students, particularly due to their young age at the time of our study, needed assurance that the laws and principles of the simulation also apply in reality. A study by Dunbar [(1993), see also Couture (2004) and Srinivasan, Perez, Palmer, Brooks, Wilson, and Fowler (2006)], showed that in a simulation environment, some students have a strong inclination to search for evidence that supports their intuitive conceptions, and that they fail to accept alternative views even when their original conceptions are confronted with inconsistent evidence. In other words, students may have kept the laws and principles they had learned in the simulation environment apart from their "real" beliefs until these beliefs were further conflicted in an authentic setting with the laboratory equipment (Merenluoto & Lehtinen, 2004). Such an authentic setting may have finally 'forced' students to abandon their intuitive (mis)conceptions.

It is important to emphasize that the results of the studies reported in this chapter were obtained in a normal school environment, not in a laboratory setting, which is likely to add to the validity and applicability of the results. Nevertheless, this study has limitations that warrant further research. First, our results do not permit us to conclude unambiguously that drill-and-practice LOs are of no value and that teachers should only use interactive materials such as the simulation LO in studies III & IV, because students received less instructional support in studies I & II when they studied with drill-and-practice LOs. However, we feel strongly that more effort should be invested in the development of tools and instructional methods that support students' learning in complex domains. Even with adequate instruction, simply reproducing in digital format traditional materials that are designed for procedural learning is likely to provide only marginal gain for the effort. Second, our study focused only on "hard" cognitive factors in learning with learning objects, whereas previous research has shown that when students engage in a learning situation 'softer' factors such as learning styles (Vermunt, 1996), motivational basis (Eccles & Wigfield, 2002), and emotions (Cacioppo & Gardner, 1999) also have some bearing on their interpretation of new learning situations and their construction of meaning. Finally, this study provided some evidence for the effectiveness of LOs in education. In order to test all the premises related to the LOs, we need more empirical results in which different types of LOs are used alone and together in various contexts and instructional settings, as well as by students with different qualities and characteristics.

CONCLUSION

Researchers, educators, content providers, and even corporate leaders have high expectations for learning objects, but thus far there has been a clear lack of rigorous empirical evidence as to their effectiveness in education. The findings of this chapter indicate that LOs can support learning, but that the sheer number of available LOs does not yet guarantee high-quality academic outcomes or meaningful learning activities. Our results suggest that it is not wise simply to replicate traditional teaching methods or content in LOs or to develop LOs that promote passive knowledge acquisition. Unfortunately, it seems that most of the content providers are not aware of this, since the majority of available LOs are very simple drill-and-practice applications (McCormick et al., 2008).

Our results suggest that an interactive LO that works as a tool to support students' inquiry process, but that does not itself directly involve instruction, can be especially helpful to students' learning in complex domains such as electricity (de Jong, 2006). Such a tool can provide added value to traditional methods by revealing processes that are invisible in natural systems, and can be flexible enough to enable a teacher to create an effective pedagogy that utilizes the possibilities provided by the LO and supports student-centred inquiry process (Ilomäki et al., 2006). The findings of this chapter (see also Zacharia, 2007) also strongly suggest that we should not see LOs and traditional methods as rivals but as being complementary to one another. Learning technologies can enable faster learning object exchange and retrieval, they are highly interactive, and they can reveal processes that are invisible in natural systems; however, virtual materials cannot completely replace real experiences in student learning (Srinivasan et al., 2006). It seems that in many cases, it is necessary to demonstrate through testing that the laws and principles that students discover virtually also apply in reality. Finally, when evaluating, designing or implementing LOs, one should always remember that LOs do not have value or utility independent of other aspects of the learning environment (Haughey & Muirhead, 2005).

REFERENCES

Agostinho, S., Bennett, S., Lockyer, L., & Harper, B. (2004). Developing a learning object metadata application profile based on LOM suitable for the Australian higher education market. *Australasian Journal of Educational Technology, 20*(2), 191-208.

Anderson, J.R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Bennett, K., & McGee, P. (2005). Transformative power of the learning object debate. *Open Learning*, *20*(1), 15-30.

Butson, R. (2003). Colloquium. Learning objects: Weapons of mass instruction. *British Journal of Educational Technology, 34*(5), 667-669.

Cacioppo, J.T., & Gardner, W. (1999). Emotion. *Annual Review of Psychology, 50,* 191-214.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Collis, B., & Strijker, A. (2002). New pedagogies and re-usable learning objects: Toward a new economy in education. *Journal of Educational Technology Systems*, *30*(2), 137-157.

Collis, B., & Strijker, A. (2004). Technology and human issues in reusing learning objects. *Journal of Interactive Media in Education*, *4*. Retrieved March 26, 2008, from http://www-jime.open.ac.uk/4

Couture, M. (2004). Realism in the design process and credibility of a simulation-based virtual laboratory. *Journal of Computer Assisted Learning, 20*(1), 40-49.

de Jong, T. (2006). Technological advances in inquiry learning. *Science, 312*, 532-533.

de Jong, T., & van Joolingen, W.R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*(2), 179-201.

Dunbar, K. (1993). Concept discovery in a scientific domain. *Cognitive Science, 17,* 397-434.

Duval, E., Hodgins, W., Rehak, D., & Robson,

R. (2003, June 24). Introduction. In E. Duval, W. Hodgins, D. Rehak, & R. Robson (Eds.), *Learning objects 2003 symposium: Lessons learned, questions asked. ED-MEDIA 2003 World Conference on Multimedia, Hypermedia & Telecommunications,* Honolulu, Hawaii, USA. Retrieved March 26, 2008, from http://www.aace.org/conf/edmedia/LO2003Symposium.pdf

Eccles, J., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology , 53,* 109-132.

Educational technology. (2006, January-February).

Gibbons, A.S., Nelson, J., & Richards, R. (2002). The nature and origin of instructional objects. In D.A. Wiley (Ed.), *The instructional use of learning objects: Online version*. Retrieved March 26, 2008, from http://reusability.org/read/chapters/gibbons.doc

Goldstone, R.L., & Son, J.Y. (2005). The transfer of scientific principles using concrete and idealized simulations. *The Journal of the Learning Sciences*, *14*, 69-110.

Haughey, M., & Muirhead, B. (2005). Evaluating learning objects for schools. *E-Journal of Instructional Science and Technology, 8*(1). Retrieved March 26, 2008, from www.usq.edu.au/electpub/e-jist/docs/vol8_no1/fullpapers/Haughey_Muirhead.pdf

Hedges, L.V. (1981). Distribution theory for Glass's estimator of effect sizes and related estimators. *Journal of Educational Statistics, 6,* 107-128.

Hennessy, S., Deaney, R., & Ruthven, K. (2006). Situated expertise in integrating use of multimedia simulation into secondary science teaching. *International Journal of Science Education, 28*(7), 701-732.

Hodgins, W. (2006, January-February). The future of learning objects. *Educational Technology,* 49-54.

Ilomäki, L., Lakkala, M., & Paavola, S. (2006). Learning objects in authentic pedagogical settings. *Learning, Media & Technology, 31*(3), 249-267.

Journal Educational Multimedia and Hypermedia. (2004). 13(4).

Kay, R. (2007). A systematic evaluation of learning objects for secondary school students. *Journal of Educational Technology Systems, 35*(4), 411-448.

Kay, R.H., & Knaack, L. (2007). Evaluating the learning in learning objects. *Open Learning, 22*(1), 5-28.

Learning, Media, and Technology. (2006). 31(3).

Lee, Y., & Law, N. (2001). Explorations in promoting conceptual change in electrical concepts via ontological category shift. *International Journal of Science Education*, *23*(2), 111-149.

Littlejohn, A. (Ed.). (2003). *Reusing online resources: A sustainable approach to e-learning.* London: Routledge.

Mayer, R.E. (2002). *The promise of educational psychology volume II: Teaching for meaningful learning.* NJ: Pearson Education, Inc.

McCormick, R., Jaakkola, T., & Nurmi, S. (2008). A European evaluation of the promises of LOs. In L. Lockyer, S. Bennett, S. Agostinho, & B. Harper (Eds.), *Handbook of research on learning design and learning objects: Issues, applications and technologies* (pp. 517–533). Idea Group.

McCormick, R., & Li, N. (2006). An evaluation of European learning objects in use. *Learning, Media and Technology*, *31*(3), 213-231.

McDermott, L.C., & Shaffer, P.S. (1992). Research as a guide for curriculum development: An example from introductory electricity. Part I: Investigation of student understanding. *American Journal of Physics*, *60*(11), 994-1013.

McGee, P., & Katz, H. (2005). A learning object life cycle. In G. Richards (Ed.), *Proceedings of World Conference on E-Learning in Corporate, Government, Health Care, and Higher Education (E-LEARN) 2005* (pp. 1405-1410). Chesapeake: AACE.

McGreal, R. (2004). Learning objects: A practical definition. *International Journal of Instructional Technology and Distance Learning, 1*(9), 21-31.

Merenluoto, K., & Lehtinen, E. (2004). Number concept and conceptual change: Towards a systemic model of the processes of change. *Learning and Instruction, 14*(5), 519-534.

Nurmi, S., & Jaakkola, T. (2006). Promises and pitfalls of LOs. *Learning, Media and Technology, 31*(3), 269-285.

Parrish, P.E. (2004). The trouble with learning objects. *Educational Technology, Research & Development, 52*(1), 49-67.

Rehak, D. (2006, January-February). Challenges for ubiquitous learning and learning technology. *Educational Technology*, 43-49.

Richards, G. (2002). Editorial: The challenges of the learning object paradigm. *Canadian Journal of Learning and Technology, 28*(3). Retrieved March 26, 2008, from http://www.cjlt.ca/content/vol28.3/editorial.html

Rosenthal, R. (1984). *Meta-analytic procedures for social research. Applied social research methods series* (Vol. 6). London: Sage.

Spector, M., Orchazda, C., van Schaak, A., & Wiley, D.A. (Eds.). (2005). *Innovations in instructional technology: Essays in honor of M. David Merrill*. Mahwah, NJ: Lawrence Erlbaum.

Srinivasan, S., Perez, L.C., Palmer, R.D., Brooks, D.W., Wilson, K., & Fowler, D. (2006). Reality vs. simulation. *Journal of Science Education and Technology, 15*(2), 137-141.

Steinberg, R.N. (2000). Computers in teaching science: To simulate or not to simulate? *American Journal of Physics, 68*(1), 37-41.

Swaak, J., de Jong, T., & van Joolingen, W.R. (2004). The effects of discovery learning and expository instruction on the acquisition of definitional and intuitive knowledge. *Journal of Computer Assisted Learning, 20*, 225-234.

Triona, L.M., & Klahr, D. (2003). Point and click or grab and heft: Comparing the influence of physical and virtual instructional materials on elementary school students ability to design experiments. *Cognition and Instruction, 21*, 149-173.

Urdan, T. A., & Weggen, C. C. (2000). *Corporate e-learning: Exploring a new frontier*. Retrieved March 1, 2008, from wrhambrecht.com/research/coverage/elearning/ir/ir_explore.pdf

Veermans, K., de Jong, T., & van Joolingen, W.R. (2006). Using heuristics to facilitate discovery learning in a simulation learning environment for a physics domain. *International Journal of Science Education, 28*(4), 341-361.

Vermunt, J.D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: a phenomenographic analysis. *Higher Education, 31*, 25-50.

Vermunt, J.D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9*, 257-280.

Visser, Y.L., & Amirault, R.J. (2002). *Learning objects technology: Implications for educational research and practice*. AERA Annual Meeting 2002 Panel Proposal. Retrieved March 26, 2008, from http://www.learndev.org/dl/LearningObjectsAERA2002Proposal.pdf

Wiley, D.A. (Ed.) (2002a). *The instructional use of learning objects* (Online version) Retrieved March 26, 2008, from http://www.reusability.org/read/

Wiley, D.A. (2002b). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. A. Wiley (Ed.), *The instructional use of learning objects* (Online version). Retrieved March 26, 2008, from http://www.reusability.org/read/chapters/wiley.doc

Zacharia, Z.C. (2007). Comparing and combining real and virtual experimentation: An effort to enhance students' conceptual understanding of electric circuits. *Journal of Computer Assisted Learning, 23*(2), 120-132.

KEY WORDS

Drill-and-Practice Type LO: A digital learning resource that promotes the acquisition of knowledge or skill through repetitive practice and provides mechanistic feedback. It often refers to small tasks such as the memorization and practicing of facts and simple skills.

Explicit Instruction: Students receive both instructions for the inquiry process and information about the inquiry process.

Expository Instruction: Students learn individually by rehearsing.

Implicit Instruction: Students receive instructions for the inquiry process (e.g., regarding the procedure itself) but not about the inquiry process (e.g., a description of the rationale behind the procedure).

Inquiry Learning: Learning approach that mimics authentic scientific inquiry; it involves a process of actively exploring some realistic phenomena or part of the natural world in a way that leads to asking questions, generating testable hypotheses, making discoveries, and rigorously testing and evaluating the plausibility of those discoveries in the search for new understanding.

Learning Object: IEEE Standard definition: "any entity, digital or nondigital, that can be used or re-used or referenced during technology-supported learning." Generally, LOs are understood to be digital learning resources that can be shared and accessed through the Internet and reused in multiple teaching and learning contexts.

Procedural Learning: Learning of facts and rules, and how to perform certain activities.

Simulation Type LO: A digital learning resource that attempts to model a real-life or hypothetical system, situation, or process on a computer so that it can be explored.

ENDNOTE

1. Only 20 students in the LO LD completed the study since two had to withdraw due to illness.

Chapter XXVII
Evaluating Large-Scale European LO Production, Distribution, and Use[a]

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ABSTRACT

This chapter will examine the approach taken in the evaluation of a large-scale feasibility trial of the production, distribution, and use of learning objects (LOs). This was carried out by partners in several countries of Europe as part of the Context E-Learning with Broadband Technologies (CELEBRATE) project, coordinated by European Schoolnet. The project produced a large number of LOs and involved linking up commercial and ministry producers of LOs to make available their products to teachers in six countries. The chapter examines what it means to evaluate learning objects, given that they are both particular objects and a general idea, especially important given the dearth of empirical studies of the use of LOs. It then goes on to explore the way this was tackled strategically and tactically, bearing in mind a European context of distributed locations, different languages, and education systems.

INTRODUCTION

The CELEBRATE project was an Information Societies Technology Programme project funded by the European Commission over 30 months, from June 2002 until November 2004.[b] It involved 23 participants from 11 countries, including commercial producers of learning materials, multi-media specialists, ministries of education, software and network companies, university academics and schools and associated local authorities. Its objectives were to create and use a critical mass of material for a new generation of learning environments, and this material was distributed and used in schools in six countries: England, Finland, France, Hungary, Israel, and

Norway. The LOs were made available via a Demonstration Portal (a Web site) to selected schools across Europe in order to further stimulate the development of LOs by teachers themselves. CELEBRATE took the idea of an "exchange" and applied it to the school sector through a brokerage system. The CELEBRATE Brokerage system, initially connecting four repositories of LOs and allowing users to search for and retrieve a LO on that system, provided a working model for how both schools and commercial publishers could develop and make available media-rich LOs both separately and in partnership. Precisely because all the elements of production, distribution and use of LOs was involved, this project was considered a feasibility study, and all that could be achieved by way of use of LOs by teachers was in the form of a pilot lasting a relatively short period of time (a maximum of 4 months).

Here the focus will be on the evaluation methodology and methods (see Chapter XXV for the results of the evaluation).

CAN LOs BE EVALUATED?

When we presented our preliminary findings of the evaluation at the European Association for Learning and Instruction (EARLI) annual conference in 2005 (Ilomäki, Lakkala, & Paavola, 2005; Jaakkola & Nurmi, 2005; McCormick & Li, 2005) our discussant, Wouter van Joolingen, rightly posed the question of whether and in what way it was possible to evaluate learning objects in the general way we were apparently doing. He drew parallels between trying to evaluate "pills" (rather than a specific drug), and argued that the concept of a LO applied to a form of packaging and the metadata, not the content and, in which case, the whole process of production, storage, selection, and use had to be part of the evaluation. As he graphically put it "Just *evaluating learning objects* does not say anything." At that conference we were only reporting the results of the "use" of LOs, and it was an important reminder of the limitations of what can be claimed and for the importance of reporting our general approach to evaluating LOs in the context of the project. Here I will examine how we answered his justifiable question, which of course also contains within it the definition of what constitutes a LO.

The definition of an LO we used was rather general: any entity, digital or nondigital, that can be used or re-used or referenced during technology-supported learning.[c] This makes it difficult to answer the question that Wouter van Joolingen posed, as in a sense it has no special characteristics. There are, however, a number of such characteristics that are usually associated with LOs, namely that they are:

- Interoperable, that is, that they will operate in any technical environment;
- Reusable, that is, that they can be used by any teacher in any context;
- Modifiable, that is, that a teacher can alter some features of the LO to suit their situation;
- Adaptable, that is, that they will adapt to the learners needs.

In effect "reusability" is the main feature and the other characteristics serve to enable this feature. Chapter XXV deals in detail with these characteristics, and here it is sufficient to point out that there are technical issues that underlie interoperability and adaptability, and pedagogic issues that underlie reusability and adaptability, though inevitably they are inter-related. One assumption is that to make LOs different from "assets" (e.g., a picture), the LO must have some pedagogy "built in," as it were. This is controversial, as Chapter XXV reveals, but for the purposes of a discussion of the evaluation methodology it is only necessary to recognise that this "encapsulated pedagogy" is a possibility. Thus in evaluating LOs (as objects, rather than as part of a system), it is necessary to consider both technical and pedagogic issues.

The latter would be manifest in how flexible the LO is to fit into a teacher's pedagogy and what the factors are in allowing this to happen.

It is interesting to note that, even with this more specific notion of a LO, the *system* of production, distribution, and use is not specified, and hence to respond to Wouter van Joolingen a wider conception yet is required. But, just as individual LOs can vary greatly one from another, so too can systems of provision. It may well be possible, and indeed necessary, to define some system characteristics (e.g., that there has to be some kind of market for LOs).[d]

THE EUROPEAN DIMENSIONS AND AUDIENCES

As a feasibility project it was important to put together all the stages of producing, distributing, and using LOs to see if it was possible to set up some kind of central system to make them available to teachers throughout Europe and to create a market for them (an "LO economy," as Chapter XXV puts it). This section of the chapter will therefore examine the requirements of the evaluation strategy to cope with all these different stages, doing this in a European context with the different production traditions (e.g., ministries and commercial companies) and their existing relationships with schools, different languages, and approaches to subjects and the curriculum in general, and different school systems.

In addition to this we had within our partners and the funding body, the European Commission (EC), quite different audiences to address: commercial producers, ministry of education producers; technical software and system companies and designers interested in brokerage and portal systems; educators in schools and higher education and those in ministries trying to develop the use of ICT in schools; the EC itself who wanted to encourage European-wide initiatives in this field. Any results had to be sensitive to the various differences as well as exploring across-country effects, as the project was to see if a European-wide system could be established and would be useful.

CELEBRATE contained, within its various partners, all the interest groups that are found in the field:

- Those whose concern was to *produce LOs*: commercial content providers or ministries of education and the like, who make provision for schools.
- Ministries with additional concerns about whether to invest in LOs, and support commercial or other providers and teachers.
- Those who were trying to make LOs available to users through various electronic systems (e.g., portal and brokerage systems), and concerned about the *technical issues.*
- Those concerned to apply ideas from contemporary views of learning, a largely academic and *theoretically focused* group.
- The users, that is, teachers, and, indirectly, their students.

The producers of LOs were interested in creating the new generation of LOs, and to be able to do this across Europe. They had several concerns. One was to move away from the traditional offerings and try to build LOs based on a more sophisticated pedagogy, which can utilize the facilities that current software offers by way of interfaces and interactions (e.g., animations). As producers of *content,* they were inevitably preoccupied with this aspect, particularly the commercial organizations. But this was not exclusively so, some were interested in software tools that teachers could use to generate LOs, albeit that some of these tools only produced particular kinds of LOs (i.e., they were templates). Commercial producers were also interested to see if there was a market for their material across Europe, as they were usually confined to working in one country. Thus they required both evaluations of LOs they produced as part of the project (or currently in their stock of material), and guidance on how to construct the new generation of LOs.

Those concerned with the Portal and Brokerage systems started with the focus on metadata ("data about data" used to describe LOs in ways that a machine can read and work with). This holds the key to the exchange of information about LOs, which, for example, is the basis of any search routines in looking for LOs by the system users. These metadata were also the basis for the standardization of LOs so that they could be used across the whole system linking the different repositories. They wanted to be able to deal with pedagogical elements of the metadata, but in an unambiguous fashion that can be represented in a metadata application profile that could ultimately be machine readable. But, as part of this project, their prime concern was for its use for searching. Thus, if a teacher wants an LO that can be used with a particular age-group, in a particular learning situation (e.g., a group activity), then "age-group" and "type of activity" need to be in the metadata so that the teacher can use them to search for the LO. The situation is analogous to a library catalogue system but, because of the needs of interoperability, other information has to be stored that will allow the LO to function in a range of environments. As noted, ultimately those who use LOs also want to be able to assemble LOs automatically (see Chapter XXV), but in this project that was not a concern. Although the system designers needed to see what search terms were employed by users and how they searched, they did not build their systems around data collection such that they could respond to users requirements, something I will return to when considering "routine data."

Learning theorists on the project were also concerned with how more traditional LOs could be improved upon to produce pedagogically sophisticated digital material. They could provide cogent critiques of some existing LOs, which content providers used to understand the requirements of constructivist learning, but this was not general enough to guide providers. It was difficult to represent the complex pedagogic ideas in unambiguous categories for metadata purposes, and in any case their concern was not only whether providers could produce "good" LOs, but also that users (teachers) were able to recognize them and build them into their teaching in productive ways.

The conflicts occurred when the requirements of these groups were to be simultaneously satisfied, as each group had a different agenda and different perspectives on LOs, such that they were in tension. For example: those concerned with technical issues wanted an LO to be clearly defined in pedagogic terms to either allow it to be searched for in a repository or to be automatically assembled along with other LOs to satisfy a particular learning need. Learning theorists resisted this as they were reluctant to acknowledge producers' pedagogic categories (e.g., "exploration" *and* "drill and practice" were assigned to the same LO by producers); producers used the categories to increase the potential market or were unable to assign any (17% had no "type" assigned, the third largest category; see Chapter XXV, Figure 3, for types available).

All of them, however, needed to listen to the users and hence evaluations are essential for them to work from an empirical base. But the evaluations they each required were different and not all satisfied by the requirements of a *project evaluation*, which ultimately had to be reported to the EC. This latter stakeholder constituted the "elephant in the room," as it were, and it came to dominate at the interim reporting, for example. The agendas that the Commission creates are both intended and unintended. Of course the EC wants to know if the whole system and enterprise is feasible, as do the partners in the project. It also wants the evaluation be able to help the various users of LOs (those outlined above). But those involved in the project also see the evaluation, reported to the EC, as an evaluation of themselves, and for some this may be interpreted as an evaluation of their prospects of future EC funding (the unintended agenda). This occurs despite the fact that the outputs of the various people involved (e.g., in the LO, Portal, and Brokerage system development) were regarded as the basis of evaluations of them.

These various stakeholders and their associated interests and needs for an evaluation gave us a complex situation upon which to build an evaluation strategy.

APPROACHES TO EVALUATION

At the time of the project there had been few empirical studies of the use of LOs and none of such a large scale endeavour to make them available across many schools (See, however, Chapter XXIII.), let alone to do this at an international level. In that sense we had to try to create an evaluation that would suit the kinds of stakeholders and issues discussed above. Although evaluation studies in Europe have for many years rejected the experimental approach common in natural science studies and in particular used to study medicines, there has been a resurgence in discussions about this approach. In the early 1970s a generation of curriculum project evaluators in the UK grew dissatisfied with the experimental approach that required them to show that a new curricular approach (including curriculum materials) was better than what already existed, thus preventing them from informing users about how they might implement the new approach and what it had to offer. This led to the seminal paper *Evaluation as Illumination* (Parlett & Hamilton, 1972), which argued that the "agricultural-botany" paradigm to determine which treatment was better, and involving pre- and post-tests to determine achievement change of various "treatments" (with at least one being the innovation and another being a control group), fails to answer many of the questions that an evaluation could usefully address. In any case this paradigm is based upon situations that are not reproducible or which assume that the new approach is identical wherever it was implemented. Their solution of "illuminative evaluation" led to the predominance of qualitative approaches drawing on case studies and fully-fledged ethnography (Hamilton, Jenkins, King, MacDonald, & Parlett, 1977). These approaches to evaluation prevailed for decades, to the extent that there was a dearth of quantitative approaches, whether of the experimental kind or more conventional surveys. But in recent years qualitative approaches have come under attack from those who want to replicate the evaluations of drugs and other medical treatments, resulting in the "infamous" statement by the USA Department for Education's that educational research was "in a mess" (DES, 2002). This was backed up by a policy that would only award Federal funding for studies that involved randomised control trials (the "agricultural-botany" paradigm) that would allow investigators to say "what works."[e] Although there has been a debate that has had wider resonance within the educational research community, it has been examined in the context of ICT studies that endeavour to tell us about the effectiveness of what has become an expensive investment for all governments (e.g., McCormick, 2003). Such an approach to evaluation, where the evaluator serves a government agency or policy maker, is described by MacDonald (1977, p. 226) as "bureaucratic evaluation." Here the evaluator works to a specification and serves the funding body.

However, in the CELEBRATE project we were faced with a range of stakeholders with concerns outlined above, and so we adopted a "democratic evaluation" (MacDonald, 1977, pp. 226-227), trying to inform all these stakeholders. This implies a commitment to producing data and reports that can be accessible to nonspecialist audiences. Although we did engage in discussion with the project team to see what their needs and requirements were, the evaluation also had a commitment to produce recommendations rather than being simply a representation of a variety of viewpoints, leaving the audience to read what they could from it. (I come back to this later when I consider reporting.) The "presence" of the EC, as discussed above, also gave it an undercurrent of a "bureaucratic evaluation," as they wanted to know what worked, as I will indicate when the experimental studies are considered.

Although there had been no directly relevant studies of LOs that we could draw upon, there were many ICT studies of importance and attempts at evaluation frameworks. One such was the development of the ValNet validation framework. Within this framework (MENON Multimedia Education, 2001), the purpose of validation is taken to be to determine whether claimed results are valid and to obtain qualitative and quantitative evidence of the positive impact of the innovation, product, or service. The objects the framework can be used to validate are the:

- Project as a whole;
- Working processes within it;
- Resources/products;
- Services provided;
- Results of the projects.

Each of these objects can be reviewed in terms of the pedagogical, organisational, economic, and technological and cultural/linguistic dimensions of the innovation. This proved to be rather too structured and general of a framework for our use, though it did provide a checklist to ensure that we did not omit pertinent considerations.[f]

In terms of cross-country studies of ICT, the OECD study of the effect of ICT on change in schools had some methodological guidance to offer (Venezky & Davis, 2001). This utilized explanatory case studies in each of the countries, using a common framework, which informed our use of case studies, though with much less control over the methods and analysis.[g]

Another result of the multiple stakeholders and their interests was the range of types of questions that we had to address. Yin (2003, pp. 5-9) examines how different types of questions might require different approaches (e.g., experimental, survey or case study) and from this we were faced with considering all of them. This, and a recognition of the critiques of the "what works" approach (McCormick, 2003) and indeed of the exclusively qualitative basis of the "illuminative approach," contributed to us taking a more pragmatic approach involving the use of a range of quantitative and qualitative approaches and methods.

THE EVALUATION STRATEGY

Following Yin (2003, p. 22), who argues that the various questions have to be turned into propositions (which are then manifest as hypotheses), we built our strategy around an hypothesis about the production, distribution and use of LOs, which enabled us to cast the evaluation in a way that we could test the feasibility of the project's goals. The strategy used:

- A multilevel approach to cope with all the stages of production, distribution, and use;
- A mixture of qualitative and quantitative methods to cope with general judgements of efficacy as well as explanations for them;
- A whole range of respondents to address both the audiences of the evaluation and those who were involved in the production, distribution, and use.

The strategy was formulated into a framework for the evaluation to enable us to negotiate with the project team as stakeholders, and to make our intentions clear to the EC (the framework was reported formally to them). The first part of the framework outlined the general principles and structure of the evaluation design, upon which the details were then built: the purposes of the evaluation, what would be evaluated, the basic questions that were the subject of the evaluation, the instruments to be used for answering these questions and the role of the evaluation team, and the other parts of the project team in collecting data from the various instruments and sources. The second part outlined the areas of evaluation and, for each area, gave the detailed questions to be answered and whose responsibility (among the project team) it was to provide the data and analyses to answer them. The third part covered the same content as the second, but ordered the areas and questions in terms of the means of answering these questions (i.e., the instruments) and the main actors who are being catered for by the CELEBRATE project (rather than by parts of the project team).

The first part of the framework started with the evaluation hypothesis, expressed as a series of statements that we could attempt to address, which we combined to correspond to the production, distribution, and use of LOs, as follows.

Given suitable preconditions and working methods learning objects can be:

a. Successfully created, translated, and modified by content developers and teachers;
b. Successfully created, translated, and modified within a "market" that can be created to protect the rights of creators and provide necessary income where appropriate;
c. Distributed and presented (to users);
d. Selected and employed usefully and efficiently by teachers,
    i. of varying backgrounds and interests,
    ii. working with students of selected ages, ethnicities, social backgrounds, levels of previous achievement, and diverse first languages and cultures,
    iii. in a range of subject areas and classroom contexts reflecting diverse education systems
    iv. with students of selected ages, ethnicities, social backgrounds, levels of previous achievement, and diverse first languages and cultures.

This hypothesis identified the areas of the project that were to be evaluated, expressed in general terms, and in a positive way, such that we could determine if the project had been successful.

The purposes of the evaluation were to:

1. Examine each of the areas of the hypothesis to determine if it had been achieved and, where there have been problems or issues arising, to determine what the reasons were for these;
2. Identify whether there were significant differences in the judgments of usefulness and efficiency made by different categories of users and developers; and if so why;
3. Provisionally identify what changes in the preconditions and working methods would be needed to make the CELEBRATE system outcomes more effective and useful to all users and developers in the future.

The first part of the framework was based on the analysis of the requirements of each of the parts of the project team (expressed in "EC-speak" as "work packages") re-oriented to prioritise the actors in the system (the respondents to the evaluation or users of the products of the project). This emphasis implied also that we therefore would *not* evaluate all work packages, but focus on the LO production, Demonstration Portal, Brokerage system, and the pilots in schools.

From this first part we then laid out what we saw as the ideal detailed requirements (in second and third parts of the framework), though these

Table 1. Instruments mapped against respondents

Respondents	Instrument
Teacher: users of LOs	Questionnaire (Web-based)
Teacher: developers of LOs	Interviews (Group)
Teacher as developer of LOs	Questionnaire (Web-based in Portal and LCMS/LMS)
Teacher: users of LOs	Interviews (individuals)
Teacher: users of Portal (and LCMS/LMS)	Questionnaire (Web-based)
Teacher: users of Portal (and LCMS/LMS)	User Trails
Teacher: users of Brokerage System	Questionnaires (Web-based in Portal and LCMS/LMS)
Learner: users of LOs	Questionnaire (Web-based in Portal and LCMS/LMS)
Learner: users of LOs	Self Report Log
Local Education officials (e.g., Advisers)	Questionnaire (Web-based?)
Local Education officials (e.g., Advisers)	Interviews
Content Providers as developers/modifiers of LOs	Interviews
Content Providers as developers/modifiers of LOs	Questionnaire (Web-based in Portal and LCMS/LMS)
Content Providers as users of Brokerage system	Interviews
LMS/LCMS operators	Interviews

were inevitably reduced to fit the timing, resources and practicalities of a large-scale project and evaluation.[h] We did not, for example, interview education local authorities, mainly because for most the impact of the use of LOs was invisible to them. Nor did we collect data directly from learners, rather relying on their teachers to report their general reactions, for practical reasons related to amount of data, translation problems and being able to conduct data collection at the time they used the LOs. Table 1 shows the ideal list of respondents and instruments that we had hoped to employ.

THE EVALUATION METHODS

For each of the actual evaluation methods used there will be a brief description of what was involved, including the construction of instruments and data collection processes, given that this was a distributed project working in at least six countries and their respective languages. These methods covered surveys, routine data collection from the Portal, interviews with teachers and others, and experimental and classroom case studies of the use of particular LOs. This will then be followed by a reflection on all the methods and in particular what kinds of questions they helped to answer.

As noted above, the delays in the work plan for the project, and the difficulties of asking otherwise busy project members in each of the pilot countries to help with the translation of instruments, affected the implementation of the evaluation methods. More important, however, was the worry on the part of the pilot country representatives about the load of the evaluation on the teachers who were trying out the use of the LOs. It became clear as the project progressed that many were taking part in the project as an extra duty, with no addition remuneration or lightening of workload. Some of our original assumptions about the roles of individuals (e.g., teachers as producers of LOs) did not materialise and hence some instruments directed specifically at them were dropped. The final instruments employed were:

- Teacher registration questionnaire: background data on teachers.
- Routine data: taken from the Demonstration Portal about LOs and their use by teachers.
- Portal questionnaire: questions directed at the operation and facilities of the Demonstration Portal as experienced by teachers.
- Teacher as user of LOs questionnaire: questions that addressed the use of the LOs including issues of reusability, and curriculum, language and cultural appropriateness.
- "Pop-up" questionnaire: a short questionnaire asking teachers to evaluate a particular LO they had selected.
- Teacher interviews: interviews carried out in schools of teachers using the LOs, and in some cases the ICT coordinator.
- Experimental study: a specific study of particular LOs in various subjects in one country.
- Case studies: of the use of LOs in particular classrooms in the countries using the LOs.

In addition, interviews were conducted with providers (two commercial and one ministry) of LOs, to ascertain their views of the issues surrounding production and the market for LOs. Each of these methods will be briefly discussed before considering how they related to the phases of the system of LO production, distribution and use.

Teacher Registration Questionnaire

This questionnaire was integrated with the Demonstration Portal registration process. Teachers were invited by e-mail to complete the questionnaire and register with the Demonstration Portal. [i] The questionnaire was designed to capture data on teachers' background such as age, gender and teaching experience and their experience of using ICT, which was to help build up a profile of the teachers involved in the CELEBRATE project. We drew on our knowledge of the ICT literature to determine the questions asked.

Routine Data

These data were of two basic types: that related to the LOs, drawing on the metadata; that related to the interactions of the teachers on the Demonstration Portal, indicating their use of the Portal facilities and in particular the LOs. Originally the evaluation team had expected that much of these data would be provided by the Brokerage system, and to that end an extensive specification of requirements was drawn up at four levels:

1. General system requirements defining the principles upon which the data should be collected and recorded. For example: usage records should be gathered from individual LOs; a distinction should be made between when teacher or student uses LOs.
2. Routine data to be collected on the activities in the system. For example: the number of LOs (and their characteristics) held in the repositories; which LOs a particular user selects (and when), downloads, and uses. This would enable reports such as the number of LOs accessed each month by subject, and so forth; number of LOs accessed by teachers and by students; and the designated age range of LOs accessed by students.

3. Specific data to be collected on particular events or objects; in particular when a LO is selected/used, to request teachers evaluate that LO (see *Pop-up questionnaire* below).
4. Specific questions that relate to the activities of particular users, to enable linking the responses to online questionnaires (e.g., “Teacher as user of LOs’ questionnaire”) with the other data collected above; an issue of database linking via user identification (ID).

The heart of the routine data is at Level 2, where the main activities are recorded. We had hoped that we would be able to uniquely identify a user (and hence the type of user) through login details, and relate this to each LO used. But there were serious issues in doing this, most notably that, although we could be sure that a user *chooses* a LO, and even perhaps downloads it, we can be less sure what then happens (i.e., is it “played” by the teacher to see what it is like, or used with students). This was exacerbated by the fact that the system was extremely complex, with users operating in their own local system (mediated by a local network), on the Demonstration Portal, and then requesting information and indeed LOs from the networked repositories. Thus in terms of validity of the data, the issue was more one of clear definitions of the “events” than of the knowing if they were the correct events.

As it turned out the Brokerage team (those constructing the Brokerage system) had quite enough to do implementing their requirements and were unable to respond to the needs of the evaluation, even if in the long term some of the data would have helped to show the effectiveness of the system. It would have also give invaluable information such as what LOs were most used and by whom, which providers could then monitor to “test” the market. When it was clear later on in the project that the Brokerage team were not going to be able to implement this, and indeed that the Demonstration Portal would provide direct access to the LOs by virtue of them being loaded onto it from the repositories, we then tried to influence the Portal team. They were by then at the final stages of their design and could only provide some basic information on usage of LOs, and were quite unable to link within a single database user ID and the various online questionnaires (Level 4 requirements). There seemed to be a lack of appreciation of what was needed for an evaluation that we attributed in part to the different training and concerns of Web designers. But there was also the difficulty of trying to ascertain what particular “clicks” on specific Web pages meant, especially as it was not possible to link this to user ID. It seemed to the evaluation team that there was a missing link in the design concerns of both Brokerage system and Portal designers, particularly in such a project with tight deadlines and funding body evaluations that relate to having working systems as the priority.[j]

Teacher as User of LOs’ Questionnaire

This was an online closed-end response questionnaire, designed to collect teachers’ views and their experiences of using CELEBRATE LOs. No open-ended questions were included to avoid either a large translation problem (with central analysis) or local analyses with the corresponding reliability issues. The questionnaires were piloted in English and then translated into each local language.

The questionnaire covered the:

- Experience of using LOs in general;
- Reactions to the quality of design and content of CELEBRATE LOs;
- Use of LOs in teaching and learning;
- Issues of language and culture (i.e., whether LOs fitted with their local context[k]).

Validity was addressed first by using the hypothesis and the framework of questions derived from it, and by involving the whole project team in considering the various versions of the questionnaire. The reliability depended not only on how well the whole user population was represented by the sample responding, but also on the numbers in each country. Tests were carried out on the overall representativeness of the sample against the population background data (from the registration questionnaire), and indicated no problems. However, the large differences in the numbers of teachers participating in the project across the various countries made it difficult to make many claims about country differences.

Teachers were invited by e-mail to complete the questionnaire when the Demonstration Portal record suggested that they had been registered with the Demonstration Portal for more than three weeks and well into the pilot period for use of LOs. Responses to the questionnaires were coded and analysed through the use of SPSS V11.5 (*Statistical Package for the Social Science*). These data were related to the registration data, though there were issues about correspondence of the two databases via the ID, resulting in considerable effort to clean up the data.

"Pop-Up" Questionnaire

This was a very short structured online questionnaire. It aimed to collect teacher feedback on specific LOs they selected and/or saved in their "basket" on the Demonstration Portal. The six questions on the questionnaire repeated some of those used in the questionnaire related to teaching and learning (Teacher as user of LOs), but of course answered specifically for a particular LO (not in general terms). Originally we wanted them to be directly associated with the LO so as to "pop-up" when the teacher downloaded the LO. As noted with regard to the "routine data," this is not a simple event, and could not be implemented. We thus resorted to collecting data for each user about the LOs they had selected in their baskets by e-mailing users at regular intervals with a list of the LOs chosen, asking them to evaluate them (each LO given a Web link to a pop-up questionnaire). This proved useful and we were able to determine if teachers had used a LO in the classroom (one of the six questions) as sufficient time had elapsed between the selection and when they were asked to evaluate the LO. Nevertheless the time delay from selection and use of the LO to the evaluation, and the fact that it required an initiative on the part of the user, reduced the likely reliability of these data. This is not a problem that can easily be overcome, whatever technical solution is adopted.

The Portal also provided a facility for users to evaluate each LO as they selected it (giving ratings and comments), much the same as is done with "customer reviews" on the *Amazon* Web site. However, this facility was rarely used by teachers despite its potential to guide both users and providers on the effectiveness and use of LOs. This was in part because the period of use was relatively short within the project and the Portal had not become the area to share experience and expertise as we had hoped. (The user ratings displayed with any LO that a user had searched for were intended to be part of this sharing of expertise.)

Portal Questionnaire

The aim of this questionnaire was to collect teachers' opinions and experiences of using the CELEBRATE Demonstration Portal. It covered the following issues:

- Experience of using Demonstration Portal in general;
- Functionality of Demonstration Portal;
- Professional usefulness and training in the use of the Portal.

The questionnaire was originally constructed in English, and piloted with some project teachers in two workshops. Then each pilot country coordinator organised the translation of the revised version from English to their local language. Responses to the questionnaires were coded and analysed through the use of SPSS V11.5. The validity and reliability issues were much the same as for the "teacher as user" questionnaire.

Teacher Interviews

Design of what we termed the "interview studies" was discussed at a project meeting with the coordinators of the six pilot countries, who implemented the data collection for these studies. A semistructured interview schedule and instructions for the conduct of the studies were discussed and agreed at this meeting. The schedule covered the areas listed under Teacher questionnaire (above) and in addition included the background of the interviewees and their schools, what they thought of the Demonstration Portal, and training and support issues in relation to LOs. The interviews aimed to give us some insight into teachers' views and experience of using the CELBREATE LOs and Demonstration Portal, to elaborate and give reasons for the more general questionnaire responses. Also the intention was to explore school issues (through questions to the headteacher and the ICT coordinator), rather than just those of individual teachers. However, in the event such issues were not apparent because only one or two teachers in a school were using the LOs, and there were few associated school issues (e.g., impact on the school network). At the end of the pilot period an analysis meeting was held in London, with most of the pilot coordinators and some of the evaluation team, to work through samples of the data and agree on the analysis and write-up of reports from each pilot country (Israel was involved separately by telephone). The authors of the reports for each country were not all professional researchers, some were from engineering backgrounds and ministries of education, and the researchers in the evaluation team at one of the universities combined the reports of the various countries. The different data collecting conditions were kept consistent through the use of the standard schedule (yet responsive to local context) and the analysis through the discussions prior to it being carried out. This maximised validity and reliability, but in the end the evaluation team could not check this because of the language difficulties preventing access to the "raw" data.

Experimental Studies

The aim of the experimental studies was to examine whether or not LOs could enhance student learning outcomes in different pedagogical settings and with different types of LOs. This element was added later in the project in response to an EC interim review of the evaluation strategy. This review reflected the developing trend to "what works" studies discussed under *Approaches to evaluation*, and we felt obliged to introduce this experimental element. In order to test the effectiveness, three independent experimental studies, with different kinds of structuring and pedagogical approaches were conducted in Finland (see Chapter XXV and Nurmi & Jaakkola, 2006). In all these studies the participants were from the same sample. In the first study students were learning aspects of the Finnish language in two different learning environments: with "Drill and practice" LOs and with traditional textbook assignments. In the second study the experimental design was the same, but students were learning mathematics, namely fractions and mixed numbers. In the third study, three groups were learning simple electrics. The first of these three groups was working with traditional hands-on laboratory activities (e.g., batteries and bulbs); the second group used an electricity simulation LO, and the third group used a combination of both of these methods (laboratory work and simulation LO). In order to compare learning outcomes between the conditions, each study administered pretest and post-tests measuring subject knowledge matched to the tasks and what was known about common misunderstandings in the areas (in mathematics and science these are well known). Student answers were scored against model answer templates to maximise reliability. Results were analysed through statistical and qualitative analyses, the latter including observational data collected during the experiments.

Case Studies

These were conducted in four of the pilot countries plus Ireland (added to strengthen the range), altogether 13 studies being undertaken. The data collected from the case studies included the following (see Ilomäki, Lakkala, & Paavola, 2006):

- Background information of the school and the setting. These data were gathered by questionnaire.
- The participating teachers' "agendas" based on short interviews with them before and after the observed lessons.
- Observation notes and video recording of the classroom activities.
- Informal discussions with the students during the classroom activities.
- Notes of discussions with the teacher.
- Written/discussed evaluation of the teaching and learning sequence by the teacher.
- Other informal data, for example, e-mails from the teacher, notes of the informal preparatory meetings.

The amount of observation for each study varied to reflect the nature of the classroom activity (some lasted several weeks, others one lesson). In the Finnish case studies, the "case" consisted of a larger working sequence or a pedagogical unit: one teacher and his/her students conducted one teaching and learning sequence, which concentrated on a topic or theme and which had a definite goal. The study examined the whole sequence, including the use of the LOs. The French cases consisted of one to four lessons. The three Hungarian case studies consisted of cases of different length: a collection of observations of special days which was organized around LOs, a longer period of which four lessons were observed and one case of two lessons. Both the Irish and English case studies consisted of one lesson during which the LO were used.

The field work in Finland and England was undertaken by members of the evaluation team, but in Hungary and France, local researchers were recruited. Each country worked to a standard written brief (an elaboration of the above list along with methodological issues), although the case studies produced were varied, reflecting researcher and classrooms differences, and the particular LOs and resulting activity the teachers and students worked through. This made a "cross-country" analysis less powerful than simply treating each study (or group of studies from a country) as an individual case. The validity of the studies was based on how well these cases represented the reality in schools. The cases give a rich picture of classroom life; however, they concentrated on schools and teachers that were experts in the pedagogical use of ICT, or at least interested in developing such expertise. From that point of view these cases represent active, technology-interested schools and teachers, and are not representative of teachers more generally. Although each case is unique, and not withstanding the reservations about the cross-country analysis, they share several common features related to the use of technology and LOs from which general lessons could be drawn.

Reflection on Methods Chosen

Looking over the methods, it is evident that they follow the multimethod approach discussed earlier, though not without difficulties of implementation. The use of routine data offers unprecedented quality and detail to answer "what" questions, namely what system users do. Although the teacher questionnaire can give parallel information, it suffers from it being reported data, and that it requires the teachers to generalise about their behaviour. However, apart from the implementation problems noted above, there remains difficulties of quantity of data, its apparent meaning, and the time range upon which it is based. On this latter point, our data on the most used LOs indicates that even over a matter of months there is little data on any one LO and on many no data at all. Such routine data requires clear definition, efficient collection and summarising (without losing the link to individuals through aggregation prior to reporting by the system) and a continuous supply over time so that sufficient data are collected for any one LO, and trends, to become evident. Questionnaires (registration, portal and LO use) are still important to gauge user attitudes and values, and through user IDs to link them to actual use, but this requires careful initial design not just of the evaluation but the system for LO distribution and use. Had we been able to link the questionnaires and routine data, we would also have been able to check the reliability of the questionnaire reports of teacher behaviour.

Obtaining specific information on LOs through questionnaires, where all LOs are listed and users asked to evaluate those used (as we attempted in the "pop-up" questionnaires), is more difficult as usage of any one LO is low (the top 10 having between 20-44 selections; see Chapter XXV, Table 1), with data that can hence be unreliable. Again a longer time of use is required to improve this. Also it is essential to have any evaluation at a time close to when the LO is used, hence an e-mail request was a poor second to a "pop-up" mechanism, though as noted earlier there are no simple technical solutions. Leaving it to the user to take the initiative (as in *Amazon*-like reviews) will also reduce reliability. Little of this questionnaire data gives sufficient details of what teachers do with LOs and hence the "how" questions are not easily answered, although the teacher questionnaire does give some information. To elaborate these "how" questions, and more importantly to get to "why" questions, teacher interviews and case studies are essential. Questionnaires do not allow contexts to be taken into account, nor to explain the reasons for views given in a questionnaire. The teacher interviews potentially gave a way of combining a standard set of questions with an openness to issues not predetermined. (I have pointed out the impracticality of open-ended questions in the questionnaire from the point of view of language variations and quantity of data.) The interviews also offered access to contextual issues, which questionnaires could not deal with, though again I have already noted the problem of the lack of school issues.

The case studies offer the richest set of data in terms of their explanatory power, as they can explore the contextual issues and a range of factors for which we may not have predicted. But they are only snapshots of particular LOs, country settings, schools and classrooms, and so forth. Their power, as with all case studies, is to build on theory to explain the issues through rich accounts. They also depend upon consistent researcher methodological understanding and performance. Although a proforma was used for the data collected and protocols in the classroom, the consistency of types of researchers would require a level of funding that few projects will devote to evaluation activities (as opposed to specific research, as in the OECD study discussed earlier).

The experimental studies offered another kind of exploratory approach that is able to give information on the effectiveness of the LOs ("what works"), though they have to include data on the process of use (observational data parallel to the case studies) to explain *why* outcomes are more effective (or not) in different conditions of the use of LOs. This way the explanatory power was improved, and it resonated with the other data sources, in telling us how impact depended not on the pedagogy within the LO, but upon that "created around it" by the teacher. As with the case studies, there is a sampling issue of the various dimensions that will be relevant (e.g., only one country was involved), and most important of all, only a limited number of LOs were studied and upon which some evaluation of effectiveness can be obtained. Even here it is important to draw on other studies (e.g., in this case of simulations) to aid the design of the experiment and the interpretation of the results. This implies some strategic decisions about a selection of main types of LOs being used (based on say routine data), which could then be subjected to a specific experimental study. Although the response to EC in adding an experimental study could perhaps be seen as tokenism (given the limitation of types of LOs and choice of context that could be evaluated), we were trying to take into account the requirements of a major stakeholder!

There was no doubt strength in this multiple-method approach as it was possible to triangulate both data and interpretations in the final evaluation report. We could be confident in our response to the hypothesis when such triangulation existed and where it was absent we had to be cautious (e.g., in relation to cross-country comparisons).

LO SYSTEM CONSIDERATIONS

We now turn to some of the considerations for the evaluation that derive not from the methods of data collection, but from the need to evaluate particular stages of the LO system of production, distribution, and use.

Production of LOs

The data sources for this were routine data from the Portal on the LOs, along with interviews with the producers. A prime concern was to know if enough LOs could be produced in the subjects and languages required, to satisfy the creation of a market and ascertain if providers had implemented approaches to learning that reflected contemporary views of learning. The analysis of the metadata of the LOs in the Portal answered some of these concerns. However, the problems with providers "incorrectly" entering "LO type" (reflecting its pedagogy), age-range, or subject, limited the power of these data. Some of these data were usefully compared with the data on use of LOs (e.g., comparing the most common available LO types with those most often chosen). The interviews of producers revealed that the commercial and ministry providers had different concerns; for example, the former wanted to test a "market" in LOs and the latter wanted to know what a critical mass of LOs might be, and also if there were any innovative or "niche" LOs (e.g., for special needs). This meant that the focus for the evaluation was quite different for each.

Provider interviews revealed market issues concerning intellectual property rights, though the sample was too small to be sure that the various sizes and nature of the providers were adequately covered. For example, we were not able to arrange an interview with the one provider who had a commercial virtual learning environment (VLE), and who was concerned, not only with this kind of environment, but with teachers and students constructing their own LOs from templates.

We were also able to carry out an "intrinsic analysis" of some LOs to ascertain the extent to which they were constructivist.[l] Naturally this was limited to particular LOs, and we chose them based on data on use (see below). This kind of analysis was also carried out on some of the LOs that featured in the case studies, focusing on features of constructivist pedagogy, and examining the way in which these features were built upon by the teacher or the way the LO prevented or reduced the scope for teachers to implement constructivist pedagogy (affordances[m]): for example, the way in which a "drill and practice" LO might limit the teacher's pedagogy. Although these analyses were helpful to providers after the evaluation, they only provide general lessons and were not systematic and extensive in their coverage to even cover the major genre or types of LOs.

Distribution of LOs

The routine data collected from the Portal gave descriptive information on the LOs searched and chosen, thus it was possible to say which were the most "popular" (see Chapter XXV, Table 1); partly a "use" issue and partly one that indicated *what* was being "distributed." The online Portal questionnaire asked about the search facilities, access to the LOs and other services offered (e.g., a discussion forum, template authoring and pedagogical guidance), and was combined with data from the teacher interviews, some of whom talked about the Portal particularly within the context of the face-to-face training that they may have attended. Views of the Portal during this trial period varied and it was evident from the interviews that those who had started work early in the pilot period, when the Portal was still not stable, commented on quite a different provision than those who did so at a much later date. Inevitably there were the equivocal data on the Portal design where the low-key, minimalist, design was no doubt being compared with the "busy" designs of other educational Web sites. While the questionnaire data indicated general approaches and views of the use of the Portal, and the process of choosing LOs, it was the interviews that revealed how the Portal was understood. In particular, the issue of seeing the Portal not just as a "facility to find LOs," but one through which students were given access to LOs (see the Chapter XXV discussion of the Portal as a VLE).

Selection and Use of LOs

This is where the bulk of the data were collected. The routine data collection enabled us to see which LOs were chosen by teachers, at least in terms of the most popular. However as noted earlier, the large number of LOs available (over 1400), and the relatively short time they were available for use, meant that even with several hundred users the most popular only attracted 44 selections, and the "pop-up" evaluation of particular LOs chosen gave relatively limited sample sizes (maximum 18). The online questionnaire survey was more robust with some 400 respondents, but this gave only teachers' general views on LOs and the practical, technical and pedagogic issues. These views were important in answering some of the basic questions about whether teachers were interested in LOs at all, but of course such general judgements suffer exactly from the critique of Wouter van Joolingen, discussed earlier. Each respondent to the 'teacher as user questionnaire' was responding to a unique set of LOs that they selected, and hence any general judgements are not comparing like with like (from one teacher to another). Nevertheless the data did give sensible findings, and we were usually able to triangulate the questionnaire data with the interviews and classroom case studies.

Our cross analysis of data from the registration questionnaire with the "teacher as user questionnaire" data revealed two important findings. First that the level of ICT skill was a statistically significant factor in predicting how teachers responded to the use of LOs, and secondly that there were apparent differences in some aspects of use according to the teacher's country. Unfortunately the skewing of the users towards one country (42% were Finnish) meant that we could not show statistical significance. Again, interviews provided triangulation for many of our conclusions on these differences. Despite these limitations we were able to provide evidence to examine the elements of the hypothesis to the various conditions, and for whom, teachers used LOs (d (i)-(iv) above).

The detailed studies of particular classrooms, both through experimental and qualitative classroom studies, enabled a rich picture of use of LOs. Both types of studies provided views on particular LOs, but they allowed us to make some important analytic generalisations (Yin, 2003) about the nature of LO use. For example: the importance of context in determining the pedagogy and the effectiveness of the LOs; the conditions under which teachers could respond to the affordances of LOs.

The questionnaire data were much less prone to bias from language and cultural differences than either the interview or qualitative classroom case studies. Although we defined how the interviews and case studies were to be undertaken, the actual conditions and choice of samples was opportunistic and lacking in consistency across the countries. Nevertheless these very differences allowed us to deal authentically with the different languages, curricula and educational systems. As already noted, triangulation was used to minimise bias in our interpretations, and we were suitably cautious in reporting findings that were dependant on only one source. While we may have limited confidence in some of our findings, we reported them as issues for further investigation, given the relative lack of empirical studies that exist.

ANALYSES CROSS-COUNTRY

We assumed that, provided the translation of questionnaire items was accurate, the quantitative analyses were free from any bias, although we have already noted bias in the teacher sample. We did not have any chance to carry out trials of the translated versions and, in any case, without a multilingual evaluation team, we would always be working "second hand," as it were. There seems to be no easy way of avoiding this unless the evaluation team is made up of members from each language group and that they are intimately involved in the questionnaire design; conditions which require considerable resources.

I have already made the point about our efforts to reduce bias in the qualitative data collection (interviews and qualitative classroom studies), through the specification of the data collection types and procedures. But there were still sources of bias in the analyses carried out separately by each country. In the case of the interviews, we were able to organise a session to help standardise the analysis, including sets of heading under which to report. However, differences still emerged. The most graphic difference was in the way evidence was cited. For example, here are two contrasting examples from different countries:

It is conspicuous by the analysis of the answers, that everybody's opinion—without any exceptions!—was positive about the effect of the use of LOs. They think that, through using LOs, they can hold their students' attention more successfully and they can persuade them easily into individual work and thinking. It is also important that, according to teachers' opinion, not only higher motivation level of students in and outside of the class could be observed, but also significant improvement of exam grades.

The enthusiasm of the students has had a great influence on the working environment. In two teachers' opinion, it was difficult to evaluate the influence of the LOs on learning, however, they also find that the use of LOs brings pleasant variety into the teaching practices, and they have been able to observe how even the poorer students have begun to make an effort in their learning.

The first tries to aggregate the data across an unknown number of teachers, the second identifies the number.

For qualitative classroom studies the issue was the different kinds of data collected resulting in different interpretations. But some differences in interpretation also resulted from particular theoretical orientations of the local researcher, some of which coincided with the evaluation team (e.g., socio-cultural theory), and some which did not. There was no possibility to enter into a process of either joint analysis or discussion of individual analyses, partly because of the cost of doing this, and partly because of the lack of time to build in such a stage. Inevitably case studies are more complex and the data take longer to collect, and are more difficult to analyse and report. For most of these studies there was also an added translation of the report from the local language, adding yet further time. As noted earlier, the case studies showed the complexities and inter-relations of issues and conditions in the use of LOs, and we were still able to draw out some general issues, by way of analytic generalisation.

REPORTING

A single report was constructed that dealt with the initial hypothesis and covered all the stages in the production, distribution and use of LOs. Through this hypothesis we were thus addressing the various stakeholders, but there was inevitably a problem of whether they would all find it comprehensible or accessible. In particular at 202 pages, it was hardly an attractive proposition to read, which we could only ameliorate by dedicating quite specific chapters to some of the stakeholders (e.g., production for software manufacturers and ministries). We certainly did not try to achieve "best seller" status, as MacDonald (1997) advocates for democratic evaluations! Mindful of the particular need of LO producers, for advice on LO design to enable constructivist pedagogy, we included an appendix in the report that analysed some of the LOs and how they could be given more affordances. There are also plans to produce booklets for producers and for teachers in schools.

ISSUES

Can we thus evaluate LOs and if so what can we say? The answer to the first question is both "yes" and "no." "Yes" in as much as we investigated the system of production, distribution and use, in the kinds of way our EARLI discussant required. Indeed we were able to show that such a system can be constructed and that it was largely successful. There were worries about whether a LO economy and hence a market could exist, especially across Europe, and a relatively short-term project and associated evaluation was not the best situation to examine this. I argued earlier that the routine data, especially seen over the longer term, where trends could be examined, would give the most robust data to answer this question. This also raises the issue of whether a summative evaluation is desirable, not only for the market concern, but for the whole system. The EC interim review of the evaluation indicated that they wanted to see a more formative approach to the evaluation, so that we could feed back into the project some of the findings of use of LOs. But, neither the evaluation design, nor the timescale of the pilots, would allow this. More informal means through country coordinators were used for the formative evaluation, especially with regard to the Portal functionality. Even here, though, the best evaluation would have been from routine data. For example, the Portal design team tended to respond to particular problems that were reported by the coordinators, as they did not have the resources to staff a helpline in all the languages of the project. Not only might this helpline have enabled more accurate assessment of the problem, but could established how general or specific problems were.

In answering "No" to the question of whether LOs can be evaluated, even given that a system was being considered, it has to be recognised that this system is still a particular model of distribution and use. It is not possible to generalise about other models, each of which would need evaluation. Defining a set of system characteristics, as suggested earlier, might be one way of building up evidence on the effectiveness of them, but this is not something discussed in the literature on LOs. The special feature of CELEBRATE was its international dimension, again one that is not usually of any concern in the literature, even though many education systems in the world are considering the use of repositories and want to learn and benefit from the development of LOs elsewhere.

We also have to answer “No” in that, although we can say something about a particular “genre” of LOs (e.g., science simulations), we cannot say much about others. As one of a first set of studies providing empirical evidence on the use of LOs, it might be acceptable to give general answers to what teachers think about LOs (albeit substantiated by quite specific evidence). However, future studies will need to look at a variety of genre and types of LOs. Even here the system of distribution and context of use will need to be defined in ways that enable generalisation. For example, the fact that CELEBRATE was aimed at classroom teachers, who used a mixed classroom and virtual environment with the LOs, gives quite a different context than say their use in a VLE.

In as much as we can try to say anything about LOs as objects, this again takes us back to the need to use routine data. These can be accompanied by special studies where a particular genre of LOs, or particularly innovative ones, are investigated using both outcome (i.e., experimental) and process (i.e., qualitative classroom) studies.

REFERENCES

Department of Education (DoE). (2002). Strategic Plan 2002-2007. Washington DC, DoE. Retrieved March 26, 2008, from http://www.ed.gov/about/reports/strat/plan2002-07/index.html

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Hamilton, D., Jenkins, D., King, C., MacDonald, B., & Parlett, M. (1977). *Beyond the numbers game*. London: Macmillan Educational.

Ilomäki, L., Lakkala, M., & Paavola, S. (2005, August 23-27). *Virtual learning objects in advanced pedagogical settings*. Paper to be presented at the EARLI 11th Biannual Conference, Cyprus.

Ilomäki, L., Lakkala, M., & Paavola, S. (2006). Learning objects in authentic pedagogical settings. *Learning, Media & Technology, 31*(3), 249-267.

Jaakkola, T., & Nurmi, S. (2005, August 23-27). *Exploring the basics of electricity - can online electricity simulation enhance learning?* Paper to be presented at the EARLI 11th Biannual Conference, Cyprus.

MacDonald, B. (1977). A political classification of evaluation studies. In D. Hamilton et al. (Eds.), *Beyond the numbers game* (pp. 224-227). Basingstoke and London: Macmillan Education.

McCormick, R. (2003, November 9-10). *Reliable evidence for policy making in complex situations.* Presentation to Expert Meeting of International and National Education NeTworks (EMINENT), Geneva.

McCormick, R., & Li, N. (2005, August 23-27). *An evaluation of LOs in use: An overview of the CELEBRATE evaluation findings.* Paper to be presented at the EARLI 11th biannual conference, Cyprus.

McGreal, R. (2004). Learning objects: A practical definition. *International Journal of Instructional Technology and Distance Learning, 1*(9), 21-31.

MENON Multimedia Education. (2001). *VALNET validation framework: Methodological proposal* (Version. 1.0). Retrieved March 26, 2008, from http://www.eun.org/insight-pdf/valnet/ValNet_Validation_Framework_final.doc

Nurmi, S., & Jaakkola, T. (2006). Effectiveness of learning objects in various instructional settings. *Learning, Media & Technology, 31*(3), 233-247.

Parlett, M., & Hamilton, D. (1972). Evaluation as illumination: A new approach to the study of innovatory programmes. Occasional Paper 9.

Edinburgh: Centre for Research in the Educational Sciences, University of Edinburgh. (Reprinted in Hamilton et al., 1997, pp. 6-22)

Stake, R. (1967). The countenance of educational evaluation. *Teachers' College Record*, *68*(7), 523-540.

Venezky, R. L., & Davis, C. (2001). *Quo vademus? The transformation of schooling in a networked world* (Unpublished research report). Organization for Economic Cooperation and Development/ Centre for Educational Research and Innovation. Retrieved March 26, 2008, from http://www.oecd.org/dataoecd/48/20/2073054.pdf

Yin, R. K. (2003). *Case study research: Design and methods.* Thousand Oaks, CA: Sage Publications.

KEY TERMS

Adaptability: The condition for a learning object that will adapt to the learner's needs.

Bureaucratic Evaluation: An evaluation approach that seeks to serve the needs of those who control education and which accepts their values and helps them accomplish their policy objectives. The methods must be credible to them and not leave them open to public criticism.

Democratic Evaluation: An approach to evaluation that provides information to the community about an educational programme, adopting a pluralistic approach and serving all the stakeholders in the programme.

Experimental Approach to Evaluation: An approach that requires an experimental group of respondents to receive a treatment (e.g., a new approach to teaching) and to be compared to a control group (who are subjected to traditional treatment). Ideally individuals should be randomly assigned to the experimental or control groups, or that the two groups are matched on significant variables (e.g., prior attainment).

Illuminative Evaluation: An approach to evaluation that seeks to illuminate the conditions of an educational programme mainly through a qualitative evaluation approach (e.g., ethnography).

Interoperability: The condition for a learning object to operate in any technical environment.

Learning Object: Any entity, digital or non-digital, that can be used or re-used or referenced during technology-supported learning.

Metadata: Data used to describe a learning object in ways that a computer or computer system can read and work with.

Modifiability: The condition for a learning object that a teacher can alter some its features to suit his or her situation.

Reusability: The condition for a learning object to used by any teacher in any context.

Routine Data: Data that is collected automatically by a learning object distribution system.

ENDNOTES

[a] I would like to acknowledge the contribution of the whole evaluation team on CELEBRATE: Carmel Clifford, Liisa Ilomäki, Tomi Jaakkola, Minna Lakkala, Nai Li, Sami Nurmi, and Peter Scrimshaw. Also the ministry and university staff who were responsible for the pilots in the various countries (Finland, France, Israel, Hungary, and Norway), who translated instruments and collected and analysed data for the school interviews.

[b] Details are given at http://celebrate.eun.org/eun.org2/eun/en/index_celebrate.cfm (accessed 2 July 2007).

[c] This is part of an IEEE standard: http://ltsc.ieee.org/wg12/ (accessed 2 July 2007). See McGreal (2004) for a range of definitions.

[d] Indeed the complete evaluation of CELEBRATE (*Final Evaluation Report (D7.2)*; see note (b), which did try to do this.

[e] Indeed they created a "what works" Web site where such evidence could be accessed by teachers and the like (http://www.whatworks.ed.gov/ checked 2 July 2007).

[f] We undertook a mapping exercise of our respondents and instruments against the ValNet framework.

[g] One partner in the evaluation team had carried out one of the country case studies in the OECD project.

[h] For example, the producers were slow to produce LOs and the Brokerage system was not ready in time, thus limiting the time teachers in schools could use the LOs, reducing in turn the number of evaluation instruments to which we could expect teachers to respond.

[i] A variety of methods were employed across the pilot countries to recruit the teachers and coordinators submitted their e-mail addresses to the central system.

[j] We have come across parallel problems in other projects where Web-based systems have very crude data collection, without adequate ability to relate data to users. This may also be because these data systems are provided by database companies who themselves are not using the data and who then only provide aggregate data, which are too crude to be anything other than a general indication of activity.

[k] For example, a LO on nutrition gave a menu of food types that might not be found in all countries.

[l] Such an analysis considers the nature of the activities and interactions with the students and what this implies about the view of learning and knowledge, the roles of the teacher, learner and LO, and the assessment (i.e., the pedagogy), in contrast to an analysis of empirical data about what students and teachers do and their views on this activity (see Stake, 1967).

[m] The concept of "affordances" is taken from Gibson (1979), and refers to the ways in which LOs enable the teacher to realise their pedagogy. Thus, a "drill and practice" LO is likely not to give a teacher the affordances related to her pedagogy where she is trying to encourage open questions. On the other hand, an information giving LO, which allows different routes through the material, can be undermined (i.e., the affordance may not be used) by a teacher who gives students a sequential series of factual questions. See Ilomäki et al. (2006) for a discussion of this concept.

Chapter XXVIII
Collaborative Argumentation in Learning Resource Evaluation

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ABSTRACT

The Learning Object Review Instrument (LORI) is an evaluation framework designed to support collaborative critique of multimedia learning resources. In this chapter, the interactions among reviewers using LORI are framed as a form of collaborative argumentation. Research on collaborative evaluation of learning resources has found that reviewers' quality ratings tend to converge as a result of their interactions. Also, novice instructional designers have reported that collaborative evaluation is valuable preparation for undertaking resource design projects. The authors reason that collaborative evaluation is effective as a professional development method to the degree that it sustains argumentation about the application of evidence-based design principles.

COLLABORATIVE ARGUMENTATION IN LEARNING RESOURCE EVALUATION AND DESIGN

There are several reasons why producing high quality multimedia learning resources is challenging. Many types of media, media features, and design models are available to resource developers, yet there are few standards that can guide selecting them. Relevant research on multimedia learning has expanded, yet many developers are unaware of its full scope and value. Personnel are available who specialize in media development, instructional design, usability design, subject knowledge, and teaching, yet they are rarely coordinated so that that their expertise can be effectively brought to bear. Learners usually have opinions about the resources they use, yet their opinions are rarely heard by developers.

The challenge is seen most clearly when design decisions are informed by conflicting recommendations from different specializations. Decisions about text layout are a case in point. Psychologists and educational researchers who have studied readers using computer screens to read text with a fixed number of alphabetic characters per line have observed that more characters per line (possibly up to 100) may be optimal for rapid reading, but that as few as 40 or 50 characters per line may be optimal for reading comfort and comprehension (Dyson, 2004). Ling and van Schaik (2006, p. 403) concluded that "longer line lengths should be used when information is presented that needs to be scanned quickly…. [and] shorter line lengths should be used when text is to be read more thoroughly, rather than skimmed." Specialists familiar with this research who are designing the text components of a resource to be used for a defined learning activity might choose a fixed line length of, say, 70 characters. On the other hand, many Web developers advocate a "liquid design" for Web pages in which the number of characters per line varies according to the width of the browser window, character size, and presence of images (Weiss, 2006). They argue that readers can resize the browser window to the optimal width for normal reading, or to a much wider width that minimizes scrolling when scanning through a large document. Because neither fixed nor liquid approaches to line length is likely to be the best choice in all design situations, an analysis of how specific circumstances play into the decision seems necessary, and that process requires knowledge of both the fixed length and flexible length strategies. Finding the best design solutions and evaluating existing designs requires an exchange of specialist knowledge in relation to situated learner needs. The nature and requirements of this exchange are the concern of the present chapter.

Any approach to ensuring quality in learning objects that is built around rigid standards for technologies or implementation will quickly become obsolete. Instead, what is needed is a system for evaluating learning objects that applies design principles, recognizes that the best way to operationalize these principles will change from context to context, and has a mechanism for continued interpretation and clarification of how these principles relate to specific learning objects. We maintain that continued interpretation of quality standards requires reasoned discussion or argumentation among learning object stakeholders—media developers, instructional designers, instructors, students, and so on—and that this argumentation can also serve as a form of professional development for the stakeholders. Such dialogue provides the opportunity for professionals and students to test their ideas and see the views of other stakeholders who may be approaching the same object from different professional perspectives.

The purpose of this chapter is to present theory and evidence that collaborative argumentation can be a powerful method for the design and evaluation of multimedia learning resources. We describe how a model of collaborative argumentation that we have developed, convergent participation, has been used to evaluate learning resources and provide professional development for learning resource designers. Before taking up this main theme we introduce an instrument for evaluating multimedia learning resources that offers substantive guidance to collaborating reviewers.

LORI: AN EVALUATION FRAMEWORK

The Learning Object Review Instrument (LORI) is an evaluation framework for multimedia learning resources (Nesbit, Belfer, & Leacock, 2004). Individual LORI reviews of a learning object are published as Web pages on the E-Learning Research and Assessment (eLera) Web site (http://www.elera.net). The reviews for an object can be aggregated, allowing users to search for objects by quality ratings. Table 1 provides an overview of the nine items in LORI.

LORI has been designed as a heuristic evaluation tool. As such, it does not contain exhaustive detailed checklists and does not address every possible eventuality in learning object design. Rather, LORI identifies nine critical dimensions of quality, spanning pedagogical concerns, technological issues, and user experience factors (Leacock & Nesbit, 2007). Evaluators provide ratings for each item on a 1 to 5 scale, and may also include additional text comments on each item. The LORI Manual (Nesbit, Belfer et al., 2004) provides more detailed information on how to interpret each of the nine items, including more detailed descriptions and examples of factors that might lead one to assign a learning object a one, a three, or a five on a given item (see Figure 1 for an example). Evaluators also have access to this information when conducting online reviews on the eLera Web site.

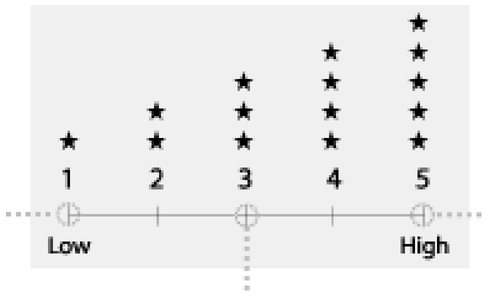
Most learning object evaluation rubrics are designed for use by teachers and focus on content, pedagogy, and usability. For example, the evaluation rubrics used by MERLOT (n.d.) and CLOE (n.d.) advise users to consider quality of content, potential effectiveness as a teaching tool, and ease of use. Australia's The Learning Federation (n.d.) asks users to "evaluate learning objects for educational soundness, functionality, instructional design and the overall fit to the educational purpose for which they were designed." Europe's ELEONET (n.d.), on the other hand, emphasizes a different area of quality evaluation. It evaluates technical aspects of learning objects, specifically, the metadata used to describe objects registered in a repository. LORI addresses all these areas of quality and others we believe are important.

Table 1. Items in LORI 1.5

Item	Brief Description
Content quality	Veracity, accuracy, balanced presentation of ideas, and appropriate level of detail
Learning goal alignment	Alignment among learning goals, activities, assessments, and learner characteristics
Feedback and adaptation	Adaptive content or feedback driven by differential learner input or learner modeling
Motivation	Ability to motivate and interest an identified population of learners
Presentation design	Design of visual and auditory information for enhanced learning and efficient mental processing
Interaction usability	Ease of navigation, predictability of the user interface, and the quality of the interface help features
Accessibility	Design of controls and presentation formats to accommodate disabled and mobile learners
Reusability	Ability to use in varying learning contexts and with learners from different backgrounds
Standards compliance	Adherence to international technical standards and specifications

Figure 1. An excerpt from the LORI content quality rubric

Content Quality



Low
One of the following characteristics renders the learning object unusable:

- Content is inaccurate
- Content is presented with biases or omissions
- Level of detail is not appropriate
- Presentations do not emphasize key points & significant ideas
- Cultural or ethnic differences are not represented in a balanced manner

High
The content is free of error and presented without biases or omissions that could mislead learners. Claims are supported by evidence or logical argument. Presentations emphasize key points and significant ideas with an appropriate level of detail. Differences among cultural and ethnic groups are represented in a balanced and sensitive manner.

The nine LORI items broadly and concisely deal with key features of learning object quality. Because most learning object evaluators are not hired specifically to conduct reviews or formally trained in the broad range of quality issues, LORI cues reviewers to important areas of consideration. The current version of LORI has been informed by literature reviews and feedback from users in learning object quality studies and in professional development workshops for teachers and other stakeholders (Leacock, Richards, & Nesbit, 2004; Vargo, Nesbit, Belfer, & Archambault, 2003).

The first two items in LORI, content quality and learning goal alignment, are equally applicable to printed instructional materials and electronic resources. Content quality is usually emphasized in learning object evaluation instruments, and is often given high priority by teachers. Sanger and Greenbowe (1999) and Dall'Alba et al. (1993) showed the negative impact that biases and errors in traditional textbook content can have on student understanding. In the domain of digital learning resources, where there is less regulation of content validity, reliability, and credibility (Hill & Hannafin, 2001), there may be even greater cause for concern about content quality. Goal alignment is a second feature that may be more neglected in multimedia resources than print textbooks. We believe that learning resource designers and evaluators should be aware of the benefits of close alignment across learning goals, learning activities, and assessments (e.g., Cohen, 1987).

The next three items—feedback and adaptation, motivation, and presentation design—focus on established areas of instructional design. The feedback and adaptation item asks whether the object tailors the learning environment to the individual learner's characteristics and needs and provides feedback that is dependent on the learner's input. Feedback and adaptation has long been understood by instructional designers as an important goal for educational technology, whether manifested as simple knowledge of results on quiz items, or as adaptation of the learning environment to a sophisticated model of the learner (Park, 1996). The motivation item asks whether the object encourages learners to invest effort in working with and learning from the object. This item encourages raters to distinguish between objects that attempt to motivate by superficial complexity (Squires & Preece, 1999), such as flashing graphics, and those that engage learners existing interests and develop new ones. The presentation design item asks whether the object communicates information clearly. It draws evidence-based principles from the field of multimedia learning (Mayer & Moreno, 2003; Parrish, 2004) and established conventions for multimedia design (e.g., Pearson & van Schaik, 2003). The presentation design item also references established stylistic conventions for clearly and concisely communicating information through graphical displays (Tufte, 1997) and writing (Strunk, Osgood, & Angell, 2000).

Two items, interaction usability and accessibility, relate to learners' experience as software users. The interaction usability item assesses interface transparency; that is, how effortlessly and efficiently users can operate links, controls, and menus to navigate through the object. It is important to distinguish between the challenges posed by the interface, which incur extrinsic cognitive load, and those posed by the instructional content, which may be germane to the learning goals. Any errors a student makes should be related to learning the content, not to navigational difficulties (Laurillard, Stratfold, Luckin, Plowman, & Taylor, 2000; Mayes & Fowler, 1999; Norman, 1998; Nielsen, 1994; Parlangeli, Marchigiani, & Bagnara, 1999; Squires & Preece, 1999). In LORI, interaction usability is treated separately from concerns about how learners perceive and interact with the learning content. The accessibility item invites reviewers to consider the important issue of how objects can be designed to take into account differing abilities to access content. For example, Paciello (2000) observed that the increasing prevalence of graphical user interfaces has produced a situation in which "blind users find the Web increasingly difficult to access, navigate, and interpret. People who are deaf and hard of hearing are served Web content that includes audio but does not contain captioning or text transcripts" (Preface: Who are you?). The Web Content Accessibility Guidelines established by the World Wide Web Consortium (1999) provide useful information on how Web pages can be designed to offer consistent meaning when accessed through a range of browsers, assistive technologies, and input devices.

The final two LORI items, reusability and standards compliance, address managerial and technical matters that support the users' experience. The reusability item addresses one of the purported benefits of using learning objects: the ability for one development team to create a resource that can be reused by learners across many different courses and contexts (Harden, 2005; Hirumi, 2005; Koppi, Bogle, & Bogle, 2005). Finally, standards compliance addresses the need for consistent approaches to learning object metadata creation and use (Duval & Hodgins, 2006). Metadata (data about data) is the information that users actually search when looking for learning objects. Several organizations have been actively developing and promoting usable metadata standards. (Advanced Distributed Learning, 2003; Dublin Core, 1999; Friesen & Fisher, 2003; IEEE LOM, 2002; IMS, 2002, 2005). Sampson and Karampiperis (2004) sum up the benefits of a consistent approach to metadata creation and use: "*searching* becomes more specific and in-depth; *managing* becomes simpler and uniform; and *sharing* becomes more efficient and accurate" (p. 207).

LORI spans quality issues that are often considered the responsibility of different stakeholders, and its scope is so wide that few professionals charged with developing learning multimedia resources have detailed knowledge of all that it covers. Wherever subjective judgments of quality are applied, as they must be in using LORI, evaluations are only as good as the knowledge of the evaluators. Clearly then, the problem of advancing quality evaluation extends beyond merely translating design knowledge into evaluative criteria, and overlaps significantly with problems of educating novice designers and broadening the knowledge of practicing design professionals. Next we consider how the process of evaluation can contribute to the education of designers.

EVALUATE TO LEARN

Multimedia learning resources are designed objects. As such, knowledge about how to construct them delineates a design discipline that belongs, along with engineering, computing science, architecture, among the "sciences of the artificial" described by Simon (1996). With contributions from cognitive science, educational psychology, and relevant areas of educational research, a design science has emerged that advances theories, principles and prescriptions for designing multimedia learning resources. The science informs a practice that must intentionally and reflectively bend theory to the exigencies of the situation in which the resources are used (Schon, 1983).

Educational programs for instructional designers typically present curricula in which the novice designer learns some of the theory, history and tools of the field, and is soon engaged in design projects. Of course, in the design sciences, "designing to learn" (Hmelo, Holton, & Kolodner, 2000) is not an innovative instructional strategy, but instead a traditional and widely practiced method that is rightly regarded as a core element in design education. Designing and developing a complete learning resource can take more time than is available within a single course. As a result, students may be assigned projects that are reduced in some way; perhaps only the design stage is completed, or only a portion of the planned content is implemented. When a student devotes much of her learning time to a single project, depending on the nature of that project, she may not have opportunity to comprehensively practice the design knowledge developed in a course. Further, design projects are often conducted individually, whether for purposes of individual evaluation, to meet unique student interests, or to allow students to design for the needs of their workplace. This can mean that students have few opportunities to discuss in detail the rationale for their design decisions.

Collaborative evaluation of learning resources can effectively complement design projects in professional development and graduate courses that teach learning resource design. The main advantage of evaluate-to-learn as an instructional strategy is that a learning object can be critiqued in less than an hour, allowing students to evaluate many cases within a single course or allowing professionals to complete evaluations within a workshop or as part of regular design work. Because real, fully developed learning resources can be evaluated, this form of case-based learning can compensate for authenticity that is lost when design projects must be scaled down to fit an academic term.

COLLABORATIVE ARGUMENTATION

Collaborative argumentation differs from the common understanding of argumentation as personally invested debate or persuasive rhetoric and is antithetical to the sense of argumentation as verbal conflict or quarrelling (Andriessen, 2006). Andriessen (2006) claims that collaborative argumentation is the essence of discourse in science, and the means by which competing theories are assessed against data and the scientific community finds agreement. Even more broadly, collaborative argumentation can be viewed as a decision-making process used in many professional fields such as medicine, engineering, and business. It is a form of productive critical thinking characterized by evaluation of claims and supporting evidence, consideration of alternatives, weighing of cost and benefits, and exploration of implications.

Researchers in the learning sciences have proposed that argumentation, particularly collaborative argumentation, can be a highly effective instructional strategy (Andriessen, 2006; Chinn, 2006). Argumentation may help learners to understand course content, enhance their interest and motivation, and improve performance on problem solving tasks (Chinn, 2006). In a study by Wiley and Voss (1999), students who wrote arguments about historical demographic changes in Ireland showed deeper understanding of the causes of demographic change than students who wrote summaries or explanations. Chinn, Anderson, and Waggoner (2001) found that sixth grade students were more motivationally engaged in argumentative discussions of stories than in traditional recitation discussion of the stories. In a review of the psychological literature on problem solving, Arkes (1991) concluded that people's problem solving performance is enhanced when they are instructed to generate counterarguments or alternative reasons.

Although little evidence is available about the effects of argumentation in the workplace, there is no reason to assume that its benefits for learning, motivation, and performance are restricted to formal educational settings. The collaborative argumentation process, whereby participants make their reasoning and knowledge explicit and co-elaborate their understanding of problems and situations, is likely an effective form of learning in organizations and professions. As with narrative (see Brown & Duguid, 1991), collaborative argumentation may be one of the activities that comprises cognitive apprenticeship.

The nature of collaborative argumentation may depend on whether the participants bring shared knowledge and fill similar roles in an organization or project, or specialize in different disciplines and fill different roles. Participants from similar backgrounds often share a great deal of background knowledge that remains implicit throughout a discursive interaction. In this case, the participants are likely to develop a complex set of claims, points of evidence, and counterarguments cognate to the shared knowledge. For example, three Web developers collaborating on a learning object project may generate richly detailed arguments about image formats, but have relatively little to say about learning goals. On the other hand, when the participants have differentiated expertise, the discussion may become simply an exchange of explanations rather than collaborative argumentation. For example, the subject matter expert may explain a misconception held by novices, the instructional designer may explain why a diagram might overcome the misconception, and the Web developer may explain how the diagram will be implemented. Although an explanatory discussion of this type has the needed breadth, it lacks the depth offered by collaborative argumentation in which claims are expected to be challenged and supported by evidence. For teams charged with developing learning resources, an important challenge is how to enhance the depth of analysis afforded by collaborative argumentation among team members with differentiated experience and knowledge.

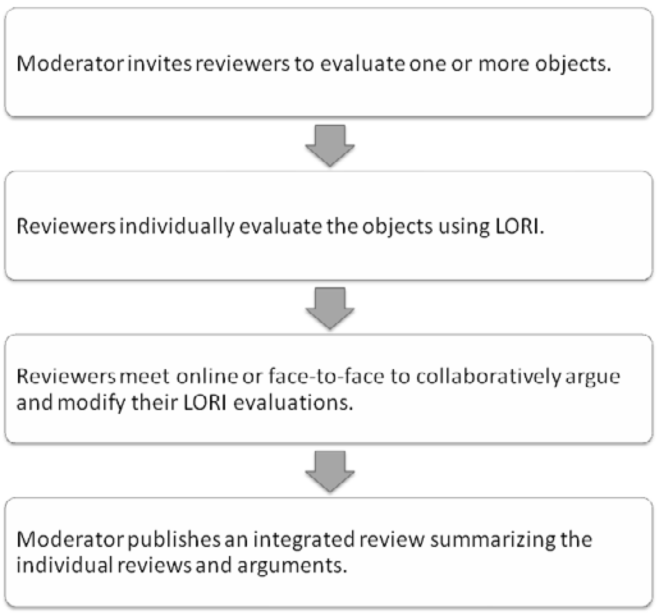
We believe that inviting stakeholders to commit to a set of ratings and supporting explanations in a common evaluation framework, and then discuss the reasons for those ratings in a diverse team will lead to the observed benefits of collaborative argumentation. We call this process convergent participation.

CONVERGENT PARTICIPATION

In the convergent participation model, summarized in Figure 2, a moderator may initiate an evaluation process by selecting a group of reviewers and inviting them to evaluate one or more learning objects. Each reviewer uses LORI to complete ratings and comments about the learning object(s). This process happens asynchronously. In the context of a course, the instructor may act as moderator and assign students to review objects over a period of a few days. Once each reviewer has individually evaluated the object, the moderator convenes the group to discuss the ratings. This discussion typically happens in an online synchronous meeting, but has also been successfully conducted in a face-to-face setting. In some contexts, the moderator may invite reviewers who have already completed reviews on their own initiative to join the process at the group discussion stage.

The moderator uses statistical tools within eLera to determine which of the nine LORI items have the most divergent ratings and then instructs the group to start by discussing these items. During the discussion, the moderator encourages reviewers to focus on explaining their reasons for their ratings and comments. Each reviewer will bring a different perspective and set of claims and evidence in support of their initial ratings. By focusing on the areas of least agreement first, the process encourages reviewers to reevaluate their claims and evidence in light of the alternatives put forward by other group members. Ideally, through collaborative argumentation, the group will come to a shared understanding of the meaning of the item and this will often lead to agreement on a single appropriate rating for the object in question on that item. However, reviewers may decide to keep their divergent ratings. The goal is not to reach a single, common rating of the learning object, but rather to increase each participant's understanding of the reasoning that underlies their judgment about a particular feature of a learning object.

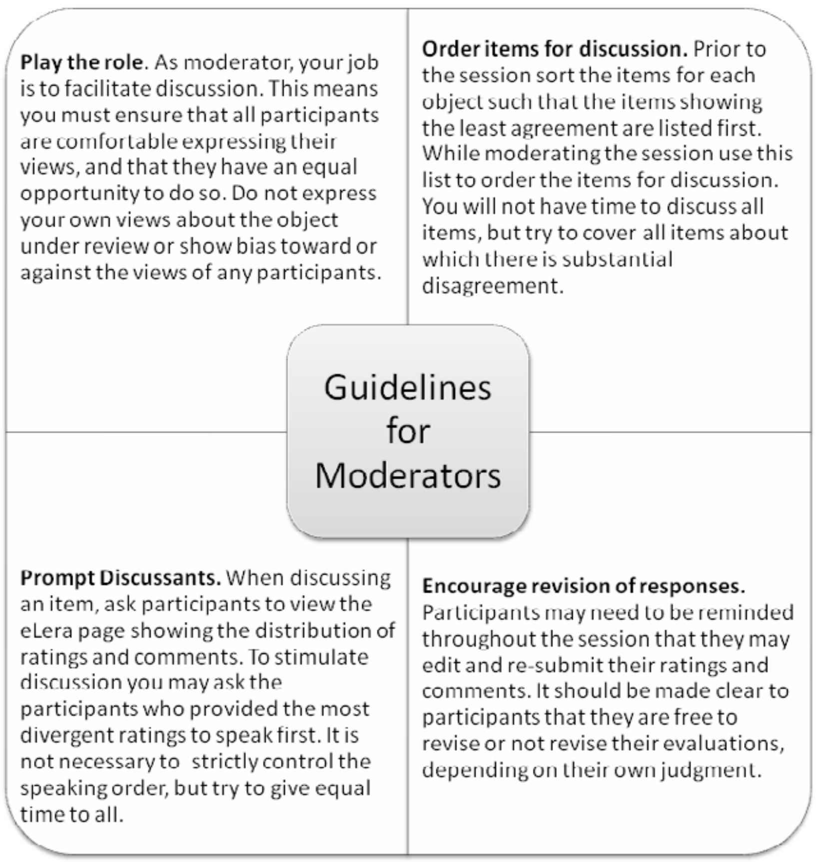
Figure 2. The convergent participation model



The moderator is responsible for ensuring the discussions stay focused and for moving the group through discussion of as many of the nine items as time allows. Reviewers may choose to modify their individual ratings during the discussion. At the end of the collaborative argumentation phase, the moderator creates and publishes a single evaluation representing the group's rating of the object. Reviewers can also choose not to have their data included with this aggregate evaluation.

There is evidence that reviewers do negotiate shared understandings and interpretations within the LORI framework. Vargo et al. (2003) conducted a study in which 12 educational technology professionals and university faculty used LORI to evaluate eight learning objects. The participants were divided into three groups of four reviewers, and the learning objects were divided into sets A and B (four objects per set). Each reviewer individually evaluated all eight objects using LORI. Two days later, each group of four reviewers met for a one-hour moderated online chat session to discuss the objects in set A. During the chat, reviewers had access to a spreadsheet showing their own ratings (identified) and the ratings of the other members of their discussion group (not identified by individual). The moderator was one of the researchers and did not rate any objects. During the online discussion, groups discussed each of the four objects in Set A focusing on the LORI items with the most divergent ratings. Finally, on the fifth day of the study, reviewers rerated the objects in both sets A and B. Results showed that the inter-rater reliability of the LORI

Figure 3. Guidelines for moderators (adapted from Nesbit, Leacock et al., 2004)



items improved for the objects that were discussed in the online chat but did not improve for the objects in Set B (the baseline set).

Nesbit, Leacock, Xin, and Richards (2004) reported a follow-up study in which eight reviewers (seven e-learning professionals and one e-learning graduate student) rated five learning objects drawn from the domains of high school science and mathematics. In this study, reviewers first received a 2-hour training session on learning objects, LORI, and eLera. The reviewers were allowed two days to rate the five objects independently, and they met again face to face (in two separate groups of four) on day four to discuss their ratings. As in the previous study, the moderator did not complete any evaluations. Figure 3 summarizes the instructions to the moderator for this study. During the discussion, reviewers had access to the eLera Web site via laptop computers, and they could choose to change their ratings during the session. Results again showed increased reliability after collaborative discussion of the ratings and their meaning. This study also included a questionnaire asking the reviewers for feedback on LORI and the usefulness of the process. They unanimously reported that the convergent participation process was a valuable professional development activity and was relevant to their work.

In a later study on the convergent participation model (Richards & Nesbit, 2004), 24 graduate students taking a course on instructional design took part in two audio conferences. After learning about the nine LORI criteria in the first session, the participants independently rated five learning objects using the eLera Web site. In the second audio conference they compared and discussed their ratings. The students submitted a written reflection on their perception of the learning activity and filled out a follow-up questionnaire 6 to 9 months later. Analysis of the written reflections and questionnaires revealed that students perceived the convergent participation activity to be valuable for learning theoretical concepts and preparing for design projects. They commented that the learning activity provided an appreciation of the complexity of learning object design, and that it "should be mandatory," "should be an entire course," and "should be the first thing taught in the course." Of the 12 students who had designed learning resources following the course, all indicated that the learning activity had influenced their design practice.

Further research is needed to investigate issues of transfer and impact on professionals' practice and students' achievement of engaging in collaborative argumentation through the convergent participation process. Collaborative argumentation on the ratings of specific learning objects is useful in producing more reliable ratings of those objects, but we also believe that the deeper understandings of varying perspectives on objects and LORI items will help participants to take multiple perspectives when rating other objects and when designing new objects, which in turn will lead to greater reliability in future ratings and a higher overall level of quality in new learning objects.

FUTURE TRENDS IN ARGUMENTATION FOR EVALUATION AND DESIGN

Until now we have investigated the use of convergent participation in graduate education, and in workshops for teachers and educational technology professionals. What broader effects can be expected when the convergent participation model for collaborative evaluation is introduced into a community of learning object developers and users? First, we anticipate that participation in collaborative evaluation will facilitate adoption of quality as a communal goal. Just as there is a recognition of the need for formal approaches to ensuring quality in more traditional publishing domains, such as textbooks and journal articles, community members will become more aware of the need for quality assurance processes in learning objects and will become better informed about the detailed meanings of learning resource quality. We anticipate this will create a demand for higher quality learning resources.

Second, as participants become practiced in the use of evidence-based reasoning to support design decisions, they will become aware of gaps in their knowledge of relevant research evidence. Consequently, they may become more active in seeking research that bears on their design decisions. We anticipate that participants will eventually become aware of gaps or weaknesses in the available evidence, leading to an increased demand for specific research.

To this point, LORI and the convergent participation model have been used only for summative evaluation. That is, resources have been assessed only after they have been completed and made available through the Internet. A natural adaptation of the model, within a community of resource developers, would be to use it formatively to support design decisions. To use LORI and convergent participation for formative evaluation one would have stakeholders collaboratively review plans and prototypes. Learning object development involves progress through phases, with only certain features developed within a phase. For example, a navigational scheme may be developed in one phase and the audiovisual content may be developed in a subsequent phase. Therefore, a formative adaptation would likely stage the assessment of the quality dimensions to parallel the development of corresponding features of the learning object.

CONCLUSION

The potential for multimedia resources to facilitate learning is still being explored as designers apply new technologies and tools to create objects, and as teachers and learners discover new uses for them. Increases in the quantity and complexity of available learning objects are making issues of quality ever more salient (Liu & Johnson, 2005). Unfortunately, learning object design is often not informed by relevant research in psychology and education, with the result that many objects available online are not of the highest quality possible (Nesbit, Li, & Leacock, 2006; Shavinina & Loraer, 1999). For this reason, we believe it is important that learning object stakeholders have opportunities to learn relevant theory in a meaningful way and apply it to their practice.

The science of learning object design is not static. Even the most enduring design principles, grounded in theory and evidence, must be adapted to constantly changing learning environments and learner needs. Collaborative argumentation is suitable for adapting design principles because it brings to the fore the differing beliefs and knowledge of diverse stakeholders. However, without appropriate tools, protocols, and moderation, attempts at collaborative argumentation may focus on surface level explanations, without reaching the level of deep discussion. Using collaborative argumentation within a convergent participation structure may be an effective means for fostering deep, nuanced understanding of design principles because the process requires participants to explain their interpretation of a principle.

We believe that quality criteria for learning object evaluation, combined with a structured collaborative argumentation process, can help users to identify existing high quality learning objects and, when used in an educational or professional development context, can also drive improvements in design practice.

REFERENCES

Advanced Distributed Learning. (2003). SCORM overview. Retrieved March 27, 2008, from http://www.adlnet.org/index.cfm?fuseaction=scormabt

Andriessen, J. (2006). Arguing to learn. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 443-460). Cambridge, UK: Cambridge University Press.

Arkes, H. R. (1991). Costs and benefits of judgment errors: Implications for debiasing. *Psychological Bulletin, 110,* 486-498.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2,* 40-57.

Chinn, C. A. (2006). Learning to argue. In A. M. O'Donnell, C. E. Hmelo-Silver, & G. Erkens (Eds.), *Collaborative learning, reasoning, and technology* (pp. 355-383). Mahwah, NJ: Lawrence Erlbaum Associates.

Chinn, C. A., Anderson, R. C., & Waggoner, M. A. (2001). Patterns of discourse in two kinds of literature discussion. *Reading Research Quarterly, 36*, 378-411.

CLOE. (n.d.) *Peer review*. Cooperative learning object exchange. Retrieved March 27, 2008, from http://cloe.on.ca/peerreview.html

Cohen, S. A. (1987). Instructional alignment: Searching for a magic bullet. *Educational Researcher, 16*(8), 16-20.

Dall'Alba, G., Walsh, E., Bowden, J., Martin, E., Masters, G., Ramsden, P., et al. (1993). Textbook treatments and students' understanding of acceleration. *Journal of Research in Science Teaching 30*, 621-635.

Dublin Core Metadata Initiative. (*1999*). *Dublin Core Metadata Element Set, Version 1.1: Reference Description*. Retrieved March 27, 2008, from http://dublincore.org/documents/1999/07/02/dces/

Duval, E., & Hodgins, W. (2006). Standardized uniqueness: Oxymoron or vision for the future? *Computer, 39*(3), 96-98.

Dyson, M. C. (2004). How physical text layout affects reading from screen. *Behavior and Information Technology, 23,* 377-393.

ELEONET. (n.d.). *European learning objects network*. Retrieved March 27, 2008, from http://www.eleonet.org/

Friesen, N., & Fisher, S. (2003). *CanCore guidelines version 2.0: Introduction*. Retrieved March 27, 2008, from http://www.cancore.ca/guidelines/CanCore_Guidelines_Introduction_2.0.pdf

Harden, R. M. (2005). A new vision for distance learning and continuing medical education. *The Journal of Continuing Education in the Health Professions, 25*, 43-51.

Hill, J. R., & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology Research and Development 49*(3), 37-52.

Hirumi, A. (2005). In search of quality: Analysis of e-learning guidelines and specifications. *The Quarterly Review of Distance Education, 6,* 309-330.

Hmelo, C. E., Holton, D., & Kolodner, J. L. (2000). Designing to learn about complex systems. *Journal of the Learning Sciences, 9,* 247-298.

IEEE Learning Object Metadata. (2002). Retrieved March 27, 2008, from http://ltsc.ieee.org/wg12/index.html

IMS. (2002). *IMS guidelines for developing accessible learning applications, version 1.0*. IMS Global Learning Consortium. Retrieved March 27, 2008, from http://www.imsglobal.org/accessibility

IMS. (2005). *IMS global learning consortium specifications*. Retrieved March 27, 2008, from http://www.imsglobal.org/specifications.cfm

Koppi, T., Bogle, L., & Bogle, M. (2005). Learning objects, repositories, sharing and reusability. *Open Learning, 20*(1), 83-91.

Laurillard, D., Stratfold, M., Luckin, R., Plowman, L., & Taylor, J. (2000). Affordances for learning in a nonlinear narrative medium. *Journal of Interactive Media in Education, 2*. Retrieved March 27, 2008, from http://www-jime.open.ac.uk/00/2

Leacock, T. L., & Nesbit, J. C. (2007). A framework for evaluating the quality of multimedia learning resources. *Educational Technology and Society, 10*(2), 44-59.

Leacock, T., Richards, G., & Nesbit, J. (2004). Teachers need simple, effective tools to evaluate learning objects: Enter eLera. *Proceedings of the IASTED International Conference on Computers and Advanced Technology in Education, 7*, 333-338.

The Learning Federation. (n.d.). User focus groups. Retrieved March 27, 2008, from http://www.thelearningfederation.edu.au/showMe.asp?nodeID=57#groups

Ling, J., & van Schaik, P. (2006). The influence of font type and line length on visual search and information retrieval in Web pages. *International Journal of Human-Computer Studies, 64*, 395-404.

Liu, L., & Johnson, D. L. (2005). Web-based resources and applications: Quality and influence. *Computers in the Schools, 21*, 131-146.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*, 43-52.

Mayes, J. T., & Fowler, C. J. (1999). Learning technology and usability: A framework for understanding courseware. *Interacting with Computers, 11*, 485-497.

MERLOT. (n.d.). Evaluation criteria for peer reviews. Retrieved March 27, 2008, from http://taste.merlot.org/evaluationcriteria.html

Nesbit, J. C., Belfer, K., & Leacock, T. L. (2004). *LORI 1.5: Learning object review instrument*. Retrieved March 27, 2008, from www.elera.net

Nesbit, J. C., Leacock, T., Xin, C., & Richards, G. (2004). Learning object evaluation and convergent participation: Tools for professional development in e-learning. *Proceedings of the IASTED International Conference on Computers and Advanced Technology in Education, 7, 339-344*.

Nesbit, J. C., Li, J., & Leacock, T. L. (2006). *Web-based tools for collaborative evaluation of learning resources*. Retrieved March 27, 2008, from http://www.elera.net/eLera/Home/Articles/WTCELR

Nielsen, J. (1994). Enhancing the explanatory power of usability heuristics. In *Proceedings of the Association for Computing Machinery CHI 94 Conference*, Boston, MA (pp. 152-158).

Norman, D. (1988). *The design of everyday things*. New York: Basic Books.

Paciello, M. (2000). *Web accessibility for people with disabilities, Preface*. Norwood, MA: CMP Books. Retrieved March 27, 2008, from Books 24x7 database.

Park, O-C. (1996). Adaptive instructional systems. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 634-664). Mahwah, NJ: Lawrence Erlbaum Associates.

Parlangeli, O., Marchigiani, E., & Bagnara, S. (1999). Multimedia systems in distance education: Effects of usability on learning. *Interacting with Computers, 12*, 37-49.

Parrish, P. E. (2004). The trouble with learning objects. *Educational Technology Research and Development, 52*(1), 49-67.

Pearson, R., & van Schaik, P. (2003). The effect of spatial layout of and ink colour in Web pages on performance in a visual search task and an interactive search task. *International Journal of Human-Computer Studies, 59*, 327-353.

Richards, G., & Nesbit, J. C. (2004). The teaching of quality: Convergent participation for the professional development of learning object designers. *International Journal of Technologies in Higher Education*, *1*(3), 56-63.

Sampson, D.G., & Karampiperis, P. (2004). Reusable learning objects: Designing metadata systems supporting interoperable learning object repositories. In R. McGreal (Ed.), *Online education using learning objects*. New York: Routledge/Falmer.

Sanger, M. J., & Greenbowe, T. J. (1999). An analysis of college chemistry textbooks as sources of misconceptions and errors in electrochemistry. *Journal of Chemistry Education, 76*, 853-860.

Schon, D. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Shavinina, L. V., & Loarer, E. (1999). Psychological evaluation of educational multimedia applications. *European Psychologist, 4*(1), 33-44.

Simon, H. (1996). *The sciences of the artificial* (3rd ed.). Cambridge, MA: MIT Press.

Squires, D., & Preece, J. (1999). Predicting quality in educational software: Evaluating for learning, usability and the synergy between them. *Interacting with Computers, 11*, 467-483.

Strunk, W., Osgood, V., & Angell, R. (2000). The elements of style (4th ed.). Boston: Allyn & Bacon.

Tufte, E. R. (1997). *Visual explanations: Images and quantities, evidence and narrative*. Cheshire, CN: Graphics Press.

Vargo, J., Nesbit, J. C., Belfer, K., & Archambault, A. (2003). Learning object evaluation: Computer mediated collaboration and inter-rater reliability. *International Journal of Computers and Applications*, *25*, 198-205.

Weiss, A. (2006). The Web designer's dilemma: When standards and practice diverge. *netWorker, 10*(1), 18-25.

Wiley, J., & Voss, J. F. (1999). Constructing arguments from multiple sources: Tasks that promote understanding and not just memory for text. *Journal of Educational Psychology, 91*, 301-311.

World Wide Web Consortium. (1999). *Web content accessibility guidelines 1.0*. Retrieved March 27, 2008, from http://www.w3.org/TR/WCAG10

KEY TERMS

Collaborative Argumentation: A form of productive critical thinking characterized by evaluation of claims and supporting evidence, consideration of alternatives, weighing of cost and benefits, and exploration of implications.

Convergent Participation: An evaluation protocol in which individuals first rate learning objects independently and then discuss the reasons for their ratings in a structured, moderated discussion. Participants may choose to change their ratings during the group discussion.

eLera (E-Learning Research and Assessment Network): A Web site featuring Web-based tools for evaluating learning resource quality. Members can register the metadata for any learning object and then use evaluation tools within eLera to rate the object individually or collaboratively. The goals of eLera are (1) to improve the quality of online learning resources through better design and evaluation; (2) to develop effective pedagogical models that incorporate learning objects; and (3) to help students, teachers, professors, instructional designers, and others to select pedagogical models and digital resources that meet their requirements.

Learning by Evaluation: A process in which students learn design principles by critiquing existing objects. In the course of forming and explaining their evaluation, students gain a deeper understanding of design principles than they would by only reading about them. Learning by evaluation complements learning by design in which students must create their own objects and may often be distracted by technical matters.

Learning Object Review Instrument (LORI): A nine-item heuristic quality rating tool for digital learning resources developed by the E-Learning Research and Assessment Network (Available from: www.elera.net). The nine items are: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability, and standards compliance.

Learning Objects: Digital multimedia learning resources that combine text, images, and other media, are intended for re-use across educational settings, typically require a few minutes to perhaps an hour of a learner's time for initial study, and usually focus on one topic or a small set of closely related elements, which could then be integrated with other objects and activities in a particular teaching context to form a full course

Chapter XXIX
For the Ultimate Accessibility and Reusability

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ABSTRACT

This chapter first argues that current approaches for sharing and retrieving learning objects or any other kinds of information are not efficient or scalable, essentially because almost all of these approaches are based on the manual or automatic indexation or merge of independently created formal or informal resources. It then shows that tightly interconnected collaboratively updated formal or semiformal large knowledge bases (semantic networks) can, should, and probably will, be used as a shared medium for the tasks of researching, publishing, teaching, learning, evaluating, or collaborating, and thus ease or complement traditional methods such as face-to-face teaching and document publishing. To test and support these claims, the authors have implemented their ideas into a knowledge server named WebKB-2 and begun representing their research domain and several courses at their universities. The same underlying techniques could be applied to a semantic/learning grid or peer-to-peer network.

INTRODUCTION

The smaller and less contextual the "learning objects (LOs) available for re-use" are, and the more precisely indexed or interconnected via metadata they are, the more easily they can be semi-automatically retrieved and combined to create "LOs to teach with" that are adapted to particular course objectives or kinds of users, and thus create contextual LOs (Downes, 2001; Hodgins, 2006). Although this general idea is well advocated in the LO community, its ultimate conclusion—the idea that we advocate—is hardly attempted or even written about: each "re-usable LO," which from now on is simply referred to as an "object," should either be one formal term (a category identifier) or an "undecomposable statement" (typically, one semantic relation between two other objects, with some information about the context of this relation, such as its creator and temporal, spatial or modal constraints on its validity, all of which preferably being expressed in a formal way, that is, with a knowledge representation language). Furthermore, each object should be connected to all other semantically related objects by semantic relations. In other words, there should be no difference between data and metadata, and there should be only one virtual well-organized knowledge base (KB) that all object providers can complement by inserting their objects "at the right place," or more generally, in a "normalized way" that permits the KB to stay well organized and hence to be searched and updated in an efficient or scalable way. A virtual KB does not imply only one actual KB; it simply means that all potential redundancies and inconsistencies detected by people or inference engines should be removed. As explained later, this also does not imply that knowledge providers have to agree with each other.

Nowadays, there is no such virtual KB, and LOs repositories are not even KBs; they are databases for informal documents containing many more than one undecomposable statement. Furthermore, current LO related standards (e.g., AICC, SCORM, ISM, IEEE WG12) and projects (e.g., CANDLE, GEODE, MERLOT, VLORN) essentially focus on associating *simple metadata* to whole documents or big parts of them (e.g., author, owner, terms of distribution, presentation format, and pedagogical attributes such as teaching or interaction style, grade level, mastery level, and prerequisites). Such superficial indices do not support the answering of queries such as "What are the arguments and objections for the use of an XML-based format for the exchange of knowledge representations?" "What are all the tasks that should be done in software engineering according to the various existing 'traditional system development life cycle models?" and "What are the characteristics of the various theories and implemented parsers related to Functional Dependency Grammar and how do these theories and parsers respectively compare to each other?" Answering such queries requires presenting and allowing the browsing of the KB as a semantic network: (i) for the first question, a network with argumentation, objection, and specialization relations, (ii) for the second question, a subtask hierarchy of all the advised tasks, and (iii) for the third question, a network with specialization relations between the various objects or attributes related to the theories and parsers.

LOs have special purposes but no special content: all advanced information sharing or retrieval techniques can be directed applied to LOs. On the Web, this means using *Semantic Web* related techniques (Shadbolt, Berners-Lee, & Hall, 2006). However, almost all them are about supporting the manual/automatic indexation of whole formal/informal documents or merging the content of independently created formal documents. Document-based techniques permit to exploit legacy data but their efficiency or scalability for organizing, sharing, and searching increasingly large amounts of information is limited. Hence, these techniques should ideally be used only as a complement to the building of a global virtual KB, not as sole techniques for exploiting information. This is the theme of the next section. Then, we show how such a virtual KB—on the Web or within the semantic/learning grid of a community—can and ultimately will be collaboratively built and hence used as a shared medium for researching, publishing, teaching, learning or collaborating since these tasks are based on information retrieval/comparison/sharing subtasks.

BACKGROUND: CURRENT INFORMATION RETRIEVAL/ SHARING APPROACHES ARE NOT SCALABLE

Definitions

In this chapter, a "formal term" is a symbol (character string, icon, sound, etc.) whose meaning (i.e., the referred concept/relation type/individual) has been made explicit, a "statement" is a small set of symbols connected by relations, an "informal statement" is a statement without formal terms (e.g., a sentence in English), a "formal statement" is a statement with only formal terms, a "semiformal statement" is a statement with formal relations and may be formal terms for concepts or individuals, an "object" (or re-usable LO) is either a term or a statement, an "ontology" is a set of formal objects (e.g., a small flat list or a full KB), a "resource" is a stand-alone collection of several statements (e.g., an ontology, a database, a document, a section or a paragraph), and "metadata" is a set of one or several numerical values or other objects used for relating or indexing one or more statements, typically those of a resource. Some metadata related to some resource or created by some person(s) can also be considered as a resource. Scalability means keeping precision-oriented information retrieval/comparison/sharing efficient even when the number of statements written by all the information providers grows large. This cannot be done via lexical search (string-matching) nor structural organization/search (based on the structure and hyperlinks of documents or databases) but require "conceptual organization/search" (navigation or search/comparison queries "by the semantic content") exploiting conceptual relations between objects, for example, the manually set or automatically inferred generalization relations between these objects. A scalable knowledge sharing and retrieval imply a lexical, structural and ontological normalization of the knowledge (for details, see the definitions at the end of this chapter).

Approaches Based on the Indexation of Resources are not Scalable

The more statements a resource contains, and the more resources there are, the more these resources contain similar and/or complementary pieces of information, and hence the less the metadata for each resource can be useful: queries will return lists of resources that are partially redundant or complementary with each other and that need to be manually searched, compared, or aggregated by each user. Furthermore, the more statements a resource contains, the more its metadata have to be information selective, and hence the less such metadata are representative of the contained pieces of information and the more the indexation methods and usefulness are task/user/domain dependent.

Finally, the more statements some resources contain, and the less formal the statements are (or the more "contextual" they are), the less any similarity measure between these resources can have any intuitive or semantic meaning, and the less these resources can meaningfully be related by rhetorical or argumentation relations such as "arguments," "proves," or "specializes." For example, the statement "some animal sits above some artefact" is a generalization (i.e., logical implication) of both "Tom (a cat) sits on a blue mat" and "any animal sits above some artefact" because all the objects and quantifiers of the first statement are identical or generalize those of the second and third statements (such relations can be automatically inferred if the statements are formal or semi-formal). However, such relations rarely hold between two collections of statements, and especially between any two documents. Statistical similarity measures between documents, ontologies, or metadata have no semantic meaning: they are experimentally designed to be of some help for some specific kinds of data, tasks, or users. For example, Knowledge Zone (Lewen, Supekar, Noy, & Musen, 2006) allows its users to rate ontologies with numerical or free text values for criteria such as "usage," "coverage," "correctness," and "mappings to other ontologies," also allows its users to rate each other users' ratings, and uses all these ratings to retrieve and rank ontologies. This approach compounds several problems: (i) whole ontologies are rarely genuinely/intuitively comparable (given two randomly selected ontologies; it is very rare that one fully includes or specializes the other), (ii) giving numerical values for such criteria is rather meaningless, (iii) textual values for each of such criteria cannot be automatically organized into a semantic network, (iv) two sets of criteria are rarely comparable (one set rarely includes all the criteria of the other set and has higher values for all these criteria), and (v) similarity measures on criteria only permit to retrieve possibly "related" ontologies: the work of understanding, comparing or merging their statements still has to be (re-)done by each user.

To sum up, however sophisticated, techniques that index resources are inherently limited in their possibilities and usefulness for information seekers. Furthermore, since they do not provide re-use mechanisms, they force information providers to repeat or re-describe information elsewhere described and thus add to the volume of redundant data that information seekers have to sift through. Yet, techniques to index data or people form the bulk of LO retrieval/management techniques and Semantic Web related techniques, for example in the Semantic Learning Web (Stutt & Motta, 2004) and the Educational Semantic Web (Devedzic, 2004). Although the number and apparent variety of these techniques is huge, our definitions permit to categorize most of them as follow:

- As annotation tools permitting their users to index or relate resources or metadata (i) by informal terms (e.g., folksonomy tools and topic map based tools), (ii) by terms from a small predefined small list such as the Dublin Core metadata or argumentation relations as in ScholOnto (Buckingham-Shum, Motta, & Domingue, 1999), (iii) by terms from an informal hierarchy such as the DMOZ topic hierarchy, (iv) by terms from a lexical database such as WordNet, (v) by terms from a semantically organized ontology such as the SUMO, (vi) by terms from an ontology that can be updated by users, as in WebKB-2 (Martin, 2003a), (vii) by attribute-value pairs with textual/numerical values, (viii) by restricted kinds of knowledge representations (e.g., semantic wikis), or (ix) by expressive knowledge representations, as in WebKB-2 which uses Conceptual Graphs and Formalized-English.
- As tools automatically indexing or relating resources or metadata (i) by terms from a given small list, (ii) by informal terms automatically organized into a hierarchy via techniques such as Latent Semantic Indexing, Formal Concept analysis or terminological analysis, (iii) by terms from lexical databases via natural language parsing (NLP) techniques, (iv) by attribute-value pairs with textual or numerical values, (v) by a measure of similarity between resources and/or their metadata (vi) by informal sentences (e.g., summarizing tools) using statistical or NLP techniques, or (vii) by restricted kinds of knowledge representations (e.g., question-answering tools which index sentences in documents but are not able to represent most of the semantic content of different sentences and hence organize it) via NLP techniques or ad-hoc Web site wrappers. Shadbolt et al. (2006) acknowledge that current "Semantic Web"-like applications still use ad-hoc wrappers from particular Web documents or databases.

As previously noted, current LO-related standards focus on associating simple metadata to (big parts of) documents, and current LOs are almost never about *one undecomposable statement only*. For example, a typical LO about Java is an "Introduction to Java" listing some features of Java and giving an example of code, instead of being a relation between Java and one of its features. According to the IEEE LTSC (2001), a LO should consist of 5 to 15 minutes of learning material. Each of such LOs cannot be not a "truly re-usable LO" (object) but is a package of objects selected and ordered to satisfy a certain curriculum. Although such packages are useful for pedagogical purposes and ease the task of most course designers since they are ready-made packages, they are black-box packages, that is, their decomposition into objects from a shared well-organized KB has not be made explicit and hence they cannot be easily modified nor compared or efficiently retrieved: they can only be retrieved via keywords, not via arbitrary complex conceptual queries on the objects they contain or, from a browsing viewpoint or a conceptual querying efficiency viewpoint, they cannot be organized into a lattice (partial order) according to the objects they combine.

Approaches Based on either Fully Formal or Mostly Informal Resources are not Scalable

Some information repository projects use formal KBs, for example, the Open GALEN project which created a KB of medical knowledge, the QED Project which aims to build a formal KB of all important, established mathematical knowledge, and the Halo project (Friedland et al., 2004) which has for very long term goal a system capable of teaching much of the world's scientific knowledge by preparing and answering test questions for students according to their knowledge and preferences. Such formal KBs permit to support problem solving but they are not meant to be directly read or browsed, and designing them is difficult even for teams of trained knowledge engineers, for example, the six-month pilot phase of Project Halo was restricted to 70 pages of a chemistry book and had encouraging but far-from-ideal results. Hence, such fully formal KBs are not adequate for scalable information sharing or retrieval.

Informal documents (articles, e-mails, wikis, etc.), that is, documents mainly written using natural languages such as English, as opposed to knowledge representation languages (KRLs), do not permit objects to be explicitly referred and interconnected by semantic relations. This forces document authors to summarize what has been described elsewhere and make choices about which objects to describe and how: level of detail, presentation order, and so forth. This makes document writing a time consuming task. Furthermore, the lack of detail often makes difficult for people or softwares to understand the precise semantic relations between objects implicitly referred to within and across documents. This leads to interpretation or understanding problems, and limits the depth and speed of learning since retrieving or comparing precise information has to be done mostly manually. The automatic indexation of sentences within documents permits to retrieve sentences that may contain all or parts of some required information (this process is often called "question answering"; tools supporting it are evaluated by the TREC-9 workbenches) but the lack of formalization in the sentences does not permit to extract and merge their underlying objects and relations.

Cognitive maps and concept maps (Novak, 2004)—or their ISO version, topic maps—have been used for teaching purposes. However, they are overly permissive and hence do not guide the user into creating a principled, scalable, and automatically exploitable semantic network. For example, they can use relations such as "of" and nodes such as "other substances" instead of semantic relations such as "agent" and "subtask." Thus, concept maps are often more difficult to understand or retrieve, aggregate and exploit than regular informal sentences (from which, unlike deeper representations, they can currently be automatically generated); Sowa (2006) gives commented examples.

Similarly, the modelling of the preferences and knowledge of students or other people is often very poor, for example, a keyword for each known LO (e.g., "Java") and a learning level for it (e.g., "advanced"). This is for example the case with the CoAKTinG project (Page et al., 2005) which aims to facilitate collaboration and data exchange during or after virtual meetings on a semantic grid, and the Grid-E-Card project (Gouardères, Saber, Nkambou, & Yatchou, 2005) which manages a model of certification for each LO and student on a grid to facilitate her learning and her insertion within relevant communities. A more fine-grained approach in which all the statements for which a student has been successfully tested on are recorded is necessary for efficacy and scalability purposes.

We believe that the main reasons why more knowledge-oriented solutions are not developed can be listed as follows: (1) most people, including many tool developers, have little or no knowledge about semantically explicit structures, (2) many tool developers fear that people will be "scared away" by the looks of such structures or by having to learn some notations, (3) precise and correct knowledge modelling is complex and time-consuming, (4) KB systems are not easy to develop, especially user-friendly ones supporting collaboration between their users, (5) there currently exists a lot of informal legacy data but very little well-organized explicit knowledge.

Point 2 was the reason given by many creators of "knowledge-oriented" hypermedia systems or repositories to explain the limited expressiveness of their formal features or notations, for example, the creators of SYNVIEW (Lowe, 1985), AAA (Schuler & Smith, 1992), ScholOnto (Buckingham-Shum et al., 1999), and the Text Outline project (Sanger, 2006). Shipman and Marshall (1999) note that the restrictions of knowledge-based hypermedia tools often lead people not to use them or to use them in biased ways. Although this fact appears to be presented as an argument against knowledge-based tools, it is actually an argument against the restrictions set to ease the tasks of tool developers (especially for designing graphical interfaces) and supposedly to avoid confusing the users. We agree with the conclusion of Shipman and Marshall (1999) that annotation tools should provide users with generic and expressive structuring features but also convenient default options, and the users should be allowed to describe their knowledge at various levels of details, from totally informal to totally formal so that they can invest time in knowledge representation incrementally, collaboratively and only when they feel that the benefits out-weight the costs.

The above points 1 to 5 are valid but we believe that effective or scalable knowledge sharing and retrieval cannot be achieved without a global virtual KB, and to a large extent, without this KB being collaboratively updated by the information providers. Although this requires the learning of graphical or textual notations for representing information precisely, we will probably not be a problem in the long term: the need for programming languages and workflow/database modelling notations is already well accepted and more and more students learn them. Since the need for small LOs is recognized and since it is part of the roles of teachers and researchers to (re-)present things in explicit and detailed ways, a global virtual KB is likely to be updated by them first. Their students would then complement it, thus providing their teachers a way to evaluate their knowledge and analytic skills.

Approaches Based on Independently Created (Semi-)Formal Resources are not Scalable

Like previous distributed knowledge sharing strategies, the W3C's strategy is minimal: the W3C only proposes a low-level KRL (RDF+OWL) and some optional rudimentary "best practices" (Swick et al., 2006), and envisages the Semantic Web to be composed of many small KBs (RDF documents), more or less independently developed and thus partially redundant, competing and very loosely interconnected since the knowledge provider is expected to select, import, merge and extend other people's KBs into her own (Rousset, 2004). This formal document relying approach has problems that are analogue to those we listed for informal documents: (i) finding relevant KBs, choosing between them and combining them is difficult and suboptimal even for a knowledge engineer, let alone for softwares, (ii) a knowledge provider cannot simply add one object "at the right place" and is not helped nor guided by a large KB (and a system exploiting it) into providing precise and re-usable objects that complement the already stored objects, and (iii) as opposed to normalized insertions into a shared KB which directly or indirectly guide all other related insertions, creating new ontologies actually increases the amount of poorly interconnected information to search, compare and merge by people or software agents. Most of current Semantic Web related approaches focus on supporting the manual setting or automatic discovery of relations between formal terms from different ontologies. Euzenat, Stuckenschmidt, and Yatskevich (2005) gave an evaluation of such tools and concludes that they are quite understandably very imperfect but can be sufficient for certain applications. Euzenat (2005) recognizes the need for the approach we advocate: (semi-)formal KBs letting both people and software agents directly exploit and save new knowledge or object alignments, that is, query, complement, annotate and evaluate the existing objects, guided by these large and well-organized KBs. Those ideas are further developed in the next section.

MAIN FOCUS: APPROACHES FOR SCALABLE KNOWLEDGE SHARING

This section focuses on techniques to support the only approach that we deem efficient and scalable for knowledge sharing and retrieval on the Internet or within large intranets: the collaborative creation of a global virtual well-organized (semi-)formal KB without redundancies nor implicit inconsistencies. This implies techniques supporting (i) knowledge replication between KBs, (ii) collaborative knowledge edition within a KB, (iii) the valuation and filtering of knowledge or knowledge sources, and (iv) knowledge normalization.

Supporting Knowledge Sharing Between KBs

In a global virtual KB, it should not matter which (non-virtual) KB a user or agent chooses to query or update first. Hence, (1) object additions/updates made in one KB should be replicated into all the other KBs that have a scope which covers the new objects, and (2) a query for which the content of a KB will not yield a complete answer (with respect to the content of the virtual global KB) should be forwarded to the appropriate KBs. To achieve those points, in Martin, Eboueya, Blumenstein, and Deer (2006) we note that each KB server can periodically checks more general servers, competing servers and slightly more specialized servers, and (i) integrates all the objects generalizing the objects defined in the "reference collection"[1] that defines the scope of this KB server, (ii) integrates all the objects (and direct relations from/to them) more specialized than those in the reference collection until it reaches a maximum specialization depth if one has been specified (if so, the URL of the object is stored instead of the object), and (iii) also stores the URLs of the direct specializations of the generalizations of the objects in the reference collection (this is needed for any object in the global virtual KB to be directly or indirectly referred to). This seems the simplest approach because (i) the approaches used in distributed databases would not work since KBs do not have any fixed conceptual schema (they are composed of large, explicit and dynamically modifiable conceptual schemas), and (ii) a fine-grained classification or ontology for all the objects is necessary since classifying servers according to fields or domains is far too coarse to index or retrieve knowledge from distributed servers, for example, knowledge about "neurons" or "hands" are relevant to many domains. This approach would work with servers on the Web but also in a peer-to-peer network where each user has her own KB server: the main difference is that a peer-to-peer network permit to implement systematic push/pull mechanisms instead of relying on KB servers to regularly check KBs of other servers and integrate new additions. We found no other research aiming to solve the above specifications 1 or 2. Works dealing with "Ontology Evolution in Collaborative Environments." For example Vrandecic, Pinto, Sure, and Tempich (2005) and Noy, Chugh, Liu, and Musen (2006), or Rousset (2004) in a peer-to-peer context, are solely about accepting/rejecting and integrating changes made in other KBs, not about making these KBs have an equivalent content for their shared sub-scopes.

Integrating knowledge from other servers of large KBs is not easy but it is easier than integrating dozens or hundreds of (semi-)independently created small KBs. Furthermore, since in our approach the first integration from a server is loss-less, the subsequent integrations from this server are much easier. A more fundamental obstacle to the widespread use of this approach is that many industry-related servers are likely to make it difficult or illegal to mirror their KBs; however, this problem hampers all integration approaches. The above described replication mechanism is a way to combine the advantages commonly attributed to "distributed approaches" and "centralized approaches." The inadequacy of this terminology—and its related misconceptions—are thereby also highlighted: (i) not just "mostly independently created resources" can be distributed, and (ii) as shown by the next two subsections, "collaboratively editing a same KB" (i.e., centralization) does not imply that the users have to agree or even discuss terminological issues or beliefs, nor that a committee making content selection or conflict resolution for the users is necessary.

Supporting Collaborative Knowledge Editions within a KB

Most knowledge servers support concurrency control and users' permissions on files/KBs but WebKB-2 (Martin, 2003a) is the only server having editing protocols permitting and encouraging people to tightly interconnect their knowledge into a shared KB, without having to discuss and agree on terminology or beliefs, and while keeping the KB consistent. Co4 (Euzenat, 1996) had knowledge sharing protocols based on peer-reviewing for finding consensual knowledge: their output was a hierarchy of KBs, the uppermost ones containing the most consensual knowledge while the lowermost ones were the KBs of the contributing users. All other "protocols" used in knowledge portals (Lausen, Ding, Stollberg, Fensel, Lara, & Han, 2005) or knowledge oriented approaches in peer-to-peer networks (Rousset, 2004) or Semantic Grids (Page et al., 2005) focus on managing the integration of some source KB into a private/shared target KB: these protocols are not guiding nor even permitting the users of the two involved KBs to tightly interconnect their knowledge. The next paragraph summarises the principles of WebKB-2's editing protocols.

Each category identifier is prefixed by an identifier of the category creator (who is also represented by a category and thus may have associated statements). Each (formal or informal) statement also has an associated creator and hence, if it is not a definition, may be considered as a belief. Any object (category or statement) may be re-used by any user within her statements. The removal of an object may only be done by its creator but a user may "correct" a belief by connecting it to another belief via a "corrective relation." Definitions cannot be corrected since they are neither true nor false; a user "fg" is entitled to define `fg#cat` as a subtype of the WordNet type `wn#chair`:

there is no inconsistency as long as the ways these types are further defined respect the constraints associated to each other. If entering a new belief introduces a redundancy or an inconsistency that is detected by the system, it is rejected. The user may then either correct this belief or re-enter it again but connected by specialization relations (e.g., "example") or "corrective relations" (e.g., "corrective_generalization") to each belief it is redundant or inconsistent with. For example, here is a Formalized-English statement by Joe that corrects an earlier statement by John: "any bird is agent of a flight" (John) has for corrective_specialization "most healthy French birds are able to be agent of a flight" (Joe). The use of corrective relations allows and makes explicit the disagreement of one user with (her interpretation of) the belief of another user. This also technically removes the cause of the problem: a proposition A may be inconsistent with a proposition B but a belief that "A is a correction of B" is not technically inconsistent with a belief in B. Choices between beliefs may have to be made for an application, but then the explicit relations between beliefs can be exploited, for example by always selecting the most specialized beliefs.

Supporting the Valuation and Filtering of Knowledge or Knowledge Sources

The above described recording of each object's creator, and the possibility for any user to represent information about each creator, permit to combine conceptual querying "by the content" with conceptual querying "on the creators." For example, WebKB-2 allows any user to set up filters on certain (kinds of) creators to avoid their knowledge being displayed during browsing or within query results. This is handy when bad quality knowledge from certain users becomes a nuisance for exploring and comparing the objects of certain domains despite the conceptual organization of the KB and hence its limited amount of redundancies. However, to allow a much better filtering of knowledge and/or their sources, additional information on each statement and each statement creator need to be recorded and exploited: their originality, popularity, acceptation and other characteristics related to the "usefulness" of a statement or creator. In Martin et al. (2006), we gave a template algorithm to quantify the usefulness of each statement in a KB, and then also on each of their creators, based on votes from users on statements and on how each statement is (counter-)argued using argumentation relations. To be even more useful, this algorithm should accept parameters permitting each user to specify her own view about which kinds of statements or users should be displayed and, if so, how. This approach eliminates the need for (i) allowing or forcing "special users" to perform some content selection in the KB for other users, thereby restricting the scope, goals and interest of the KB, or (ii) allowing any user to delete anything, as in wikis, which leads to edit wars. However, there is still a need for some special users to remove (or not) completely irrelevant statements (spam) that have been voted as such by some users and not prevented automatically. Given the way our template algorithm attributes a usefulness value to each statement and each user, this approach should incite the users to be careful and precise in their contributions and give arguments for them: unlike in traditional discussions or reviews, a value for each statement can be given by the template algorithm and each user can refine the problematic statements to improve them and be rewarded.

In his description of a "Digital Aristotle," Hillis (2004) describes a "Knowledge Web" to which researchers could add "isolated ideas" and "single explanations" at the right place, and suggests that this Knowledge Web could and should "include the mechanisms for credit assignment, usage tracking, and annotation that the Web lacks" (pp. 4-5), thus supporting a much better re-use and evaluation of the work of a researcher than the current system of article publishing and reviewing. Hillis does not give any indication on such mechanisms but those proposed in this sub-section and the two previous ones seem a good basis. Other valuation and trust propagation mechanisms exist, such as those of Lewen et al. (2006), but unfortunately (i) they are used on attribute-values representing/indexing the content of whole documents, not on the “usefulness” characteristics of precise statements, and (ii) they generally do not take argumentation relations into account. A primitive and informal version of our statement valuation approach was implemented in SYNVIEW (Lowe, 1985). Finally, we mentioned how Co4 allowed its users to evaluate how consensual their knowledge was.

Supporting Knowledge Entering and Normalization

To ease the automatic or manual comparison of objects within and between KBs, and hence also their retrieval, these objects should be represented as precisely and uniformly as possible. This implies easing and guiding knowledge entering by providing the users with at least the following supports, all of which should be designed to ease the adoption of knowledge modelling “best practices”: (1) for each KB, a large well-organized ontology that integrates the various existing ontologies related to the scope of the KB, (2) knowledge entering/querying/entering interfaces exploiting these ontologies and hence dynamically generated from them, (3) expressive, intuitive and concise KRLs, and (4) parsers for simple natural language sentences that propose normalized representations for these sentences. Many complementary knowledge modelling methodologies (e.g., CommonKADS, Ontoclean, Methondology and On-To-Knowledge) and “best practice” rules exist but most of them are unsupported by all low-level KRLs (e.g., KIF, the Knowledge Interchange Format, and RDF, the Resource Description Format), by almost all other KRLs and ontologies and by most KB editors. Almost all the examples and ontologies officially related to the Semantic Web, including those provided by the W3C, ignore the lexical, structural and ontological best practices that we collected in (Martin, 2000). Some examples are given in the definitions at the end of this chapter. Only Point 2 of the above four points is not uncommon in advanced KB systems, as for example in SHAKEN (Chaudhri et al., 2001). CYC provides approximate solutions for the four points: it has a parser of English sentences (Witbrock et al., 2003), it has the biggest existing general KB and CycL (the KRL of CYC) is expressive albeit not very intuitive nor concise. However, CYC does not respect lexical, structural and ontological best practices; for example, because of CyCL, CYC often contains statements based on N-ary relations instead of using more explicit and matchable forms using binary relations. Furthermore, CYC does not store the sources of each object (e.g., its creator or a source in a document and the user that represented it into the KB) and does not have protocols to permit the update of the KB by any Web user.

As a step toward Point 1, we transformed WordNet into a genuine lexical ontology and complemented it with many top-level ontologies (Martin, 2003b) into WebKB-2. We have also begun an ontology of knowledge engineering (Martin & Eboueya, 2007) and we shall invite researchers and lecturers in this field to represent their ideas, tools and LOs when such additions will be sufficiently guided by the ontology and WebKB-2 to be made in a scalable manner. This means that we have to represent and organize the main tasks, data structures and technique characteristics in knowledge engineering. An ontology such as the Semantic Web Topics Ontology of ISWC 2006 is by no mean usable for knowledge representation and is not even scalable for document indexation since (i) it does not follow knowledge representation/sharing best practices, is not integrated into a lexical ontology, and updates should be suggested to its creators by e-mail or via a wiki, and (ii) it is based on “topics” and uses quite vague relations such as topic_subtopic, topic_requires, topic_relatedTo and topic_relatedProjects, and hence does not permit the user to find "a right place" to insert a new concept—as noted by Welty and Jenkins (1999), placing a topic into a specialization hierarchy of topics is quite arbitrary, whereas a category for a task or a data structure has a unique correct place into a partOf/specializationOf hierarchy of tasks or data structures, given the intended formal meaning of the categories and the formal meanings of the used partOf/specializationOf relations.

As a step toward Point 3, WebKB-2 proposes notations such as "Formalized English" (FE), "Frame Conceptual Graphs" (FCG) and "For-Links" (FL; a sublanguage of FCG when quantifiers need not be used). They are more high-level and compact than currently existing notations and often much more expressive too (Martin, 2002). High-level means intuitive and normalizing: the syntax of our notations includes many components (e.g., various extended quantifiers and collection "interpretations") that (i) would be very difficult for users to define correctly and in comparable or formally exploitable ways, (ii) make the syntax more English-like, and (iii) lead the users to follow best practices and hence provide more precise and automatically comparable knowledge, thus, more retrievable and checkable for redundancies and inconsistencies. More compact means that more knowledge can be displayed in a structured way in a short amount of space, which is

Table 1. Compact representations of English sentences into FL

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E: According to the user with identifier "jo", (i) any human body has at most 2 arms and 1 exactly head,
  and (ii) most arms belong to at most 1 human body.
  According to "pm", male_body and female_body are exclusive subtypes of human_body,
  and most human bodies have legs.
  According to "oc", most human_bodies are able to sleep for 12 hours.
FL: human_body part: arm [any->0..2(jo), 0..1<-most(jo)]  head [any->1(jo)]  leg [most->0..*(pm)],
           subtype: excl{ male_body(pm) female_body(pm) }(pm),
           can be agent of: [(sleep, period: 12 hour)][most->a(oc)];
```

Note. The creators of the terms are not specified and hence the representations are informal.

Table 2. Formal representations of an English sentence into FL, FCG and KIF

```
E:  According to "jo", most human_body (as understood in WordNet 1.7) may have for
    part (as understood by "pm") one or two legs (as defined by "fg") and
    have exactly 1 head (as understood by "oc").
FL:  wn#body pm#part: 0..2 fg#leg (jo)  1 oc#head (jo);
FE:  `most wn#body pm#part at most 2 fg#leg and for pm#part 1 oc#head' (jo);
FCG: [most wn#body, pm#part: at most 2 fg#leg, pm#part: 1 oc#head](jo);
KIF: (believer '(forall ((?b wn#body)) (atLeastN 1 '?l fg#leg  (pm#part '?b ?l ))) jo)
     (believer '(forall ((?b wn#body)) (exactlyN 1 '?h oc#head (pm#part '?b ?h))) jo)
```

very important to ease the manual retrieval and comparison of knowledge in a large KB. This is one of the reasons why KB systems should allow the entering, querying, display and browsing of knowledge using textual notations in addition to graphic notations. The following tables show examples of simple representations in FE, FCG and FL, languages that we are still extending. RDF translations of them would be long and ad-hoc. We packed many details into these examples and we invite the reader to really delve into these details in order to get a better intuition of the proposed approach.

We have used FL to represent the content of three courses at Griffith Uni: "Workflow Management," "Systems Analysis & Design," and

Table 3. Interconnection of semiformal statements in FL

```
"knowledge_sharing_with_an_XML-based_language is advantageous"
 extended_specialization of: "knowledge_sharing_with_an_XML-based_language is possible" (pm),
 argument: - "XML is a standard" (pm)
         - ("knowledge_management_with_classic_XML_tools is possible"
             corrective_specialization:
               "syntactic_knowledge_management_with_classic_XML_tools is possible" (pm)
          )(pm),
 argument: "the use of URIs and Unicode is possible in XML"
         (fg, objection: "the use of URIs and Unicode can easily be made possible in most syntaxes"
                     (tbl, pm) //according to pm, the last statement is an objection by Tim Berners
                             //Lee on F.G.'s argument (the use of the relation, not its destination)
         ),
 objection: - ("the use_of_XML_by_KBSs implies several tasks to manage"
            argument: "the internal_model_of_KBSs is rarely XML" (pm)
          )(pm)
         - ` "an increase of the number of tasks *t to_manage" has for consequence
            "an increase of the difficulty to develop a software to manage *t" ' (pm),
 objection: - "knowledge_sharing_with_an_XML-based_language forces
           many persons (developers, specialists, etc.) to understand
           complex_XML-based_knowledge_representations" (pm)
         - ("understanding complex_XML-based_knowledge_representations is difficult"
            argument: "XML is verbose" (pm)
          )(pm);
```

Notes. In this example, only the creators of the relations have been made explicit, not the creators of the statements. The terms used below for the relations and the terms including an underscore are informal but the relevant related formal terms/categories for these informal terms can be automatically found. To normalize the formulation of the statements and ease their organization and retrieval, most of the statements begin by a process and all the processes have related formal terms/categories. The parenthesis are used for two different purposes which the indentation help distinguish: (i) allowing the direct representation of relations from the destination of a relation, and (ii) representing meta-information on a relation, such as its creator (e.g., "pm" or "fg") or a relation on this relation. Dashes are used for joint arguments/objections (e.g., a rule and its premise). Most notations proposed by argumentation systems do not have this expressiveness and compactness, and hence restrict or bias the work of their users. The statement beginning by a back quote is in FE; it connects two informal statements.

"Introduction to Multimedia." Figure 1 shows an extract of the input file for the first course, while Figure 1 and Figure 2 show very simple queries on its knowledge. Nearly each sentence of each slide for these courses has been represented into a semantic network of tasks, data structures, properties, definitions, and so forth. The students of these courses have recognised the help that the semantic network provides them in relating and comparing information otherwise scattered in many different slides and other lecture materials. Having to learn FL was however perceived as a problem, especially by the students who were evaluated on their contributions to the semantic network (Martin, 2006). An intuitive table-based knowledge entering/display interface for FL should reduce this problem.

FUTURE TRENDS: BIGGER AND FEWER KNOWLEDGE REPOSITORIES

Nowadays, many businesses grow or merge to stay competitive, and de-facto standards tend to persist despite their widely recognized short-

Figure 1. Extract from a file representing statements from Workflow Management book (the book is referred to by the variable $book; any Web user can create such a file and ask WebKB-2 to parse it and hence integrate its knowledge representations into the shared KB).

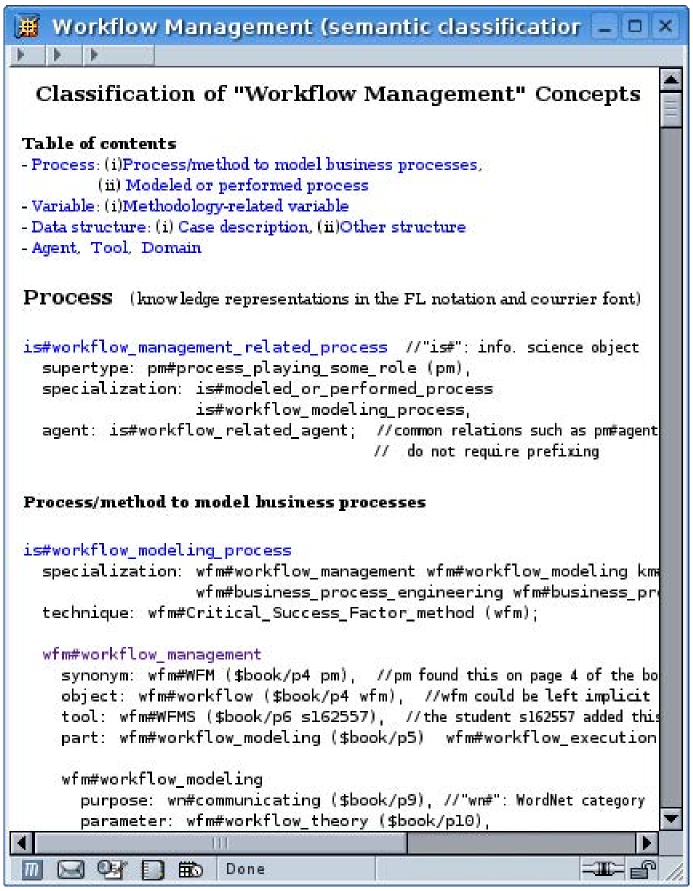


Figure 2. A search for the specializations of a statement in FCG and its first result

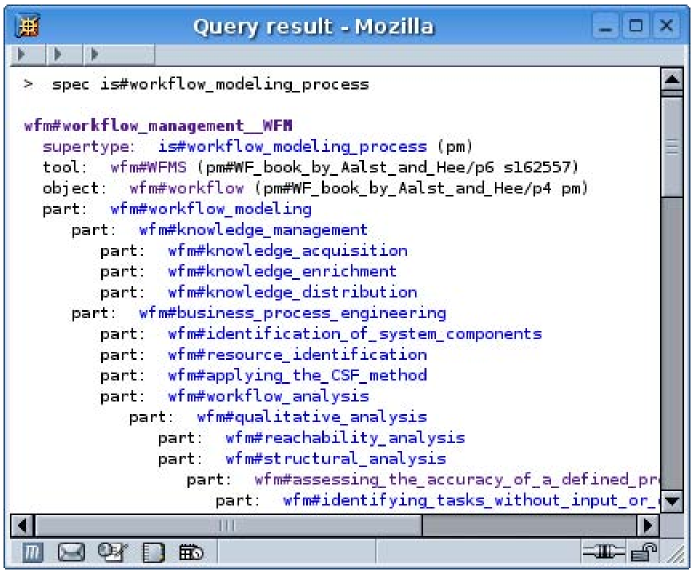
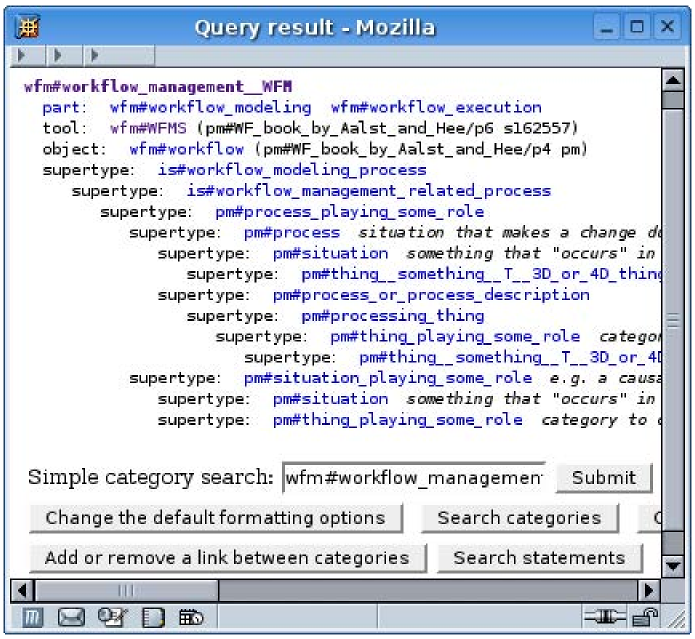


Figure 3. Expansion of the supertypes of wfm#workflow_management



comings, especially in information technology. The KB and knowledge sharing conventions or mechanisms of the first company that will propose a general KB that people will be able to update in a somewhat organized way are likely to quickly become de-facto standards in the same way that the Web, Google and Wikipedia quickly became widely used. Given current knowledge sharing practices, it is unfortunately unlikely that this initial KB and chosen conventions or mechanisms will be the best ones for scalability purposes. In any case, this KB will be collaboratively updated by all kinds of persons (researchers, lecturers, students, company employees, etc.) and purposes (storing LOs, advertising or giving feedbacks on products, etc.). Indeed, we have shown that a KB server can be used by many people for collaboratively organizing and valuating knowledge at various levels of details, and that alternative technologies are less efficient for sharing and retrieving information.

One hypothesis behind our approach is that a sufficient number of persons will take the time to be precise and learn notations and conventions to do that. We do not think this will be a problem once the approach becomes popular with researchers, teachers and students, and we concluded in the Background section that this was likely to happen. The social success of Wikipedia shows that despite its problems many persons are willing to contribute, and our approach would solve these problems. In this approach people can engage in “structured discussions” by connecting statements via argumentation/corrective relations, thereby not only representing debates in unprecedentedly structured ways but are also collaboratively evaluating themselves on each of their statements; this intellectual challenge and opportunity for recognition may attract a lot of people. More generally, this approach is in-line with the constructivist and argumentation theories and can be seen as a particular implementation and support of the “critical thinking” theories approaches and Brandom’s model of discursive practice (Brandom, 1998).

CONCLUSION

We argued that a virtual global normalised well-organized collaboratively-updated formal and semi-formal KB is necessary and achievable for the scalable and efficient sharing and retrieval or comparison of precision-oriented kinds of information (LOs included) within intranets or on the Internet, and therefore as a shared medium for the tasks of publishing, researching, teaching, learning, annotating, evaluating, and collaborating. In comparison, synchronous approaches (e.g., online chats and face-to-face teaching) and approaches based on indexing or relating formal or informal documents or KBs, are extremely suboptimal for information publishing, retrieval, comparison, and learning. Ideally, a normalized KB is like a decision tree: the place or way to insert or find information is quickly found, however huge the KB, and the existing information (fact, hypothesis, feedback, etc.) can be incrementally completed or refined. Documents often do not contain precise enough information to create such a KB directly from them; the proposed approach leads information providers to deepen and structure their knowledge and permits to evaluate or filter out each of the individual contributions. Automatic knowledge extraction, alignment or merging methods are needed to help building this KB but need to be adapted to take into account knowledge sharing best practices and used for combining the advantages of centralisation and distribution rather than just creating new resources. Documents and synchronous collaboration or teaching will always exist and be needed but these works will hopefully also lead to the completion of more semantically structured media and hence permit other people to easily find and re-use the results of these works.

REFERENCES

Brandom, R. (1998). Action, norms, and practical reasoning. *Noûs*, *32*(12), 127-139. Pittsburgh, PA: Blackwell Publishing.

Buckingham-Shum, S., Motta, E., & Domingue, J. (1999). Representing scholarly claims in Internet digital libraries: A knowledge modelling approach. In S. Abiteboul & A.-M. Vercoustre (Eds.), *European Conference on Digital Libraries* (pp. 423-442). Paris, France: Springer-Verlag.

Chaudhri, V., Rodriguez, A., Thoméré, J., Mishra, S., Gil, Y., Hayes, P., et al. (2001). Knowledge entry as the graphical assembly of components. *K-Cap'01* (pp. 22-29). BC, Canada: ACM Press.

Devedzic, V. (2004). Education and the Semantic Web. *International Journal of Artificial Intelligence in Education, 14,* 39-65.

Downes, S. (2001). Learning objects: Resources for distance education worldwide. *International Review of Research in Open and Distance Learning, 2*(1).

Euzenat, J. (1996). Corporate memory through cooperative creation of knowledge bases and hyper-documents. In B. Gaines (Ed.), *Knowledge Acquisition Workshop* (pp. 1-18). Banff, CA, Canada: ksi.cpsc.ucalgary.ca/KAW

Euzenat, J. (2005). Alignment infrastructure for ontology mediation and other applications. In M. Hepp, A. Polleres, F. Harmelen, & M. Genesereth (Eds.), *International Workshop on Mediation in Semantic Web Services* (pp. 81-95). Amsterdam, Netherlands: CEUR-WS.org.

Euzenat, J., Stuckenschmidt, H., & Yatskevich, M. (2005). Introduction to the ontology alignment evaluation 2005. In B. Ashpole, M. Ehrig, J. Euzenat, & H. Stuckenschmidt (Eds.), *K-Cap'05* (pp. 61-71). Banff, Canada: CEUR-WS.org

Friedland, N.S, Allen, P., Mathews, G., Witbrock, M., Baxter, D., Curtis, et al. (2004). Project halo: Towards a digital aristotle. *AI Magazine*, *25*(4), 29-48.

Gouardères, G., Saber, M., Nkambou, R., & Yatchou, R. (2005). The grid-e-card: Architecture to share collective intelligence on the grid. *Applied Artificial Intelligence*, *19*(9-10), 1043-1073.

Hillis, W.D. (2004). Aristotle (the knowledge Web). *Edge Foundation*, *Inc*., *38*.

Hodgins, W. (2006). Out of the past and into the future: Standards for technology enhanced learning. In U. Ehlers & J. Pawlowski (Eds.), *Handbook on quality and standardisation in e-learning* (pp. 309-327). Springer.

Horn, R. (2003). *Mapping great debates: Can computers think?* Retrieved March 28, 2008, from http://www.macrovu.com/CCTGeneralInfo.html

IEEE LTSC. (2001). *IEEE learning technology standards committee glossary*. IEEE P1484.3 GLOSSARY WORKING GROUP, draft standard 2001.

Lausen, H., Ding, Y., Stollberg, M., Fensel, D., Lara, R., & Han, S. (2005). Semantic Web portals: State-of-the-art survey. *Journal of Knowledge Management*, *9*(5), 40-49.

Lewen, H., Supekar, K.S., Noy, N.F., & Musen M.A. (2006). Topic-specific trust and open rating systems: An approach for ontology evaluation. *Workshop on Evaluation of Ontologies for the Web* at WWW'06. Edinburgh, UK: km.aifb.uni-karlsruhe.de/ws/eon2006

Lowe, D. (1985). Co-operative structuring of Iiformation: The representation of reasoning and debate. *International Journal of Man-Machine Studies*, *23*(2), 97-111.

Martin, P. (2000). Conventions and notations for knowledge representation and retrieval. In B. Ganter & G.W. Mineau (Eds.), *International Conference on Conceptual Structures*. Springer. (LNAI 1867, pp. 41-54)

Martin, P. (2002). Knowledge representation in CGLF, CGIF, KIF, Frame-CG and Formalized-English. In U. Priss, D. Corbett, & G. Angelova (Eds.), *International Conference on Conceptual Structures*. Springer. (LNAI 2393, pp. 77-91)

Martin, P. (2003a). Knowledge representation, sharing and retrieval on the Web. In N. Zhong, J. Liu, & Y. Yao (Eds.), *Web itelligence* (pp. 263-297). Springer.

Martin, P. (2003b). Correction and extension of WordNet 1.7. In G. Ellis & G. Mann (Eds.), *International Conference on Conceptual Structures*. Springer. (LNAI 2746, pp. 160-173)

Martin, P. (2006). Griffith e-learning fellowship report. Retrieved March 28, 2008, from http://www.webkb.org/doc/papers/GEL06/

Martin, P., & Eboueya, M. (2007). Sharing and comparing information about knowledge engineering. *WSEAS Transactions on Information Science and Applications, 5*(4), 1089-1096.

Martin, P., Eboueya, M., Blumenstein, M., & Deer, P. (2006). A network of semantically structured wikipedia to bind information. In T. Reeves & S. Yamashita (Eds.), *World Conference on E-Learning* (pp. 1684-1702). Honolulu, HI: AACE.

Novak, J.D. (2004). Reflections on a half century of thinking in science education and research: Implications from a twelve-year longitudinal study of children's learning. *Canadian Journal of Science, Mathematics, and Technology Education, 4*(1), 23-41.

Noy, N.F., Chugh, A., Liu, W., & Musen, M. A. (2006). A framework for ontology evolution in collaborative environments. In I. Cruz, et al. (Eds.), *International Semantic Web Conference*, Springer. (LNCS 4273, pp. 544-558)

Page, K., Michaelides, D., Buckingham-Shum, S., Chen-Burger, Y., Dalton, J., De Roure, et al. (2005). Collaboration in the semantic grid: A basis for e-learning. *Journal of Applied Artificial Intelligence*, *19*(9-10), 881-904.

Rousset, M-C. (2004). Small can be beautiful in the Semantic Web. In S. McIlraith, D. Plexousakis, & F. Harmelen (Eds.), *International Semantic Web Conferenc*e, Springer. (LNCS 4273, pp. 6-16)

Sanger, L.M. (2006) The future of free information. *Digital Universe Electronic Journal*, 2006-01. Retrieved March 28, 2008, from http://www.dufoundation.org/downloads/Article_2006_01.pdf

Schuler, W., & Smith, J.B. (1992). Author's argumentation assistant (AAA): A hypertext-based authoring tool for argumentative texts. *Hypertext: Concepts, Systems and Applications*, 137-151. Cambridge University Press.

Shadbolt, N., Berners-Lee, T., & Hall, W. (2006). The Semantic Web revisited. *IEEE Intelligent Systems*, *21*(3), 96-101.

Shipman, F.M., & Marshall, C.C. (1999). Formality considered harmful: experiences, emerging themes, and directions on the use of formal representations in interactive systems. *Computer Supported Cooperative Work, 8*, 333-352.

Sowa, J.F. (2006). *Concept mapping*. Retrieved March 28, 2008, from http://www.jfsowa.com/talks/cmapping.pdf

Stutt, A., & Motta, E. (2004). Semantic learning webs [Special issue on the educational Semantic Web]. *Journal of Interactive Media in Education*, *10*.

Swick, R., Schreiber, G., & Wood, D. (2006). Semantic Web best practices and deployment working group. Retrieved March 28, 2008, from http://www.w3.org/2001/sw/BestPractices/

Vrandecic, D., Pinto, H.S., Sure, Y., & Tempich, C. (2005). The DILIGENT knowledge processes. *Journal of Knowledge Management, 9*(5), 85-96.

Welty, C.A., & Jenkins, J. (1999). Formal ontology for subject. *Journal of Knowledge and Data Engineering, 31*(2), 155-182.

Witbrock, M., Baxter, D., Curtis, J., Schneider, D., Kahlert, R., Miraglia, P., et al. (2003). An interactive dialogue system for knowledge acquisition in Cyc. In G. Gottlob & T. Walsh (Eds.), *International Joint Conference on Artificial Intelligence* (pp. 138-145). Acapulco, Mexico: Morgan Kaufmann.

KEY TERMS

Although classic string-matching methods can also be used for retrieving knowledge, *knowledge retrieval* mainly refers to a "conceptual search" or "search by the content," that is, to manual navigation along conceptual relations between objects, or to queries that exploit the formal definitions of these relations. Both cases rely on *comparisons* between *objects (categories or formal/informal statements).* Two objects are *incomparable* when no generalization relation between them has been set manually or can be inferred.

Knowledge Normalization: Aims to ease manual or automatic knowledge comparison and retrieval by reducing the number of incomparable ways information is or can be written and by improving the way objects are (re-)presented and connected. *Lexical normalization* involves following object naming rules such as "use English singular nouns or nominal expressions" and "follow the undescore-based style instead of the Intercap style." *Structural and ontological normalization* involves following rules such as "when introducing an object into an ontology, relate it to all its already represented direct generalizations, specializations, components, and containers," "use subtypeOf relations instead of or in addition to instanceOf relations when both cases are possible," "avoid the use of non binary relations" and "do not represent processes via relations." These last example rules lead to the introduction of the concept type "sitting_down" instead of the relation types "sits," "sitsOn" and "sits_on_atPointInTime" which are incomparable. Thus, the sentence "some animal sits above some artifact" can be represented in the following explicit form in the Formalized-English notation: "some animal is agent of a sitting_down above some artefact" (this sentence uses the very common basic relations "agent" and "above"). As this example illustrates, knowledge normalization means reducing redundancies as well as increasing the precision and scalability of knowledge modelling. *Scalable* knowledge modelling and sharing approaches maintain the possibility of efficiently and correctly finding and/or inserting a piece of information even when the KB becomes very large. Scalability implies the exploitation of automatic procedures for (i) discovering consistencies and redundancies during knowledge updates, and (ii) filtering knowledge according to various criteria during searches.

Knowledge Sharing: The act of publishing information in a more or less normalized way.

ENDNOTE

[1] A reference collection is a list of objects with possibly some maximum depth for some relations from these objects. For a completely general server, this collection is reduced to most general conceptual category imaginable (often named "Thing").

Chapter XXX
A Needs Analysis Framework for the Design of Digital Repositories in Higher Education

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ABSTRACT

As the notion of learning objects has grown in popularity, so too has interest in how they should be stored to promote access and reusability. A key challenge to all repository projects is to understand the various motivations and needs to those wishing to contribute to and access the collection. To date there has been considerable attention given to technical issues of repositories, with much less consideration of how to *attend to the needs of those who will use them. This chapter presents a needs analysis framework that was developed to guide the design of a new repository currently being created for the Australian higher education sector, The Carrick Exchange. The project to develop the framework is described, outlining the findings from analysis of literature and existing repositories, with input from a survey of potential users. The purpose of the framework was to distil key issues that should be considered in the design of the repository and we offer it here as an analytical tool that could be applied by others.*

INTRODUCTION

With the advent and adoption of the Internet it has become easy to share and distribute information. This has generated considerable interest in how digital resources can be stored and organised. In the early years of the Internet, many had visions of "virtual libraries," a digital analogy to the familiar physical library. More recently as the idea of reusable and sharable "learning objects" has emerged, attention has become focused on digital repositories.

In higher education, the vision is for learning objects developed for specific teaching purposes to be housed in digital repositories in which they are catalogued and described in ways that make the resources accessible across institutions (Littlejohn, 2003b; Littlejohn & Buckingham Shum, 2003). The activities involved in populating and using these repositories would create an economy in which individual academics design and prepare resources appropriate for reuse by others in exchange for access to a much wider range of similarly reusable resources contributed by other individual academics (Malcolm, 2005). In addition, institutions, government bodies, and commercial educational developers could also contribute to such an economy. There is also considerable interest within institutions to make the most of digital resources, a trend that can be observed in the current move to content management systems, though this issue is somewhat separate from the broader notions of the learning object economy.

It is difficult to define a "learning object" with any precision or authority as there is still significant debate in the literature as to what should be regarded as a learning object (see Agostinho, Bennett, Lockyer, & Harper, 2004). For the purposes of this chapter, the term will be used to encompass teaching and learning materials and guides that range in granularity from single files to full courses. As such, learning objects can be considered items relevant to the teaching and learning process that are made available for others to use and adapt to their own contexts.

Thus, learning objects made available in digital repositories promise a new way of creating learning environments within and outside the traditional boundaries between courses, disciplines, and institutions. Digital repositories that accommodate high quality learning objects could be of assistance to university teaching by increasing the reusability of content thereby:

- Saving time and money in course development,
- Enhancing students' learning experiences, and
- Engaging teaching staff in a dynamic community of practice.

The basis of digital repositories is the sharing of digital resources. The fundamental premise is that digital resources are submitted according to specified criteria and accessed according to another set of conditions. The submission of digital resources may occur in a variety of ways, for example:

- Contributors freely provide digital resources that may be assessed, enhanced, or peer reviewed before being accessed from the repository (e.g., Apple Learning Interchange, Connexions, and iLumina).
- Only registered members are able to contribute digital resources that may be peer reviewed prior to being made available to repository users; for example, Campus Alberta Repository of Educational Objects (CAREO), Cooperative Learning Object Exchange (CLOE), EducaNext, Education Network Australia (EdNA), Jorum, and Multimedia Educational Resource for Learning and Online Teaching (MERLOT).
- An education advocate selects, develops or designs digital resources that are made available from the repository (e.g., Blue Web'n and INTUTE).
- Educators design and produce digital resources for a specific higher education course or purpose and use the repository as a means for dissemination (e.g., LEARNet, Massachusetts Institute of Technology (MIT) Open CourseWare (OCW) and Scottish electronic Staff Development Library (SeSDL)).
- Contributors provide details and/or information about the digital resource and a link to the Web address where the resource is housed, external to the repository (e.g., Educause and Learning Resources Community (LRC) Project).
- Registered members use tools that are made available through the repository to create digital resources that once developed are described by metadata and added to the repository for other registered members to reuse; for example, European Knowledge Pool System (ARIADNE) and The Carnegie Foundation for the Advancement of Teaching (KEEP).

The diversity of digital repository implementation strategies indicates some of the complexity faced by those embarking on the design of a new initiative. Although, there is a range of options for repository management, all require effective search mechanisms to assist users in their assessment and selection of a resource. To do this well the designers of any repository must develop a sound understanding of the potential users of their system and of the culture into which the repository will need to be integrated. In this chapter we focus on how the notions of learning objects and digital repositories informed the conceptualisation and planning for *The Carrick Exchange*, a repository under development for the Australian higher education community, and in particular on the framework developed to capture users' needs.

BACKGROUND

The Carrick Institute for Learning and Teaching in Higher Education was established by the Australian Commonwealth government in 2004 with the aim of promoting and advancing learning and teaching in Australian higher education. In addition to administering competitive grant funding for teaching and learning initiatives and overseeing a system of national teaching awards, part of the Institute's brief is to establish *The Carrick Exchange*, "a new online service that will provide learning and teaching resources and functions to support communication and collaboration across the (Australian) and international higher education sector" (Carrick Institute, 2007, p. 3). This project is part of the wider *Resource Identification and Networking Portfolio* charged with identifying, disseminating, and embedding good practices in higher education and with promoting the development of networks and communities (see http://www.carrickinstitute.edu.au/carrick/go/home/rin). The development of networks and communities of practice is seen as a key component to enable the sector to engage with *The Carrick Exchange*, moving beyond the idea of just exchanging resources.

The Carrick Institute's initial collection will comprise teaching and learning resources and research outcomes funded under current projects and grant schemes, and an archive of material funded by earlier government initiatives. It will include a directory of contributors, a description of their expertise, and will provide space for the developing network of educators to dialogue through *The Carrick Exchange*. There will also be a federated search mechanism linking it with other national and international repositories. The purpose of *The Carrick Exchange* is to provide:

- Access to quality resources that support teaching and learning by searching and browsing;
- Access to learning materials available for sharing and repurposing;
- Information about new technologies that impact on teaching practice and student learning experiences;
- Ideas about learning and practice;
- Opportunities to network with other academics with similar interests in group spaces and/or through creating networks of colleagues;
- The ability to save resources and search results;
- The ability to comment on and exchange ideas on the relevance and usefulness of particular teaching resources and to view the comments of others;
- The ability to participate in discussions, debates and dialogue about teaching in higher education (Carrick Institute, 2007, p. 3).

To inform the development of the repository, a project was established to investigate the "state of play" with respect to digital resources for enhancing teaching and learning in the higher education sector, the key success factors and issues in the utilisation of such digital repositories, and requirements for a successful reusable resource repository. Undertaken in late 2006, the purpose of this project was to develop a sound understanding of existing repository initiatives in Australia and around the world, and relate those to the particular context of the project.

One of the major difficulties in the uptake of digital repositories is their adoption by individual academics and institutions, and the application of resources in contexts other than the development environment. The aim of the project was to examine strategies for incorporating the use of these repositories into normal academic work practices. Much of the research and development in this area has focussed on technical and supply-side issues, with insufficient attention paid to the needs of the people using repositories. Understanding the needs of users, and contexts of use, for such digital repositories is a neglected area, and a better evidence base is urgently needed to avoid unwise investment and development strategies.

The approach adopted by the research team was to concurrently undertake an analysis of the relevant research literature and an analysis of existing repositories in Australia and around the world. The team also developed an online survey of potential users, seeking volunteers from the membership of three professional associations in Australia—*ascilite* (http://www.ascilite.org), the Open and Distance Learning Association of Australia (http://www.odlaa.org) and the Higher Education Research and Development Society of Australia (http://herdsa.org.au). The survey asked respondents a series of multiple-choice questions to determine: (1) their disciplinary/topical area of interest; (2) the likelihood they would access a learning object repository to support a range of content selection, activity design or professional learning tasks; (3) the importance they placed on various characteristics of a repository, such as local content, easy access, detailed metadata; (4) the importance of various types of recognition for contributions they might make to a repository;

(5) their awareness of major repositories. Options were also provided for respondents to add additional information as free text where they wished. A total of 86 respondents completed all questions in the survey, which, though too small to be considered representative of the sector, was useful in gathering some background information from those who might use the system. The outcome of the project was the development of a needs analysis framework which was presented at a "think tank" meeting that included key stakeholder representatives from across the sector to inform the further development of the repository.

KEY THEMES DERIVED TO INFORM THE NEEDS ANALYSIS FRAMEWORK

Use of Digital Repositories

There is very little information or research to conclusively determine the extent to which university educators are using existing digital repositories. This is particularly so of very large repositories that seek to appeal to a mass audience, rather than within-institution or more targeted initiatives with a smaller number of potential users. One empirical study to support the notion that educators are using digital repositories is that of Najjar, Ternier, and Duval (2004). This study investigated the ways in which users interacted with learning object repositories by logging the queries of the ARIADNE digital repository over periods of 4 to 10 months. These queries when analysed equated to 4,723 queries from about 390 different users, and were found to have come predominantly from educational institutions. However, the authors concluded that it was difficult to draw conclusions about the motivations of users from their search activities.

It appears that educators are using digital repositories in different ways and with varying purposes. A review of literature (Bradley & Boyle, 2004; Campbell, Littlejohn & Duncan, 2001; Koppi & Lavitt, 2003; Koppi, Bogle, & Lavitt, 2004; Lambropoulos & Christopoulou, 2004; Littlejohn, 2003a; Malcolm, 2005; Oliver, 2001; Poupa & Forte, 2003; Wilson & Mundell, 2004), the online survey conducted to inform this project, and case studies reported in digital repositories indicate that some of the reasons educators are using digital repositories are to:

- Acquire resources to develop or enhance learning and teaching experiences or course materials;
- Manage information and knowledge for sharing among communities of practice; the repurposing and subsequent development of digital resources, by educators from various departments, faculties and universities, can be stored and shared from a common repository;
- Promote the collegial and collaborative development of learning and teaching resources and practices across communities of practice;
- Save time that might otherwise be spent developing new learning and teaching resources or course materials;
- Gain recognition, educators who have put time and effort into developing learning resources are able to share the products and communicate the educational developments with peers;
- Archive course resources for students to access (e.g., the background reading for a lecture or the actual lecture taped for students to access and review prior to the face-to-face session so that other forms of instruction/topics can be covered in class);
- Provide students with additional resources to supplement or consolidate their learning (e.g., WebQuests with real-world implications that allow learners to revise, analyse and synthesize data);

- Document evidence of excellence in teaching, for promotion and tenure.

As part of this project an online survey was conducted to ascertain why respondents might access digital repositories. A summary of responses, shown in Table 1, suggests that obtaining resources to use in teaching would be a significant motivation to access a repository.

GENERAL ISSUES FOR THE IMPLEMENTATION OF DIGITAL REPOSITORIES

Rogers (1995) proposed a list of features that largely determine or impact on the acceptance of technology. Some of these features are relevant for the acceptance of digital repositories and can be adapted as questions that should underpin consideration of the key success factors and issues in the use of digital repositories:

Is the operation of the repository easy to understand, maintain, and use?

- Are the benefits of the repository as an educational tool obvious?
- Is the use of the repository more convenient, more worthwhile?
- Does the repository address the needs of the potential users?
- Is there enough support for the use of the repository?
- Is there enough time, energy, money, and resources to ensure the repository's success?

A register of contributing conditions can also be generated to anticipate potential reasons for the failure of an innovative initiative, such as the introduction of a digital repository. Latham (1988) identified a number of features common to failed innovations that could be relevant to the introduction of a digital repository. Understanding these features could ensure that barriers do not thwart key success factors or exacerbate challenges to the use of digital repositories. In terms of the current project, these include the following possibilities:

Table 1. Reasons for accessing a digital repository (n=86)

I would access a repository to obtain:	never	rarely	some-times	often	always
a. A learning object to complement an aspect of a lecture or other learning experience I was developing (e.g., text, images, video, sound)	0%	12%	34%	**48%**	7%
b. An activity for a lesson I was teaching (e.g., quiz, discussion starter, workbook, exercise, assessment task)	2%	16%	**38%**	35%	8%
c. A plan for a session in a course I was teaching (e.g., tutorial, workshop, lecture).	6%	28%	**37%**	24%	5%
d. A course program for a subject I was teaching (including lecture notes, tutorial sessions, workshops, recorded lecture presentations, assessment tasks, etc.)	8%	**40%**	28%	20%	5%
e. Information about learning and teaching pedagogy	5%	17%	**38%**	31%	8%

- Practitioners become disenchanted and disillusioned because the use of the digital repository is more difficult than expected, causing unnecessary disruptions and lengthy delays to their progress.
- Champions for the digital repository leave or are not available.
- People lack training in the use of the digital repository and subsequently lose enthusiasm.
- Funding to support the implementation and promotion of the digital repository runs out.
- There is inadequate supervision and support for users accessing the digital repository.
- The transitional stage of the digital repository's introduction lacks accountability, monitoring, review, assessment, and or evaluation.
- There is a "take-it-or-leave-it" attitude on behalf of the repository's promoters.

KEY FACTORS CONTRIBUTING TO THE SUCCESS OF DIGITAL REPOSITORIES

There have been a number of studies and literature reviews conducted evaluating digital repositories and proposing motivating factors for their use (Bradley & Boyle, 2004; Gosper, Woo, Gibbs, Hand, Kerr, & Rich, 2004; Littlejohn, 2003a; Littlejohn, Jung, & Broumley, 2003). A summary of the factors proposed in these studies and literature identifies the following as incentives for using digital repositories:

- Saves time in preparation,
- Quality assurance,
- Communities of practice,
- Acknowledgment,
- Provides flexibility, and
- Access and control of educational information.

Saves Time in Preparation

Educators can save time and money in the development of teaching activities, sessions, or courses by reusing and adapting existing educational resources for a new context. Instead of creating every learning resource from scratch, which is an activity that consumes many educators' time; digital repositories provide a mechanism that enables educators to access quality resources aligned to teaching aims. The time required to search for, access, and adapt resources available from digital repositories is far less than that required to create a learning resource from scratch, which is an enormous incentive for educators to use digital repositories.

The studies of Gosper et al. (2004) and Koppi and Lavitt (2003) both found that time and workload pressures were incentives in the utilisation of digital repositories. However, it is important to note that participants in both these studies indicated they were prepared to spend time searching for learning objects if they were confident that the available resources were:

- relevant to teaching aims,
- quality resources,
- atypical or uncommon and
- potential assets to enhance students' learning.

Campbell (2003), in support of the notion that time saving is a powerful incentive for educators to utilise digital repositories added that this was conditional on the digital resources being contained in a pedagogical framework. The incentive for using digital repositories to save time is dependent on the perceived quality and value of the learning objects stored in the repository. As such, the management of most digital repositories includes some form of quality assurance to warrant and promote the merit of the learning objects it contains.

Quality Assurance

Quality assurance is critical for widespread adoption of a digital repository (Poupa & Forte, 2003). Enthusiasm for reusing learning objects housed in digital repositories is influenced by the quality control mechanisms engaged by the repository. There are three different aspects of quality assurance related to resources contained in digital repositories:

- The technical quality of a learning object, and
- The quality of a learning object's content, and
- Ease of use.

It would be assumed and expected that digital repository learning objects should be technically sound in relation to standards and usability, and that they function as expected. However, quality assurance of content does not necessarily hold the same guarantee. Most digital repositories engage a peer review process of some sort to exercise control over the quality of the objects collected and to encourage the participation of community members. There are varying protocols for the review process undertaken by digital repositories but the intentions of these are largely concerned with an assessment of the:

- Validity and quality of the content,
- Pedagogical value of the learning object, and
- Overall contribution of the learning object to student learning.

Methods are also emerging to assist educators to judge the quality of the learning resources for themselves. The generation of dynamic histories, to provide users with the ability to search for the most widely used learning objects on a given topic, is one strategy being investigated as a mechanism for learning object validation (Campbell, 2003).

Educators accept that resources published in peer-reviewed books and journals are of adequate quality. However, aligning this judgment of quality to the learning objects housed in digital repositories appears to be a little more difficult. Peer review that is facilitated within communities of practice is assisting this transition and serving as an incentive for using digital repositories.

Communities of Practice

Many digital repositories are created with a specific community in mind, for example a university repository will primarily serve its community of university students, educators, and academics. These repositories can be either public or restricted to serve only the community, or can provide mixed access with a blend of privileges depending upon user identity and role.

There are incentives for using repositories that target a community of practice, particularly in regard to the resources they house. The resources in these repositories will predominantly be developed by members of the particular community of practice to address the needs and focus areas of that community. Consequently, the learning resources will inevitably be content appropriate with only contextual modification by the user necessary. The availability of this calibre of resource will make the development of learning and teaching resources a far more efficient process.

Accessing resources in these repositories is time efficient, as the metadata attached to the resources is relevant and familiar to the members of the community of practice. As such, searches within the repository can be explicit and refinement of the available resources more exact.

Gosper et al. (2004) reported that educators would be willing to share resources on a professional basis in an effort to develop a community of practice. These educators were also keen to engage in a learning object economy within this community because it exposed them to new ideas and high-quality practice. By sharing learning resources educators could see that they were contributing to building communities of practice in which academics assisted each other to provide students with high quality learning resources.

A further incentive for using digital repositories is the opportunity and mechanism they provide for educators to promote their contributions and efforts within their particular community of practice to other members of the community. This is a means of gaining acknowledgement and recognition in much the same way as an educator's contributions to peer reviewed books and journals will achieve. Identification of a network of expertise, including individuals with similar interests and specific strengths, results in a valuable community of practice to be supported by a repository such as *The Carrick Exchange*.

Acknowledgment

Acknowledgement of an individual's contributions in the development of a learning object is highly regarded as an incentive for contributing resources to digital repositories. Gosper et al. (2004) found acknowledgement was a far greater incentive for sharing learning objects than was payment.

The online survey further endorsed this finding with respondents confirming that financial remuneration was not as great an incentive for contributing to a digital repository as was formal recognition and acknowledgement of the contribution by the repository's management or the contributor's university, faculty, or department (see Table 2).

Educators, according to Koppi and Lavitt (2003), require professional recognition of the contributions they make to digital repositories especially if that recognition could possibly lead to promotion. This notion is supported in other literature affirming the importance of recognising digital repository contributions in tenure or promotion processes (Campbell, 2003; Taylor & Richardson, 2001). Engagement in the learning object economy needs to align to the opportunities and rewards provided through traditional forms of sharing in academic circles.

Table 2. Incentives for contributing to a digital repository (n=86)

Rate the following in terms of how strongly you agree or disagree					
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**
a. I would be willing to contribute a learning object to a learning repository.	1%	2%	15%	**60%**	21%
b. I would be willing to contribute a learning object to a learning repository if I received formal recognition from the repository's management of my contribution.	0%	2%	12%	**60%**	26%
c. I would be willing to contribute a learning object to a learning repository if I received formal recognition of my contribution from my University/ Faculty/ Department.	0%	2%	16%	**53%**	28%
d. I would be willing to contribute a learning object to a learning repository if I received remuneration for my contribution.	8%	17%	**40%**	27%	8%

Acknowledgement of repository contributions is a significant innovation in the CLOE repository. Members who submit learning objects receive yearly updates on CLOE letter-head, signed by the director and providing details of how many different courses benefited from the learning object throughout the year, at what level those courses were offered and how many students were involved. Additionally, submitters receive written notification advising when their learning objects are accepted by CLOE for reuse. These activities are specifically intended to assist submitters in promotion and tenure processes, and to include in their curriculum vitae.

Provides Flexibility

Flexibility is applicable to two aspects of digital repository use. First, flexibility is the capacity for educators to repurpose or customise learning objects to suit their specific learning requirements; for example, changing the wording of a learning object to give a local voice or changing content examples to suit a particular student group. According to Gosper et al. (2004) an educator's ability and rights to customise learning objects is an essential criterion in their use of learning objects and a subsequent incentive for using digital repositories.

This incentive is the essence of why digital repositories are created; consequently, measures to reinforce this aspect of flexibility are often promoted in the operation and management of a repository. Some repositories encourage the repurposing of learning objects by providing tools to assist users to customise the digital resource (e.g., the tools for modifying learning objects that are available from the ARIADNE repository and the KEEP toolkit offered for users in the Carnegie Foundation for the Advancement of Teaching repository).

The second aspect of flexibility that is an incentive for using digital repositories is the flexibility that educators have through federated searches to access resources from a range of digital repositories and not just the one source. The digital resource economy provides educators with the flexibility and resources to adapt, adopt, and add to their course materials as desired.

Access and Control of Educational Information

The most common reason for educators to choose a learning object was the object's relevance to curriculum according to Gosper et al. (2004). The educators in this study specifically reported that when choosing between resources, they were more likely to look for relevant materials that were easy to locate, access, and acquire. Apart from educational efficacy, the reported appeal of learning objects for teachers in the Gosper et al. (2004) study was the potential to improve the efficiency of their work through the provision of a large repository of relevant objects that could be accessed via search mechanisms that used educational criteria relevant to their own context.

Participants indicated that they were generally unsatisfied with the outcomes of Internet searches, and required systems that categorised learning objects in a way that more closely matched their local syllabus and curriculum outcomes, as was the case with some digital repositories. These educators also indicated that they preferred learning objects that had clear instructions for use, to ensure they selected resources that all students could access and had the technical skills to use. Overall, the teachers in this study placed educational efficacy and efficiency as the main concerns for using and choosing between learning objects.

Unlike the Web, digital repositories can provide certain control functionalities. Some repositories provide educators with the ability to:

- Determine who can access the published resources (e.g., access could be limited to those enrolled in a course/class, anyone registered with a particular university/uni-

versities, anyone possessing a valid user ID certificate, or to anyone in the world),
- Place restrictions on the reuse and re-purposing of digital resources,
- Record details.

Other strategies offered in digital repositories to encourage reuse and repurposing of learning objects centre around the issue of rights security. Repositories often use licences, memorandums of understanding and terms and conditions to ensure the integrity of learning objects. In many instances learning objects cannot be submitted or accessed without attending to these agreements. These measures are intended to assure users of their rights and thereby encourage the reuse and repurposing of learning objects accessible from the digital repository.

Respondents to our online survey indicated that the most significant factors for selecting digital repositories are that the:

- Learning objects are easily accessed, downloaded, and manipulated;
- Search mechanism is consistent with Internet searching protocols;
- Repository provides detailed information (metadata) about the learning object; and
- Repository engages sound quality control practices that are applied to all learning objects prior to being accepted (see Table 3).

KEY BARRIERS TO THE SUCCESS OF DIGITAL REPOSITORIES

Digital repositories are capable of delivering significant benefits for communities of teachers and learners but the human barriers to encouraging sharing can be difficult to overcome. Wetterling and Collis (2003) found that the major problems

Table 3. Reasons for accessing a digital repository (n=86)

Rate the following in terms of importance to you when selecting a learning repository					
	of no importance	**not important**	**not sure if it is important**	**important**	**vitally important**
a. The repository is suitable for the Australian context.	3%	8%	17%	**48%**	23%
b. The repository stores the actual learning object rather than directing the user to a secondary Web site where the object is held.	5%	22%	13%	**36%**	24%
c. The repository learning objects are easily accessed, downloaded and manipulated.	0%	0%	1%	31%	**67%**
d. The repository search mechanism is consistent with Internet searching protocols.	0%	2%	12%	**44%**	42%
e. The repository provides detailed information (metadata) about the learning object.	0%	7%	13%	**43%**	37%
f. The repository engages sound quality control practices that are applied to all learning objects prior to being accepted.	1%	5%	9%	**45%**	40%
g. The repository provides an evaluation (e.g., peer review, user review) of the learning objects.	1%	6%	17%	**57%**	19%

in the utilisation of digital repositories were often culturally based in relation to collaboration among partners and a lack of overall willingness of users to participate in a learning object culture where educators share and use learning objects created by each other. Littlejohn, Jung, and Broumley (2003) identified barriers in the use of digital repositories as:

- Insufficient hardware to support the use of multimedia Web resources within classrooms;
- Too few reusable resources that would directly map with lesson objectives;
- Outdated resources that often require updating;
- Not enough time to search for good quality materials and evaluate existing materials;
- Lack of robustness of external materials;
- Poor accessibility of resources;
- Copyright issues;
- Insufficient time to use Web resources in class; and
- Lack of evidence of the effectiveness of using Web resources.

A summation of these and other factors identified in literature and research studies as disincentives for using digital repositories include issues related to:

- Intellectual property rights, copyright, and learning object management,
- Time, workload, and effort,
- Communities of practice,
- Quality control,
- Context appropriateness, and
- Interoperability.

Intellectual Property Rights, Copyright, and Learning Object Management

The sharing of intellectual property is often conditional on certain copyright conditions. The management of these conditions can be daunting for some educators and the proposition of dealing with them a greater burden than many are willing to accept for the sake of sharing resources with others. The Gosper et al. (2004) study affirmed this premise that educators were not prepared to deal with unresolved copyright issues and that these copyright issues can be a disincentive to them for using digital repositories. They also found that a lack of knowledge about copyright was a deterrent to educators reusing learning objects. Educators in this case see the responsibility of copyright clearance a burden that they are not willing to bear to utilise the learning objects held in digital repositories.

A study conducted to investigate the use of ICT for teaching and learning found that educators were not as comfortable providing students with electronic resources as they were with supplying them with hardcopy materials. Their issues related to the copyright of materials, with educators feeling under scrutiny and insecure with regards to copyright of materials distributed to students online, compared with the distribution of paper-based resources (Littlejohn, Campbell, Tizard, & Smith, 2003). This is a disincentive to using digital repositories that is addressed in some repositories with a copyright statement. This statement or in some cases agreement is intended to elucidate the importance of exchange, requiring contributors to agree to users freely using, developing and adapting their materials either to improve their own practice or to help develop others' skills.

Some educators are wary of sharing their resources within and beyond their communities of practice if there is a perception that intellectual property rights are at risk of being violated. Concerns exist in relation to the repurposing of learning objects. If an original learning object is adapted, repurposed and republished by another user, then who is the recorded "author"? This inability to control intellectual property rights is often a disincentive for educators to share their resources.

Participants in the Gosper et al. (2004) study were conversely apprehensive about customising learning objects. They were concerned with limitations that could be imposed on them by the creators of learning objects. Inadequate resolution of these intellectual property issues, particularly in relation to customisation requirements, can have a negative effect on the use of digital repositories.

In addition there is often no formal means of recording learning object management information such as: acquisition details, the extent to which a resource can be distributed, whether or not it can be adapted, the boundaries of the community for which it is intended and the number of versions a single repository may hold. With the reuse of learning objects across communities of practice and international boundaries, many educators are reluctant to contribute to repositories when these management issues are not formally addressed in the submission or utilisation of digital resources (Campbell, 2003).

Time, Workload, and Effort

Although repositories can offer substantial time savings through the utilisation of resources that others have produced, there is a time commitment required to learn about and use this tool. Often the perception is that the commitment of time to learn about and use a repository is great. This is a barrier that technology cannot solve but is one that requires changing work practices and culture.

The studies both found that time and workload pressures were issues in the utilisation of digital repositories according to two recent studies (Gosper et al., 2004; Koppi & Lavitt, 2003). Participants in these studies indicated that institutions encouraging the reuse of learning objects needed to allocate sufficient time to allow educators to:

- Search for and acquire learning objects,
- Make the necessary changes to their curricula and teaching practices, and
- Attend professional development programs developing the underpinning technical and pedagogical skills required.

To ensure others can source materials from a digital repository, each resource submitted must be tagged with metadata during upload. A major shortcoming of using metadata, and a disincentive for submitting resources to digital repositories, is the time spent on completing metadata fields (Goodacre & Rowlands, 2005; Neven, Duval, Ternier, Cardinaels, & Vandepitte, 2003). This time pressure was highlighted amongst the issues identified in a study of the uptake of learning objects conducted by Koppi and Lavitt (2003). Staff found uploading and tagging their learning objects time-consuming and intrusive to their daily work.

Standards for recording Learning Object Metadata (LOM) have been instigated to warrant some consistency in the classification of learning objects. It has been noted, however, that the full set of 86 elements in LOM are not worthy of the investment of time required to compile the complete classification record (Goodacre & Rowlands, 2005; Mohan & Greer, 2004; Richards, McGreal, & Friesen, 2002). Even if it were possible to capture the metadata elements specified in LOM, the usefulness of the metadata in reusing learning objects is questionable (Farance, 2003; Mohan & Brooks, 2003; Wiley, 2002). For example, the LOM standard contains elements such as Semantic Density and Interactivity Level, which mean different things to different people therefore the benefits of standardisation are lost.

The time taken to enter metadata can be considerably reduced by using "application profiles" such as CanCore, which contains only 36 elements from the LOM, and are considered essential for promoting the discovery and reuse of learning objects. According to Neven et al. (2003), it is also possible to automatically generate several metadata fields before data entry by a human user.

Another solution is to make available tools that automatically create as much metadata as possible. Given access to these tools, tutors need not be concerned with metadata standards, though they are still required to describe a few, specific elements by selecting from a controlled vocabulary or by entering free text (Littlejohn, 2003a).

Culture Change

Research has shown that although educators are willing to reuse resources produced by others, many are much less willing to share their own materials (Campbell, Littlejohn, & Duncan, 2001). There are a number of reasons why this may be the case, and Duncan and Ekmekcioglu (2003) maintain that for some educators it may be more than an unwillingness to share, there may be a fear or insecurity of exposing how they teach.

Whilst collaboration is viewed as desirable, rivalry, particularly among universities where competition for students is high, does exist. Academics are generally happy to share resources with their colleagues in other universities if there is no competition for student enrolments, as is the case with subjects in high demand. However, in disciplines where there is greater competition for student enrolments and less demand for certain subjects, academics may be less likely to share with each other in order to protect their own interests (Gosper et al., 2004). Another significant disincentive for using digital repositories was that some faculties considered the learning objects held in digital repositories to be inappropriate to their learning and teaching programs (Gosper et al., 2004; Koppi & Lavitt, 2003).

A situation that has been encountered by some repositories is that in the early stages of operation people in some large institutions do not want to share with those in smaller institutions on an equal basis because they perceive that the smaller institutions gain more than they contribute, at the expense of the larger institutions. This issue has been managed in some instances with an agreement that states that all affiliated and participating institutions are bound to share equally.

These issues require a shift in the culture and perception of the learning object economy and adequate promotion of the benefits of a viable economy. Duncan and Ekmekcioglu (2003) advise that to realise the benefits of digital repositories, it is best to start with communities of noncompetitive, natural collaborators and quickly establish a critical mass of shared resources.

Quality Control

The perceived quality of available resources can influence educators' use of the digital repository. Educators are quite reluctant to spend time searching a repository for a resource if they believe that the quality of the resource they might acquire could be questionable. The content shared in a repository is key to its success. One primary motivation for using digital repositories is to get access to a wide variety of high-quality knowledge resources. If this need cannot be satisfied for any reason, users will not persist in using the repository. According to Koppi, Bogle, and Lavitt (2004), some users believe that their materials are not good enough to be considered "quality resources"; but this is a perception only based on the undefined subjective criteria of these individual users. In the case of the Universitas 21 Consortium (U21), regarding this notion of quality resources, a decision was made to let the owner of the resource make the decision (without formal criteria) as to whether or not the learning object would be submitted. Eventually it became a matter of trust with the recommendation made that teachers were trusted to provide their students with quality learning materials, so why should it be any different for the submission of resources to the digital repository.

Context Appropriateness

In general, when designing resources educators take into consideration the constraints of the educational setting within which they operate and consequently design learning objects to suit the context of their particular educational setting, resulting in resources that are context-dependent and less reusable in other settings.

Learning objects are predominantly designed and produced to meet specific educational needs, this motivation or stimulus for the creation of a learning object does not necessarily align to the requirements for a learning object to be transferable across educational settings, contexts and needs. Therefore educators utilising learning objects are often required to spend large amounts of time modifying the learning object which can equate to the time it would take to entirely develop the resource themselves.

To maximise their durability, it is generally agreed that resources must, as far as possible, be context-free. While contextual considerations may pervade the initial design process, specific context limitations should not, any more than necessary, constrain the durability of the object. Maximum durability requires the removal of as much contextual information as possible relating to approach, learner-target and even objective, from anywhere other than metadata (Oliver, 2001).

Interoperability

In order to participate in a learning object economy, educators must have access to the appropriate tools and resources such as content authoring and management systems, digital repositories and virtual and managed learning environments. Furthermore, if learning objects are to be shared then it is crucial that the tools, systems and components are "interoperable"; and the user and the contributor should be able to exchange information and use the information that has been exchanged (Campbell, 2003). An inability to provide or utilise this interoperability is a disincentive to using digital repositories.

The key principle of digital repositories is the interoperability between systems. Interoperability enables learning objects to be deployed in many systems, and it also enhances content sharability among individuals and between institutions (Mohan & Daniel, 2004). Currently there are many regional and international organisations working on the development of common standards for learning objects (e.g., ARIADNE, PROMETEUS, CEN/ISS; SCORM, CanCore, and CANARIE) to enhance the likelihood of this interoperability.

Users need to be able to search easily for and locate the learning object resources they require using a method that is consistent with Internet searching protocols. There should be a benchmark of standards set to ensure that learning objects are interoperable. Interoperability means that a resource would be delivered in a form that can be used by all, or at least most, other systems (Duncan & Ekmekcioglu, 2003).

A lack of interoperable standards among the different learning systems is a significant hindrance to system interaction. Though there are standards like IMS Global Learning Consortium, 2003 and SCORM (2004) to define and describe learning materials to be exchanged and reused across the different e-larning platforms the communication and interaction of learning objects can still be lacking.

A learning resource catalogue (LRC) that comprised records of learning objects was developed and used by members of the Universitas 21 Consortium for three years (Koppi, Bogle & Lavitt, 2004). The LRC provided a standardised means of identifying and describing learning and teaching materials in order to facilitate reuse and minimise replication. The interoperability qualities that the LRC set were aimed at academic staff and may be a model useful in negating the disincentive that a lack of interoperability can evoke.

The Web-based interface also needs to be fairly intuitive to accommodate the large numbers of people for whom training in the use of the digital repository is not feasible. If a user cannot operate the mechanics of the repository quickly they will inevitably disregard the resource as a viable educational tool.

NEEDS ANALYSIS FRAMEWORK

Using the emerging themes from the literature, existing repository projects and the online survey, the project team developed a needs analysis framework, reproduced in full in Appendix A. The framework was used to structure a one-day "think tank," which brought together 50 representatives of stakeholder groups from around Australia, including teaching staff, researchers, administrators, and technical experts. The outcomes of this meeting were used to further guide the development of specifications for the repository.

The framework is founded on the assumption that the following factors need to be considered in the design of a digital repository if the eventual repository is to be effective and successful:

- Adequate and appropriate encouragement for contributors;
- Willing and extensive sharing of learning objects;
- Viable rewards for both contributors and users of the repositor;
- Broad promotion of the digital repository.

The framework comprises a list of considerations that have been developed based on the success factors and key issues for using digital repositories identified within the context of *The Carrick Exchange* project. However, it is possible to apply these more generally and developers of other repositories may find them helpful in informing their process in identifying requirements for a project. The items could be used as a basis for discussions amongst stakeholders, or as the basis for survey or interview questions in the collection of data from potential users or a repository. Further, this structure could be used in reporting options or decisions made back to stakeholders. Importantly, it would support a methodical approach to address key issues in repository design and development. It is important to note that this is not an exhaustive list and can be adapted or appended according to the context. Decisions made on the basis of such a framework could then be used to inform technical specifications.

A JISC-funded project in the UK, Community Dimensions of Learning Object Repositories (CD-LOR), recently released their study on the barriers and enablers to engagement in such repositories (http://www.academy.gcal.ac.uk/cdlor/). Their research, coupled with the ongoing research by *The Carrick Exchange* research team, will aim to address some of the major issues identified through the design and development phase of *The Carrick Exchange* (Lefoe, O'Reilly, Parrish, Bennett, Keppell, & Gunn, 2007; Littlejohn, 2005; Margaryan & Littlejohn, 2007). This collaboration will inform future development of this and similar projects.

FUTURE TRENDS

Although the project had initially been focused on a repository as a means of storing, cataloguing and sharing teaching and learning resources, the key stakeholders participating in the "think tank" identified a need to go beyond the conventional notion of a repository to one where tools for networking and communicating were integrated. The potential for adopting Web 2.0 technologies for communication and collaboration to foster the development of a learning community in higher education, whilst also providing a central access point to an extensive database of resources was agreed to be the way forward. This has led to an emphasis on *The Carrick Exchange* as a "hub for Australian higher education, and integrating communities, users, networks, and resources."

Thus, one of the future trends for repository developers is to understand how emerging technologies, such as social bookmarking and community ratings, can enhance the usability and value of a resource repository in order to attract and engage users. The strategies that will be successful are the ones that take into account the needs of their target users, and in higher education this means understanding the needs and work practices of time-pressured teaching academics and support staff attempting to cater for a diverse student population. Furthermore, we need to learn much more about what can attract university educators to reusing learning resources created by others and to sharing resources they have created themselves in an academic culture that is slow to change.

CONCLUSION

Since the emergence of the learning object concept there has been considerable interest from educators, researchers, and technical experts. Key to the success of any learning object initiative is the provision of repositories that enable effective storage and retrieval. To be successful the design of such repositories must be based on a sound understanding of the needs and motivations of potential users. Without such an understanding the initiative is likely to fail.

This chapter has presented a needs analysis framework for developing repository functionality to meet the needs of potential users of the system. Although developed to inform *The Carrick Exchange* project, it offers a more generic framework that could be adapted or appended for other repository development projects. Frameworks of this kind are necessary to inform the technical decision making of any repository initiative.

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REFERENCES

Agostinho, S., Bennett, S., Lockyer, L., & Harper, B. (2004). Developing a learning object metadata application profile based on LOM suitable for the Australian higher education context. *Australasian Journal of Educational Technology*, *20*(2), 191-208.

Bradley, C., & Boyle, T. (2004). The design, development, and use of multimedia learning objects *Journal of Educational Multimedia and Hypermedia*, *13*(4), 371-389.

Campbell, L.M. (2003). Engaging with the learning object economy. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 35-45). London: Kogan Page.

Campbell, L.M., Littlejohn, A.H., & Duncan, C. (2001). Share and share alike: Encouraging the reuse of academic resources through the Scottish electronic staff development library. *Association of Learning Technologies Journal (ALT-J)*, *9*(2), 28-38.

The Carrick Institute. (2007). The Carrick exchange overview 2007. Retrieved March 28, 2008, from http://www.carrickinstitute.edu.au/carrick/webdav/site/carricksite/users/siteadmin/public/rin_carrickexchange_overview_2007.pdf

Dalziel, J. (2006). Building communities of designers. In H. Beetham & R. Sharpe (Eds.), *Design for learning: Rethinking pedagogy for a digital age*. RoutledgeFalmer: London.

Duncan, C., & Ekmekcioglu, C. (2003). In A. Littlejohn (Ed.), *Reusing online resources: A* *sustainable approach to e-learning* (pp. 135-145). London: Kogan Page.

Farance, F. (2003). IEEE LOM standard not yet ready for "prime time." *Learning Technology*, *5*(1).

Goodacre, C., & Rowlands, D. (2005). Real world metadata management for resource discovery: Proof of concept across education and library sectors in Tasmania. In J. Dalziel, R. Philip, & J. Clare (Eds.), *The COLIS project: Collaborative online learning and information services* (pp. 163-185). Sydney, NSW: Macquarie University E-Learning Centre of Excellence.

Gosper, M., Woo, K., Gibbs, D., Hand, T., Kerr, S., & Rich, D. (2004). Learning objects: User perspectives on the conditions surrounding their use. In L. Cantoni & C. McLoughlin, (Eds), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004* (pp. 66-72). Chesapeake, VA: AACE.

IMS Global Learning Consortium. (2003). *IMS learning design best practice and implementation guide version 1.0 final specification*. IMS Global Learning Consortium Inc. Retrieved October 11, 2006, from http://www.imsglobal.org

Koppi, T., Bogle L., & Lavitt, N. (2004). Institutional use of learning objects: Lessons learned and future directions. *Journal of Educational Multimedia and Hypermedia*, *13*(4), 449-463.

Koppi, T., & Lavitt, N. (2003). Institutional use of learning objects three years on: Lessons learned and future directions. In D. Lassner & C. McNaught (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 644-648). Chesapeake, VA: AACE.

Lambropoulos, N., & Christopoulou, M. (2004). Cultural-based learning objects in a blended environment for Greek and Greek-Cypriot students in U.K. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004* (pp. 1851-1856). Chesapeake, VA: AACE.

Latham, G. (1988). The birth and death cycles of educational innovations. *Principal*, *68*(1), 41-43.

Learning Technology Standards Committee. (2002). IEEE Standard for Learning Object Metadata. IEEE Standard 1484.12.1, Institute of Electrical and Electronics Engineers, New York. Retrieved March 28, 2008, from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

Lefoe, G., O'Reilly, M., Parrish, D., Bennett, S., Keppell, M., & Gunn, C. (2007). The Carrick exchange: Not just another repository. In C. Montgomerie & J. Seale (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007* (pp. 108-113). Chesapeake, VA: AACE.

Littlejohn, A. (Ed.) (2003a). *Reusing online resources: A sustainable approach to e-learning.* London: Kogan Page.

Littlejohn, A. (2003b). An incremental approach to staff development in the reuse of learning resources. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 221-233). London: Kogan Page.

Littlejohn, A. (2005). Keynote presentation: Community dimensions of learning object repositories. In H. Goss (Ed.), *Balance, fidelity, mobility: Maintaining the momentum? Proceedings of the 22nd Annual Conference of ascilite* (p. 3). Brisbane: Teaching & Learning Support Services, QUT.

Littlejohn, A., & Buckingham Shum, S. (2003). JIME special issue on reusing online resources. *Journal of Interactive Media in Education*. Retrieved March 28, 2008, from http://www-jime.open.ac.uk/2003/1/

Littlejohn, A.H., Campbell, L.M., Tizard, J., & Smith, A. (2003). From pilot project to strategic development: Scaling up staff support in the use of ICT for teaching and learning, *Journal of Further and Higher education*, *7*(1), 47-52.

Littlejohn, A., Jung, I., & Broumley, L. (2003). A comparison of issues in the reuse of resources in schools and colleges. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 212-220). London: Kogan Page.

Malcolm, M. (2005). The exercise of the object: Issues in resource reusability and reuse, *British Journal of Educational Technology*, *36*(1), 33-41.

Margaryan, A., & Littlejohn, A. (2007). Community dimensions of learning object repositories. In C. Montgomerie & J. Seale (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007* (pp. 4335-4343). Chesapeake, VA: AACE.

Mohan, P., & Brooks, C. (2003, July). Engineering a future for learning objects. *Proceedings of the International Conference on Web Engineering* (pp. 120-123). Oviedo, Spain.

Mohan, P., & Daniel, B. (2004). The learning objects approach: Challenges and opportunities. In G. Richards (Ed.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher education 2004* (pp. 2512-2520). Chesapeake, VA: AACE.

Mohan, P., & Greer, J. (2003). Reusable learning objects: Current status and future directions. In D. Lassner & C. McNaught (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 257-264). Chesapeake, VA: AACE.

Najjar, J. Ternier, S., & Duval, E. (2004). User behaviour in learning objects repositories: An empirical analysis. In L. Catoni & C. McLoughlin (Eds.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher education 2004* (pp. 4373-4378). Chesapeake, VA: AACE.

Neven, F., Duval, E., Ternier, S., Cardinaels, K., & Vandepitte, P. (2003). An open and flexible indexation and query tool for ARIADNE. In D. Lassner & C. McNaught (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 107-114). Chesapeake, VA: AACE.

Oliver, R. (2001). Learning objects: Supporting flexible delivery of online learning paradigms. In G. Kennedy & T. Petrovic (Eds.), *Proceedings of Annual Conference of the Australian Society for Computers in Learning in Tertiary Education* (pp. pp 453-460). Melbourne: Melbourne City Press.

Poupa, C., & Forte, E. (2003). Collaborative teaching with learning objects in an international, non-profit context. The example of the ARIADNE community. *Educational Media International*, *40*(3/4), 239-248.

Richards, G.R., McGreal, R., & Freisen, N. (2002, June). Learning object repository technologies for telelearning: The evolution of POOL and CanCore. In *Proceedings of the IS2002, Informing Science + IT Education Conference*. Cork, Ireland: IS2002. Retrieved March 28, 2008, from http://proceedings.informingscience.org/IS2002Proceedings/papers/Richa242Learn.pdf

Rogers, E.M. (1995). *Diffusion of innovations* (4th ed). New York: Free Press.

SCORM. (2004). Advanced distributed learning - SCORM. Retrieved March 28, 2008, from http://www.adlnet.gov/scorm/

Taylor, P.G., & Richardson, A.S. (2001). *Validating scholarship in university teaching.* Canberra, Australia: Higher education Division, Department of Employment, Education, Training and Youth Affairs.

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice*. Boston, MA: Harvard Business School Press.

Wetterling, J., & Collis, B. (2003). Sharing and reuse of learning resources across a transnational network. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 182-194). London: Kogan Page.

Wiley, D.A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D.A. Wiley (Ed.), *The instructional use of learning objects*. Retrieved March, 28, 2008, from http://reusability.org/read/chapters/wiley.doc.

Wiley, D.A. (2002). The instructional use of learning objects. Retrieved March, 28, 2008, from http://www.reusability.org/read/

Wilson, S., & Mundell, R. (2004). E-learning development using re-usable learning objects. In L. Catoni & C. McLoughlin (Eds.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2004* (pp. 4373-4378). Chesapeake, VA: AACE.

KEY TERMS

Community of Practice: Communities of practice are characterised by a shared domain of knowledge, a shared community, and shared practices built up over time. Wenger, McDermott, and Snyder (2002, p. 4) define a community of practice as "A group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise . . . by interacting on an ongoing basis."

Digital Repository: A collection of items in digital format that can be accessed via an online catalogue. The collection might be colocated on a single server or distributed across numerous locations. The collection may be made available to users within a particular computer network, to registered users or to the public.

Granularity: Granularity refers to the "size" or "extent" of a learning object. A fine grained learning object may be a single file, but also be tightly focused on a single concept or idea. A learning object of larger granularity would contain more extensive content, perhaps linking together multimedia concepts or with multiple activities for learners.

Learning Object: The term is often used quite broadly, and for the purposes of this chapter the term refers to teaching and learning materials and guides that range in granularity from single files to full courses. The term also has a very specific meaning in certain research fields. Wiley (Wiley, 2000, p.7) defines a learning object as "Any digital resource that can be reused to support learning." The IEEE Learning Technology Standards Committee includes nondigital objects in the definition: "Any entity, digital or nondigital, which can be used, re-used or referenced during technology supported learning (The Learning Technology Standards Committee, 2002). A more specific definition is that offered by Dalziel (2002): "An aggregation of one or more digital assets, incorporating metadata, which represents an educationally meaningful, stand-alone unit."

Learning Object Economy: The learning object economy refers to the process whereby learning objects are shared and exchanged through mechanisms such as licensing or royalties.

Needs Analysis: A needs analysis is carried out upon the initiation of a project to determine the characteristics and the needs of users of a system or intervention.

Reusability: Reusability is essential to the notion of the learning object in that a learning object can be more effectively shared and used if it can be adapted to multiple contexts.

APPENDIX A

Needs Analysis Framework for Developing Repository Functionality for Users

1. What personnel, skills, and roles are required to create and manage the digital repository?
    - Will there be specialised contributors, reviewers of repository resources?
    - Will the repository require day-to-day management and therefore need an administrator or management team?

2. How will resources be submitted?
    - Will there be restrictions on who can contribute resources to the repository?
    - How will learning resources be uploaded to the repository?
        - How can the submission tool or process be user friendly and intuitive?
    - Will there be standards for the learning resources set?
        - What is the baseline level of accessibility and quality?
        - Will metadata standards be used to provide an effective means for describing and cataloguing individual learning objects?
    - How will learning resources be classified and labeled?
        - How will issues of intellectual property rights be addressed?
        - What framework will be used for efficient and effective searching?
        - Could templates be used, underpinned by consistent standards?
        - How can this assist the evaluation of the resources to ascertain whether they meet specific needs?
    - What is the best way to store information?
        - Will the learning resources be housed in the repository or will it provide descriptions of the resources and then a link to the resource housed elsewhere on the Internet?
    - What guidelines are required to assist contributors to develop effective learning objects that can be reused, re-purposed and referenced?

3. How will resources be utilised?
    - Will there be a cost for accessing the repository's resources?
        - Will the collection be perceived of as having more value if it comes at a cost?
        - Should the cost be charged to the university and only members access the repository?
        - Is there a question mark over the quality of material where no charge is made?
    - Will there be restrictions on who can access the resources?
    - How will users search for their desired learning resources?
        - Is the search function easy and simple to use? Can users select just one or two metadata elements to form their learning resource queries so time investment is small?
    - Will there be an authoring capability provided?
    - What are the technical considerations in regard to reliability, usability and accessibility of the learning object?
    - Will participating universities consider providing academic and teaching

staff, time and assistance to facilitate digital repository contributions?

4. How will quality assurance be addressed?
   - How will quality control be managed?
     - What personnel, skills, and roles are required?
     - What will be the focus of quality control measures (e.g., quality of content, potential effectiveness as a teaching-learning tools, and ease of use)?
     - Will formal peer review be used as a means of quality control? Will informal peer review by the users such as commentary or star ratings be used?
     - How will quality assurance be integrated into the whole content creation process? What guidelines and standards should underpin the development of content?
   - What quality assurance will there be for the functionality and usability of the actual repository?

5. What incentives will there be for educators to contribute to the digital repository? How will this relate to promotion practices within universities?

6. How will the repository be promoted?
   - How will educators and students be made aware of the strategies and advantages of using digital repositories?
   - What support and training will be provided? Will it be face to face or online or both?
   - Is there opportunity for repository promotion through Carrick networks and activities?
   - What opportunities are there for repository review publications to be used for promotion?

7. What are the strategies for monitoring, assessment and evaluation?
   - What monitoring strategies are there for regularly checking the progress of the repository? And who is responsible for this monitoring?
   - What are the targets and timeframes for these targets that can be measured and formally assessed to make an informed decision about the progress of the repository? And who will be responsible for conducting these planned assessments?
   - What are the specific aims, goals or objectives that will inform an evaluation of the project? And who will perform this evaluation?
   - Could these monitoring assessment and evaluation activities be managed in a similar manner to journals with an editorial board and reviewers?

Chapter XXXI
Costs and Sustainability of Learning Object Repositories

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ABSTRACT

Reusable learning objects (LOs) constitute a promising approach to the development of easily accessible, technologically sound, and curriculum aligned learning resources. Many research forums and scholarly articles have focused on the reusability of learning objects, metadata, and context issues, but few sources describe the economic challenges involved in implementing and sustaining an LO repository. What are the costs of establishing and maintaining a LO repository? Should funding for establishing and maintaining LO repositories come from institutional resources, consortium fees, grant money, LO sales, or other sources? To answer these questions we consider a variety of LO cost factors. We look at economic models used in distance education to see what they can tell us about LO economies. We discuss the relationship of funding approaches and operational scope (of a LO system) through considering a funding matrix that describes possible funding approaches. We discuss several emerging trends that may contribute to the future of learning resources from an economic perspective. Lastly, we provide several practical recommendations for funding LO repositories. In conclusion, we highlight developmental factors for LO repositories as they relate to the scope of operation and funding methods.

INTRODUCTION

According to David Wiley, the reusable learning objects (LO) movement began as early as the 1970s. The term itself was coined in 1994. Key questions about LOs for educational researchers and practitioners have included the nature and definition of learning objects, their underlying learning philosophy, their design principles, and the proper metadata standards to be applied to these objects (Wiley, 2002). When institutions began to create courses from LOs (Mason, Pegler, & Weller, 2004), a critical question arose as to how to sustain such efforts. This led to a consideration of methods to support these integral units of learning. In the absence of a national curriculum (which is the case in many advanced countries) and international learning standards, full national or international funding of a repository similar to the funding of the World Wide Web Consortium (W3C) does not appear likely. What alternative mechanisms then, can sustain LO development and repositories? This chapter attempts to shed light on issues of sustaining LO repositories and provides information about models that have benefited practitioners and institutional administrators wishing to develop and sustain LO repositories.

The capacity for creation of actual learning objects may or not be included in the operation of a given LO repository. Simply creating a database/repository to catalog and access existing resources (via metadata and pointers) does not preclude issues of sustainability and cost for repository managers. Our focus in this chapter, however, is to consider sustainable and flexible support for repositories that also build and contain LOs. The creation (content) and support (technology and operations) of a collection of LOs entail different patterns of costs. Large, linking-only repositories (e.g., MERLOT, Canada's SchoolNet) experience largely fixed recurring costs in their start-up and system operation. Since these linking-only repositories do not directly develop the content of the LO database they do not face the potentially large, variable costs of LO design and development. On the other hand, systems that address both content generation and repository maintenance have to address both the fixed and variable costs associated with their two-pronged effort.

BACKGROUND

What is a "learning object"? There are multiple metaphors: Wiley's LEGO metaphor (2002), Wiley, Gibbons, and Recker's atom metaphor (2000), and the film montage metaphor (Parrish, 2004). There are also multiple approaches of defining LOs. In our work, we use the definition proposed by the IEEE: a learning object is "any entity, digital or non-digital, that can be used, reused, or referenced to during technology-supported learning" (IEEE LTSC, 2000). This admittedly broad definition includes a great variety of potential LO types and their respective repositories. A particular repository will specify the type(s) of LOs it supports more precisely. The specific definition may be couched in different ways, but it serves to more precisely define the content and functionality of the system and the types of users and potential supporters. Further specification of the system relate to the form of the metadata and search parameters built into the system. As seen in existing repositories, several approaches are employed. There are repositories presenting their potential users and guests with a list of characteristics (searchable, basic building blocks, etc.) of a learning object (for example, Wisconsin Online). There are also repositories like the Canadian CLOE, where the visitors and users are presented with several definitions on learning objects and are free to choose any of them as a working definition. Various taxonomies have been proposed for learning objects. However, none of them constitutes a recognized standard in the field. Keeping the system definition flexible may facilitate the creation of a LO repository for educational administrators and practitioners. The question remains, however, as to what type of economic model will support the development and sustenance of the repository, whatever form it takes. Consider the following factors.

FORMAT OF A LEARNING OBJECT: FREEFORM VS. TEMPLATE

LO format is an important factor in determining the cost and economic sustainability of LO repositories.Format is often associated with the type of LO repository. A large-scale commercial repository may develop and use templates to reduce the costs of LO creation. Indeed, CafeGenius uses small Java applets, relatively consistent in style and color rather than "freeform" LOs. In noncommercial repositories, a variety of approaches are sometimes used. Some repositories (e.g., Wisconsin Online) have one or more templates to simplify and facilitate the object creation process. Others (e.g., Maricopa, JORUM) incorporate a variety of LO formats varying from Microsoft Word tutorials to complex animations and simulations. Using freeform development processes leads to greater flexibility with granularity and learning approaches. Granularity of the LO (or the smallest possible size contributing to learning) is usually determined from the perceptions of the teachers, creators, and subject field requirements. Therefore, limiting LO format in a repository to certain specified attributes (e.g., minutes of instruction) can prevent some instructors from using the objects. Examples from a Canadian experience (CLOE) demonstrate that: (1) having a differing "look-and-feel" of the LOs in a repository does not tend to be an issue for the instructor (Carey & Harrigan, 2003a) and (2) showing the connections of LOs to the curriculum, that is, adding learning tasks and assignments, appears to be unnecessary since instructors tend to use a LO as an object, not a lesson template (Carey & Harrigan, 2003b). Using a template will probably help to reduce the costs of LO creation, but it may also bring additional developmental and marketing costs. There is thus a trade-off from a variable costs standpoint between reduced costs of LO creation and increased developer support costs that may accompany the use of templates. Freeform development, on the other hand, can be beneficial in addressing granularity and learning styles issues, but it is generally a more expensive approach to LO authoring than authoring through templates. Decisions about the choice between template-based or freeform LO development may depend on other factors as well (e.g., timeline, type of content, and size of repository). In general, decisions related to the form of LO development should consider both usage issues and the costs and quality of LO development.

PURPOSE OF LO DATABASES

LO repositories can be classified according to their purpose. Some examples are as follows:

1. Repositories established to support an organization's specified needs for training/education materials.

This type grew out of the time-honored instruction and training manuals used by business enterprises and companies. In the age of computer-supported learning many of these manuals were turned into bits of knowledge adapted to provide the ultimate symbiosis of human and machines or human and the Enterprise. This approach is highly valued by the U.S. military and is expressed in careful attention to design and standardization issues, seeing technical standards as solutions to pedagogical problems (Friesen, 2004). The idea of this type of repository differs from that used in a market economy. Indeed, highly specialized LOs containing not only instruction, but an organizational culture ("Relevant and ready manpower in service to the nation"), may not be so attractive to other potential buyers. Besides, organizations like the U.S. Army have little incentive to disseminate training information resources outside of their specified circle. In essence, they are closed repositories. Repositories for this purpose contain actual LOs. On the other hand, it is difficult to envision a large MERLOT-type repository containing only metadata pointers designed for this purpose. With centralization, LOs can be aggregated and placed on a server system reliable enough to satisfy thousands of users. Distinctive features of this human-machine approach to effectiveness are: fine granularity adapted to the particular skill (an Army paralegal does not need to know what an Army supply clerk knows), relatively high quality and high fidelity associated with high throughput (it is easier to create a high quality LO than to retrain a soldier or to pay a compensation in case of injury), and standardized interface (to mitigate the costs of dissemination). Curricular scope is another consideration; following an Army axiom "You don't need to know what you don't need to know," the scope of LOs tends to be limited to the required sets of skills.

2. Repositories established to support a broader market.

The word "market" is often related to its place in a commercial enterprise. Can we consider education to be a part of a market economy? The answer, perhaps to the dismay of educational purists, is of course, "yes." And, quite successfully in some cases. Good examples of this type of a repository are Goeng.com with its thousands of metadata pointers or big publishing houses (like Prentice Hall) which are now making the workbooks for their texts available online. The latter example is more content-specific (i.e., depth of curriculum) and contains actual LOs, while the former is more generic. The former does not include LOs, but contains the metadata pointers to them. In both cases, however, the LOs are commercially produced. Levels of granularity in this type of repository vary depending on the demands of the marketplace. Learning modules may require higher fidelity to increase LO marketability, but then high fidelity of LOs tends to increase production costs and influence the bottom line. The quality issue for repositories supporting a broader market is twofold: big enterprises (publishing house) may already have access to content experts as staff or affiliates and can employ them for LO development. Other commercial enterprises may be tempted to use shortcuts, assuming that only experts (not their potential users) can distinguish the difference. A good feature of market-driven repositories can be breadth and depth of curricular scope. Anything that can attract a potential user (buyer) can be represented in such a repository. Attractive interfaces as well as professional approach to marketing can make subscription to this type of repositories a "convenience" for large school districts and universities, sharing subscription agreements for digital libraries.

3. Repositories established to serve a special purpose such as distance education or online learning.

Here we have a variety of applications and approaches. Given the nature of its funding and goals, the ability of the public education sector to implement highly specialized and customized LO repositories similar to type 1 above is doubtful. Multimillion dollar projects undertaken by various governments—the Curriculum Online project (UK), Australian Learning Federation, eduSource and SchoolNet (Canada); HEAL and iLumina (US) are examples of uses where LOs have been considered potentially helpful without in-depth studies of the pedagogical consequences of these systems (Friesen, 2004). On the other hand Open Courseware (for example, the *Connections* repository—cnx.org) and barter exchanges (for example, the *Maricopa* repository—www.mcli.dist.maricopa.edu/mlx/) present potentially attractive options for educators. Features of educational repositories are often discussed, but still largely undefined (different levels of granularity, broad curriculum scope for minor courses vs. in-depth approach for major courses). Quality control for the LOs in the educational world is often approached in the same way as journal publications and peer-review. However, repositories differ in their approaches as to whether allow materials to appear in advance of the peer-review (MERLOT) or only to show materials vetted by editorial boards (LOLA).

SUPPORT FOR LO REPOSITORIES: ECONOMIC MODELS

The previous section addressed the classification of LO by purpose. Our discussion now turns to the LO economy and the types of funding available to different repositories as it relates to their purpose.

One funding type is the Commercial or Revenue-Based Model (characterized by large-scale development and fees for using the repository, and/or its learning objects). These repositories were discussed under type 2 in the previous section. Commercial or revenue-based repositories are based on premise that general economic rules and models used in business are also applicable to the area of learning and training. Their creators are concerned about coherent business models more than a self-emerging LO economy that may appear as a result of widespread use of the LOs (see Krull, Mallinson, & Sewry, 2006). The commercial approach is often used in defining costs for consumers (Duncan, 2003) and rewards for authors (Quinn, 2000). In this model standard fees are charged for individual or organizational use of repository (Goeng.com). Under this model emerge specific job descriptions (for example, content expert or multimedia developer for Prentice Hall). Levels of repository access differ between type 1 and 3 repositories. For example, if the repository requires an access fee, there may be a situation when a course instructor only has access to those LOs which the instructor chooses to demonstrates during a course.

Institutional (internal) or governmental funding may support repositories established to enhance an entity's need for training (type 1 of the previous section). Here the likely funding source depends on the type of organization, for example, commercial (e.g., Hewlett-Packard) or governmental (e.g., the U.S. Army or a federal agency). Few general educational institutions are examples of the type 1 repositories. The one institution/one repository case is extremely rare in public education. Institutions starting such an endeavor may (for obvious economic reasons) move to extend the repository scope from a local to a national, if not international level, consortium or partnership (e.g., Wisconsin-Online and CLOE). Type 1 repositories do not typically have high outreach and marketing costs and do not include cataloging-only repositories. Type 1 technology and system maintenance costs are covered internally as a part of the organizational budget. LO creators are different from instructors or trainers (as in the type 2 repositories). Overall, such repositories are intended for highly specific audiences with all the relevant financial assets used to address the needs of their audiences (Richards, McGreal, Hatala, & Friesen, 2002).

A more complex case in terms of funding and economic models for sustainment of a repository is type 3 (educational, distance education repositories). This type of repository may use institutional (internal), grant (limited term), or governmental funding. The sustenance of this type of repository has been discussed to some extent in the LO literature, though not definitively. Learning objects are sometimes presented as a "currency of exchange" (Littlejohn, 2003); economic models are based on micro trading (Campbell, 2003); on negotiated values of the LO (Bennetta & McGeeb, 2005). No coherent economic model or collection such models describing different solutions as in case of distance education (Bramble & Panda, 2008) has been developed and accepted for this type of repository.

In countries where the educational system is largely supported by the national or state government, direct government funding may appear to pose a reliable approach for the development of LO repositories (Oliver, 2003). In this case, public universities are considered a public resource. Shared and reusable curriculum resources may be viewed as unnecessary if the government covers all the costs for creation of unique curricula and courses for the universities or they may be viewed as an integrated way to cut overall costs. In the case of distance and online education the cost of development and production of learning resources greatly exceeds that of delivery, especially in the last decades (Malcolm, 2005). This level of development expense is not typically addressed in the budgeting for public universities. Funding sources for type 3 repositories are more diverse than for previous two types. Type 3 repositories may have internal, or grant sources of funding, or use OpenSource resources. An institution can also have instructor-designer situation where instructors/trainers also act as creators of the LOs

A consideration for funding of type 3 repositories is that grant or government support systems tends to end when programs meet the point of transition from limited-term public funding to a commercial model (Liber, 2005). This illustrates the importance of selecting an appropriate funding scheme for the long-term viability of the system. An OpenSource, user-designer approach at the other extreme appears to eliminate the vagaries of funding, but works only as long as volunteer effort is sustained. There are, of course, other approaches between these two extremes.

CHARACTERISTICS THAT AFFECT THE COST OF LO REPOSITORIES

Databases that Include LO Development vs. Cataloging only

For databases in which LO development is an integral part of the effort, there is a substantial cost associated with developing LOs. If a system merely catalogs and provides a reference database pointing to other systems' LOs the cost of LO development need not be directly considered. Thus, some databases that include actual LOs include a usage fee or limit the usage of materials to the internal users (for example, National Learning Network—http://www.nln.ac.uk/Materials/default.asp is created for U.K. users). At the same time, cataloging-only resources (e.g., MERLOT) may include pointers to objects requiring an additional fee for their usage (for example, http://www.merlot.org/merlot/viewMaterial.htm?id=89657) which use this model to cover development costs.

Scope of the LO Repository

The greater the inclusion of material in a database the more expensive it will be to develop and maintain. Scope is reflected in the variety of curricula covered or the number of LOs contained in a particular area of curriculum. Costs will be reflected in personnel, infrastructure, and LO development (if included). A repository with narrow scope may have the luxury to use high fidelity LOs (for example, AVIRE—www.avire.net), while repositories with a very broad scope may tend to have a large number of low fidelity, general-definition objects (for example, the CAREO repository; http://careo.ucalgary.ca/cgi-bin/WebObjects/CAREO.woa/).

Technology Costs

The sophistication of hardware and software that underlie the repository and the LO development process affects costs. The resultant operations and maintenance needs and the implied rate of enhancement and replacement also affect costs. Using OpenSource software can reduce the overall costs of technology, while issues of materials validity and content evaluation will raise the technology cost factor. Still, there is a possibility of trade-off: using premade templates for an LO creation to simplify the development process as well as the reviewers' evaluation of the content (Wisconsin-online is a good example of this type of trade-off).

System Maintenance

System design and purpose will affect the level of maintenance required on a recurrent basis. Higher levels of maintenance, trouble-shooting, and client assistance require higher levels of resources. The repository scope plays an important role in this issue: large repositories present more tutorials and may offer more customer support vs. small specialized projects where help may be available only at the level of the site hosting (http://www.thegateway.org/help/ vs. http://opencourse.org/support/help/FrontPage), even if both entities are using an Open-Source content management system technology (i.e., Plone).

Sophistication of LO Design

Sophistication of LO design will be reflected in such factors as design methods, differential costs for developers, media use, granularity, and other related quality factors. Quality obviously comes at a cost. Sophistication and quality are also highly related to the first two factors, namely cataloging options and repository scope. Specialized repositories (for example, FLORE—http://flore.uvic.ca) can contain hundreds pointers to fine-grained LOs in a specific area. FLORE contains a catalog, but not the actual LOs. It is a good example of sophistication with minimal additional cost.

Outreach and Marketing

Costs will be affected by the level of effort required for coordination of the efforts of multiple LO developers contributing to the repository or multiple users of the repository. The more complex the task of user support the more costly the system. For a system to be successful it also needs to be marketed at an appropriate level. This requires resources to do well. Repository scope also matters. For example, a large repository such as GEM (http://www.thegateway.org/) catering to a teachers audience will include not only learning resources, but extensive outreach (e.g., a special National Education Association toolbar for the Internet browser or a link to the College Affordability Campaign).

A SPECIAL CASE: THE ROLE OF LOS IN DISTANCE AND ONLINE LEARNING

Bramble and Panda (2008) discusses the economics of *online and distance learning* in detail. The common approach to studying the costs of distance and online learning is to separate program costs into those costs that are regarded as fixed and those that are variable, as in the equation:

Equation 1 $$C = F + (V * N)$$

In equation 1 C is the total cost of educational delivery, F represents fixed costs, V represents variable costs, and N is the number of students enrolled. To understand costs and compare them across delivery systems total cost, C is often converted to average cost per course or per student, dividing C by the proper number of courses or students. Note that LO repository costs will be categorized differently; system development and operations costs will be mostly fixed and LO costs will constitute the variable element of the equation.

An example of costs in distance education is reported by Bramble and Rao (1998, p. 129). The cost estimates are adapted from a study of a military teletraining course in which transmitted, mediated materials are used for group training at multiple sites. The costs are roughly divided into fixed and variable site-specific costs and are reported as follows.

Note here that a major portion of the cost of such training was associated with the fixed costs of the technology and course design and development. Average costs decrease as a function of economy of scale, except for the costs associated with greater site numbers and numbers of students. The site costs are variable costs associated with the distributed nature of the group training. Had the example been of an online course in higher education, the greater student numbers would have increased costs due to the greater (variable cost) requirement for instructor support. In the military teletraining example, savings in average costs accrue as throughput is increased. However, the fixed costs of developing the training are quite substantial in relationship to the large variable costs that would be expected with on-site delivery. Thus development costs can be mitigated through the reusability of learning materials across students and courses, and, as we shall see, that is where learning object repositories are especially relevant.

Elaborating on this theme, Jung (2008), following the work of Whalen and Wright (1999), reports that the costs of virtual university education, as an example of distance or online learning, can be studied in terms of their basic components. *Fixed costs* (F) are such things as the initial costs to purchase and install the required infrastructure and to develop electronic courses. Fixed costs also include the recurring costs of student services, employing support staff, maintaining virtual systems, and offering training to faculty and staff. The largest *variable costs* (V) for distance education systems relate to instructor/faculty salaries and benefits necessary to offer the specific array of courses. Consumables and expense items, based on student enrollments (N), are also represented in variable costs. In virtual education, in contrast to traditional education, there are proportionately higher fixed costs because of more sophisticated course development and the increased support requirements of information and communication technology (ICT) capabilities. The traditional, campus-based instruction model places a greater emphasis on variable costs (i.e., each new section of a course offered on campus requires the assignment of an instructor in a classroom). The hope then, as Jung points out, for a workable cost of virtual education is the following. Even though the fixed costs of virtual education are higher than classroom-based programs, a virtual program can be cost-effective due to economy of scale: increased enrollments, increased student access to quality programs, and resources and other benefits (Jung, 2003).

Economy of scale is an important factor in sustaining a number of programs involving distance

Table 1. Costs of army teletraining

Number Of Sites	Students Per Site	Total Students	Total Cost (%course configuration)	Costs per Site	Cost per Student
3	20	60	$131,716 (68%)	$43,905	$2.105
5	20	100	$180,464 (49%)	$36,093	$1,805
7	20	140	$208,451 (43%)	$29,779	$1,489

learning. This is especially true in the "mega-universities" (this refers to single mode distance institutions which serve 100,000 or more students) in both developed and developing countries, see Perraton (2000). For an example of economy of scale in a mega-university see the case of the Indira Gandhi National Open University - IGNOU (Panda, 2005). Here the strategy has been to serve very large numbers of students to allow for large economies of scale and thereby contain costs on the fixed side of the equation through making use of less expensive instructional technologies and using lower cost labor for student support at the user end. The strategy makes sense, especially in developing countries, because of the relatively weaker installed base of both brick-and-mortar institutions and technologies such as personal computers and Internet access, as compared with that in more advanced countries.

An important factor in comparing the costs of traditional and technology-supported education is the cost of labor for instruction. As Hulsman (2008), following the work of Jewett (2000), notes, the faculty positions' requirement under traditional higher education is given as:

Equation 2 $$FP_C = \frac{N}{k * G} \Rightarrow$$

$$FP_C(N) = \left(\frac{1}{k * G}\right) * N$$

where FPc is the number of faculty positions under conventional classroom technology, G is the average section enrollment, N is the overall enrollment of the course, and k is the number of classes taught per full time equivalent faculty member. Thus (by either equation above), for 200 students taught in 10 class sections of introductory psychology enrolling 20 students each, and with each faculty member teaching two sections of the course, the number of faculty positions required is 200 divided by 40 or five faculty.

On the other hand the function for the case of distributed education with technology is given as:

Equation 3 $$FPd = \frac{p1 + p2}{k} + \left(\frac{p3}{k}\right) * \frac{N}{G}$$

where FPd is the number of faculty positions required under distributed (or distance) education with technology, p1 is the cost of developing content, p2 is the cost of instructional design for presentation, and p3 is direct student-related workload. Note that for p1 through p3 new faculty roles and the nature and cost of support assistance for these functions help determine the final costs per student or per course. It is apparent from equation 3 that in an instructional model which requires greater levels of technology support, the costs of p1 and p2 place new demands on the system in comparison to the example of the introductory psychology course under the classroom model above, Note that average class size (and the instructors that would otherwise have staffed them) may undergo some change under the online delivery model. Because of technology's possible influence on G there is the potential for cost savings. However, a complicating factor in the technology of course delivery is the needed level of interactivity provided for the students and the manner in which the interactivity is provided.

Interactivity in mediated learning can be of two basic types. First is the case where interactivity between teacher and student is largely replaced by automated interactive lesson capabilities as in stand-alone learning modules. Second is the case where technology is used to provide asynchronous or synchronous interactivity between the students and instructors. In the second case in particular, the degree of electronically mediated interaction between the student and teacher affects costs in two ways. There is a cost for the technological means of interaction itself (a fixed cost) and there is an increased requirement (and variable cost) for instructors to engage in the interaction now required by the system. Many distance educators view interactivity with instructors as essential to social presence and learning. However, with increased interactivity between and among students and teachers, there is a corresponding increase on the variable costs side of the basic cost equation and a concomitant loss in savings that accrue under economy of scale.

An important point has been made by distance educators about the use of LOs in this context. A remedy posed by those studying the costs of online learning (see Hulsman, 2008) is that the increased use of reusable LOs as a method of cost savings for courseware. If a less costly learning resources result from the use and reuse of the building blocks of learning (reusable learning objects), the overall costs of distance or online learning can be lowered. As a consequence, the general cost of instruction will not be as strongly affected by the increased costs brought about by rising expectations for real-time teacher/student interactivity. This jury is still out on the feasibility of this assertion, but the potential is strong for cost savings through reusability of learning objects.

Costs of LO Repositories

Reusable learning objects, however, are not merely a tool for cost savings in distance and online learning. There are a wide variety of potential applications for learning objects in education and training. For example, LOs can play an important role in the context of mediated classroom, hybrid instruction and training models, or as a key element in knowledge management systems. What then is a basic cost model that can apply to this case? Again, we can conceptualize costs as comprised of both fixed and variable components, but we need to rethink them a bit. First, the production of LOs is a relatively separate activity from their indexed storage and retrieval/distribution, and it is instructive to determine how fixed and variable costs apply to each aspect of a system. Second, since a stand-alone LO repository provides access to LOs, but may include no formal course offerings per se, we need to consider how revenues might enter the system from the use of the LOs. Consider the basic cost model for LO repositories. Some components of the model relate to the overall development and operation of the learning objects repository (R). These are largely fixed costs, including such items as computer hardware and software, system development, systems operations and maintenance, contributor and customer interface, standards and quality control, and so forth. The LOs themselves and distribution of the LOs to users constitute yet another cost center (call this L). These costs are such things as developer interface, client marketing and interface, standards and quality control, payment to LO contributors (if applicable), and so forth. The number of LOs contained in a system is arbitrary and the costs associated with LO development and maintenance can be considered variable. The basic model for the cost of a LO repository (LOR) and its contents is then as follows.

Equation 4

$$C_{LOR} = R + L = R_F + (L_F + L_V{*}N)$$

In the model C_{LOR} is the overall cost of the LO repository, R_F is the (mostly) fixed cost related to establishing and maintaining the repository (sans content) and L_F and L_V are the fixed and variable costs related to the content of the repository. What this tells us is that LO repositories have to cover both fixed and variable costs in order to be viable. It says further that the essential costs of the physical repository are largely fixed costs of start-up and operation of the system. On the other hand, the costs of the content (LOs) of the repository are both fixed and variable and depend in large measure on the number of learning objects developed and housed (N). Both types of costs have to be covered for the LO repository to remain viable.

The general costs of a project in which the senior author of this chapter participated serve to illustrate the use of equation 4 above. The $10 million+ project was funded under the U.S. Department of Education's STAR Schools Program and involved a grant to the Navajo Education Technology Consortium (NETC). The University of New Mexico (UNM) did the developmental and operational work of establishing the LO repository of learning objects designed to represent the context and curriculum of learning for Navajo school children. UNM also served as one of five university sites developing relatively high quality, multimedia learning objects at the rate of approximately 70 LOs per year. Our annual costs associated with the repository itself were approximately $150,000 per year in fixed costs (plus $30,000 in variable costs. The costs for development of the LOs were about $5,200 each. Under equation 4 above, the overall annual costs of the LO repository for UNM were approximately $150,000 plus ($30,000 + $5,200 * 70) or $514,000. The other contributing universities contributed solely to the effort in producing LOs. The overall number of LOs across a five-year period exceeded 2,000. The costs and levels of production varied somewhat but were comparable to ours. The very substantial costs for LO development are illustrated by this example.

From where are the revenues derived that support LO repository cost requirements? In the case where a learning repository is attached to or an integral part of a system of distance or online learning, a training program, the standard academic offerings of an educational institution, or the offerings of an academic publisher there are revenues against which these costs can be charged (e.g., tuition, state funding, corporate revenues, sales of published works, etc.). An example of this type of integrated repository is a transnational collaboration of several universities from Hong Kong and Australia - Learning Resources Community (http://www.lrc3.unsw.edu.au/). Each university creates its own learning objects. It has an internal (institutional use only) and common (all the members of the Community) catalog listing these objects. Program administrators can plan a budget for the legitimate costs of the LO repository that are funded through institutional revenues, but access to system-wide benefits results. In cases where there is no such direct linkage to program revenues support for the activities must come from other sources.

CURRICULUM AND LO CHARACTERISTICS AFFECTING COSTS

Some factors affecting the level of costs for learning objects in repositories are as follows.

- Granularity. A LO repository can be established for objects of various lengths and applications. For example, LOs could be 3-week course units or 5 minute applets illustrating a single concept. The size and complexity of the objects stored in a repository affect the cost of unit production and storage and is a variable cost for the system.
- Activity complexity or fidelity. Complex or high fidelity activities in a LO repository are more costly. This affects the variable costs of the content stored in the repository. Greater complexity or fidelity adds to the variable costs of the development of content for the system.
- Quality. High quality comes at a cost as well. Standards must be developed and applied, copyright clearances closely monitored, quality control measures, perhaps including peer review, instituted to ensure that all objects work as advertised and that the LOs fit with the ambient curriculum requirements. This results in added variable costs.
- Curriculum Scope. The scope includes two facets: the breadth and the depth of

curriculum addressed by the repository. Greater curriculum scope leads to higher expenditures in content development and to higher costs of managing the repository. The concomitant costs are both fixed and variable, although the variable costs can be far greater than the fixed portion (i.e., a new server costs less than the recurrent commitment to personnel required to develop LOs in quantity and oversee a repository with greater levels of content).

- Marketing and interface requirements. There is a need for effective marketing and user interface to assure that the objects of a LO repository are actually used as intended. Without this, the objects in the repository may go unused and not serve their intended purpose. And, without this effort the repository will generate few supporters and few revenues. Marketing and interface require personnel expenses of a recurring nature and these grow as the system expands. The costs are both fixed and variable.

REPOSITORY SCOPE AND FUNDING SOURCE

Other factors influence the sustainability LO repositories. We propose a two dimensional matrix (scope by funding source) as a way of thinking about the variety of possibilities for funding LO repositories. Repository *scope* can be categorized as:

- ✓ *Local* (one institution case and regional partnerships)
- ✓ *National* (international comparisons and national partnerships)
- ✓ *Transnational* (commercial and international organizations)

Funding sources discussed in one of the previous sections are highly related to the purpose of the repository. The matrix presented as Figure 1 illustrates the existing repository types by categorizing them according to their operational scale and funding source. While repositories of type 1 and 2 are most likely to occupy one of the cells in the grid (for example, Government-supported and National for the U.S. Army), the whole matrix is designed to explain complex and contradictory models of the type 3 (educational repositories).

The matrix shows the relationship of repository scope and funding sources and contains examples of existing repositories. We employ these examples to show how funding questions relate to changes in scope and funding source over time and to illustrate different funding strategies for particular systems.

Figure 1. Repository scope x funding matrix

	Local	National	Transnational
Institutional	CLOE		
Grant-funded	Wisconsin-Online	HEAL	Harvey Project
Government-supported		JORUM	ARIADNE
Commercial	Cafe Genius		

In this matrix we see that Wisconsin Online is a local repository (at least at its outset), HEAL and JORUM are national in scope, and CLOE, Harvey, and ARIADNE are transnational. One tendency that is graphically illustrated in the matrix is that repositories don't necessarily remain in a particular cell of the matrix. They morph both in their scope and the type and/or mixture of types of funding as time goes by. Whatever the change we see in a particular system, LO repositories have both a need to cover startup costs and annual operating costs. These costs and the strategies for funding them change over time. Let us explore this further through illustrative examples.

Local Funding Model to Mixed Funding Model

Wisconsin-Online (http://www.wisc-online.com/) is an example of collaboration of several institutions within a state (a local project). Wisconsin-Online began as a partnership of institutions within Wisconsin Technical College System. Funding was originally provided through a small NSF grant to the Wisconsin Technical College System and Fox Valley Technical College. There is no cost for linking to the repository or revising a LO it contains, but users are required to pay a fee if they wish to download and use an LO off-line, to buy source code, or to buy a CD containing LOs from the repository. In this example, an instance of institutional and grant funding, there is an emerging change toward a commercial model designed to recoup the cost of LOs and other products through sales. The developing commercialization is also seen in a set of on-demand workshops/training sessions for LO development now advertised on the Web site. The project facilitates the development of learning objects by nonmembers (either through existing templates or with the assistance of the Wisconsin-Online development team), but there is a fee charged to the developer for including new, user-developed objects in the repository. Local level planning is evident in several ways, for example, copyright questions, technical assistance. However, there is no clearly defined peer-review or institutional review process for the created objects for quality control. It is hoped that the mixed funding method will help Wisconsin-Online sustain the system after grant funding has ended. With increasing usage and appropriate fee recovery, an economy of scale may be established that will help support the variable costs of Wisconsin-Online. Fixed costs (initially funded by the grant) may be shifted to the budgets of the participating organizations.

Local Funding Model to Transnational Model with Mixed Support

The Canadian Learning Objects Repository (CLOE, http://cloe.on.ca/) serves as an example of a local (Ontario-based) enterprise growing toward the national (including the provinces of Manitoba and Newfoundland) and transnational (including Thailand) levels. It would be premature to call this repository fully transnational but it has a start in this direction since it supports connections with at least one foreign country. CLOE incorporates several levels of peer-review. It has a quality assurance program and a clear copyright policy (Creative Commons). Funding for the CLOE repository is provided by Canadian governmental agencies (the Human Resources and Social Development Department and the Department of Industry); commercial entities (Inukshuk Wireless), and a nonprofit organization (CANARIE Inc.). The creation of learning objects is left to the institutional members, and CLOE does not allow nonmembers to use its learning objects. There is no central source of technical support for development of the LOs. Ownership issues are resolved on institutional level (different participating institutions have different regulations). The LO repository may be considered one of the best examples of LOs as a "currency of exchange," since an institution that develops more highly used LOs on a system-wide basis earns more credits than for less-used LOs. However, the "currency of exchange" principle does not provide any base funding. In CLOE's mixed funding model, the variable and fixed costs of LO creation are covered on an institutional level, while fixed costs of operation and start-up of the repository are covered from mixed sources.

Local Funding to National and Commercial Funding

CafeGenius (http://www.cafegenius.com) is a creation of the Texas-based Smartacus Corporation. It advertises 24/7 support for learning in a variety of disciplines for high school students. Paying a modest monthly fee allows a student to access about 500 LOs (Java-applets) in the repository. The repository contains training LOs and LOsimulations that can aid students in resolving their high school difficulties. The goal of the repository is optimistic. There is limited information available on the Web site about the content development and evaluation process for the LOs. The fixed start-up costs and marketing costs are covered by the corporation. The costs of continued operation are expected to derive from charges to end-users.

National Grant-Funded Model

HEAL (http://www.healcentral.org/index.jsp) can be characterized as a digital library and a free learning objects repository (images, videos, animations, and audio files). It was created through the efforts of a consortium consisting of UCLA, the University of Utah and the University of Oklahoma. HEAL is funded by grants from National Science Foundation (as a part of National Sciences Digital Library) and National Library of Medicine. This large project contains about 22,000 assets (or learning objects). The repository also has a team of developers and programmers assisting the content authors to get "published." The process includes a clear copyright policy (Creative Commons), and a relatively easy to complete submission form, which includes providing metadata for a newly created asset. A peer review process is utilized to evaluate the quality of LOs. Objects pending review are also displayed by the system and can be used "as is" by health science educators and learners. HEAL is also trying to create a reward system so that LO authors can receive some form of academic credit as a reward for their contributions. With HEAL, the fixed costs are currently covered by grant money while variable costs of LO creation are on the shoulders of authors and/or their home institution.

National Funding Model with Governmental Support

JORUM (http://www.jorum.ac.uk/) is a free online repository service for teaching and support staff in UK Higher Education Institutions. It receives governmental support through the Joint Information Systems Committee and is described on the Web site as a simple way to preserve already created LOs when grant money has expired. The LO repository is set-up on a relatively large scale with 24/7 access and a help desk. A peer-review process and quality assurance mechanism are not clearly identified, nor does the repository have a mature copyright policy. Jorum has created a "Deposit License" for contributors. However, an institution obtains the license simply by applying, with no particular review. Creation of metadata is simplified, but it involves more than just filling out a submission form (unlike the process of HEAL described above). The contributing author establishes the metadata himself/herself using an OpenSource tool (for example, RELOAD). In case of JORUM both fixed and variable costs are covered by the national government. The repository both creates new LOs and gathers created resources.

Transnational Grant-Funded Model

The Harvey Project (http://opencourse.org/Collaboratories/harveyproject) is a free, small-scale (40 LOs) transnational repository dedicated to topics in human physiology. It was created under a grant from National Science Foundation (as a part of National Sciences Digital Library) and involves an international collaboration of nearly 20 different countries. The repository includes LOs that are mostly Java applets and Flash animations. The project is still evolving, and information is not yet available on how metadata are handled. Since the creators of the repository use OpenSource software (see the section on Future Trends), some of the fixed costs of operations are kept low, start-up costs were covered by the grant, but the approach to the coverage of variable costs requires an additional attention. The small scale of the repository is reflected in the low level of attention paid to marketing, the narrow content area, and the volunteer-based approach to LO authorship. The system has a relatively involved and thorough "publication" process. This process includes not only peer review but also classroom testing as a part of the LO release process. High variable costs of quality assurance are balanced by low marketing costs. High variable costs for content (based on the technical complexity of the LOs, and a volunteer-based approach to content creation) result in a complicated picture for project sustenance.

Transnational Model with Governmental and Commercial Funding

ARAIDNE (http://www.ariadne-eu.org/) is a large-scale European network funded by the European Union and the Swiss government. The network protects multilingualism and the use of national/regional languages in education. Its repository has about 2,400 LOs, including everything from Microsoft Word documents to simulations. Many LOs are available only to ARIADNE members. Membership fees help to support the cost of LO creation. ARIADNE offers centralized development of LOs on demand, but members are expected to be able to employ software tools (at the institutional level) for the creation of the LO's metadata. The goal of ARIADNE is to provide the members with free software and establish independence from existing commercial authoring tools. No direct LO evaluation process is described for members, but members are encouraged to submit their suggestions about evaluation of LO quality to the Steering Committee. Fixed costs are covered in this model through governmental funding of each country's participants, while costs of LO creation (both, fixed and variable) are drawn from institutional resources and membership fees. The ultimate goal of the repository is to be self-sustaining through membership fees.

LOST DOMAINS

What happens if there is an inadequate plan for funding a LO repository through one of the above models or through "mixed methods"? What if the managers of such systems don't develop realistic strategies for a further development and simply operate in a "day-to-day" survival mode? Will a LO economy "emerge by itself" to support their systems? We believe that the answer is probably "no." An illustrative example may serve to make our point. Created as a part of a larger ($6 million) NSF grant to the Apple corporation, the Educational Objects Exchange is a repository that contained 2600 Java applets to be used free of charge. The repository name still appears on many Web sites devoted to the learning objects. However, the link to the Web portal (http://www.natomagroup.com/eoe.html) has been stripped of all of its interactive content. The latest information at this portal is dated 2002 coinciding with the end of the 1997-2002 grant-funding period.

These objects lost somewhere on a deserted server like treasures after the mother ship sunk? This project illustrates an all-too-familiar situation where the funding for the long-term costs of LO creation and system operation and maintenance were not built into the plans for the system. With the expiration of the grant funding, the costs could not continue to be covered, and the repository ceased to exist. This is an all too familiar story with various efforts at educational improvement and is becoming a more familiar story with LO repositories.

FUTURE TRENDS

In reviewing the literature, we became aware of several possible future trends that may affect the growth and financing of LOs. The trends can be classified as: (1) the continued development of OpenSource software and courseware development applications; (2) the development of "Shopping malls"; (3) increased Globalization (corporate, mega-universities and large scale educational efforts in developing countries, and technology developments); and (4) the possible emergence of barter economies.

OpenSource Software: A Possible Answer?

OpenSource software appears to be one of the profound, yet simplest, ways to help sustain LO repositories. Indeed, OpenSource allows for resolving metadata questions with easy-to-use tools similar to RELOAD (http://www.reload.ac.uk), albeit without the presence of the high degree of technical assistance one expects with commercially developed software. The basis for an OpenSource and the Open Education movement in general is the Linux (free software) movement. This guarantees freedom of access to and use of materials in its domain. Copyright issues are resolved with a flexible Creative Commons licensing permit allowing users to customize of downloaded or found LOs for educational purposes. OpenSource can also be extended to the LOs themselves. Such a collection would not require as much funding as a paid repository, since LOs are created and contributed on a voluntary, nonpaid basis. However, this strength can also be a major weakness if volunteerism does not serve to create comprehensive, high-quality repositories or if the LO producers start to ask for royalties for the objects they have created. With voluntary repositories it may be difficult to ensure the quality of the learning objects and to sustain an effective all-volunteer, peer-review process.

An example of an OpenSource Repository is *Connections* at Rice University (http://cnx.org/) in Houston, Texas. This repository contains some 3,800 LOs that vary from short learning modules to whole courses, all developed by enthusiasts. Because the authors are unpaid, the LOs are largely paper-based tutorials. LO quality is quite variable (http://cnx.org/content/m11061/latest/). One perhaps fortunate aspect of the LO collection is that OpenSource *Connections* creators often subscribe to constructivist learning theory. Thus the perceived quality of the LOs can be discussed through a forum at the end of the each page. This may ultimately result in improvement of the LOs through accumulated feedback. In the case of OpenSource usage, it is difficult to plan for variable expenses (those associated with the number of LOs included in the system). Repository managers don't usually know the ultimate size of their repository ahead of time and can only estimate its growth in the broadest terms. OpenCourseWare (e.g., http://ocw.mit.edu/index.html; http://ocw.usu.edu/Index/ECIndex_view) adopts an Open-Source means for creation of learning objects and metadata (e.g., http://www.reload.ac.uk). Supporters state that freedom of access to LO repositories will attract multiple users and creators to this type of exchange. From an economic standpoint, however, free software is a small part of the overall funding picture for a

LO repository. The additional costs of repository operations may turn to be too great for repository to sustain. In the Connections example grant money is presently covering this aspect of the repository operations.

Shopping Malls

At the same time that it is experiencing the free resources movement, education is becoming more consumer-oriented and commercialized. A "shopping mall" model could be what emerges as a viable way to support LO repositories. A shopping mall might be developed by a large academic publisher (though it would require innovations in product creation and marketing strategies). The mall might include a commercial portal containing links to for-profit learning objects and resources, rather than resources themselves or it might sell the LOs directly. Large-scale subscription fees (at the level of a school district, university, or state) could guarantee quick and broad-scale access to a repository's resources and its online catalog. Learning objects developed by commercial organizations and/or publishers, might also enjoy reasonably high quality control measures to ensure their marketability. A prototype of the shopping mall model is a specialized collection of LOs for math and science for K-12 at Goeng.com. This portal provides access to information about LOs, not the LOs themselves. It acts as a catalog for 27,000 commercially produced learning objects. Copyright issues are handled through a licensing agreement. For the most part the LOs cannot be modified. That limitation aside, this type of model could turn out to be very popular in future along the lines of E-bay or Amazon.com. Start-up costs could be covered through commercial investment and the ultimate costs of operation by revenues generated from customers. The growing number of LOs in such a system could ultimately raise the variable costs of the system, but increased sales would theoretically cover this increase in cost, as long as operational costs are held in check.

Globalization

Certain commercial strategies adopted by large corporations in the U.S. might also be adopted through global transnational alliances. Such a strategy for establishing and sustaining a LO repository may benefit from large economies of scale as discussed earlier in this chapter. As with mega-universities, such global systems can contain fixed costs by using lower-end technologies or lower cost program support strategies. They may also benefit from increased national or corporate revenues due to higher levels of commitment to a consortium that is transnational. There are a growing number of transnational corporations with multi-billion dollar budgets and a global presence who have the ability to finance undertakings of this scale.

Globalized repositories might also incorporate already created LOs through transferring them to larger repositories (e.g., JORUM). This strategy may help to aggregate both LO producers and users and could create an economy of scale that reduces costs for individual members. National interests often play a significant role in developing and sustaining LO repositories. Some countries are attempting to solve the LO repository issue on a national level (Canada, Australia, etc.). They may ultimately finance them as a part of their overall educational system. However, there are few current, successful attempts at self-support for global repositories, even with larger projects.

Barter Economy

Features of a barter economy are visible in existing repositories highlighted in this chapter. Collaborations of universities (CLOE) or community colleges (Maricopa) often use "free exchange," "shared exchange," or "peer-to-peer exchange" models described by Johnson (2003). Such networks are usually closed to outsiders, but allow access for LO contributors. Sometimes, as in the Maricopa case, outsiders can use existing objects in the repository, but they do not often participate in the design and development of new resources. Funding is sometimes provided on a local (e.g., institutional) or governmental level for countries, where higher education is funded by the national government. Positive aspects of a barter model are usually quality and reusability of LOs. Indeed, LOs are created by subject matter experts (e.g., by professors) for classroom use (for professionals). Copyright issues are handled on the institutional level. Variable costs of the system are distributed among all participating institutions. Since all of them are creating new objects for exchange fixed costs are typically handled at the institutional level.

RECOMMENDATIONS FOR PRACTITIONERS

As we consider the future of higher education, the role of learning objects could change considerably. Students of the future may become better informed of the options posed by extensive LO repositories and become more picky about their choices for higher education. They may reasonable expect to take courses which are more closely tailored to their specific interests, rather than the standard course packages of today. If universities are not responsive to this new demand, students may decide not to wait for a given university to create uniquely suited courses. In this case students may search for tailored learning opportunities suited to their precise needs and selected from products that are widely available on the market, ranging from commercial, to partially-accredited institutions to formal online universities. Or, students may choose a "just-in-time" educational delivery mode to meet their more immediate education/training needs, instead of unique and limited enrollment programs in established institutions. Given this potential for sweeping change, it is hard to tell when and if a coherent market will emerge for LOs, and what form it will take.

Methods for incorporating learning objects into instruction are varied and often misunderstood. This is an evolving field in which application still needs to move from the laboratory to practice. However, the approach has natural appeal in terms of sharing the best ideas for instruction among professionals and thereby improving the quality of their instruction. For the approach to be successful, however, the long-term viability of LO repositories needs to be established. Various methods of financing LO repositories are a being tried. Both fixed and variable costs of the system must be taken into consideration when establishing a new repository. Sustainable revenue sources must be found to cover these costs if a system is to be sustained. Cost projections (see Bramble & Rao, 1998) should be considered when building a system. One can ask questions such as the following. What user numbers are needed in order to economically justify collection of objects in a repository? What are the possible levels of revenue to be generated from the use of the repository and the various types of LOs it contains? The answers to these and related questions will help to determine which LO repositories can be supported, which are perhaps questionable, and which are unlikely to be supported in the long run.

In summary, it is useful to look at both costs and funding requirements for establishing and maintaining a LO repository. Costs are both fixed and variable. Repository costs are related to two basic categories: the system and its contents. These are related in turn to various characteristics of an LO repository. The main point is that these costs exist, and the costs must be met for a repository to be successful and sustained. Costs can be covered through various revenues available to the managers of the LO repository. The revenues to support a LO repository may be in the form of fixed-term grants, governmental support, revenues generated from sales of the LOs or other products which result from them (a LO economy), institutional contributions, or funds from a system in which the LO repository is imbedded (e.g., a distance education or online learning system or training program, etc.). In any case, revenues must meet or exceed the start-up and operating costs of the LO repository in order for the repository to continue to be viable. Care should be taken in system planning to ensure that this is the case. As we point out in this chapter, it is not always the case that long term revenues are available to support the LO repositories that have emerged. This often leads to lost domains and to disappointment on the part of both LO managers and the users of such systems.

CONCLUSION

As the history of existing LO systems illustrates, common challenges include planning for operational requirements of a new repository and then coping with the increase in variable costs associated with increased levels of LO creation. Repository managers can attempt to reduce the level of fixed costs through economies of scale. They may create and use a common LO template to help to contain variable costs. Managers may attempt to reduce repository costs through aggregating LOs previously created by other repositories. They may try to attract LO authors through volunteerism or providing non-monetary perks such as academic recognition. They may try to maximize fee-based membership by closing the system to outsiders. All of these approaches have been employed with various degrees of success in attempts to meet the continued costs of sustaining past and present repositories. All of the approaches will probably be a part of the future of repository sustenance in the future, and no one way appears to be a panacea. Other factors are emerging that may improve the funding picture in the long run (e.g., barter economies, shopping malls, etc.).

Probably the best advice we can offer present and future managers of LO repositories is to look carefully at the pattern of costs that need to be met by a system and the way they will likely evolve as the repository evolves. Then take a good, hard look at the alternative means for sustaining these costs into the future. Do not be lulled to inaction through the availability of limited-term funding into thinking that the issue of long-term sustainability of a system will somehow work itself out when start-up funding ends. Active planning is a must! From the outset, develop a phased plan to shift to sustainable long-term funding as short-term funding drops off. Otherwise the repository may be doomed to become one of the derelict systems referenced in the title to this chapter. With careful planning it is possible to create a system that sails proudly into the future for the benefit of all of us.

REFERENCES

Bennetta, K., & McGeeb, P. (2005). Transformative power of the learning object debate. *Open Learning*, *20(1)*, 15-30.

Bramble, W.J., & Panda, S. (Eds.). (2008). *Economics of distance and online learning: Theory, practice and research*. London, New York: Routledge.

Bramble, W.J., & Rao, L. (1998). A model for cost analysis of a distance education programme. In D. Shomaker, D. (Ed.), *Distance learning in professional education* (Chap. 7). Salisbury, Wiltsire, UK: Quay Books.

Campbell, L. (2003). Engaging with the learning object economy. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 35-45). London, Sterling, VA: Kogan Page.

Carey, T., & Harrigan, K. (2003a). Commentary on Mary Thorpe, Chris Kubiak and Keir Thorpe, designing for reuse and versioning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (Chap. 9). London: Kogan Page. *Journal of Interactive Media in Education*

[Special issue on reusing onling resources], *1*. Retrieved March 30, 2008, from http://www-jime.open.ac.uk/2003/1/

Carey, T., & Harrigan, K. (2003b). Commentary on Ron Oliver and Catherine McLoughlin, pedagogical designs for scaleable and sustainable online learning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (Chap. 8). London: Kogan Page. *Journal of Interactive Media in Education* [Special issue on reusing online resources], *1*. Retrieved March 30, 2008, from http://www-jime.open.ac.uk/2003/1/

Duncan, C. (2003). Granularization. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 12-20). London; Sterling, VA: Kogan Page.

Friesen, N. (2004). Three objections to learning objects and e-learning standards. In R. McGreal (Ed.), *Online education using learning objects* (pp. 59-70). London: Routledge.

Hulsman, T. (2008). From baobab to bonsai: Revisiting methodological issues in the costs and economics of distance education and distributed e-learning. In W. Bramble & S. Panda (Eds.), *Economics of distance and online learning: Theory, practice and research*. New York/London: Routledge.

IEEE LTSC. (2000). *Standard for information technology—education and training systems – learning objects and metadata*. Retrieved March 30, 2008, from http://ltsc.ieee.org/wg12/index.html

Jewett, F.I. (2000). A framework for the comparative analysis of the costs of classroom instruction vis-à-vis distributed instruction. In M.J. Finkelstein, C. Frances, F.I. Jewett, & B.W. Scholz (Eds.), *Dollars, distance, and online education: The new economics of college teaching and learning* (pp. 85-122). Phoenix, AZ: American Council of Education, Oryx Press.

Johnson, L. (June 2003). *Elusive vision: Challenges impeding the learning object economy*. Retrieved March 30, 2008, from http://download.macromedia.com/pub/solutions/downloads/elearning/elusive_vision.pdf

Jung, I.S. (2003). A comparative study on the cost-effectiveness of three approaches to ICT teacher training. *Journal of Korean Association of Educational Information and Broadcasting*, *9*(2), 39-70.

Jung, I.S. (2008). Costing virtual education. In W. Bramble & S. Panda (Eds.), *Economics of distance and online learning: Theory, practice and research*. New York, London: Routledge.

Krull, G. E., Mallinson, B. J., & Sewry, D. A. (2006). Describing online learning content to facilitate resource discovery and sharing: The development of the RU LOM Core. *Journal of Computer Assisted Learning 22*, 172-181.

Liber, O. (2005). Learning objects: Conditions for viability. *Journal of Computer Assisted Learning*, *21*, 366-373.

Littlejohn, A. (2003). Issues in reusing online resources. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 1-6). London, Sterling, VA: Kogan Page.

Malcolm, M. (2005). The exercise of the object: Issues in resource reusability and reuse. *British Journal of Educational Technology 36*(1), 33-41.

Mason, R., Pegler, C., & Weller, M. (2004). E-portfolios: An assessment tool for online courses. *Journal of Educational Technology 35*(6), 717-727.

Oliver, M. (2003). Rethinking the reuse of electronic resources: Contexts, power, and information literacy. Joint commentary on Carmel McNaught, Identifying the complexity of factors in the sharing and reuse of resources. In A. Littlejohn (Ed.), *An incremental approach to staff development in* *the reuse of learning resources* (Chap. 16) and *A. Littlejohn (Ed.), Reusing online resources: A sustainable approach to e-learning* (Chap. 8). London: Kogan Page. *Journal of Interactive Media in Education* [Special issue on reusing online resources], *1*. Retrieved March 30, 2008, from http://www-jime.open.ac.uk/2003/1/

Panda, S. (2005). Higher education at a distance and national development: Reflections on the Indian experience. *Distance Education, 26*(2), 205-225.

Parrish, P. (2004). The trouble with learning objects. *Educational Technology Research and Development, 52*(1), 49-67.

Perraton, H. (2000). *Open and distance learning in the developing world*. London: Routledge.

Quinn, C. (2000). Learning objects and instruction components. *Educational Technology & Society, 3*(2), 13-20.

Richards, G., McGreal, R., Hatala, M., & Friesen, N. (2002). The evolution of learning object repository technologies: Portals for online objects for learning. *Journal of Distance Education, 17(3),* 67-79.

Whalen, T., & Wright, D. (1999). Methodology for cost-benefit analysis of Web-based telelearning: Case study of the Bell Online Institute. *American Journal of Distance Education, 13*(1), 23-44.

Wiley, D. (Ed.). (2002). *The instructional use of learning objects*. Bloomington, IN: Agency for Instructional Technology.

Wiley, D., Gibbons, A., & Recker, M. (2000). *A reformulation of the issue of learning object granularity and its implications for the design of learning objects*. Retrieved March 30, 2008, from http://reusability.org/granularity.pdf

KEY TERMS

Cost of Learning Objects Repository: Includes fixed and variable costs of a start-up and a system maintenance as well as costs of LOs development (in case they are applicable). Cost of LO repository is largely defined by LOs characteristics, such as: granularity, form, curricular scope, as well as repository characteristics, such as linking-only repository or collection of the actual learning objects.

Curricular Scope: Characteristics of the LOs related to the depth of the content; may range from a very particular in-depth presentation of a single topic/skill to the general, broad description of a branch of science or a discipline.

Form of a Learning Object Reflects Creators' Philosophy and Technical Capabilities of a Repository: This characteristics of the LO is related to (1) the unification options (template, possible technical help with including the content in the template) or (2) the freedom of expression for the author (the author in many case is held responsible for the technical side of the LO development).

Granularity: Characteristics of the LOs related to the size of the object; may include a single topic, theme, or the whole course.

Learning Objects (LOs): Documents, Web sites, simulations, and so forth, on the Web that can be used (and reused) for learning, including metadata and classifiers reflecting their nature and subject area. Learning resources are sometimes used interchangeably with learning objects. Overall, learning resources can include any resources on the Web, not necessarily formatted/containing metadata for including in a course/learning management system, that are used for learning (may not be reusable).

Learning Objects Repository: (1) collection of the actual learning objects on one or several servers with one Web portal serving as an entry, simplifying the search and access to the learning object through the use of metadata; (2) Web portal linking to the appropriate sites, simplifying the search of the learning objects through the use of metadata, with the objects themselves located on Web sites of their creators (in this case some links may be broken if the LO no longer exist or the third party creators of the LO may require access fee).

Reusable Learning Assets (RLAs): See LOs.

Section III
Integration

This final section of the book brings together papers concerned with the integration of learning objects and learning designs. Since the emergence of learning objects, there has been considerable discussion and debate about how learning objects should be integrated effectively into learning activities. This comes from recognition of the challenges involved in taking resources from which context had been deliberately removed or avoided to enhance reusability and combining them to achieve a coherent and effective learning experience. At around the same time the learning design concept has become more prominent as a means of describing teaching and learning experiences using a formalised "language." Some researchers are now beginning to consider how learning objects and learning designs might be used in concert, leading to the idea of integration. This offers the possibility of considering a learning object as a resources that may or may not incorporate pedagogy (i.e., it may contain only content or be highly interactive) that is best integrated into classroom or online activities via a clear, pedagogically sound "learning design." Each of the following chapters contributes to this notion of integration, either implicitly or explicitly, and advances understanding of its implications.

Chapter XXXII
A Learning Design to Teach Scientific Inquiry

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ABSTRACT

This chapter reports the authors' experiences of developing a learning design to teach scientific inquiry, of integrating the learning design with learning objects to create online inquiry projects, and of investigating student attitudes following implementation in second year biochemistry units at a major Australian university. We discuss constructivism, problem based learning (PBL), and inquiry learning as the philosophical and pedagogical approaches informing the learning design, and highlight how critical components of each approach were transformed into a learning design. We specify the learning design and highlight its important features. The claimed efficiencies of the learning object approach were evaluated during the development phase. Outcomes reported here indicate that reuse was most cost effective if many, elaborate learning objects were reused. Little benefit was gained by the reuse of many, simple learning objects. Finally, student perceptions indicate benefits from the inquiry projects that warrant their inclusion in a traditional teacher-centred course.

INTRODUCTION

The learning of science is not only about the acquisition of knowledge regarding scientific principles, theories, and concepts, but constitutes an understanding and appreciation of the scientific method of inquiry—how science is accomplished. The laboratory has traditionally been the primary domain for teaching methods of science. In the 1970s, the promotion of scientific thinking and the scientific method was considered to be one of the five major goals of laboratory teaching (Shulman & Tamir, 1973). Hofstein and Lunetta (2003) have since pointed out that the "uniqueness of the laboratory lies principally in providing students with the opportunities to engage in processes of investigation and inquiry" (p. 203).

However, with regard to teaching scientific inquiry, it is still not clear precisely what features of laboratory learning promote student understanding of these processes or, more importantly, whether understanding actually improves following laboratory experiences. In the past, research studies that compared the effects of practical work in the laboratory with other teaching approaches such as discussion groups, demonstration groups, computer simulations, and filmed chemistry experiments found no significant differences in student achievement, attitude, critical thinking, and in knowledge of the processes of science (see review by Hofstein & Lunetta, 1982). Significant improvements, however, were found in the development of laboratory manipulative skills.

Hofstein and Lunetta (1982) are critical of prior studies for poor control of variables, small group size, limited validity of the instruments chosen to measure effect, failure to consider teaching behaviour, and low quality of laboratory manuals. Nevertheless, when viewed with caution, the studies point to the fact that the major strength of laboratory work may lie in the teaching of technical skills (e.g., handling and operating equipment) and practical abilities (e.g., report writing), rather than achieving more abstract learning objectives such as the conceptual understanding of scientific inquiry processes.

The personal experience of one of the authors, who has taught science to tertiary students for over 15 years, tells a similar story. Despite regular sessions in the laboratory, students find it difficult to grasp the notion of a process that guides the progression of scientific inquiry, and which may include: making observations, defining research questions, gathering information, forming hypotheses, performing experiments, collecting, analysing, and interpreting data, drawing conclusions, and communicating results. With little or no understanding of this iterative process, students have difficulty recognising which stage of the process they are undertaking or identifying the next step in the investigation. Therefore they rely heavily on direction from educators or written laboratory manuals.

Along with an understanding of science facts and an understanding of the scientific method of inquiry, a third goal of learning science is the development of intellectual skills necessary to perform competent investigations. Also referred to as "problem solving skills," "science process skills," "scientific thinking," the rationale behind developing these skills is to provide training for would-be scientists (Zachos, Hick, Doane, & Sargent, 2000). In terms of the learner, the distinction between the latter two goals of science education is, in the first case, knowing the sequence of steps to take to perform an investigation, and second, having the cognitive skills to perform them.

Within the context of his work on technological advances in inquiry learning, de Jong (2006) noted that, "[s]tudies of young students' knowledge and skills indicate that many students in large parts of the world are not optimally prepared for the requirements of society and the work place" (p. 532). In Australia, this concern has been expressed about science students at tertiary level, "few students appear to have developed expert problem solving skills that enable them to cope effectively with learning independently and effectively in the sciences" (Hollingworth & McLouglin, 2001, p. 32). The concern that many tertiary-level science students lack the higher order thinking skills (e.g., problem solving) to enable them to carry out competent investigations, is reiterated by the authors.

Given the problems outlined above, there is an argument for the use of formats other than the science laboratory to promote understanding of the scientific method of inquiry and to develop problem solving skills.

Since the 1980s, computers have been used to create environments that engage students in scientific inquiry activities. The advantage of using computers is that it allows investigations to be simplified or "scaled down" to a size that is manageable for novices (van Joolingen, de Jong & Dimitrakopoulou, 2007). There are many examples of how computers can be used for scientific inquiry activities including:

- Computer simulations, which present natural phenomena or processes (often a simplified version)
- Support tools, which help students gather, organise, visualise and interpret data, and manage the inquiry learning process
- Collaborative tools, which allow students to communicate and to share data and ideas
- Computer-based modelling tools, which allow students to express their theories in models

Many of these applications claim to have positive effects on the development of learners' inquiry and problem solving skills. However, a review of studies on the use of discovery learning with computer simulations to improve learning outcomes revealed "no clear and univocal outcome in favour of simulations" (de Jong & van Joolingen, 1998, p. 181). While there may be limitations to the transfer of knowledge and skills acquired in virtual environments to real situations (Mayer, 1999), the main explanation put forward by de Jong and van Joolingen (1998) was the intrinsic problems that learners have with inquiry processes. Therefore, in recent years, considerable effort has been made to document the problems that learners encounter in inquiry learning and to develop scaffolds or cognitive tools for computer environments, which support students through the inquiry process. Supported inquiry leaning of this kind with simulations has been shown to be an effective mode of learning (van Joolingen, de Jong & Dimitrakopoulou, 2007).

As scientists, science educators, educational designers, and researchers of educational technologies, the authors of this chapter sought to develop a theoretically informed learning design that could be used as a template for online inquiry projects. The major objectives of these projects were to promote an understanding and appreciation of the scientific method of inquiry and to promote development of problem solving skills. The learning design was subsequently used to produce five online inquiry projects covering a range of topics in biochemistry. Three projects were used in studies with second year biochemistry students studying at a major Australian university to determine whether they achieved the objective of promoting understanding and appreciation of the scientific method of inquiry.

To investigate the learning object (LO) paradigm and how it might work in reality, the online inquiry projects used for this study were primarily developed by aggregating and sequencing pre-existing learning objects, rather than creating new ones. New objects were only developed if existing ones could not be found that met our requirements. The types of learning objects integrated with the learning design included images and diagrams, text readings, animations, digital videos, interactive exercises and online quizzes. To quantify the benefits of the LO paradigm, this method of development was compared (in terms of time and cost) to the *de novo* development of equivalent projects.

This chapter begins with a discussion on the theory informing the development of a learning design to promote understanding of the scientific method of inquiry and development of problem solving skills. It goes on to define, describe, and highlight important features of the learning design, and includes a conceptual model of the learning design. Next, we describe how the learning design was integrated with learning objects to create five online inquiry projects. One project, *A Long Wait: Emphysema*, is used as a case study to describe methods used to collect data to evaluate the claimed efficiencies of the learning object approach and to investigate what problems might occur in practice. Finally, we report student perceptions of the learning experience and discuss whether the online inquiry projects achieved the objective of promoting understanding and appreciation of the scientific method of inquiry. We conclude with a discussion on the outcomes of the work presented in the chapter.

PEDAGOGICAL FRAMEWORK INFORMING THE LEARNING DESIGN

In developing the learning design, the authors investigated different learning theories to identify which, when applied in practice, would most likely achieve the major objectives of promoting scientific inquiry and developing problem solving skills. In an attempt to formalise definitions, we have used the terminology proposed by Goodyear (2005) to describe the pedagogical framework. For example, we use *pedagogical philosophy* to describe our beliefs about how people learn, *high level pedagogy* to describe our broad approach between philosophy and actions (i.e., problem based learning), *pedagogical strategy* to describe actions and intentions at a level which hides confusing detail, and *pedagogical tactics* to describe detailed methods by which the strategy is effected.

Pedagogical Philosophy

The overarching pedagogical philosophy that informed our learning design was constructivism, that is, the notion that conceptual development occurs through cognitive activity rather than the passive absorption of information (Mayes & de Freitas, 2004). Constructivism originated in part from Piaget's (1970) theory of learning, which describes learning as an active process with individuals constructing meaning through personal experimentation with their environment. This emphasis places the learner at the centre of activities, and teaching becomes a process of supporting construction rather than communicating information (Bannan-Ritland, Dabbagh, & Murphy, 2002).

A common assumption of constructivist learning is that students must be behaviourally active during learning (Mayer, 2004). Therefore, approaches such as discovery learning are encouraged where students are allowed to work in a learning environment with little or no guidance. For a social constructivist perspective students are expected to work in groups. However, Mayer (2004) argues that rather than behavioural activity, it is cognitive activity that needs to be encouraged in learners, and increasingly research is pointing to guided discovery, which provides guidance and structure for learners, as a more effective way of supporting the construction of knowledge.

In recent years, Bannan-Ritland et al. (2002) highlighted the urgent need "to consider the implications of learning object use and implementation in an instructional context" (p. 1). At the time, little attention had been given to the application of constructivist approaches to learning object systems. More broadly, questions were being raised as to whether elaborate pedagogical approaches could actually be formalised. For example, Nicol (2003) asked the question, "can a learning design template really capture the essence of a pedagogical approach and can pedagogical knowledge really be formalised in this way?" (online). We use the following discussion about the high level pedagogy informing the learning design to explore this question further.

High Level Pedagogy

Cognitive research, particularly in the areas of information processing theories of problem solving and reasoning, metacognitive processes, schema theory, and mental models has given rise to cognitive learning theories (Mayes & de Freitas, 2004). The underlying theme of these theories is to model the process of interpreting and constructing meaning in such a way that knowledge acquisition proceeds from a declarative to a procedural form (Mayes & de Freitas, 2004). Problem based learning (PBL) is a well-established example of a pedagogical approach based on cognitive learning theory. Our account of medical PBL below illustrates how this approach has been formalised. Repeated practise of a well-defined model, in this case, the clinical reasoning process improves learners' ability to perform the skill. If a pedagogical approach can be formalised into a procedure, arguably the next step is to specify the details of the procedure in a learning design.

Problem Based Learning (PBL)

PBL was first developed at McMaster University in medical education in the 1960s, but today is used as a model to reform curricula in many disciplines. In medical education, the main focus of PBL is on the use of authentic, biomedical problems as a context for small groups of students to acquire factual knowledge, to learn processes such as clinical reasoning, and to develop self-directed or lifelong learning strategies (Albanese & Mitchell, 1993; Norman & Schmidt, 1992). The problems at the centre of learning are real-life problems that students may encounter in their future professions as clinicians. Students work together under the guidance of a facilitator, and with access to resources. PBL also enables information from more than one discipline to be integrated during learning, for example the understanding of basic sciences is integrated with clinical knowledge (Norman & Schmidt, 1992).

In the literature, PBL is often used to describe a variety of educational methods that base learning activities around problems. However, for the purpose of our discussion here, we refer to PBL that strictly follows the structures and procedures first classified by Barrows and Tamblyn (1980). Implementation of PBL does vary, for example, some courses implement an exclusive PBL curriculum, while others employ a hybrid version with some lectures and laboratory sessions incorporated into the curriculum. Increasingly, educational technologies are being used to enhance the PBL experience.

The many differences within PBL prompted Barrows (1986) to devise a taxonomy of PBL methods based on (i) the design and format of problems, (ii) the degree to which learning is teacher-directed or student-directed, and (iii) the degree to which each of the following four educational objectives are addressed by the educational design:

- Structuring of knowledge for use in clinical contexts
- Development of an effective clinical reasoning process
- Development of effective self-directed learning skills
- Increased motivation for learning.

The PBL procedure that students use to solve problems is based on clinical reasoning processes and generally involves the following sequence of events: (1) clarify problem, (2) formulate hypothesis(es), (3) identify individual learning needs, (4) individual study/research, (5) evaluate understanding, and (6) develop solution (decision making) (Barrows & Tamblyn, 1980). Students not only concentrate on the content of the problem, but are made aware of the process they are undertaking. Barrows (1986) proposed that through the repeated practise of the PBL procedure, students acquire problem solving skills in a clinical context (clinical reasoning skills). Moreover, students are encouraged to take responsibility for their own learning by identifying their own individual learning needs to follow up. In this way, PBL recognises learning as an integrated process of cognition, metacognition, and personal development (De Grave, Boshuizen, & Schmidt, 1996).

Although cognitive theories predicted that students in PBL curricula should be better at problem solving than those in traditional courses, early reports indicated mixed outcomes (Albanese & Mitchell, 1993; Vernon & Blake, 1993). Evensen and Hmelo (2000) suggest this is because in the past traditional academic measures were used to assess outcomes. More recently, studies have shown that PBL students are able to transfer their problem strategies to new problems and to create more coherent solutions than traditional students (Evensen & Hmelo, 2000). Moreover, PBL students were more accurate, more likely to use hypothesis-driven inquiry (as they had been taught), and constructed better quality solutions.

In summary, PBL provides a powerful learning and teaching practice for health professions. Its major strength is the philosophy that learning is an integrated process of cognition, metacognition, and personal development. Its success in teaching clinical reasoning skills through the repeated practise of a model suggests that this method could be used to teach other process-oriented skills, such as the scientific method of inquiry. Moreover, the focus of PBL on developing independent learners may promote independent problem solving skills in science students.

Inquiry Learning

The scientific method of inquiry is a process or procedure for handling a set of scientific problems. It applies to the entire cycle of discovery and is a gradual process that may require repeated experiments, often by multiple research groups. Bunge (1967) described the most important components of the process as:

1. Defining a research question (this may include making initial observations or gathering information from the body of available knowledge)
2. Forming a hypothesis (e.g., a suggested explanation of a phenomenon)
3. Predicting logical consequences of the hypothesis (information must be valid for past, present, and future observations)
4. Performing experiments and collecting data (information that is reliable and replicable)
5. Analysing and interpreting data
6. Drawing conclusions that may serve as a starting point for new hypotheses
7. Communicating results.

Intrinsic to scientific inquiry is the shared belief amongst scientists that the process must have objective measures. However, a high degree of creativity is involved in developing new ideas and techniques. Moreover, each component of the process is subject to peer review, hence data and methodology must be documented and made available for scrutiny so that other researchers are able to verify results.

Inquiry learning is an approach that imitates real world inquiry (de Jong, 2006). It can be described as the process of solving a problem through exploration of the natural world; asking questions, making discoveries, and rigorously testing these discoveries in the search of new understanding (National Science Foundation, 2000). By allowing students to participate in processes of scientific inquiry it is thought that they will come to understand the skills, values and attitudes of scientists during scientific pursuit. In effect, students take on the role of scientist, albeit novice scientists, pursuing simplified investigations.

The main idea underpinning inquiry learning is that within the context of discipline specific content, students develop the general skills necessary to become independent, lifelong learners. These skills generally involve internal regulation by the student, for example, monitoring the learning progress (e.g., recognising the need to move beyond a current level of understanding, setting learning goals, adapting and applying knowledge to new situations), reporting their learning, and identifying and using quality resources.

DESCRIBING THE LEARNING DESIGN

For the purpose of our studies, we defined a learning design as the specification of the critical components of a high level pedagogical approach. Critical components include pedagogical strategies, tasks students are required to perform, resources and supports to help students complete tasks, and expected cognitive outcomes for students. The learning design also describes the sequence of events and specifies at what stage particular resources and supports are available. It may also include a time line and suggestions for implementation.

Specifications can be described using text, object modeling languages (e.g., unified modeling language), pattern languages, or can be represented visually (e.g., flow charts) (Agostinho, 2006). Some learning designs may be annotated with explanatory notes or symbols to highlight important components of the approach. Oliver, Harper, Hedberg, Wills, and Agostinho (2002) describe a visual representation that assigns symbols for each of three learning design elements and places them in chronological sequence (e.g., squares for tasks, triangles for resources, and circles for supports). Since a learning design may serve as a model to be re-used in different educational contexts, some people might find a visual representation easier to understand.

Our learning design incorporates descriptive text and a conceptual model annotated with explanatory notes. Major pedagogical strategies, examples of problems, supports and suggested time lines are described in detail using text. Tasks students are required to carry out, resources to help students complete tasks and cognitive outcomes for students are represented as a conceptual model.

The learning design that the authors developed to promote understanding of the scientific method of inquiry is described below.

Pedagogy Framework

The high level pedagogies that informed the learning design were PBL and inquiry learning. The major pedagogical strategy employed to operationalise these approaches was the use of real life projects with students taking on the professional role of scientist, for example, pathologist, viticulturist or forensic scientist. Each project presented an authentic, ill-structured problem related to a particular biochemistry topic, which students were guided through to completion. This strategy enabled students to see a model of how experts organise and undertake investigations.

Students conducted investigations by following a standardised science inquiry process, which required them to analyse the problem, formulate a hypothesis, plan an investigation, test the hypothesis by performing virtual experiments, and researching the "body of available knowledge" for further information. For the purpose of the projects, the "body of available knowledge" was a carefully selected subset of information available from authoritative sources such as scientific journals, which was contained within the learning environment. Students then reviewed the evidence (experimental data and additional information) and, if it fitted their hypothesis, went on to draw conclusions. However, if there was a mismatch between the evidence and hypothesis, students continued through further iterations of the research loop (see Figure 1), collecting more virtual experimental data and information, evaluating the evidence and, finally, drawing conclusions.

The tasks that students engaged in throughout the standardised science inquiry process served different cognitive purposes (Norman & Schmidt, 1992; Schmidt, 1993a). The intention of the *Problem Analysis* stage was to activate students' prior knowledge and to stimulate their curiosity in the problem, posing questions such as "What does this scenario remind me of?" or "What could be causing this scenario?" During the *Inquiry Planning* stage, it was expected that students would elaborate their personal interpretations of the problem, placing them in context and identifying different attributes of the problem (e.g., variables, functions, or issues). At this stage, students should begin to formulate an understanding of the type of additional information they might need to know to understand the problem more fully. The purpose of the *Research Loop* stage was to enable students to test their hypothesis and ask themselves whether the additional information they gathered fitted their hypotheses. A mismatch between a student's existing state of knowledge and new details creates cognitive dissonance or conflict, which may lead to conceptual changes in the student's knowledge (Schmidt, 1993b). Finally, the *Problem Closure* stage provided an opportunity for students to reflect on the entire investigation by summarising experimental findings and explaining the main arguments.

Conceptual Model of Tasks, Resources and Cognitive Outcomes

The tasks students performed, resources to help students complete tasks, and expected cognitive outcomes for students are represented in a conceptual model (see Figure 1). The model also illustrates the sequence of tasks and the resources available to students at specific stages of the process.

Pedagogical Tactics

Within projects, expert hints and feedback guided students through the inquiry process. For example, in one of the projects *A Long Wait: Emphysema* students are given the following task during the *Inquiry Planning* stage:

As a scientist working in the hospital's laboratory you have established that Joe's blood sample contained abnormally low levels of the protein alpha-1-antitrypsin. What do you think could be the cause of the low levels of alpha-1-antitrypsin? Make a note of these in the text field below.

If students are unsure of how to proceed they can access an expert's hint: "Think about the significance of the protein alpha-1-antitrypsin. You will need to determine what role it plays in cellular function."

In another project *A Race Against Time: Toxoplasmosis* students are asked to interpret data, "Using the reference ranges provided, state and interpret Ken's results in the text field below." After submitting their response, students are able to compare their interpretation to the head pathologist's:

See what the head pathologist concludes from these results - the average optical density of Ken's duplicate serum samples is 2.2. This means that he has tested positive for T. gondii-specific IgM antibodies. A positive result for IgM antibodies in serum indicates to clinicians that Ken's infection is acute and that he must have acquired the infection recently, at least in the last four months.

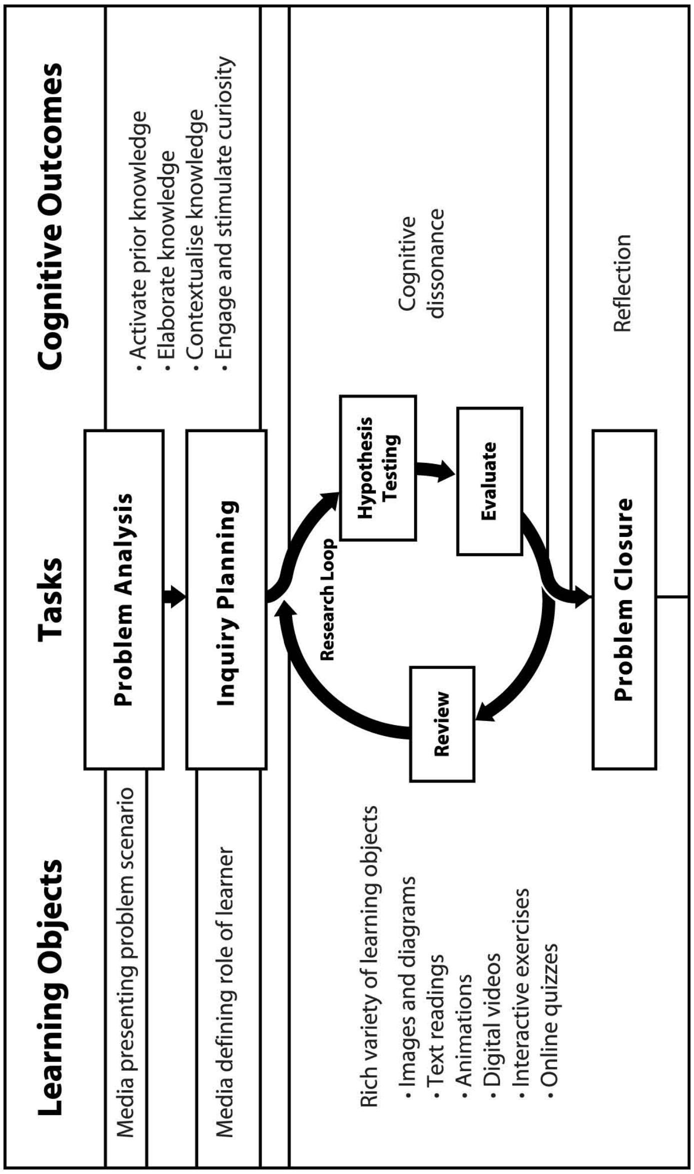
Text fields are provided for students to document task outcomes, for example, their hypothesis(es), learning needs, predictions, data interpretation, conclusions, and closing reflections.

Descriptive headings and explicitly worded instructions and procedural prompts are used to continually remind students which stage of the inquiry process they are undertaking and where the research is being carried out, such as the pathology lab or in the field. A number of examples are listed below:

Headings: Back at the lab... What is the problem?

Back at the lab... What is already known about the mutation?

Figure 1. A conceptual model of the tasks students were required to perform, resources to help students complete tasks, and cognitive outcomes for students



Back at the lab... Experimental methodology
Back at the lab... Further experimentation
Instructions: Task: Planning your investigation
Task: Explore the following medical details about Joe to help you focus your investigation
Prompts: Go forward to define the problem further
Go forward to begin your investigation
Go forward to incorporate additional information
Continue on with your lab work
Go forward to reflect on your knowledge

Problems

As in everyday life, the problems presented to students were complex, in that they contained many elements. They were also ill-structured, meaning that not all the elements involved in the problem were initially known, and some additional elements only become apparent after further investigation. In the project *A Long Wait: Emphysema*, students were required to identify the biochemical defect causing Joe to be in hospital awaiting a lung transplant. Students investigated information pathways and the relationship between the structure and function of proteins in order to solve this problem. In another project *A Waste of Energy: Diabetes*, students studied the principles of bioenergetics and the regulation of metabolic pathways to determine why Guinevere had collapsed at a late night party. In the parasitology project *A Race Against Time: Toxoplasmosis*, students conducted diagnostic tests to discover the cause of Ken's splitting headache. For more information about different types of problems, readers are directed to Jonassen (2000).

Implementation

The inquiry projects developed for this study were housed within *The Virtual Laboratory*, a pre-existing shell of HTML templates developed by St Vincent's Institute of Medical Research and the Victorian Department of Education (Brack, Elliott, Fisher, & Stapleton, 2003). This shell was chosen because its structure and function suited our purposes. A license was obtained to use and modify the shell if necessary. Projects consisted of HTML pages containing images in GIF or JPEG format, Macromedia Flash animations and interactive exercises programmed in Javascript.

The Virtual Laboratory can be used as a self-contained, self-directed learning resource that students access at any time via a student portal. Alternatively, by allocating scheduled computer classes for each project, it can be integrated with the curriculum and closely aligned to topics covered in lectures and laboratory sessions. Facilitators can be used during dedicated computer sessions to provide further guidance and support to students. However, this arrangement differs from the PBL model discussed earlier because facilitators provide assistance to any member of the class rather than only a small group of students.

Inquiry projects were designed to be completed within a 2-hour time frame, although optional content, such as background information to refresh student's memory or follow up extension material, may need to be completed outside this time. Students can complete the projects individually or be placed in small groups of two or three to encourage collaboration. The small group interactions would be particularly helpful when students are required to brainstorm hypotheses or predictions.

Characteristics

The learning design is flexible. The *Research Loop* can be used to alter the complexity of the investigation. Many new problem elements can be introduced during one iteration of the loop, or alternatively, the *Research Loop* can be used multiple times with students progressively refining their hypothesis during each iteration.

The learning design is articulated to a level of specificity that allows educators to integrate learning objects. During the *Problem Analysis* stage educators are encouraged to present trigger media that evokes an overall view of the problem. The trigger is intended to engage students and stimulate their curiosity. It is also recommended that media such as images, sequences of images, digital video, audio, or descriptive text be used to set the context of the inquiry and the role of the learner during the *Inquiry Planning* stage. Again, the intention of this media is to "suspend the disbelief" of students and allow them to engage in the type of thinking a professional scientist would undertake.

The exploratory nature of the *Research Loop* allows it to be populated with a rich variety of learning objects to support learning. Images, diagrams, text readings and animations can be used to present the 'body of available knowledge' (e.g., content that is already known about a topic). Similarly, they can be used to demonstrate experimental procedures, techniques (digital video is particularly useful for this purpose) or equipment, and to display experimental results. Interactive exercises or summative quizzes are useful in the *Problem Closure* stage for students to self-test knowledge. Although we did not consider links to external Web sites to be learning objects, links to external online tutorials are particularly useful as follow up material in *Problem Closure*.

INTEGRATING LEARNING OBJECTS WITH THE LEARNING DESIGN

The approach taken by the authors to create the online inquiry projects was to reuse and embed as much existing material as possible. Among the several potential benefits claimed for the LO approach is that of efficiency (Parrish, 2004). The claimed economy of scale is based on the idea that the development costs of a single object can be effectively defrayed over the several packages or institutions where it is used (Downes, 2001). According to this line of thinking, it should be quicker, and hence cheaper, to develop a program through reuse of existing objects compared to creating the whole program and its objects *de novo*.

Whilst the primary focus of this project was to develop projects for the learning and teaching of biochemistry, a secondary goal was to evaluate the claimed efficiencies of the LO approach and to investigate what problems might occur in practice. It is not guaranteed that the reuse of existing material will lead to greater efficiencies in comparison to the re-creation of the same material. It is possible that the time and cost of searching for, modifying to suit context and negotiating the right to use an object may exceed that incurred from creating the object anew. A question the authors sought to answer was, "At what point does the effort required to reuse an LO outweigh the benefit gained?" Any general answers we find to this question may be of use to other developers of educational programs.

We have used a form of break-even analysis as a method to quantify the economic efficiency of the reuse of LOs. The Concise Oxford English Dictionary defines break-even as "the point or state at which profits are equal to costs." We have compared the total time taken to reuse an LO to an estimate of the time it would take to create the LO anew. The break-even point is where costs are equal. Where the cost of reuse is greater than the estimated cost to produce the learning object *de novo*, the break-even point has been passed and reuse becomes uneconomic. While this is not strictly the meaning of a break-even point in the financial sense, it suited our purposes

There are several assumptions underlying this approach. We only measured individuals' work time, as this is generally the major cost item in development of educational packages. The cost of material items such as stationery, photocopying or other business costs such as computer time or office space are not accounted for. It was assumed that these costs would be proportional to work time and therefore any variation is incorporated in that measure. Another assumption was that an existing LO and one created anew are pedagogically equivalent. It is not always possible to find an existing LO that precisely meets the requirements of the educational designer/educator. Sometimes there is a compromise between the ideal object and what is available. There is a greater likelihood of achieving the ideal when creating an object anew as the developer has greater control over the content and function.

The authors acknowledge that there are many benefits other than economic ones in the LO paradigm. From our own experiences, we found that examining other academics' solutions to the challenges of teaching biochemistry can lead to greater awareness and appreciation of alternative approaches. However, we have restricted this study to the evaluation of the claimed economic benefits of LOs.

Several factors were considered in determining the cost of reuse:

- The time devoted to finding and evaluating LOs. The first step in development was to define the broad characteristics of a desired LO. A number of object repositories (ARIADNE, BIOME, Bitstream's medical links, CAREO, European Schoolnet, HEAL, LEARNet, MERLOT, TryScience, UCEL) were searched, in addition to using the Internet search engine *Google*™. Candidate objects returned were evaluated for appropriateness to proposed use. This evaluation included an assessment of the pedagogical value, technical suitability, aesthetic appeal and compatibility with the overall graphic design of the learning environment.
- The time required to modify an LO to suit the context and technical environment.
- The time required to negotiate permission to reuse the LO with its owner and the cost of any financial payments necessary.

Method

The production of projects was conducted by a professional multimedia development unit dedicated to the development of educational technologies for teaching and learning. Original content was provided by academics with expertise in the relevant topics, supported by a research assistant. Technical development was undertaken by an educational designer and a Web developer.

The time taken on tasks such as the educational design and writing of original content additional to the LOs were not measured as they were considered to be the same regardless of whether an existing LO was reused or a new one created. The majority of searching for LOs was conducted by a research assistant who recorded the time spent on the search, and the details of the LOs that were found. On some occasions, several LOs were found as part of a single search session. In these circumstances, time was apportioned equally across identified LOs. Sometimes an LO identified in a search required some modification to make it suitable for our purpose. In such cases, the time taken to make the modification and the reason for the modification was recorded.

The break-even analysis estimates the time it would take to create anew the LOs that were reused. An experienced Web developer (WD) not involved with the project reviewed the LOs and provided an estimate of the time it would take to develop them. One of the authors (A) independently estimated the time to develop based on a review of historical time data for similar LOs created in other projects by the multimedia development unit. The Pearson correlation coefficient for the time estimate variable of the two estimators was very high and significant ($r=0.96$, $p< 0.0001$). On average, A's time estimates exceeded those of WD. Therefore, in the interests of caution, we chose to use the estimates of the second estimator, A.

A potential problem with this approach is that of underestimation. It is a common occurrence that Web development staff underestimate the time required on a project (Moløkken & Jørgensen, 2005). We compensated for this by adding a further 20% to all estimates resulting in a time range for each object. The lower bound of the range is the original estimate made by the estimator A and the upper bound is the original plus 20%.

Results

Searching

A total of 157 LOs were found to be broadly consistent with the content requirements for the *A Long Wait: Emphysema* project. After evaluation, 74 (47%) of the objects were selected for use in the learning design. While we have no firm data, our impression is that the majority of LOs were found through the use of *Google™*.

Permission

Of the 74 LOs selected for use, permission to reuse was obtained for 71 (96%). Most of the objects were owned by academics, who in general, were very willing to have their material reused. The only stipulation was that appropriate acknowledgement be made.

Permission was refused or could not be negotiated on terms favourable to the authors for only 3 (4%) objects. The reasons for these rejections were:

- Usage would go beyond patient consent obtained by the owner for use of materials
- The source of learning object identified in our search was not the rightful owner
- Commercial terms of use were not suitable.

Reuse

In addition to the 71 LOs reused in the project, 17 new LOs were included giving a total number of 88 LOs. The reason for creating these new objects was that the specific content required was not available in any objects found for reuse. For example, diagrams of isoelectric focussing points displaying data peculiar to the student project needed to be created. Therefore the overall rate of reuse in the project was 81%.

Modification

Of the 71 LOs that were reused, 66 (93%) required some form of modification. Figure 2 displays the relative proportions of the type of modification made. The contextual modifications reflect the design imperative of making sure that a disparate collection of objects is moulded into an integrated, consistent whole. The majority of contextual changes were relatively simple alterations, such as adding an arrow or label to a diagram that illustrated a point being made in the accompanying text or adding a title to an image. A small number of static images were recombined with added text into a single Flash animation and represents the 14% of objects that were modified for reasons of interactivity. The file format modification typically involved changing the format of an image to one more suitable for the Web, for example from TIFF to PNG.

Break-Even Analysis

Table 1 compares the actual time taken to reuse LOs in the project. The reuse time consists of the time spent searching for and evaluating LOs, including ones that were subsequently not reused, and the time spent modifying the object to suit its intended purpose. The estimated time to create includes only LOs that were actually used in the project.

As the data illustrates, when taken in its entirety (the "All objects" row), the reuse approach

Figure 2. Type of modification made to learning objects in the student project, A Long Wait: Emphysema

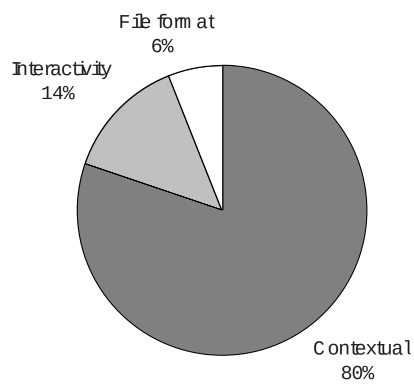


Table 1. A comparison of the overall time taken to reuse vs. create learning objects in the student project, A Long Wait: Emphysema

	Reuse (actual hours)	**Create (estimated hours range)**
All objects	131	754-904
No elaborate objects	130	117-140

saved a considerable amount of development time in comparison to the creation approach. However, the estimates did reveal that a small number of LOs accounted for a relatively large proportion of the estimated development time. We have labelled these LOs as "elaborate" in that they were highly detailed animations of biochemical processes that would have required many hours to recreate. We estimate that it would take at least 70 working hours for a developer to create the simplest of these objects. Removing these elaborate LOs from the calculation reveals that the time taken to create the module *de novo* was roughly equivalent to the time taken using a reuse approach (see the second row of Table 1).

With the reuse approach, approximately 75% of the total time was spent searching for LOs, evaluating them and negotiating intellectual property arrangements.

Discussion

In summary, we found that reused LOs formed a substantial part (81%) of the final content of the student project *A Long Wait: Emphysema*. Gaining permission from authors to reuse LOs was generally not an obstacle to reuse, but it did consume a reasonable amount of time along with searching and evaluation.

By far, the majority of time in the reuse approach was spent searching for and evaluating the suitability of LOs. As the adoption of e-learning catalogues and repositories becomes mainstream, there are potential savings to be made in search time. However, this must be offset against the time spent cataloguing LOs. Most systems require LOs to be tagged with descriptive metadata. However, even when searching for LOs in repositories, time is needed to evaluate LOs, since individual educators may have their own specific needs and learning context to consider.

During searching, many more LOs were found than were actually used in the final product. This is a natural outcome of the "search and evaluate" approach; it is unlikely that the very first LO retrieved will be precisely what is required for the project being developed. In our study, a search would be conducted for a particular LO, the found LOs would be evaluated and, if unsuitable, further searches were conducted. This resulted in a "hit rate" of less than 50%, that is, less than half the LOs found were suitable for our purpose. A low hit rate reduces the efficiency of the reuse approach. It also highlights the need for quality metatagging of LOs.

Of the LOs reused, the majority needed some form of modification (93%). The main reason for modification was to make the LO fit the context of the student project. This highlights the need to adapt reused LOs so that they are relevant to the context of the new educational purpose.

Reuse is most cost-effective when reusing elaborate LOs in comparison to creating elaborate LOs *de novo* (by a factor of around 6 to 1).

We found that the reuse of simple LOs was not cost-effective in our context of a professional multimedia development unit. The time spent searching for and evaluating simple objects can sometimes outweigh the time saved by not having to create them.

STUDENT PERCEPTIONS OF THE LEARNING EXPERIENCE

The online learning environment described in this chapter was implemented in a traditional, teacher-centred course at a major Australian university. It was introduced to second year biochemistry students during lectures and made available as a self-directed learning resource, which students had unrestricted access to through a student portal. At the same time, specific inquiry projects were integrated with other curriculum components in the subject. This meant that when a topic was being covered in lectures or laboratory sessions, a dedicated computer session was scheduled for students to complete the relevant project. Facilitators provided additional guidance and support during these computer sessions.

Preliminary evaluation of two inquiry projects, *A Long Wait: Emphysema* (n=177) and *A Race Against Time: Toxoplasmosis* (n=186), revealed encouraging student responses about the value of the projects as biochemistry learning resources. Of the student's surveyed, 72% agreed that the *Emphysema* project was valuable to their understanding of biochemistry and 77% of students agreed that the real-life, inquiry approach was beneficial to their understanding of biochemistry (64% and 60% respectively, for the *Toxoplasmosis* project).

The purpose of the current study was to determine how second year biochemistry students valued three online projects in comparison to other sources of information about biochemistry. It also sought to determine students' opinions of the scientific method of inquiry that they utilised in projects, with a particular emphasis on their understanding of the process, real-world application of knowledge, their engagement with the process and the challenges of carrying it out. More specifically, the study investigated the value students placed on different stages of the scientific inquiry process, in assisting their overall understanding of the real-world problems presented in projects.

Method

Participants

This study was carried out with second year students undertaking compulsory biochemistry units in their courses of Bachelor of Pharmacy (210 students) and Bachelor of Pharmaceutical Sciences (15 students) at a major Australian university.

Measures

A questionnaire was developed that addressed the three major objectives of the study. The first questionnaire item asked students to rate on a nine point Likert scale (1 not at all helpful to 9 very helpful), how helpful they found different sources of information about the topic (e.g., lectures, text books, online project, discussion with peers, laboratory sessions, other Web sites, journals). The second questionnaire item asked students to rate on a nine point Likert scale (1 not at all helpful to 9 very helpful), how helpful different stages of the scientific inquiry process were to their understanding of the project (e.g., *Problem Analysis* (including hypothesis formulation), *Inquiry Planning*, *Hypothesis Testing*, *Evaluation*, *Review* and *Problem Closure*). The final questionnaire item asked students to rate on a five point Likert scale (1 strongly disagree to 5 strongly agree): their understanding of the scientific method of inquiry; their ability to recognise the process; their real-world application of knowledge; relevance to their future profession; their engagement with the inquiry process (whether they found it beneficial or interesting in terms of theory and techniques); and the challenges of carrying out the process (whether they needed to know more, found it difficult or confusing).

Procedure

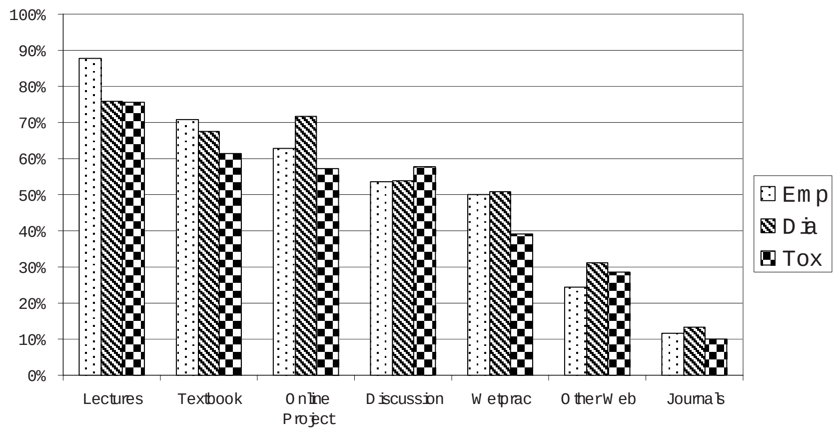
This study had human research ethics approval. Data collection took place in March of 2006 for the project *A Long Wait: Emphysema,* in May of 2006 for *A Waste of Energy: Diabetes* and in October of 2006 for *A Race Against Time: Toxoplasmosis.* Students completed an anonymous paper-based survey that was administered immediately after each dedicated computer session had finished. The survey was distributed by teaching staff and participants were informed of the study methods and asked to return completed surveys to an anonymous drop box. Completion and return of surveys implied student consent to participate in the study. Since the survey was anonymous, individual student responses could not be linked across each of the three projects.

Results

Student reporting of information sources they found helpful to their understanding of a range of topics in biochemistry is shown in Figure 3. Percentages were obtained by collapsing the nine point Likert scale (1 not at all helpful to 9 very helpful) into three categories: *Not Helpful* (points 1-4), *Neutral* (point 5), and *Helpful* (points 6-9) and determining the number of students in each category. Figure 3 displays percentage of responses in the *Helpful* category.

A high percentage of students reported that lectures were helpful to their understanding of emphysema (88%), diabetes (75%), and toxoplasmosis (75%). While fewer students reported that the online projects were helpful (e.g., 62%, 72%, and 58% for the topics of emphysema, diabetes, and toxoplasmosis, respectively) these results were similar to those obtained for textbooks (e.g., 71%, 68%, and 61% for emphysema, diabetes, and toxoplasmosis, respectively). The online project about diabetes appeared to be particularly helpful to students. This is presumably due to a perceived direct relevance to their future profession in the health sciences as distinct from the other projects,

Figure 3. Percentage of students reporting information sources they found helpful to their understanding of a range of topics in biochemistry



which dealt with less common disease states. Consistently, more students found the online projects helpful than laboratory sessions (e.g., 50%, 51%, and 40% for emphysema, diabetes, and toxoplasmosis, respectively).

Student reporting of their understanding of the scientific method of inquiry utilised in three online projects: (a) *Emphysema*, (b) *Diabetes*, and (c) *Toxoplasmosis* is shown in Figure 4. Percentages were obtained by collapsing the five point Likert scale (1 strongly disagree to 5 strongly agree) into three categories: *Agree* (points 1-2), *Neutra*l (point 3), and *Disagree* (points 4-5) and determining the number of students in each category. Figure 4 displays percentage of responses in the *Agree* category.

After completing the project *Emphysema*, 81% of students agreed that it had given them a greater understanding of how scientific investigations are performed, 68% agreed that they could recognise the process, and 75% agreed that it had shown them real-world applications of their biochemical knowledge. It is interesting that only 45% of students agreed that the process was relevant to their future profession, although this may reflect the fact that surveyed students were training to become pharmacists, rather than research scientists.

In terms of engagement with the process, 70% of students agreed that it was beneficial to their learning, but only 48% indicated that they enjoyed learning this way. Furthermore, just over half of the students surveyed felt that the process fostered an interest in background theory (55%) or biochemical techniques (52%).

While 50% of students agreed that the scientific method of inquiry was challenging to perform and that they needed to know more about it to get the most out of the project (52%), fewer students reported that the process was actually confusing (20%) or difficult (21%).

The observed trends in student reporting of their understanding of the scientific method of inquiry were consistent across all three projects; *Emphysema*, *Diabetes*, and *Toxoplasmosis* (see Figure 4), however, the percentage of students agreeing with statements was lower for *Diabetes* and *Toxoplasmosis*. An exception to this was profession, with 55% of students agreeing that the inquiry process used in *Diabetes* was relevant to their future profession. It appears that this project aligned better with student perceptions of their future careers as pharmacists. Additionally, as students completed more projects, fewer reported finding the inquiry process confusing or thought they needed to know more about it.

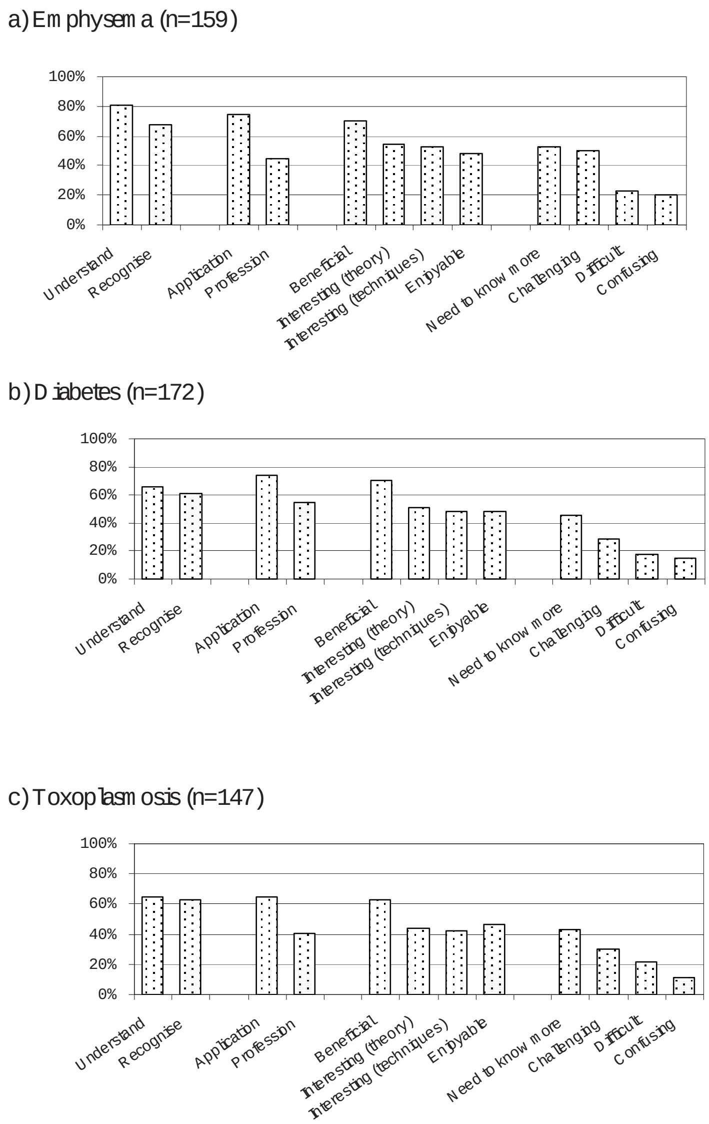
Student perceptions of how helpful different stages of the scientific method of inquiry were in assisting their overall understanding of the real-world problems are shown in Table 2. Perceptions were assessed on a nine point Likert scale (1 not at all helpful to 9 very helpful) and mean scores calculated for each sample.

Review, which often included a summary of material covered in the project and involved students revising their hypothesis(es) and thinking about further experimentation, was reported to be helpful, as was *Evaluation*, where new data or information was incorporated and evidence appraised. *Closure*, which presented conclusions and follow up details about the problem was considered helpful for the *Toxoplasmosis* project. Consistently across all three projects, students perceived *Problem Analysis*, which in this case included identifying problem elements and the formation of a hypothesis based on limited data to be less helpful than other stages of the inquiry process.

Discussion

It is not surprising that a high percentage of students considered lectures to be helpful to their understanding of biochemistry, since this is their primary source of information in the teacher-centred course (Figure 3). However, considering the student-centred nature of the inquiry projects, it is encouraging that many students also perceived

Figure 4. Student reporting of their understanding of the scientific method of inquiry utilised in three online projects: (a) Emphysema, (b) Diabetes, and (c) Toxoplasmosis. Each graph displays percentage of responses in the Agree category



these projects to be helpful to their learning. This was particularly evident for the *Diabetes* project, and appears to be due to students' perception of a direct relevance to their future profession in the health sciences and the role they might play in the management of this disease.

It is interesting that more students perceived the inquiry projects to be helpful than laboratory sessions (Figure 3). Although we did not specifically investigate the reasons behind this outcome, it may relate to our contention that

Table 2. Mean ± SD of student reporting of the value of different stages of the inquiry process assessed on a Likert scale (1 not at all helpful to 9 very helpful)

Variable	Emphysema	Diabetes	Toxoplasmosis
Problem Analysis	5.32 ± 2.09	5.21 ± 2.12	4.71 ± 2.13
Inquiry Planning	7.06 ± 1.34	6.69 ± 1.33	6.07 ± 1.62 *
Hypothesis Testing	6.41 ± 1.31	6.43 ± 1.30	6.38 ± 1.44
Evaluation	7.57 ± 1.92	6.79 ± 1.34 *	6.47 ± 1.39 *
Review	7.73 ± 1.29	n.a.	7.17 ± 1.59 *
Problem Closure	6.89 ± 1.46	5.19 ± 2.35 *	7.29 ± 1.79

n.a. not applicable as the Diabetes project did not contain a specific Review phase.
** nonoverlapping 95% confidence limits for the means*

some laboratory work is more likely to develop technical skills than inquiry skills. Students may find it difficult to relate the experiments they do in the laboratory to the "big picture" of a real-world investigation in its entirety. Only about half of the students surveyed felt that the projects fostered an interest in biochemical techniques (52%), again suggesting that the laboratory with its "hands-on" experimentation may be better suited to teaching techniques.

Student perceptions of the scientific method of inquiry replicated in projects suggest that the process encouraged understanding of how investigations are performed, allowed students to recognise the inquiry process, and demonstrated the real-world applications of their biochemical knowledge (Figure 4). While many students (70%, 70%, and 63% for the *Emphysema*, *Diabetes*, and *Toxoplasmosis* projects respectively) agreed that the process was beneficial to their learning, fewer students (48%, 48%, and 46% for the *Emphysema*, *Diabetes*, and *Toxoplasmosis* projects respectively) agreed that they enjoyed learning this way. This seems to suggest that even though students are able to appreciate the benefits of inquiry learning, they find it hard work requiring substantial effort from them. This outcome aligns with current research that indicates students have difficulties with many of the processes involved in inquiry (de Jong, 2006).

It is noteworthy that students perceived the initial *Problem Analysis* stage (including the formation of a hypothesis based on limited data) to be amongst the least helpful stage in assisting their understanding of the problem (Table 2). This fits with current understanding of the types of problems students encounter with inquiry learning. Studies in scientific discovery learning with computer simulations have shown that, even at a tertiary level, students do not necessarily understand what a hypothesis is, and may be unable to state or adapt hypotheses on the basis of collected data (de Jong & van Joolingen, 1998). Moreover, these researchers found that "subjects tend to avoid hypothesis that have a high chance of being rejected" (p. 184), referring to this as "fear of rejection."

Within the context of de Jong and van Joolingen's (1998) research, hypothesis generation involved the formulation of a statement or a set of statements to describe the relationship between a number of known variables involved in a scientific phenomenon or process (e.g., the physics of movement). In our case, the generation of hypothesis(es) was not intended to be a strict set of statements, but was used as a trigger to engage students in the problem and start them thinking about how their biochemistry knowledge could explain what they were observing in the initial problem presentation. To support hypothesis generation in online inquiry learning, van Joolingen and de Jong (1991) have used a hypothesis scratchpad that offers a template for students to fill in with relations and variables. While this may not be suitable for our context, the introduction of a collaborative, hypothesis generation task in which a small group of students collectively come up with the most appropriate hypothesis, may provide support during this difficult stage of inquiry. Teacher facilitation could also assist at this stage.

Generally, students found the later stages of the inquiry process (e.g., *Evaluation, Review, Problem Closure)* more helpful to their understanding of the problem. However, this outcome seemed to be influenced by the topic under consideration, for example, *Problem Closure* was considered helpful only for the *Toxoplasmosis* project (Table 2). These three stages often contained appraisals of new evidence, overviews of what had been done in the project (including, predictions, results of experiments and interpretations), summative experts' opinions and, conclusions and the culmination of the problem.

In their review of studies in scientific discovery learning with computer simulations, de Jong and van Joolingen (1998) suggest that some of the features noted above could be included as support measures in online inquiry learning. For example, overviews of what the student has done in the learning environment and "expert views" that show the relevance of the student's action have been shown to provide effective support for monitoring the inquiry process. This may explain why students found these stages so helpful to their understanding. Anecdotal evidence reported to one of the authors indicated that students appreciated the experts' opinions as it confirmed their conclusions from the project. In some instances, students used the experts' opinions and hints to develop their own line of thinking.

CONCLUSION

Medical PBL has a long tradition of using well defined procedures and structures to achieve the desired outcomes for students, that is, to acquire biomedical knowledge, to learn clinical reasoning skills and to develop strategies for life long learning. This pedagogical approach is firmly grounded within a framework of cognitive learning theory.

It is possible to translate critical components of a pedagogical approach, such as PBL, into a learning design because of the well-defined nature of the procedures and structures it uses. There is a clear understanding of what is required for an effective teaching and learning experience, in terms of pedagogical strategies, tactics, problem type, student tasks, resources, and instructional support.

The learning design described in this chapter provided a good template for the development of online inquiry projects (inspired by PBL) by aggregating and sequencing pre-existing LOs. We found that gaining permission from owners was not an obstacle to reusing these materials. Most LO owners, particularly academics, were willing and in fact very eager to allow their objects to be reused. However, it did consume a reasonable amount of time, along with searching for and evaluating the suitability of LOs.

In terms of the efficiencies of the LO paradigm, most benefit was gained if a project contained many elaborate LOs (e.g., highly detailed animations of biochemical processes). Little benefit was gained by the reuse of many simple LOs, such as images or diagrams. This was because the time and cost involved in searching for, evaluating, and modifying LOs meant that it was equally efficient to create them *de novo*. However, this finding stands within the context of development being undertaken by a professional multimedia development service with experienced, skilled staff able to efficiently produce simple LOs. Educators without this type of support may find that the time taken to create LOs *de novo* is greater and the break-even point for reuse higher.

Overall, students in the second year of their degree course perceived the online inquiry projects to be a valuable resource to their learning of biochemistry. The scientific method of inquiry replicated in projects encouraged an understanding of how investigations were performed, allowed students to recognise the inquiry process and demonstrated the real-world application of their biochemical knowledge. These benefits warrant their inclusion in the practice of biochemistry teaching. However, at the same time as appreciating the benefits of inquiry learning, some students found the process difficult.

Students in a teacher-centred course who have relied on lectures as their primary source of information may initially experience difficulties adjusting to the introduction of an educational technology requiring a more independent, self-directed approach to learning. Therefore, the findings of this study are encouraging and suggest ways that these difficulties can be minimised. For example, during dedicated computer sessions in which students completed inquiry projects, teaching staff took on the role of facilitator, providing additional support and gently prompting students through the inquiry process. Moreover, scaffolding was built into the projects to guide students through the process. Such measures included the structuring of content to step students through each stage of the entire inquiry process, the use of immediate expert hints and feedback, the use of leading questions, and the provision of summaries and overviews as support for monitoring the inquiry process.

The integration of the inquiry projects with other curriculum components such as lectures and laboratory sessions was also important. This meant that at the same time as students were being taught factual information about a topic in lectures, they could participate in an investigation related to the same topic in the inquiry projects and observe the real world application of their knowledge. Furthermore, the use of particular experimental techniques and equipment during the online investigations was often reiterated in laboratory sessions. Regarding science education, de Jong (2006) argues that "sound curricula combine different forms of tuition, both inquiry learning and direct instruction" (p. 533). Since the learning goals of each approach are different, there is merit in the use of multiple approaches for a more complete science education for students.

While it is accepted that students have difficulties with some aspects of the inquiry process (de Jong & van Joolingen, 1998), students need to understand that the processes involved in scientific inquiry require effort. In her research on the transfer of critical thinking skills, Halpern (1998) makes the point that

> *students need to be told to expect that a thoughtful consideration of evidence and arguments will require expenditure of mental effort so that they do not expect quick and easy answers and will not be surprised by the amount of effort required of them. (p. 455)*

To this end, an introductory module for the learning environment to inform students about the nature of inquiry learning is currently under development and will make the aims and objectives of inquiry learning explicit. Although the social perspective of constructivism has not been the focus of this study, we plan to incorporate a collaborative, hypothesis generation task into the inquiry project design. Thus, future research may investigate social aspects of inquiry learning.

Finally, as students completed more projects, fewer reported finding the inquiry process confusing or thought they needed to know more about it. While it may be that students found the content of later projects easier, another possibility is that students found the scientific inquiry process less challenging over time. Future research may be able to determine whether students develop a deeper understanding of the scientific inquiry process over time. Invariably, students in the current study only completed projects that were part of the compulsory curriculum (a total of three in 2006). In a PBL curriculum, students would undertake PBL sessions on a weekly or more frequent basis. It might be expected that more frequent repetition of the inquiry process by science students would develop a deeper understanding and appreciation of the scientific inquiry process.

REFERENCES

Agostinho, S. (2006). The use of visual learning design representation to document and communicate teaching ideas. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds), *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who's Learning? Whose Technology?* (pp. 3-7). Sydney: Sydney University Press.

Albanese, M.A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, *68*(1), 52-81.

Bannan-Ritland, B., Dabbagh, N., & Murphy, K. (2002). Learning object systems as constructivist learning environments: Related assumptions, theories and applications. In D.A. Wiley (Ed), *The instructional use of learning objects.* (pp. 1-52). Distance-Educator. Retrieved March 30, 2008, from http://www.distance-educator.com/dnews/?name=News&file=article&sid=7612

Barrows, H.S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*(6), 481-486.

Barrows, H.S., & Tamblyn, R.M. (1980). *Problem-based learning: An approach to medical education*. New York: Springer.

Brack, C., Elliott, K.A., Fisher, J., & Stapleton, D. (2003, December 7-10). The virtual laboratory: An online program to integrate authentic activities into the biology curriculum. In G. Crisp, D. Thiele, I. Scholten, S. Barker, & J. Baron (Eds), *Interact, integrate, impact*: *Proceedings of the 20th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 581-584). Adelaide.

Break-even (term definition). In C. Soanes & A. Stevenson (Eds.), The Concise Oxford English Dictionary (11th ed.) (2006). Oxford University Press. Retrieved May 13, 2008, from Oxford Reference Online, http://www.oxfordreference.com/viewsENTRY.html?subview=Main&entry=t23.e6845

Bunge, M. (1967). *Scientific research I: The search for system*. Berlin, Heidelberg, Germany: Springer–Verlag.

De Grave, W.S., Boshuizen, H.P.A., & Schmidt, H.G. (1996). Problem based learning: Cognitive and metacognitive processes during problem analysis. *Instructional Science, 24,* 321-341.

de Jong, T. (2006). Technological advances in inquiry learning. *Science, 312,* 532-533.

de Jong, T., & van Joolingen, W.R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, *68*(2), 179-201.

Downes, S. (2001). Learning objects: Resources for distance education worldwide. *The International Review of Research in Open and Distance Learning, 2*(1). Retrieved March 30, 2008, from http://www.irrodl.org/index.php/irrodl/article/view/32/81

Evensen, D.H., & Hmelo, C.H. (2000). *Problem-based learning: A research perspective on* *learning interactions*. Mahwah, NJ: Lawrence Erlbaum Associates.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australian Journal of Educational Technology, 21*(1), 82-101.

Halpern, D.F. (1998). Teaching critical thinking for transfer across domains. *American Psychologist*, *53*(4), 449-455.

Hofstein, A., & Lunetta, V.N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, *52*(2), 201-217.

Hofstein, A., & Lunetta, V.N. (2003). The laboratory in science education: Foundations for the 21st Century. *Science Education, 88*(1), 28-54.

Hollingworth, R.W., & McLouglin, C. (2001). Developing sciences students' metacognitive problem solving skills. *Australian Journal of Educational Technology, 17*(1), 50-63.

Jonassen, D.H. (2000). Towards a design theory of problem solving. *Education Technology Research and Development, 48*(4), 63-85.

Mayer, R.E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research, 31,* 611-623.

Mayer, R.E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*(1), 14-19.

Mayes, T., & de Freitas, S. (2004). Review of e-learning theories, frameworks and models. JISC e-Learning Models Desk Study. Retrieved March 30, 2008, from http://www.jisc.ac.uk/uploaded_documents/Stage%202%20Learning%20Models%20(Version%201).pdf

Moløkken, K., & Jørgensen, M. (2005). Expert estimation of Web-development projects: Are software professionals in technical roles more optimistic than those in non-technical roles? *Empirical Software Engineering, 10*(1), 7-30.

National Science Foundation. (2000). *Foundations: A monograph for professionals in science, mathematics, and technology education*. *Inquiry: Thoughts, views, and strategies for the K-5 classroom*. National Science Foundation, Directorate for Education and Human Resources.

Nicol, D. (2003). Conceptions of learning objects: Social and educational issues. Commentary on C. Duncan, Granularisation. In A. Littlejohn. (Ed.), Reusing online resources: A sustainable approach to e-learning (Chap. 2). London: Kogan Page. *Journal of Interactive Media in Education* [Special Issue on Reusing Online Resources], *1*. Retrieved March 30, 2008, from http://www-jime.open.ac.uk/2003/1/

Norman, G., & Schmidt, H.G. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine*, 67(9), 557-565.

Oliver, R., Harper, B., Hedberg, J., Wills, S., & Agostinho, S. (2002). Formalising the description of learning designs. In A. Goody, J. Herrington, & M. Northcote (Eds), *Quality conversations: Research and development in higher education, 25,* 496-504. Jamison, ACT: HERDSA. Retrieved March 30, 2008, from http://www.ecu.edu.au/conferences/herdsa/main/papers/ref/pdf/Oliver.pdf

Parrish, P.E. (2004). The trouble with learning objects. *Educational Technology, Research and Development, 52*(1), 49-67.

Piaget, J. (1970). *Science of education and the psychology of the child*. New York: Orion Press.

Schmidt, H.G. (1993a). Foundations of problem-based learning: some explanatory notes. *Medical Education*, *27,* 422-432.

Schmidt, H.G. (1993b). Problem-based learning: Rationale and description. *Medical Education, 17,* 11-16.

Shulman, L.D., & Tamir, P. (1973). Research on teaching in the natural sciences. In R.M.W. Travers (Ed.), *Second handbook of research on teaching*. Chicago: Rand McNally.

van Joolingen, W.R., & de Jong, T. (1991). Suppporting hypothesis generation by learners exploring an interactive computer simulation. *Instructional Science, 20,* 389-404.

van Joolingen, W.R., de Jong, T., & Dimitrakopoulou, A. (2007). Issues in computer supported inquiry learning in science. *Journal of Computer Assisted Learning, 23,* 111-119.

Vernon, D.T.A., & Blake, R.L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine, 68*(7), 550-563.

Zachos, P., Hick, T.L., Doane, W.E.J., & Sargent, C. (2000). Setting theoretical and empirical foundations for assessing scientific inquiry and discovery in educational programs. *Journal of Research in Science Teaching, 37*(9), 938-962.

KEY TERMS

Break-Even Analysis: The point or state at which profits are equal to costs.

Learning Design: A specification of the critical components of a general pedagogical approach. Critical components include pedagogical strategies, tasks students are required to perform, resources and supports to help students complete tasks, and expected cognitive outcomes for students. The learning design also describes the sequence of events and specifies at what stage particular resources and supports are available. It may also includes a time line.

Learning Object: Any digital entity that can be reused as a resource for teaching and learning. Simple learning objects may include images or "chunks" of text, whereas elaborate learning objects may include examples such as a stand alone, online tutorial containing content and questions, or a digital video demonstrating the use of a piece of scientific equipment.

Pedagogical Approach: The broad principles and methods of education used in teaching practice. Goodyear (2005) suggests that pedagogical approach can be subdivided into *Pedagogical Philosophy* (to describe beliefs about how people learn) and *High Level Pedagogy* (to describe a broad approach between philosophy and action).

Pedagogical Strategies: The actions and intentions of a pedagogical approach described at a level that hides confusing detail. Tactics describe detailed methods by which the strategy is effected.

Reuse: The use of a pre-existing learning object created for a particular educational context in a new educational context.

Tasks: Here we follow the approach by Goodyear (2005) and use task to describe a specification for learner activity. Activity is what students actually do.

Chapter XXXIII
Adapting Problem-Based Learning to an Online Learning Environment

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ABSTRACT

This chapter explores through a case study approach of a tertiary-level unit on Land Assessment for Sustainable Use, the connections between three key elements of learning—learning outcomes, learning design, and learning objects—in the context of problem based learning conducted in an online environment. At the "heart" of learning is the achievement of learning outcomes guided pedagogically by the learning design ("head") with the support of well-designed, pedagogically-sound learning objects ("hands"). All the students participating in this case study were undertaking the unit as off-campus or "distance" students, either at under- or post-graduate level. This chapter defines the use of learning objects and learning design in a problem based learning context. Primary evidence is presented to demonstrate the effectiveness of the problem based learning design and integrated learning objects in facilitating learning outcomes when students communicated online on discussion boards within a course management system (WebCT) under two circumstances: one, as a collective group (2001-2003) before face-to-face instruction and practice in problem based learning; and two, in small groups (2004-2006) after receiving face-to-face instruction and practice in problem based learning. Improved student participation rates and quantity and quality of online student interactions on discussion boards seemed to be the consequence of early scaffolding of student learning through face-to-face instruction and practice in the problem-based learning activity, as well as working in small peer groups for subsequent discussion board activity. Overall there seemed to be improved student comprehension of and interaction with the learning design and learning objects in the small group experience of the problem based learning activity, which resulted in a more fulfilling and robust form of learning.

INTRODUCTION

Educational developments such as the online delivery of unit content, learning activities and assessments, and Web-based learning resources have arisen from the perceived need to diversify university teaching approaches to produce more competent and competitive graduates who can meet the challenges of the workplace. Before university graduates enter the workplace, employers expect them to have proven and demonstrable ability in a range of skills and competencies along with the knowledge base.

The reasons for introducing problem based learning (PBL) into the teaching of natural resource management were primarily to immerse students in the knowledge of the discipline and for them to understand the process of knowledge acquisition and building rather than just learning content. Many undergraduate students on completion of their degree will find work in natural resource management agencies either at local, state, or federal levels, and will most likely find themselves working in small teams with disparate backgrounds and experiences with problem solving. Graduates are expected to function effectively as group members, as well as advance the work activity they are jointly responsible for. Thus, students need to understand and experience "working" as part of a small team, delegate tasks, make joint decisions, and allocate resources. PBL allows students to do this by involving them in learning about teamwork, skills (e.g., interpersonal skills, time management, report writing, communication, and active listening), and experiencing a range of team member roles to achieve an outcome. In addition, the other desired learning outcomes from using PBL in this context are: problem solving, information literacy (i.e., the ability to access, read, synthesise and interpret information), alignment of content and assessment tasks, fostering student motivation, acknowledgement of prior learning, and encouragement of "intellectual prospecting" (Lobry de Bruyn, 2005; Lobry de Bruyn & Prior, 2001).

The use of PBL as a learning design has been well accepted in vocational degrees such as medical sciences, education, law, and business (e.g., MBA). However, the use of problem based learning as a learning design in natural sciences, particularly natural resource management remains rare. Combining PBL as a learning design in an online environment, and the use of computer-mediated communications in the delivery of learning objects[1] (including problem based learning situation statements, replies to student questions as rejoinders, and internal and external links to Web-based learning resources) is even rarer.

Traditionally PBL is conducted in a classroom environment and the various steps of the problem-solving process are conducted face-to-face in small groups in which students: introduce themselves to each other, set ground rules, acknowledge prior learning, identify contributions to group learning, identify learning needs and activities, and finally work through the problem-solving process. Transferring the problem-solving process to an online environment, asynchronous computer-mediated communication allows students to communicate independently of time and place, provides social interaction with peers, and even allows small peer groups to be created to communicate questions, opinions, and queries. The use of threaded discussion boards that allow asynchronous computer-mediated communication is advantageous when it is not possible to predict precisely when students will access discussion boards. Threading also allows students to trace and keep track of conversational chains, as each message or posting has a subject label, and is organised in a hierarchical structure that only includes those messages that are related. Unrelated threads are kept separate, and this allows students to pursue multiple avenues of thought without becoming confused (Hewitt, 2001).

This chapter will explore and expound on the confluence between learning design (pedagogy and learning strategy) and learning objects (learning resources and tools), their application to problem based learning in the context of natural resource management, and a particular use of the learning design and learning objects with off-campus students undertaking a tertiary-level unit on *Land Assessment for Sustainable Use* either at under- or post-graduate level.

The specific objectives of this chapter are to:

- After examining the literature, clarify and define the use of the terms learning object and learning design and their application in this particular instance to problem based learning (PBL), its online delivery, and use of Web-based learning resources.
- Demonstrate how technologies (such as computer-mediated communication, and course management systems) can be used to support PBL, its online delivery, and use of Web-based learning resources.
- Examine the ability of the PBL design and its related leaning objects to build an interactive learning environment that can support student-centered learning and student mastery in the context of a PBL activity, when student discussions of the situation statements and rejoinder were only able to occur via discussion boards
- Test strategies such as early positioning of face-to-face instruction on and practice in problem based learning prior to student interaction in discussion boards in the PBL activity to examine their influence on: student participation, student concentration on problem-solving in the learning activity, convergent processes (i.e., degree of analysis, synthesis, and summarising), and social presence.

BACKGROUND

The literature is awash with papers debating the meaning of learning objects, and their subsequent use in e-learning, often without any substantive evidence to support the author's preferred definition. This debate seems to be needlessly creating divergent "camps" of thought and misconceptions concerning those scholars or practitioners who are perceived to value "learning" above "object" and vice versa, as expressed by McGreal (2004). The areas of contest concerning learning objects include: what is a learning object, use of the LEGO analogy (Wiley, 1999), the nature of a learning object, the reticence of learning object authors to "share" or inability of learning objects to be "re-used," who designs the learning objects, and who controls and manages their access, use, and re-use. Metros (2005) in a succinct critique of the term writes that "the label learning object may have run its course, but the slow shift to modularized and sharable education content perseveres" (p. 13). The vanguard is being lead by the next generation of course management systems and instructional designers rather than educators in their "long-established discipline silos" to make possible "learner centered, non linear, customizable, media-rich educational content to access, share and store a variety of media types within course content" (Metros, 2005, p.13).

Hodgins (2002) describes the potential of learning objects as "a completely new conceptual model for the mass of content used in the context of learning" (p.1), driving the development of interoperability standards and creation of packages of learning materials that can be easily reused and placed in varying contexts. The following definitions of learning objects demonstrate the points of contrast as well as commonly-held views of what a learning object is.

The Institute of Electrical and Electronic Engineers (IEEE) Learning Technology Standards

Committee (2002) defines learning objects as: "any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning" (p. 5). Wiley (2000) criticises this definition on two counts: firstly, as too broad because it "fails to exclude any person, place, thing or idea that has existed in any time in the history of the universe" (p. 5), and secondly because the "use of an object during learning doesn't connect its use to learning" (p. 8).

Wiley (2000) refined the definition of a learning object, by excluding nondigital entities, to "any digital resource that can be reused to support learning" (p. 7), but he even admits in a recent blog on the topic (Wiley, 2006) that the primary weakness of the definition was the word "reused," as "the role of context is simply too great in learning, and the expectation that any educational resource could be re-used without some contextual tweaking was either naïve or stupid.".

Shepherd (2000) contributed to the debate by defining a learning object as "a small, reusable digital component that can be selectively applied—alone or in combination—by computer software, learning facilitators or learners themselves, to meet individual needs for learning or performance support."

In order to understand what a learning object is, it is helpful to appreciate what a learning object looks like by visualising its scale or granularity. On the one hand learning objects can constitute a single file such as an animation, a video clip, a discrete piece of text or URL, or on the other hand a learning object could be a collection of contextualised files that make up a learning sequence or a fully self-contained piece of instruction, including information, mechanisms for practice, and a means of assessment, for example, Learning Management System (LMS). A learning object is characteristically "a digital resource that can be identified, tracked, referenced, used and reused for a variety of learning purposes" (DETWA, 2006). For instance some would argue that a learning object should be able to refer to off-line media, possibly stored on a CD-ROM, on video-cassette or in a book, synchronous or asynchronous computer mediated communication on discussion boards, and even to face-to-face events such as workshops or on-campus lectures, while others question nondigital resources re-usability or inclusion as learning objects (Harman & Koohang 2005; Koper, 2003; McGreal, 2004; Shepherd, 2000). Metros (2005) simply states that for a learning object to be considered as such the digital resource must facilitate learning by the inclusion or link to a learning objective, a practice activity and an assessment (also supported by L'Allier 1997; Liber, 2005). But even at this juncture there is disagreement with some scholars excluding learning activities and learning objectives, as they are a function of the learning activity, not the resources (Koper, 2003). Koper (2003, p. 47) defines a learning object as "any digital, reproducible and addressable resource used to perform learning activities or learning support activities, made available for others to use."

The proliferation of definitions for the term learning object makes communication of their use and opportunities confusing and difficult (Wiley, 2000). McGreal (2004) has neatly summarised the commentary on learning objects and their definition and presents a dichotomy of the definitions that existed up to that point. By far the most common criticism of learning object and its definition is that even the more restrictive definitions of learning objects to "digital resources" is not sufficiently narrow for the definition to be useful. Metros (2005) would agree with McGreal (2004) that for a learning object to be useful it needs to have a formal, expressed learning purpose, and in addition the potential for re-use of learning objects can only be evaluated once it has been placed in a specific learning context, and shown to be effective. Hence, McGreal's definition of learning object is "any reusable digital resource that is encapsulated in a lesson[2] or assemblage of lessons grouped in units, modules, course, and even programmes" (McGreal, 2004, p. 9). Indeed as Polsani (2003, p. 6) summarises:

It is evident that [learning objects] (LOs) are the most meaningful and effective way of creating content for e-learning. Unfortunately, the current definitions and practices of LOs are confusing and arbitrary. Consequently, they will never be able to avail themselves of the flexibility, scalability and speed offered by information technology. To break from this impasse, a commonly accepted, accurate and functionally effective definition of a LO is an immediate necessity.

Following on from the debate over the vague definition of learning objects are questions regarding their fundamental characteristics (form, granularity, and purpose), especially as these characteristics influence a learning object's accessibility, re-use, and adaptability to other contexts (Collis & Strijker, 2003; Downes, 2004; Nash, 2005; Orrill, 2000). Polsani (2003) summarises the functional characteristics of learning objects as:

1. Accessible: it should be tagged with metadata so that it can be stored and referenced in a database.
2. Interoperable: it should be independent of both the delivery media and knowledge management systems.
3. Reusable: once created, it should function in different instructional contexts.

Polsani's (2003) defines a learning object as "an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts" (p. 3), while others (Koper, 2003; Sicilia & Garcia, 2003) would insist that the learning object definition needs to be further refined by adding that they are digital entities (i.e., digital files or streams); and second, that they are tagged with a metadata record which describes the potential contexts in which they may be used. The metadata records attached to each learning object contain fields placed in a relational database (or content management system (CMS) or learning object repository (LOR)) such as authorship, location, specifications regarding access, learning objectives, contexts of use, and educational properties of the learning object, so that the learning object can be identified, retrieved and re-used in other educational contexts.

As Polsani (2003) and Sicilia and Garcia (2003) point out the early "catch all" definitions of learning objects proposed by IEEE (2002) and others (e.g., Wiley, 2000) may paradoxically result in learning objects that are not designed to meet the functional characteristics described above, because the "everything goes" principle neglects that learning object design requires following specific technical guidelines, such as those described by Boyle (2003), which allow them to be used in diverse educational contexts.

Orrill (2000) argues that many learning objects are designed for an "additive approach to education" (p. 2), contrary to the view that learning objects could be "support tools in a project-based action learning environment" (p. 2) that immerses the student in real-world problems and provides scaffolding of various kinds to support their inquiry, and importantly includes social interaction among peers (Jonassen, 1999). This type of learning object, which includes nondigital resources and support tools, will undoubtedly not meet the technical criteria of learning objects defined by some scholars (e.g., Koper, 2003; Polsani, 2003; Sicilia & Garcia, 2003).

The learning objects examined in this chapter were all embedded in online delivery of the unit *Land Assessment for Sustainable Use* through WebCT. The learning objects discussed in this chapter are a combination of resources and scaffolding (as supported by Orrill, 2000) for a constructivist learning environment including:

1. Text of the situation statements which initiate discussions regarding the natural resource management problem,
2. Links from the situation statements to external and internal e-learning resources,
3. Instructions on the learning activity which refer students to a structured learning guide (Appendix A),
4. Use of a discussion board (Harman & Koohang, 2005) for exploration of the problem, and finally
5. Reply to students' questions through a rejoinder that is accessed through the discussion board as an attachment.

As stated earlier, these learning objects do not comply with the functional characteristics, largely technical, articulated by Polsani (2003) and Sosteric and Heismeier (2002). Even though they are digital and tagged within the LMS, they are yet to be tagged into an LOR, and also have not been re-used in other contexts (or UOL) as PBL activity and design is intrinsically context-specific. However, the structured learning guide, which is integral to the learning design used, is available as an exemplar on the Learning Design Web Site (Lobry de Bruyn, 2002). Nevertheless, since 2000, the learning objects were reused each year, retaining the "core" learning content relevant to the situation statements within the LMS, but refreshing the geographical context of the situation statement for each new cohort of students.

The divergent discussion over the meaning, nature, and use of learning objects ultimately is examining their purpose in e-leaning, and their incorporation into learning designs and begs the question: Is the use of learning objects appropriate for all types of learning designs or restricted to certain types of learning? The nature of many LMSs (viewed as a learning object by some) is that they deliver content-centric instruction through a transmission model of learning (Gibbs & Gosper, 2006), and as Kuriloff (2001) points out in his article *One Size Does Not Fit All*, these current LMSs encourage a consistent learning pedagogy and dissuade novel use of learning objects within learning designs. The definition of learning design to be used in this chapter is taken from Koper and Olivier (2005, p. 98) who define a learning design as:

An application of a pedagogical model for a specific learning objective, target group and a specific context or knowledge domain. The learning design specifies the teaching-learning process. More specifically, it specifies under which conditions, what activities have to be performed by learners and teachers to enable learners to attain the desired learning objectives. A learning design can refer to physical resources (learning objects and learning services) that are needed during the teaching and learning process. The learning design and the included physical resources can be packaged into a 'unit of learning' (UOL). A unit of learning can be seen as a general name for a course, a workshop, a lesson, that can be instantiated and reused many times for different persons and settings in an online environment.

My interpretation of the literature is that the learning design and not the learning object sets the learning principles for the unit of learning whereas learning objects support or facilitate the learning design principles, and the desired learning outcomes. Traditionally PBL has the following key learning principles, as exemplified by Barrow (1985, 1988, 2002), and further articulated by Orrill (2000, 2002) for inquiry-based learning in an online environment:

1. Nature of problem and problem-solving environment: The problems are presented to the learner as real world situations that are "unresolved ill-structured problems" which then stimulate the learners to generate questions about what has occurred and how they would respond. Also the problems are open-ended with no "wrong or right"

answer, allowing students to construct their solution by revisiting prior learning as well as building new understandings.

2. **Social Negotiation:** The situations are designed to motivate the learners to gather further information, test their understandings against each other, and readily share information to resolve and understand the situation, usually in small groups.
3. **Learner-centered:** The learners take on responsibility for their learning and determine their learning needs in terms of information and locating appropriate and relevant resources to assist them in solving the problem, hence problem based learning is a learner-centered pedagogy. Correspondingly the instructor acts as a facilitator of learning not a "sage on the stage," and encourages students to be autonomous learners and conduct self-directed research.
4. **Authenticity:** The problems selected are those most likely to be encountered by the learner in the "world of work," and the skills and activities required by the learners to solve the problems are also valued by the real world, making PBL an authentic learning process.

How does an instructor apply the above learning principles when transferring PBL design, based on constructivist learning values (Jonassen, 1999), to an online environment (using WebCT as the course management system), with integrated learning objects within a specified context? The use of problem based learning in this case study can be best described as learning objects embedded in a learning design (PBL) and delivered in an online environment with an intensive period of face-to-face instruction. The PBL design and off-campus students were supported by a number of scaffolds (with 2 and 3 considered as learning objects):

1. Face-to-face instruction at a 4-day on-campus residential school,
2. A structured learning guide (Appendix A; Lobry de Bruyn, 2002, 2005), and
3. Asynchronous computer-mediated communication on threaded discussion boards within WebCT (Lobry de Bruyn, 2003, 2004).

Each scaffold performs a different role in supporting the learning design and learning object. The residential school provides the opportunity for the instructor to provide off-campus students with face-to-face instruction and practice in PBL, and the opportunity for students to form small peer groups. These same groups would later "meet" in an online environment to explore the situation statement on discussion boards. The structured learning guide was designed to offer off-campus students a structured approach to problem-solving the situation and developing skills in problem-solving and independent research skills. The structured learning guide was particularly useful for scaffolding off-campus students unfamiliar with PBL design, and provided clear instructions regarding when their involvement in discussion boards was required and it explained the nature of the activity. For instance, off-campus students would need to be able to formulate and communicate questions in response to the situation statements, as well as respond to questions posted by off-campus students on discussion boards at designated times.

MAIN FOCUS

There are few published works documenting the use of learning objects in higher education, and even fewer research studies producing substantive evidence regarding their educational value (Metros, 2005). Relevant literature (Lobry de

Bruyn, 2004; Ronteltap & Eurelings, 2002) indicates that the notion of creating small groups of off-campus students as active, reflective participants in an electronically-linked learning environment is the ideal but not necessarily the reality. It seems that those researchers who report positive outcomes using an electronic learning environment for student interactive learning activities are using it in addition to, rather than instead of, face-to-face sessions (Ronteltap & Eurelings, 2002). The instructor's experience of creating a sense of learning communities within an electronic environment (threaded discussion boards using WebCT) within the context of a PBL design encountered difficulties, especially with those off-campus students unfamiliar with the learning design and/or the online learning environment (Lobry de Bruyn, 2004).

CONTEXT AND USE OF LEARNING OBJECTS AND LEARNING DESIGN IN UNIT OF LEARNING

The PBL design in *Land Assessment for Sustainable Use* with off-campus students was applied in the following way. Situation statements were introduced to the students every four weeks during the semester via the unit home page. The situation statements were structured around the unit content which focused on identification of, causes of and solutions to land degradation problems, and the concepts and practices involved in land capability assessment and land use planning. The situation statements were based on realistic scenarios of natural resource management problems that are complex, interrelated and identical symptoms could relate to different land degradation issues. Also information sources were based on the "real-world" situation in that they were imperfect, variable in quality and coverage, and needed to be assessed by the learner for their worth, relevance, and credibility. This meant that learners were encouraged, and indeed expected, to locate their learning resources, and information literacy was a learning outcome that was then assessed in the final submission of the individual written response to the PBL question at the end of the situation statement. Before the commencement of the learning activity, off-campus students were directed to online introductory notes on PBL design. These notes included information about the learning approach, how it differed from more traditional forms of teaching and learning, and how it would be delivered and executed in the UOL. The PBL activity was completed in three stages or three discrete problems, although the problems occurred in the same geographical locality: Stages 1 and 2 (contributing 30% to the unit grade) were submitted together two thirds through the semester (Week 9), while Stage 3 (contributing 30% to the unit grade) was submitted at the end of the semester (Week 13).

Off-campus students made use of the learning objects (situation statement and structured learning guide) by participating in discussion boards within WebCT, especially for the problem-solving part of the PBL design, as well as engaging in self-directed learning (i.e., reading and research) either using the online content (linked to situation statements or rejoinder) or material obtained independently through the Internet. Instructor involvement in discussion boards was timely and strategic. Instructor responses would be posted weekly to student groups on discussion boards and there would be discretionary responses to individual postings, especially if the group response was considered inadequate. A week after off-campus students were introduced to the situation statement, the instructor posted a rejoinder on the discussion board that "fleshed out" the answers to questions posed by students over the previous week. The rejoinder was a written monologue with the answers to students' questions embedded in the reply amongst other information so that students had to "hunt" for the answers to their questions, and they were not presented as a list of paired questions and answers. As a preface to the rejoinder, all the student questions were collated and tabulated indicating their nature, frequency and number of off-campus students participating. To contextualise the information supplied in the rejoinder, off-campus students were encouraged by the instructor to conduct further research and reading.

RESEARCH DESIGN AND PURPOSE

This part of the chapter examines the ability of PBL design and its related learning objects to build an interactive learning environment that would support learner-centered learning and student mastery, where the student discussions of the situation statements and rejoinder were only able to occur via discussion boards. This part of the chapter focuses on the use of learning objects (as stated earlier) within the PBL design and comparing and contrasting student postings on discussion boards from two periods 2001-2003 and 2004-2006. These two periods (2001-2003 and 2004-2006) vary only in the positioning of face-to-face instruction and practice on PBL conducted during a four-day residential school (scaffolding), but not the residential school's content or manner of delivery. In 2001-2003, the face-to-face residential school occurred 8 weeks into the semester by which time the off-campus students had already attempted two stages of the PBL activity, online and as a collective. Whereas, in 2004-2006, the positioning of face-to-face instruction was before the UOL commenced, and provided an opportunity to evaluate three different learning developments implemented from 2004 onwards. First, small peer groups were formed at the residential school for subsequent communication on discussion boards and so had met face to face. Secondly, those same off-campus students had, in a classroom situation, practiced the PBL design, and used the structured learning guide. Thirdly, off-campus students were able to meet with the instructor prior to the beginning of the unit and had the opportunity to become more familiar with instructor expectations and style of delivery, hence fostering greater instructor immediacy. None of these learning developments were possible prior to 2004 as the timing of the residential school was fixed at eight weeks into the semester, and off-campus students could only communicate as a collective because their commitment to the UOL was only confirmed just prior to attending the residential school.

This part of the chapter specifically examines whether early positioning of face-to-face instruction and practice in problem based learning can be blended with online delivery of learning design and learning objects to enhance learning outcomes. The indicators used to evaluate the quality of online delivery and student-student and student-instructor interactions on discussions boards in a PBL design with learning objects (situation statements) were: student participation, student concentration on problem-solving in the learning activity, student engagement in use of convergent processes (i.e., degree of analysis, synthesis, and summarising) and the level of social presence exhibited by students. Social presence in the context of this study was concerned with the manner in which students maintain "visibility" or "profile" with other students through asynchronous computer-mediated communication on discussion boards (Short, Williams, & Christie, 1976), and the consequences of their level of social presence on group cohesion and connectedness with each other and the learning activity.

DATA COLLECTION AND ANALYSES

The frequency and quality of discussion board activity by students was assessed by quantifying the per volume student output and changes in composition of the above indicators through content analysis of student and instructor messages on discussion boards that were electronically-archived and averaged over two 3-year periods (2001-2003, 2004-2006) over several weeks revolving around one stage of the PBL activity. In the earlier three year period (2001-2003) off-campus students were communicating on discussion boards as a "collective" before attending a residential school 8 weeks into the semester. While in the later 3-year period (2004-2006) the off-campus students were placed in "small groups" with people they had already met and worked with face-to-face at the residential school prior to the beginning of the UOL and before communication on discussion boards.

The unit of analysis was an individual posting or message to identify the presence of defined categories. Hence, a student and instructor posting could be coded several times under different categories. The content analysis scheme by Hewitt (2001) was used to examine the level of convergence occurring in postings, while the schemes developed by Rourke, Anderson, Garrison, and Archer (1999) and Stacey (2002) were used for defining and measuring social presence (see footnotes of Tables 2 and 3, respectively, for more detailed definition of content analysis terms). Also, data were statistically analysed to identify any significant differences in volume and quality of student communications on discussion boards as a consequence of group size (collective vs. small groups) combined with early scaffolding of student learning as well as to ascertain the influence of student cohort variation from year to year, and variation within year of group performance, as was the case in 2004-2006. Depending on the nature of the data distribution one-way ANOVA or nonparametric one-way ANOVA were used to examine the influence of the preceding variables (group size, year, and group performance within year). All statistically significant differences reported have a p value of less than 0.01. Data was also collected over 2001-2006 on the location and level of Internet access available to off-campus students.

The data collected and analysed compare the volume and composition of student and instructor postings on discussion boards for off-campus students placed in a collective (2001-03) compared with small group (2004-06), while undertaking learning activities related to the learning object (situation statement) over a period of several weeks early in the semester. The student learning activities executed through the discussion board included: exploring, brainstorming, compiling questions derived from reading, and interacting with the situation statement and each other. The final list of student questions was then posted on the discussion board by students for the instructor to respond to in a rejoinder and to encourage and stimulate students to respond to the rejoinder through independent research activity. Importantly the learners were challenged and assessed on their ability to locate and use their own learning resources, and to use those resources combined with the information in the rejoinder to answer the question/s at the end of the situation statement.

LEVELS OF AND MOTIVATION FOR STUDENT PARTICIPATION

Examining per student output on discussion boards showed dramatic increases in the volume of student postings (up by 201%), and student repeat postings or subsequent postings from the same individual (up by 542%), in small groups (2004-

2006), compared with previous years (2001-2003) when the off-campus students conducted the same activities but as a collective without having met face-to-face prior to undertaking the PBL activity (Table 1). Participation rates by off-campus students in small groups (2004-2006) was high (81% mean over 3 years), while the proportion of off-campus students participating as part of a collective hovered around 39% of the off-campus student cohort for 3 years (Table 1). Data collected on the location and level of Internet access available to off-campus students indicated that a high proportion (49% over 3 years in 2001-2003) had restricted Internet access either at work (12%), or limited opportunity to access the Internet (37%) at work which necessitated Internet access at home after work. In 2004-2006, similar levels of Internet access were recorded for off-campus students, with 51% only able to access the Internet after work hours at home, and 6% with restricted Internet access at work. Yet despite similar levels of restricted or limited Internet access there was a doubling in the proportion of off-campus students participating on discussion boards (Table 1).

Another possible reason for low levels of off-campus student activity recorded in 2001-2003 is that because students were placed in a large collective group without having met face-to-face, communication anxiety was increased and student concern over not contributing anything new to the discussion was heightened (Guzdial & Turns, 2000). Student reticence to get involved in discussion boards when unsupported by face-to-face instruction and scaffolding was highlighted by Hasarim (1986), some 20 years ago. Authors suggest that a lack of social presence and unfamiliarity amongst group members (students) can be alleviated when they are placed in smaller peer groups of four to six people, with whom they have already worked with in a group setting such as

Table 1. Overall assessment of student postings on discussion boards about situation statement over several weeks comparing Collective (mean number = 24.7 students in one group, 2001-03) to Small Group (mean number = 4.0 students per group, 2004-06) responses. (Total number of enrolled off-campus students in UOL; $n_{2001} = 63$, $n_{2002} = 65$ $n_{2003} = 60$, $n_{2004} = 23$, $n_{2005} = 22$, $n_{2006} = 19$)

	Collective Mean 2001-03 no	Small Group Mean 2004-06 no	Change between periods %
Messages (mean total)	47.3	25.8	-47
Threads (per student)	1.0	2.8	178
Branches (per student)	0.8	3.5	350
Ratio of Branches to Threads (%)	77	125	61
Student postings (per student)	1.6	4.8	201
Instructor postings (mean total)	6.0	5.0	-16
Student repeat postings (per student)	0.6	3.9	542
Total no of students per group	24.7	4.0	-84
Participation rate (%)	39.3	81.1	107
off-campus students in UOL	62.7	21.3	-66

a residential school (Rourke et al., 1999; Stacey, 2002). Also, this study showed that individual student concern over not contributing anything new to the discussion board was only reported when the average group size was 25 members (collective) in comparison to 4 students (small group). Students in the collective experience would express concern over repeating or duplicating what other students had already said and did not wish to be perceived as failing to contribute anything new to the discussion. For example, some students (all from the collective) wrote: "sorry for the repetition of many questions" (Message 23, July 26, 2002, 8.11am); "Hopefully not too repetitive" (Message 31, July 28, 2002, 5.05pm); and "I hope this is not repeating too much of what has already been said" (Message 33, July 28, 2002, 9.56pm). Another student, having read the questions felt what s/he would have added was already represented by other student questions:

Hi all I'm feeling a bit guilty as I haven't paid the bulletin board [discussion board] much attention over the last two weeks due to other commitments, and since so many other people have put together so many valuable comments it is hard to add anything to them without seeming like piggy-backing. (Message 62, August 5, 2001, 6.39pm).

An alternative explanation for low student participation was that off-campus students who had not managed their time well and missed the "window of opportunity" for participating in discussion boards. For example, one student wrote, "I seem to be a little late with my questions and most have already been asked!!" [by other students] (Message 51, August 1, 2002, 9.45pm). In 2004-2006, the instructor made greater efforts to model behaviours (offering advice, collating, and responding to student questions) on discussion board than in 2001-2003, and this strategy could have contributed to higher student participation rates, as suggested by Stacey (2002).

Student motivation to become involved in discussion boards was considered to be intrinsic or self-rewarding, as it was linked directly to learning outcomes, and provided significant assistance to the problem-solving aspects of the learning activity (Appendix A, Lobry de Bruyn 2002), and hence should improve the students' abilities to comprehend and complete the problem based learning activity. As discussed later under social presence, those small groups, usually with at least four active participants (and typically more than 20 threads, including instructor threads), were categorised as "self-sufficient" groups (viable, providing peer support and functioning well socially). In contrast to the collective experience, all those groups categorised as self-sufficient groups were from the small group experience of the PBL activity, where there was evidence (from content analysis) that group members were providing peer support by offering unsolicited guidance, advice and support to each other in undertaking the learning activity. Also, there was evidence (again from content analysis) of fellow student members in small groups providing a degree of gentle persuasion or "cajoling" to get involved in the learning activity (see Social Presence for further analysis). For instance, instead of instructor prompting or motivating students to participate encouragement was more likely to come from peers in the small group experience of discussion boards:

What do you guys think?? Here are some questions that might get the ball rolling, let me know what you think or if I'm completely on the wrong path. (Message 301, August 10, 2004, 8.04pm)

Nevertheless "unsustainable" groups (minimal discussion board activity and evidence of social presence) were also observed in the small group experience of the PBL activity, and could have been managed more successfully by more active monitoring of discussion board activity and earlier intervention by the instructor to "fuse" two under-performing groups together to create a viable group size to invigorate group discussions. The critical mass for group size suggests that too few members generate little discussion and too many generates a sense of being overwhelmed, such as the collective (Rice, 1994; Rovai, 2002). Rovai (2002) advises 8 to 10 people as a minimal critical mass for encouraging good interaction, while 20 to 30 people in a single group was the most students a single instructor can facilitate easily. The findings of this work would suggest that if *all* members were active then a group of four people could generate meaningful discourse, but if there are fewer active members the group size is not viable. On the other hand too many members in a group can lead to lower levels of participation and increased likelihood of "lurking" behaviour. This student behaviour has been labelled as social "loafing" or "lurking" (Nonnecke & Preece, 2003). This particular student behaviour I believe was more likely in the collective rather than small group experience of the PBL activity as the former had larger numbers of students contributing, and could "afford" students not posting messages. In addition, the potential for "lurking" would have been diminished or not deemed socially acceptable in the small group experience of communicating on discussion boards, due to small group size, greater familiarity amongst members and greater need to contribute otherwise the group would become unviable.

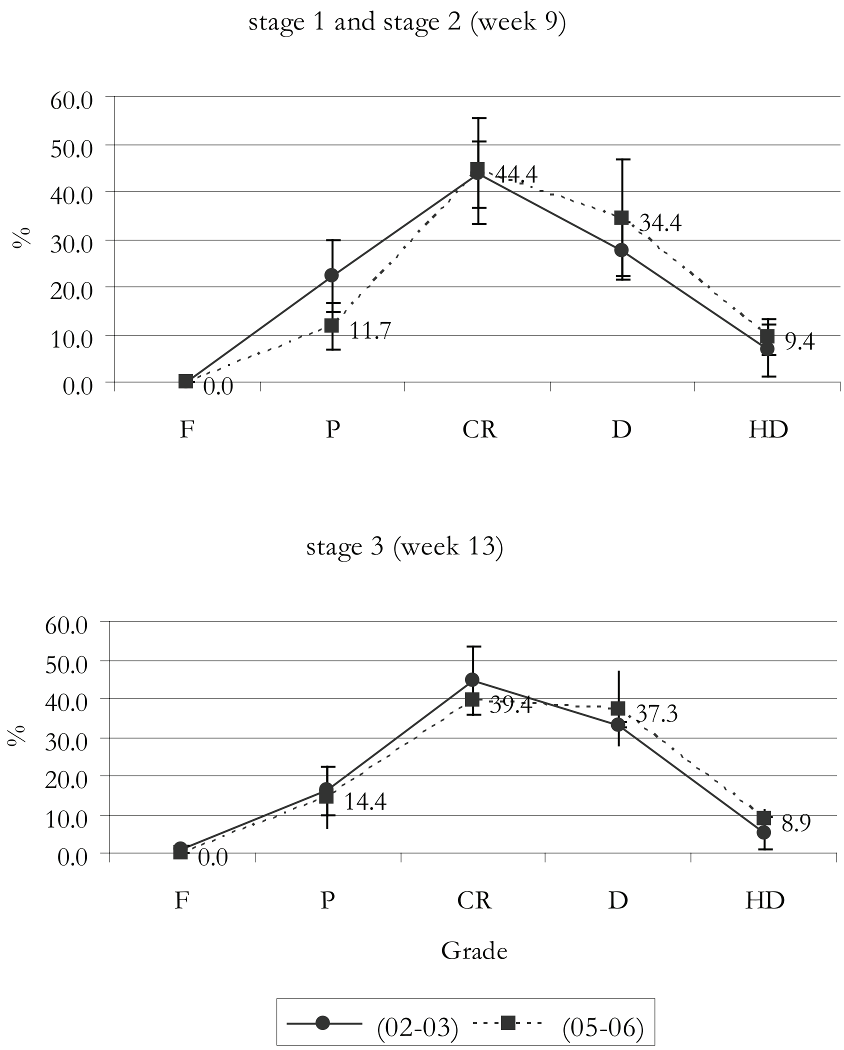
Equally, the intrinsic motivation for students to complete and do well in the learning activity does not necessarily rely on them posting messages (i.e., participation), especially if a critical mass of students were contributing, but could also accrue to those nonparticipating students who access the discussion board and read messages. In this study, "lurking" was also a student behaviour more likely to be tolerated or not noticed in a collective (potentially 60 enrolled off-campus students) rather than in small group experience of discussion boards as in small groups if several people chose not to contribute the discussion would have ceased to be viable and collapsed or alternately left too much responsibility for compiling and listing questions to one or two students.

STUDENT ACHIEVEMENT AND ENGAGEMENT IN THE LEARNING ACTIVITY

To measure student mastery of the PBL activity, the flux in grades for Stages 1 and 2 (submitted two thirds through the unit) compared with Stage 3 (submitted at the end of the unit) was compared between the collective and small group experience (Fig 1). It appears in Stages 1 and 2 that student achievement is greater in the small group experience of PBL compared with the collective, with a 10% improvement in proportion of students receiving a Distinction (D). However, by Stage 3 of the PBL activity, the students placed in small groups were only marginally out performing academically those students who had participated on discussions boards as a collective (Figure 1), since by Stage 3 the collective students had met face-to-face at a residential school and received face-to-face instruction and practice for Stage 3 of the PBL activity. Hence, they were better placed to achieve in the learning activity, and knew where they needed to improve as feedback on previous performance in Stage 1 and 2 had been given.

This study used two ways of examining students' engagement in monitoring their own understanding. One was to examine students' ability to summarise and the other was to examine the rationales they provided to explain choices or decisions they had made. Those discussion board messages or threads that were categorised as "multiple" were undertaking one or several of the following activities: compiling questions, negotiating tasks amongst the student group (such as arranging times for all students in a group to be active online), directing other students to resources either online or on the Internet, explaining land management practices and their impacts to other

Figure 1. Student results for a problem-based learning activity, completed in three separate stages: stage 1 and stage 2 (submitted week 9) and stage 3 (submitted week 13), as proportion of students completing the UOL (n_{2002} = 60, n_{2003} = 47, n_{2005} = 18, n_{2006} = 15) comparing Collective (2002-03) to Small Group (2005-06) grades. Grades correspond to following percentages: Fail (F) < 50%, Pass (P) 50-64%, Credit (CR) 65-74%, Distinction (D) 75-84%, High Distinction (HD) > 85%



students, and adding questions to the group's existing list.

The results using the first method, which analyses students' messages and thread type, indicate that there was a substantial increase in the volume of postings per student when working in small groups (2004-2006) (Table 2). These same students were scaffolded prior to interaction with the learning object or situation statement in an online environment, and there was a three fold increases in multiple threads or "stand alone" threads and a two fold increase in add-on threads compared with those students communicating on discussion boards as a large, nonscaffolded collective (Table 2). However, the increase was only statistically significant in the volume of stand

*Table 2. Assessment of degree of convergence of student postings on discussion boards with reference to situation statement over several weeks comparing Collective (mean number = 24.7 students in one group, 2001-03) to Small Group (mean number = 4.0 students per group, 2004-06) responses, using Hewitt's (2001) analysis of thread type. (Total number of enrolled off-campus students in UOL; n_{2001} = 63, n_{2002} = 65, n_{2003} = 60, n_{2004} = 23, n_{2005} = 22, n_{2006} = 19) * $p < 0.01$, ** $p < 0.001$ comparison between collective and small group*

	Collective			Small Group		
	2001-03			2004-06		
Thread type#	Mean Total	Postings per student	% of total messages	Mean Total	Postings per student	% of total messages
	Count	Mean	x = 47.3	Count	Mean	x = 25.8
Stand-alone	15	0.6	30	8	1.7**	41
Add-on	31	1.2	66	15	2.8	50
Multiple	14	0.5	30	9	1.7	26
Convergent	0.0	0.0	0	0.2	0.0	0.1

#Definition of Thread type:
Stand-alone: A message that introduces new ideas to the conference and does not build on previous lines of inquiry. Typically, a stand-alone message is one that begins a new thread.
Add-on: A message that builds on the ideas of one other message in the conference; typically, messages in which one person responds to an idea that someone else has introduced.
Multiple: A message that make a reference to two or more previous messages, but not in a way that would be considered an attempt at convergence.
Convergent: A message that discusses some of the ideas expressed in two or more other messages in the conference.

alone threads ($p = 0.0093$, $F = 9.07$) for small groups compared with the collective. However, when the per student activity data were statistically analysed comparing self sufficient and unsustainable groups, regardless of group size, there was a significantly higher volume of activity by students in self sufficient groups (all small group) compared with unsustainable groups (both collective and small group) for all thread types: add-on ($p = 0.0027$, $F = 13.2$), multiple ($p = 0.039$, $F = 5.13$), and stand alone ($p = 0.05$, $F = 4.62$). Hence even in years where off-campus students were scaffolded in the small group experience of the PBL activity there were under performing groups that were unable to engage with the learning objects, but more often than not those groups that lacked engagement with each other or the learning activity were from the collective experience of the PBL activity.

Closer examination of the composition of threads between group type revealed that the proportion of add on threads for small groups was down by 16% from the collective experience of the PBL activity, while the proportion of stand alone threads increased by 11% in small groups compared with the collective (Table 2). The higher proportion of stand alone threads were attributed to students in small groups compared with the collective could have been because students were more willing to offer their opinion on the situation statement and contribute to compiling a list of questions for other students to read, and amend. These students due to their small group size and greater familiarity with group members exhibited less concern about sounding repetitive, compared with the collective experience. Despite the significant increase in student use of discussions boards in 2004-2006 (Table 1 & 2),

*Table 3. Evaluation of level of social presence, cognitive and system responses identified in student postings on discussion boards with reference to situation statement over several weeks comparing Collective (mean number = 24.7 students in one group, 2001-03) to Small Group (mean number = 4.0 students per group, 2004-06) responses, using Stacey (2002), and Rourke et al. (1999) content analysis schemes (Total number of enrolled off-campus students in UOL; n_{2001} = 63, n_{2002} = 65, n_{2003} = 60, n_{2004} = 23, n_{2005} = 22, n_{2006} = 19) * $p < 0.01$, ** $p < 0.001$ comparison between collective and small group*

	Collective			Small Group		
		2001-03			2004-06	
Content analysis#	Mean Total	Postings per student	% of mean total messages	Mean total	Postings per student	% of mean total messages
	Count	Mean	n = 47.3	Count	Mean	n = 25.8
Interactive responses	24	0.9	52	15	2.9	50
Affective responses	13	0.5	28	5	0.9	18
Cohesive responses	25	1.0	52	18	3.6*	72
Social presence	62	2.4		38	7.4	
Cognitive responses	46	1.8	97	23	4.5*	93
System responses	5	0.2	10	0.9	0.2	2.3
Grand total	112			61.5		

#Definition of content analysis terms:

Interactive: Includes complimenting, expressing appreciation or agreement, asking unsolicited questions, referring to others' messages, quoting from others' messages, and continuing a thread.

Affective: Includes expressing emotion, feeling, or mood, use of humour and self-disclosure.

Cohesive: Includes addressing or referring to other students by name, and/or the group as we, us, our, group, and salutations.

Cognitive: Includes discussion and commentary on the unit content.

System: Includes discussion related to the software or access issues.

the proportion of multiple threads did not differ significantly between the collective and small group experience, reflecting no greater references to other students' postings, and further still, no considerable convergence of threads was observed (Table 2). In Hewitt's (2001) analysis of student use of threaded online discussions virtually all messages could be characterised as add-on threads with few people attempting to tie together ideas from different sources.

Hewitt (2001) points out that the "reply" convention of asynchronous computer-mediated communication software prompts students to respond to a single message without considering the overall discussion (thread). Often students reply to a thread and leave the subject label (thread) intact, even though the content of the message may have drifted away from the original purpose (Hewitt, 2001). It is also likely that students do not read earlier messages to grasp how the discussion has evolved. Students in posting messages on discussion boards are thus more likely to refer to the most immediate thread (Hewitt, 2003), but some groups in this study kept a thread "alive" for extended periods of time, and this behaviour was more common in small groups (2004-2006, Table 1). Evidence for this behaviour is provided by examining student postings in an early stage of the PBL activity, and examining the ratio between branches and threads. Comparing the collective and small group experience of interacting with the learning object suggests that those students discussing the situation statement in small groups are more likely to continue the thread as evidenced by the higher ratio of branches to threads in 2004-2006 (Table 1). Put another way the "conversation" in small groups is more lengthy and extensive than the collective experience of interacting with other students and the learning object.

The second method used to analyse student engagement in the learning activity, examining the use of rationale, allows the researcher to establish the level of student mastery as well as whether the students are working collaboratively by explaining their position to others (Hewitt, 2001). A posting was considered to use rationale if there was any opinion or evidence offered (Orrill, 2002). Overall, there was limited evidence of student use of rationale, and student rationale was only supplied after instructor prompting. However, this finding is more a reflection of the learning design as the use of discussions boards was restricted to the exploratory phase of learning—brainstorming, prioritising and listing questions and identifying learning resources—whereas the use of rationale was expected, and assessed in the individually written response to the PBL situation statement.

SOCIAL PRESENCE: GROUP COHESION AND STUDENT-STUDENT RAPPORT

As stated earlier the interest in social presence was to determine the degree to which small group vs. collective experience of the PBL activity may vary in individual's ability to maintain a noticeable presence to other group members and to the learning activity through communication on discussion boards. Table 3 compares the amount of social presence exhibited in a collective group of students (mean number = 24.7) communicating, but not having met face-to-face (2001-2003), with students placed in small groups (mean number = 4.0), after having met and worked together face-to-face in the residential school (2004-2006). The volume per student of social presence on discussion boards is far higher in small groups with a two to three fold increase in student postings being categorised as containing some form of social presence.

There was a significantly higher volume of cohesive responses recorded for small group (3.5 postings per student) compared with collective (1.0 posting per student) experience of the PBL activity ($p = 0.01$, $F = 8.28$), as well as significantly more activity in cognitive responses by off-campus students working in small groups (4.5 postings per student) compared with a collective (1.8 postings per student) ($p = 0.01$, $F = 8.22$) (Table 3). Again, more significant differences were found when comparing high and low performing groups' activity per student data, regardless of group type. There was a significantly higher volume of social presence exhibited by off-campus students in high performing groups (which were all small group experience of the PBL activity) compared with low performing groups (were both collective and small group experience of the PBL activity) for all types of responses: affective ($p = 0.0022$, $F = 14$), interactive ($p = 0.0022$, $F = 14$), and cohesive ($p = 0.0001$, $F = 27.2$) responses.

Overall for both groups, the majority of messages (mean 95%) were coded as cognitive (related to content of the unit), more than 50% of message were coded with cohesive responses (62%), while 51% of the messages had some form of interactive response, and less than a quarter were coded as affective responses (23%) (Table 3). Cohesive responses in small groups were 20% higher compared with the collective group experience of the situation statement, which indicates that small groups had built a stronger sense of connection. In these situations the following were typical interactive responses from students in a small group indicating gratitude, provision of peer support and motivation from other students who assisted group members when they were asked unsolicited questions around the content, for example by explaining soil pH readings and land management practices:

Thankyou to M, B and J for contributing to the list of questions and compiling them for Lisa (Message 350, August 14, 2004, 10.01am)

well I know a bit more about soils I didn't know before (Message 754, September 1, 2006, 1.40pm)

thankyou for all the input – it has been good to have someone online to bounce ideas off!! (Message 694, august 13, 2006, 9.32pm)

thanks for all your help this semester. I really appreciate it (Message 844, October 22, 2006, 12.25pm)

We're a good team aren't we?! (Message 819, September 18, 2006, 2.42pm)

The proportion of affective responses was higher in the collective compared with the small group experience of the PBL activity (Table 3), and overall was lower than all other social presence categories. Also, the nature of the affective responses varied between the two periods as students in 2001-2003 were combining two activities, one to introduce themselves and the other to formulate questions for Stage 1 of the PBL activity, while in 2004-2006 students had already been introduced to each other during the residential school. In 2001-2003, most of the affective responses were coded as "self-disclosure" where students were either introducing themselves or lamenting their lack of prior knowledge on the topic, but on the other hand hopeful of learning more:

… My farm knowledge … is limited, I have hit my limit (Message 64, August 6, 2001, 8.51am)

I don't know much about farming and land degradation … but here goes nothing. (Message 61, July 30, 2002, 2.52pm)

I am in the same boat as many of you with my limited experience in land degradation (Message 54, July 29, 2002, 8.34pm)

I have no experience with farming of any kind and looking forward to developing knowledge in the area (Message 15, July 25, 2002, 8.25am)

In the small group experience of the PBL activity, the nature of the majority of affective responses were humour-related or more personal revelations with other group members exchanging details on holidays or experiences outside the learning activity, and few were related to feelings of inadequacy regarding the learning activity compared with the collective experience.

Some 20 years ago, Harasim (1986) identified face-to-face sessions as a "critical factor" in the successful design and facilitation of a "computer learning environment" with greater active participation, improvements in group dynamic and sense of connectivity, and increased learner confidence. The use of learning objects described in this chapter, especially with small peer groups meeting face-to-face for practice and instruction in PBL activity prior to engaging on discussion boards conforms to a number of design and facilitation principles outlined by Rovai (2007) that should increase student participation and quality of online interactions and hence the quality of the student's learning experience which are:

- Authentic topics (see under main focus for detail),
- Critical mass in group size (Rovai 2002) with evidence from this case study that if all members are active then a group of four people can generate meaningful discourse, but often any fewer members, especially if not active is not a viable group size. Equally, too many members in a group, such as 20-30 people, can lead to lower levels of participation and increased likelihood of "lurking" behaviour, as shown in the collective experience of the PBL activity.
- Immediate feedback from other students or instructors that is specific or timely to help alleviate communication anxiety often experienced by students when feedback is not given (Hara & Kling, 2001).
- Students are given clear instructions as to what is expected of them in the learning activity through the use of a structured learning approach (Appendix A; MacKnight, 2000).
- Kanuka, Rourke, and Laflamme (2007) would also suggest, from empirical research, that cognitive presence or critical discourse was highest in those online learning activities that were well structured, provided clearly defined roles and responsibilities for students, and overtly provoked students to confront each others' opinions.

From the perspective of the study reported here the use of asynchronous computer-mediated communication or threaded discussion boards and degree of convergence exhibited in student messages could be improved by integrating student participation with assessment and learning outcomes, such as designing tasks that require students to demonstrate synthesis and summarising skills. Rovai (2003, 2004, 2007) strongly suggests extrinsic motivation is provided by grading students' online participation on discussion boards, and these criteria should be clearly communicated to students through a Discussion Rubric (that quantifies and describes best practice on discussion boards), so that instructor expectations regarding student involvement on discussion boards are unambiguous. Vonderwell and Zachariah (2005) observed that when students were assigned specific roles on discussion boards they maintained online presence and participated more frequently than the rest of the group members, while all of the students reported that student tasks and assessment criteria for the discussions influenced their participation. However, the mechanisms by which student interaction and messages on discussion boards will be assessed needs to be carefully crafted to avoid an unwieldy, "clunky," nonauthentic and cumbersome assessment process for students and instructors alike. The evidence provided in this chapter is overwhelmingly in favour of the retention and positioning of face-to-face instruction prior to interacting with learning objects. It appears that although online delivery of learning activities and objects is favoured for reasons of flexibility and "ease of access," there are still sound pedagogical reasons to retain a face-to-face component in online learning to scaffold student learning and create a better sense of a learning community.

FUTURE TRENDS

The use of learning object in an online environment should demonstrably enhance learning outcomes and facilitate the smooth delivery of a learning design. Much of the excitement surrounding learning objects and LOR is that they can deliver "pieces of knowledge that students can easily access" (Orrill, 2000, p.13), and it seems that some have "lost sight" of the pedagogical challenge which is to retain the principles of a learning design and to achieve the learning outcomes. There are several pedagogical concerns raised, especially when using a PBL design. The first is that by creating LORs with easy to locate accessible information, although relevant to improving student understanding of the discipline, may "mainstream" or "homogenise" the curriculum or discard the value of the learning process by not challenging the learner to locate the relevant information they need in the "real world" knowledge economy. This criticism was raised about the use of Google as a search engine for locating reference material as offering convenience and comfort, and that it lends itself to the appearance of learning rather than to actual learning (Haigh, 2007). The second concern is that, for some, possible many, academics the idea of "re-use" of learning objects is probably "foreign" as they would prefer to create their own learning materials rather than re-use someone else's. Thirdly, there is a concern that the perception of students about an LOR is that they are not receiving content-specific material from the UOL or a "unique" learning experience, and that academics would be open to criticism of repeatedly using the same learning objects across multiple UOLs without appropriate adaptation. This possible development may even be of greater concern where degrees (collections of UOLs) have been simplified by reducing the number of UOLs on offer.

Orrill (2000) also acknowledges that alignment and complementarities between the learning design and learning object is pivotal in order for learning objects to be effective, and includes resources and tools as learning objects. However, some definitions of learning objects, which are more restrictive for sound technical reasons, but not necessarily pedagogical reasons, would exclude tools and nondigital resources as learning objects. Such learning objects, some of which have been discussed in this chapter, can support and facilitate the PBL design, and hence would comply with broader definitions of the concept. It seems a widely accepted definition of learning object is unlikely just yet, but there does seem a need to address the technical concerns, as well as allow a more flexible definition that incorporates a broader range of teaching strategies.

Improving the use of learning objects also demands stronger links to the learning design and creating a sequence of activities as others have stated (Agostinho, Bennett, Lockyer, & Harper, 2004; Gibbs & Gosper, 2006). All too often present-day LMSs deliver content in a static, non-collaborative way and do not support dynamic learning (Gibbs & Gosper 2006). However, more often than not instructors need to consider through a learning design how they can provide learners with a sequence of tasks, and the support resources and scaffolding to complete the learning activity, regardless of the constraints of the LMS. Wiley (2002) argues that the learning object research agenda must begin to investigate how learning objects can be sequenced to create a high quality instructional experience, or "we will find ourselves with digital libraries full of easy to find learning objects we don't know how to use" (p. 2). Work by Lukasiak, Agostinho, Bennett, Harper, Lockyer, and Powley (2005) suggests that with the development of the Smart Learning Design Framework it can provide instructors with "seamless integration of a technical data structure with a well-supported process for developing pedagogically sound e-learning materials" (p.

153) that will show instructors how to work with learning objects and identify the support they require to create effective learning experiences. In this study the use of a PBL-inspired learning design provided a "home" for the learning objects and "a reason to visit learning objects and provides something for them [students] to anchor the information in the learning objects to" (Orrill, 2000, p.6). Also, in the UOL discussed in this chapter learners were provided with a coherent sequence of activities, and links to support structures such as the structured learning guide through an online "work schedule" with internal links to other parts of the LMS such as the explanation of PBL, situation statements, discussion board, or online content (Appendix A).

The burgeoning growth in information and the ability to store, access, update, use and reuse learning objects is another unresolved issue, with many "players" involved and with disparate levels of understanding and technical capabilities which either prevent or hamper involvement in design and use of learning objects. The difficulty here, also, is that although educators may have the pedagogical experience to design a learning activity they may be lacking the technical "know-how," while instructional designers who are highly competent in designing technically compliant learning objects may be lacking the pedagogical underpinnings or content familiarity required (Bennett & McGee, 2005). Ultimately overcoming this impasse will require the development of workable partnerships between educators and instructional designers to provide learning objects which are both technically and pedagogically robust. All too often educators or instructional designers are working alone, often in "stand alone," under-funded, short-term projects that rapidly reach their "use-by-date" and offer no prospect of being modified to meet newer technologies such as content management systems (CMS) or LOR.

CONCLUSION

This chapter described the integrated use of learning design and learning object with an emphasis on learning objects as support tools (communication, scaffolding through the structured learning guide) and learning materials (situation statements, rejoinder and resources), and hence was more inclusive of nondigital resources, as well as recognising that the learning design was integral in sequencing and delivering learning objects. The learning design in this case was based on problem based learning which set the learning principles for the unit of learning, facilitated by the learning objects, and both learning design and learning objects supported the delivery of the desired learning outcomes. Under the main focus of this chapter empirical data collected from six years of discussion board activity was analysed to investigate the role of early placement of face-to-face instruction and practice in the PBL activity to improve: student participation, student concentration on problem-solving in the learning activity, convergent processes (i.e., degree of analysis, synthesis, and summarising) and social presence. The evidence reported builds an argument for blended delivery of learning design and learning object through an online course management system combined with short periods of face-to-face instruction. The reason being that for 'distance' students face-to-face instruction and support can scaffold their learning and allow for the formation of small peer groups that can later communicate more effectively online compared with an un-scaffolded, collective. The evidence showed that small group (2004-2006) experience of problem based learning and interaction with a situation statement was superior compared with those students whose experience was as a collective (2001-2003), and who received no face-to-face instruction and practice on problem based learning prior to their introduction to the situation statement. Those students active in a small group demonstrated less communication anxiety, increased communication activity, commitment to and social negotiation in the learning activity.

Another finding is that to allow scholars to explore and experiment with blended delivery of learning design and objects in online learning warrants a more flexible definition of learning objects, one that allows for experimentation and is more inclusive of different pedagogies. Without this development the temptation, by some, is to try and bang "a square peg into a round hole" to "fit in" with the latest "trend," and with learning objects this behaviour seems to be widespread. Some, who claim to be using learning objects, and to avoid the obvious criticism by others that their learning object fails to fulfil the criteria, retreat to more accommodating definitions of learning objects. The learning objects, described in this chapter, probably do not comply with the technical definition of learning object, but the learning design combined with the related learning objects clearly does support learning and the achievement of the desired learning outcomes. Importantly, with time and investment, the learning objects could be incorporated into an LOR, and therefore provides other educators with a model for conducting a PBL design in an online environment supported by discussion boards and face-to-face instruction. In conclusion, when considering the role of a learning object, the complete picture of learning must be viewed—learning outcomes, learning design, learning object—and not just a fragment of the image.

REFERENCES

Agostinho, S., Bennett, S., Lockyer, L., & Harper, B. (2004). Developing a learning object metadata application profile based on LOM suitable for the Australian higher education context. *Australasian Journal of Educational Technology, 20*(2), 191-208. Retrieved March 31, 2008, from http://www.ascilite.org.au/ajet/ajet20/agostinho.html

Barrow, H. (1985). *How to design a problem-based curriculum for the preclinical years.* New York: Springer.

Barrow, H. (1988). *The tutorial process.* Springfield, Illinois: Southern Illinois Press.

Barrow, H. (2002). Is it truly possible to have such a thing as dPBL? *Distance Education, 23*(1), 119-122.

Barrows, H.S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education. New York: Springer.

Bennett, K., & McGee, P., (2005). Transformative power of the learning object debate. *Open Learning, 20*(1), 15-30.

Björck, U. (2002). Distributed problem-based learning in social economy – key issues in students' mastery of a structured method of education. *Distance Education*, *23*(1), 85-103.

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology, 19*(1), 46-58.

Collis, B., & Strijker, A. (2003). Re-usable learning objects in context. *International Journal on E-Learning, 2*(4), 5-16.

Department of Education and Training, Government of Western Australia (DETWA) (2006). *Resourcing the curriculum: Learning objects.* Retrieved March 31, 2008, from http://www.det.wa.edu.au/education/cmis/eval/curriculum/learningobjects/index.htm

Downes, S. (2004). Resource profiles. *Journal of Interactive Media in Education, 5,* 1-32. Retrieved March 31, 2008, from www- jime.open.ac.uk/2004/5

Gibbs, D., & Gosper, M. (2006). The upside-down-world of e-learning. *Journal of Learning Design*, *1(2)*, 46-54.

Guzdial, M., & Turns, J. (2000). Effective discussion through a computer-mediated anchored forum. *The Journal of the Learning Sciences, 9,* 437-469.

Haigh, G. (2006, February). Infomation idol: How Google is making us stupid. *The Monthly, 9*. Retrieved March 31, 2008, from http://www.themonthly.com.au/tm/?q=node/170

Hara, N., & Kling, R. (2001). Student distress in Web-based distance education. *Educause Quarterly, 3,* 68-69.

Harasim, L., (1986). Educational applications of computer conferencing. *Journal of Distance Education, 1*(1), 9.

Harman, K., & Koohang, A. (2005). Discussion boards: As learning objects. *Interdisciplinary Journal of Knowledge and Learning Objects, 1,* 67-77.

Hewitt, J. (2001). Beyond threaded discourse. *International Journal of Educational Telecommunications, 7*(3), 207-221.

Hewitt, J. (2003). How habitual online practices affect the development of asynchronous discussion threads. *Journal of Educational Computing Research, 28*(1), 31-45.

Hodgins, H.W. (2002). The future of learning objects. In D.A. Wiley (Ed.), *The instructional use of learning objects* (pp. 281-298). Bloomington, ID: AIT/AECT.

IEEE Learning Technology Standards Committee. (2002). *Learning object metadata* (LOM), Final Draft Standard. *IEEE, 1484*(12), 1-2002.

Jonassen, D. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional technology* (Vol. II, pp. 215-239). Mahwah, NJ: Lawrence Erlbaum Associates.

Kanuka, H., Rourke, L., & Laflamme, E., (2007). The influence of instructional methods on the quality of online discussion. *British Journal of Educational Technology, 38*(2), 260-271.

Koper, E.J.R. (2003). Combining re-usable learning resources and services to pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 46-59). London: Kogan Page

Koper, R., & Olivier, B. (2004). Representing the learning design of units of learning. *Educational Technology & Society, 7*(3), 97-111

Kuriloff, P C. (2001, July/August). One size will not fit all. *The Technology Source*. Retrieved March 31, 2008, from http://ts.mivu.org/default.asp?show=article&id=1034.

L'Allier, J.J. (1997). Frame of reference: NETg's map of products, their structure and core beliefs. NetG. Retrieved March 31, 2008, from http://www.netg.com/research/whitepapers/frameref.asp

Liber, O. (2005). Learning objects: Conditions of viability. *Journal of Computer Assisted Learning, 21,* 366-373.

Lobry de Bruyn, L. (2002). *Description of problem based learning in natural resource management.* Retrieved March 31, 2008, from http://www.learningdesigns.uow.edu.au/exemplars/info/LD28/index.html

Lobry de Bruyn, L.A. (2003). Online communication in dPBL: Can threaded discussion provide social presence and convergence? In C. McLoughlin, P. Le Cornu, & W. Jackson (Eds.), *16th Open and Distance Learning Association of Australia's Biennial Forum: Sustaining Quality Learning Environments* (pp. 1-9). Canberra: ODLAA.

Lobry de Bruyn, L.A. (2004). Monitoring online communication: Can the development of convergence and social presence indicate an interactive learning environment? *Distance Education, 25*, 67-81.

Lobry de Bruyn, L.A. (2005). The use of distributed problem-based learning and threaded discourse in teaching natural sciences at university level: problems and prospects. In C. McLoughlin & A. Taji (Eds.), *Teaching in life sciences: Learner centered approaches.* (pp 85-104). UK: Haworth Press.

Lobry de Bruyn, L.A., & Prior, J.C. (2001). Changing student learning focus in natural resource management education - problems (and some solutions) with using problem based learning. In L. Richardson & J. Lidstone (Eds), *Flexible learning for a flexible society*, *Proceedings of ASET/HERDSA 2000 Joint International Conference*, Toowoomba, (pp. 441-451) ASET/HERDSA: Queensland. (ISBN: 0 908557 47 7)

Lukasiak, J., Agostinho, S., Bennett, S., Harper, B., Lockyer, L., & Powley, B. (2005). Learning objects and learning designs: An integrated system for reusable, adaptive and shareable learning content. *ALT-J, Research in Learning Technology, 13*(2), 151-169.

MacKnight, C.B. (2000). Teaching critical thinking through online discussion. *Educause Quarterly*, *4,* 38-41.

McGreal, R. (2004). Learning objects: A practical definition. *International Journal of Instructional Technology and Distance Learning, 1*(9), 12. Retrieved March 31, 2008, from http://www.itdl.org/Journal/Sep_04/article02.htm

Metros, S.E. (2005). Learning objects a rose by any other name. *EDUCAUSE E-Journal, 40*(4), 12-13

Nash, S.S. (2005). Learning objects, learning object repositories and learning theory: Preliminary best practice for online courses. *Interdisciplinary Journal of Knowledge and Learning Objects, 1,* 217-288.

Nonnecke, B., & Preece, J. (2003). Silent participants: Getting to know lurkers better. In C. Leug & D. Fisher (Eds.), *From usenet to CoWebs: Interacting with social information spaces* (pp. 110-132). Amsterdam: Springer-Verlag.

Orrill, C.H. (2000). Learning objects to support inquiry-based online learning In D.A. Wiley (Ed.), *The instructional use of learning objects.* Retrieved March 31, 2008, from http://reusability.org/read/chapters/orrill.doc

Orrill, C.H. (2002). Supporting online PBL: Design considerations for supporting distributed problem solving. *Distance Education, 23*(1), 41-57.

Polsani, P.R. (2003). Use and abuse of reusable learning objects. *Journal of Digital Information, 3*(4). Retrieved March 31, 2008, from http://jodi.ecs.soton.ac.uk/Articles/v03/i04/Polsani/

Rice, R. (1994). Network analysis and computer-mediated communication systems. In S.W.J. Galaskiewka (Ed.), *Advances in social network analysis* (pp. 167-203). Newbury Park, CA: Sage.

Ronteltap, R., & Eurelings, A. (2002). Activity and interaction of students in an electronic learning environment for problem-based learning. *Distance Education*, *23*(1), 11-22.

Rourke, L., Anderson, T., Garrison, D.R., & Archer, W. (1999). Assessing social presence in asynchronous text-based computer conferencing. *Canadian Journal of Distance Education*, *14*(2), 50-71.

Rovai, A.P. (2002). Building sense of community at a distance. *International Review of Research in Open and Distance Learning*, 3(1), 1-16.

Rovai, A.P. (2003). Strategies for grading online discussions: Effects on discussions and classroom community in Internet-based university courses. *Journal of Computing in Higher Education, 15*(1), 89-107.

Rovai, A.P. (2004). A constructivist approach to online college learning. *Internet and Higher Education*, *7*(2), 79-93.

Rovai, A. (2007). Facilitating online discussions effectively. *Internet and Higher Education, 10,* 77-88.

Shepherd, C. (2000). *Objects of Interest.* Retrieved March 31, 2008, from http://www.fastrak-consulting.co.uk/tactix/features/objects/objects.htm

Short, J., Williams, E., & Chritsie, B. (1976). *The social psychology of telecommunications.* London, UK: John Wiley.

Sicilia, M.A., & García, E. (2003). On the concepts of usability and reusability of learning objects. *The International Review of Research in Open and Distance Learning*, *4*(2), 12.

Sosteric, M., & Hesemeier, S. (2002). When is a learning object not an object: A first step towards a theory of learning objects. *International Review of Research in Open and Distance Learning Journal, 3*(2). Retrieved March 31, 2008, from http://www.irrodl.org/index.php/irrodl/article/view/106/557

Stacey, E. (2002). Social presence online: Networking learners at a distance. *Education and Information Technologies*, *7*(4), 287-294.

Vonderwell, S., & Zachariah, S. (2005). Factors influencing participation in online learning. *Journal of Research on Technology in Education, 38*(2), 213-230.

Wiley, D. A. (1999). *The post-LEGO learning object.* Retrieved May 12, 2008, from http://opencontent.org/docs/post-lego.pdf

Wiley, D.A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D.A. Wiley (Ed.), *The instructional use of learning objects: Online version*. Retrieved March 31, 2008, from http://reusability.org/read/chapters/wiley.doc

Wiley, D.A. (2002). Learning objects. In A. Kovolchick & K. Dawson (Eds.), *Educational technology: An encyclopaedia*. Santa Barbara, CA: ABC-CLIO. Retrieved March 31, 2008, from http://opencontent.org//docs/encyc.pdf

Wiley, D.A. (2006). RIP-ing on learning objects. Retrieved March 31, 2008, from http://opencontent.org/blog/archives/230

KEY TERMS

Discussion Boards: Located within a course management system, discussion boards provide threaded or unthreaded asynchronous computer mediated communication that allows students to communicate independently of time and place. A thread starts off as a stand alone note or message and can be responded to by students or instructors with another note or message and is connected by a branch. It can be viewed in a linear or non-linear fashion.

Learner/Student-Centered Learning: The essence of student-centered learning is characterised by the adage "involve me and I understand." It actively engages the students in constructing new knowledge, and reflecting upon their understandings, as well as developing skills and attitudes that inform the learning process and outcomes.

Learning Design: A learning design is the application of a pedagogical model for a specific learning objective, target group, and a specific context or knowledge domain. The learning design specifies the teaching-learning process. More specifically, it specifies under which conditions what activities have to be performed by learners and teachers to enable learners to attain the desired learning objectives

Learning Object: Any digital resource that can be reused to support learning.

Online Learning: The transmission of information and/or communication via the Internet without instructors and students connected at the same time or place.

Problem Based Learning (PBL): Learning centered around a problem, a query, or a puzzle that the learner wishes to solve. It is an approach to curriculum which is problem-centered rather than discipline centered with a focus on an integrated curriculum structured by "real world" problems.

Social Presence: The ability of learners to project themselves socially and affectively into a community of inquiry.

APPENDIX A

Structured Learning Guide

Modified from Björck (2002), who originally adapted it from Barrows and Tamblyn (1980).

Step

1. Meet the situation (scenario).
2. Redefine the question/s at the end of the situation statement.
3. Gather the facts:
    - Identify relevant information from the situation statement
    - Identify what you need to know (further information and learning)
    - Identify potential information/learning resources (place ideas in step 5)
4. Generate relevant questions from the previous section:
    - For student to answer before next week
    - For instructor to answer in the next week
5. Research required (type of…)
6. Rephrase the question/s (from step 2) which define/s the scope and the nature of the question/s and boundaries or breadth of your response (half a page limit).
7. This is where you identify and justify the answer to the question/s posed at the end of the situation statement. The process may require you to generate a range of likely answers, and justify with supporting evidence the most probable response (this is the major component of your answer).
8. Advocate the most realistic answer (select the "best" answer and justify it) (overall conclusion/summary, one page maximum).

Steps 6, 7, and 8 need to be written up and presented in your answer.

Steps 3 to 4 are to be carried out by you on discussion board.

ENDNOTE

[1] "any digital resource that can be reused to support learning" Wiley (2000).

[2] A lesson is defined as a piece of instruction, normally including a learning purpose or purposes.

Chapter XXXIV
Learning Objects and Generative Learning for Higher Order Thinking

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ABSTRACT

This chapter aims to guide the readers through the design and development of a prototype Web-based learning system based on the integration of learning objects with the principles of generative learning to improve higher order thinking skills. The chapter describes the conceptual model called Generative Learning Object Organizer and Thinking Tasks (GLOOTT) which was used to design and build a technology-supported learning environment. The chapter then describes how the effectiveness of the Web-based learning system was evaluated and reflects on the importance of the findings more generally.

INTRODUCTION

While many people are actively developing Web-based learning environments, there are questions about how to keep online learners self-motivated and engaged in higher order thinking skills (HOTS). Developing such skills is important as they prepare learners to cope with the rapidly changing world. Hence, it is important to design and develop Web-based learning environments that focus on learners' needs and that can be economically customized to the individual learner in order to promote HOTS (Tan, Aris, & Abu, 2006). This transition from current one-size-fits-all approaches to customization fits well with the growing use of the learning object, an instructional technology currently being developed by educational technologists and instructional designers for the design, development, and delivery of e-learning (Wiley, 2000).

There is limited research on the use of learning objects in supporting learning. This chapter describes a conceptual model for the design and development of a Web-based learning system called Generative Learning Object Organizer and Thinking Tasks (GLOOTT). The proposed model incorporates multi-faceted learning approaches: learning object, generative learning, essential components of HOTS, and technology-supported learning environment.

BACKGROUND

The emergence of the World Wide Web has caused change and innovation in the way people learn and work. An educational innovation is gradually taking place in the development and delivery of instruction through the use of learning objects. The changes provide an opportunity to improve the learning with the appropriate use of pedagogy coupled with technologies.

Most instructional designers understand the importance of pedagogical perspectives in the design and development of Web learning environments. Snow (1989) noted that instruction differs in structure and completeness, and highly structured instruction (linear in sequence with restricted and high external control) seems to help learners with low ability but hinder those with high ability. This suggests that the concept of one-size-fits-all design is not suitable in the design and development in e-learning. Instead, the learning environment should be highly flexible in structure and transfer the control of the learning system from the instructors to the learners whereby learners can actively participate in the learning process. The concept of learning object design fits this goal very well as can provide flexible paths for the learners' exploration. Nonlinearity in the learning object approach allows students to access information in different patterns and to take control in their own actions and learning.

Learning object has been described by Wiley (2000) as reusable digital resource that supports learning. Grounded in the object-oriented paradigm of computer science, learning objects require the design of instruction into small learning contents that can be reused in different contexts, deployed into multiple setting and learning goals (Collis & Strijker, 2003; Wiley, 2000).

The idea of packaging information in small, reusable, and flexible units in a learning environment has received a lot of attention from the educators and instructional designers of e-learning environments. According to Reigeluth and Nelson (1997), when teachers first gain access to instructional materials, they often break the materials down into their constituting parts and then reassemble these parts in ways that support their instructional goals. Thus, the notion of small and reusable units of learning content, learning components, and learning object design have the potential to provide flexibility and reusability by simplifying the assembly and disassembly of instructional design and development.

Learning objects can be configured in generative learning environments based on the theoretical perspectives of constructivist learning (Bannan-Ritland, Dabbagh, & Murphy, 2000; Bonn & Grabowski, 2001). In this type of environment, learners are active and focus on the construction of their own learning. The environment promotes active processing through the linking of the concepts and includes supports that encourage them to think and construct their understanding. Learners generate and organize their ideas about the content being studied and relate new concepts to existing ones by exploring, analyzing, synthesizing, and evaluating knowledge. These processes can be accomplished through the use of concept mapping, an important strategy in generative learning environment (Bannan-Ritland et al., 2000).

The flexibility and reusablity of learning objects relate well to principles generative learning. Enabling learners to generate relationships between learning objects that are flexible and reusable engage them in higher order thinking. Thus the nonlinearity and reusability of learning objects allows students to access information in different patterns and to take control in their own learning.

Higher order thinking skills (HOTS) represent multifaceted and complex cognitive processes that develop and improve the processing and construction of information (Resnick, 1987). The term HOTS used in this research refers to the analysis, synthesis, and evaluation outcomes in Bloom's Taxonomy of thinking (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Thus, the recall of knowledge, comprehension and application are classified as lower order thinking skills (LOTS) (Bloom et al., 1956; Dori, Tal, & Tsaushu, 2003; Morgan, 1996). Reflective thinking is also often related to HOTS (Fogarty, 2002; Harrigan & Vincenti, 2004). Reflective thinking helps students to be aware of their thinking as they perform tasks and this engages them in higher order thinking. These processes are supported in the generative learning environment which encourages and requires students to manipulate the content which is designed as small chunks or learning objects. HOTS occur when students analyze, synthesize, and evaluate their design of learning by connecting and generating the relationships between the learning objects with the use of concept mapping (Tan, 2006). These enable students to generate, to evaluate their ideas, and to actively construct their understanding.

A LEARNING OBJECT ORIENTED CONCEPTUAL MODEL FOR A PEDAGOGICAL DESIGN OF WEB-BASED LEARNING SYSTEM

As acknowledged earlier, it is important to conceptualize and design Web-based learning based on pedagogical perspectives. The learning system should be designed with a focus on student-driven and student-oriented interactive learning. Merely providing a pre-determined structure for content is unlikely to significantly aid learning. The one-size-fits-all approach of traditional courseware does little to meet requirements for personal knowledge construction. Learning objects and a generative learning design together provide an environment that allows students to construct their own understanding. This learning environment enables the students to be active participants in their learning and, most importantly, engages them in HOTS.

The conceptual model on which this work was based illustrates how to integrate learning objects with pedagogy and Web-based technologies to support learning. The conceptual model is called *Generative Learning Object Organizer and Thinking Tasks* (GLOOTT). This model incorporates the three important components, namely the learning objects, generative learning, and HOTS in a technologically-supported learning environment. GLOOTT was designed based on the attributes of learning objects, generative learning, and HOTS. The model was used to develop the prototype as a "mind tool." According to Jonassen (1996), mind tools are used by learners to represent their knowledge and engage them in HOTS.

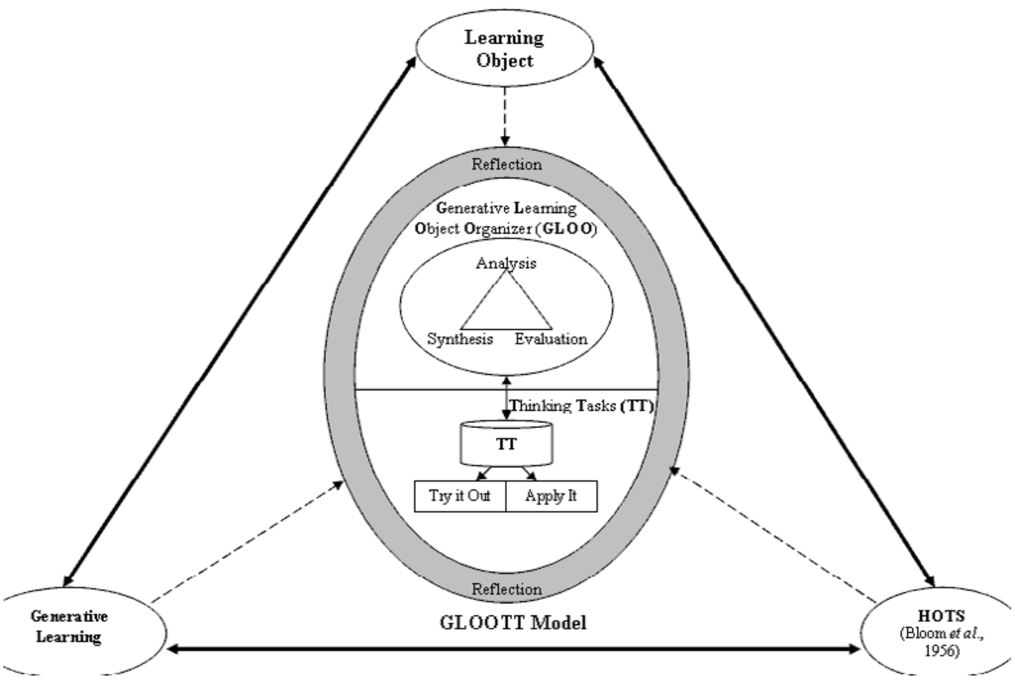
The activities in GLOOTT are learner-centered, while the learning environment is generative-oriented. Thus, various means have been considered in the design and development of the system to engage students in active learning. It is believed that an active learner will integrate new knowledge more readily than a passive learner (Lim, 2000). The students act as designers in the active learning process, in which they design pathways throughout the learning materials. The suggested model is equipped with learning object as its stem and generative learning as its pedagogical perspective to improve the HOTS. The framework is depicted in Figure 1.

GLOOTT model consists of two main parts. The first part is *Generative Learning Object Organizer* (GLOO), and the second part is *Thinking Tasks* (TT). The design of this model was based on the generative learning, which consists of generation of organizational relationships between different components through concept mapping and integration and elaboration of knowledge through solving scenario-based problems.

GLOO specifies the development of concepts and the engagement of HOTS. Students work with learning objects that engage them actively in generating or constructing the organizational relationships between the learning objects. In facilitating the students in generative learning, GLOO helps them to construct or reconstruct their knowledge by assimilating and accommodating new knowledge schemata with their existing frameworks. They analyze, organize, synthesize, evaluate, and reflect. These activities follow idiosyncratic pathways in learning. In this context, the students act as designers by constructing and designing their own learning through analyzing, synthesizing, evaluating, and organizing the learning objects in the learning object repository (LOR). LOR is a computer database that contains the content of learning materials that were designed as reusable learning objects. The key design considerations at the learning object level are reusability and flexibility. A learning object can be object independent from others or combined with others to form a lesson.

A tool named *Learning Object Organizer* is designed to enable and help the students to include, adapt, manipulate, and organize the learning objects in designing the hierarchical outline of

Figure 1. Theoretical framework of the conceptual model



their concept maps. Concept mapping encourages students to actively and generatively construct, relate and organize their concepts. These allow the students to control the selection of learning objects and design of learning. According to Alpert and Grueneberg (2000) and Dabbagh (2001), concept maps can be designed in outline form. It is called as lesson map in the proposed conceptual model. Lesson maps allows the students to share their own conceptual understanding with other students.

GLOO provides the knowledge base that engages students with HOTS through generative learning environment, whereas the *Thinking Tasks* (TT) part helps the students to test their understandings as well as to reinforce and practice HOTS. There are two parts in TT, namely "Try It Out" and "Apply It." "Try It Out" contains multiple-choice questions that consist of LOTS and HOTS questions. It is uploaded by the instructor to assess the students' understanding and reflect the lesson maps they have designed in GLOO. "Apply It" consists of scenario-based problems that engage students with HOTS. The students would need a deeper processing of content and the use of HOTS in solving the problems. It aims to assist the students to implement what they have learned, to reflect on the learning content, and to incorporate the content into related areas of existing knowledge.

There is a significant body of literature and research which has highlighted the importance of reflection in engaging students with HOTS. According to Fogarty (2002), reflection involves awareness and control over one's learning. Students think back on what they have done and what they need to do. This is important to assist students in monitoring their learning and engaging them with HOTS. In short, the GLOOTT model that is framed within the learning object, generative learning strategies, and the emphasis on HOTS, is a conceptual framework to improve HOTS.

DESIGN AND DEVELOPMENT OF A WEB-BASED LEARNING SYSTEM BASED ON GLOOTT

GLOOTT has been applied in the design of the learning environment of a Web-based learning system called *Generative Object Oriented Design* (GOOD) learning system. It specifies the development of concepts to be learnt and aims to improve HOTS among the students. GLOOTT model consists of *Generative Learning Object Organizer* (GLOO) and *Thinking Tasks* (TT). In GLOO, learners work with learning objects that engage them actively in generating or constructing the organizational relationships among the learning objects. Learning objects were designed as small chunks of lesson material that can be reused in this system (see Figure 2). The learning objects can be selected singly or assembled in combination with other objects to form a lesson. The learning objects in the learning system take the form of Web pages, animations, and graphics. The learning objects are reusable in the system whereby they can be used to form a new lesson map in the system.

To facilitate generative learning, GLOO offers learners the opportunity to construct or reconstruct their knowledge by assimilating and accommodating new knowledge with their existing one through concept mapping. GLOO is a tool that is capable of representing a student's knowledge comprehensively and allows the learners to learn through designing their own path through the learning material. GLOO contains a search engine, Learning Object Organizer, and published lesson map as shown in Figure 3.

In the learning process, the learners search for learning objects, organize learning objects, and design their own lesson maps. They search the learning objects from the LOR and the result is displayed in a table that contains a description of each of the learning objects for the learners

Figure 2. Examples of learning object

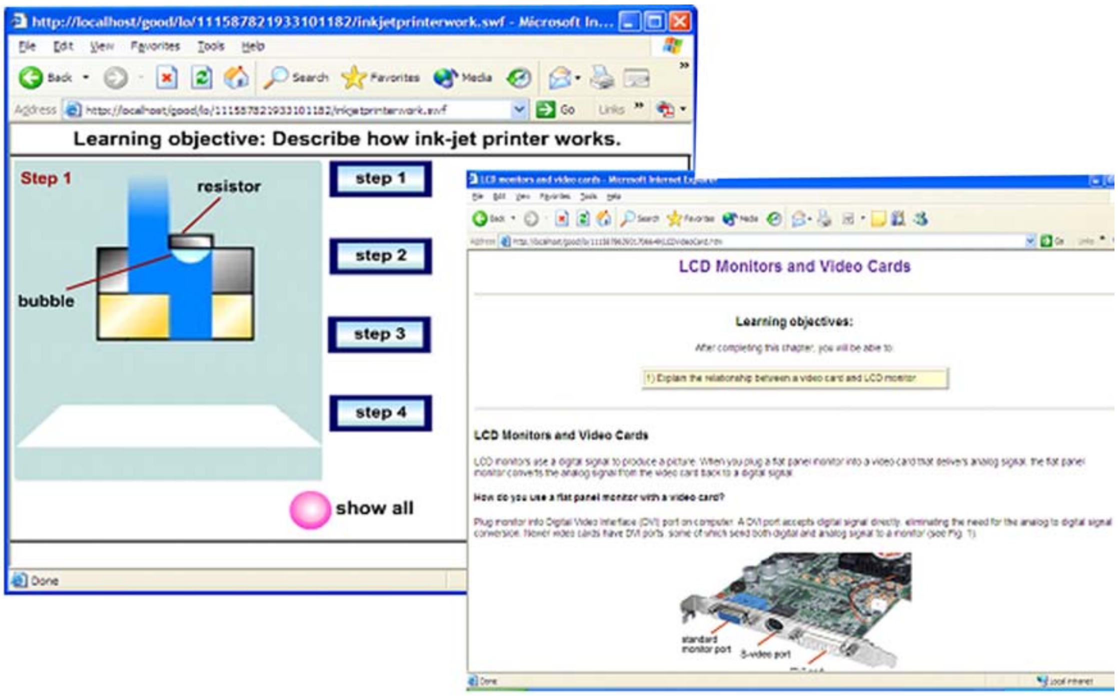
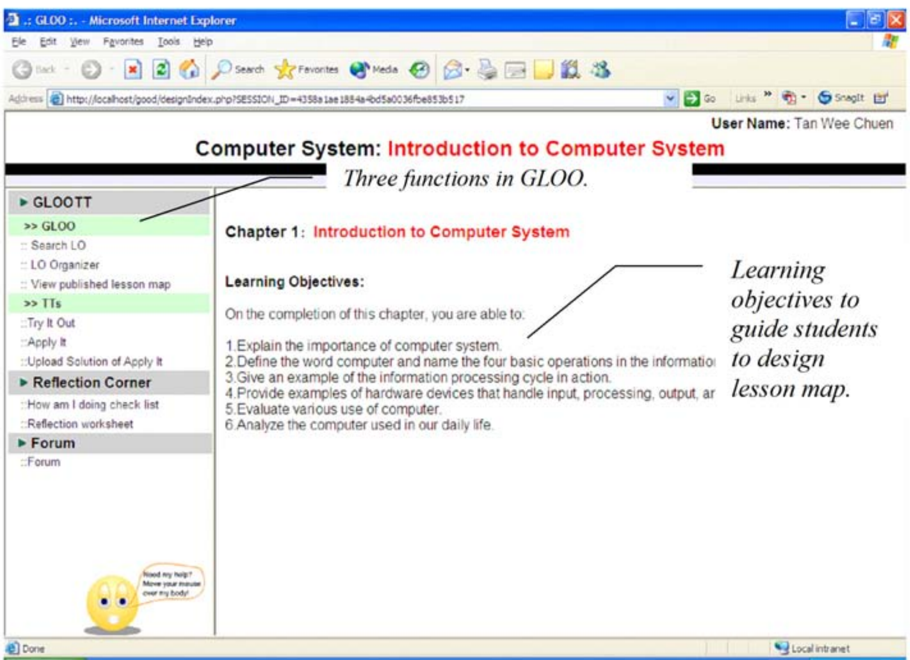


Figure 3. GLOO design in GOOD learning system



to preview. The learning objects selected for the lesson will be added into the student's learning object library where they can be organized as shown in Figure 4.

The Learning Object Organizer is a concept mapping tool that enables the representation of lesson organization in an outline form that is called a lesson map, which is the cognitive chunk of content designed by the student (see Figure 5).

Figure 4. Search engine and learning objects in library

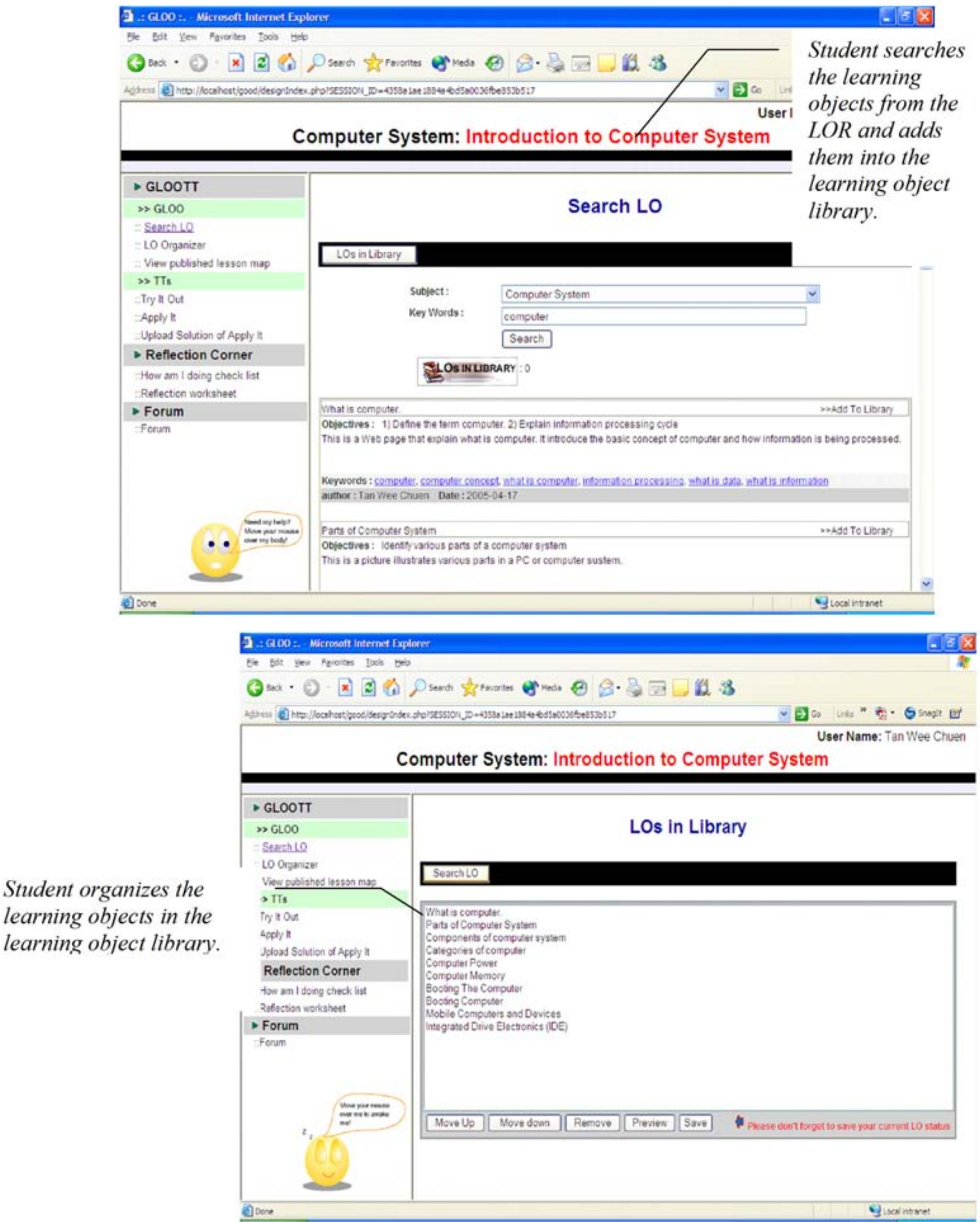
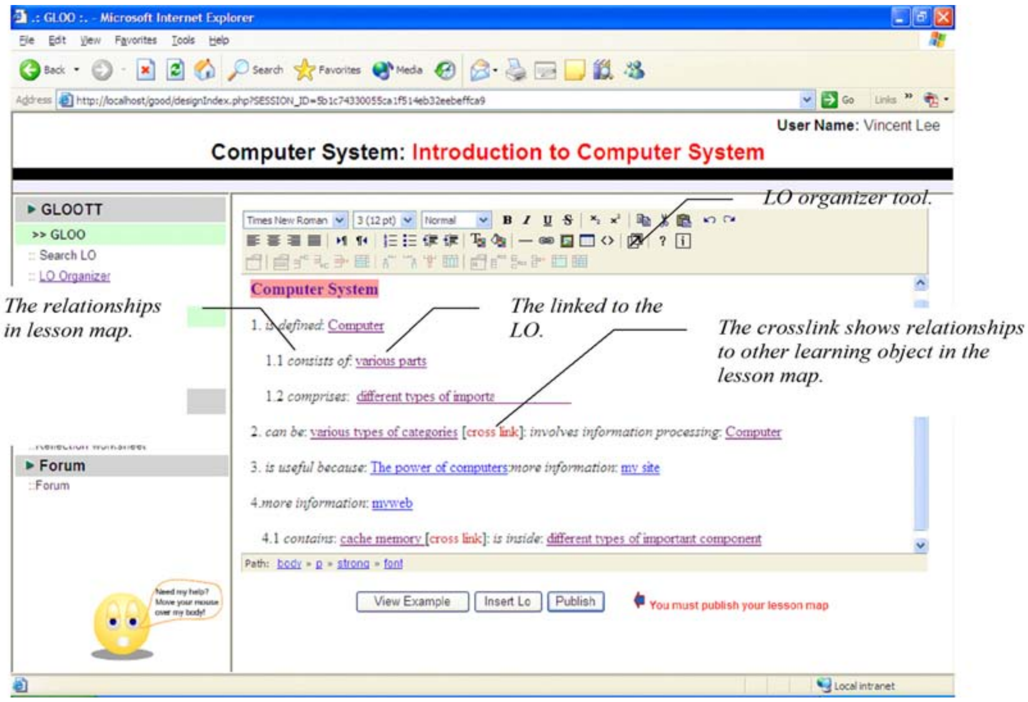


Figure 5. Lesson mapping in learning object organizer



Students generate their lesson maps based on the learning objectives of the lesson, as illustrated in Figure 3. The design of Learning Object Organizer capitalizes the capabilities of the Web allowing students to create lesson maps containing propositions and concepts hyper-linked to various learning objects stored in the database (LOR). The process of creating the lesson map contributes to the development of the students' knowledge structure. The lecturers can then assess the students' understanding through the lesson maps and give proper feedback to them through the forum and messaging tools in the system. In addition, students are able to give their feedback about the lesson maps to each other through the forum in the system.

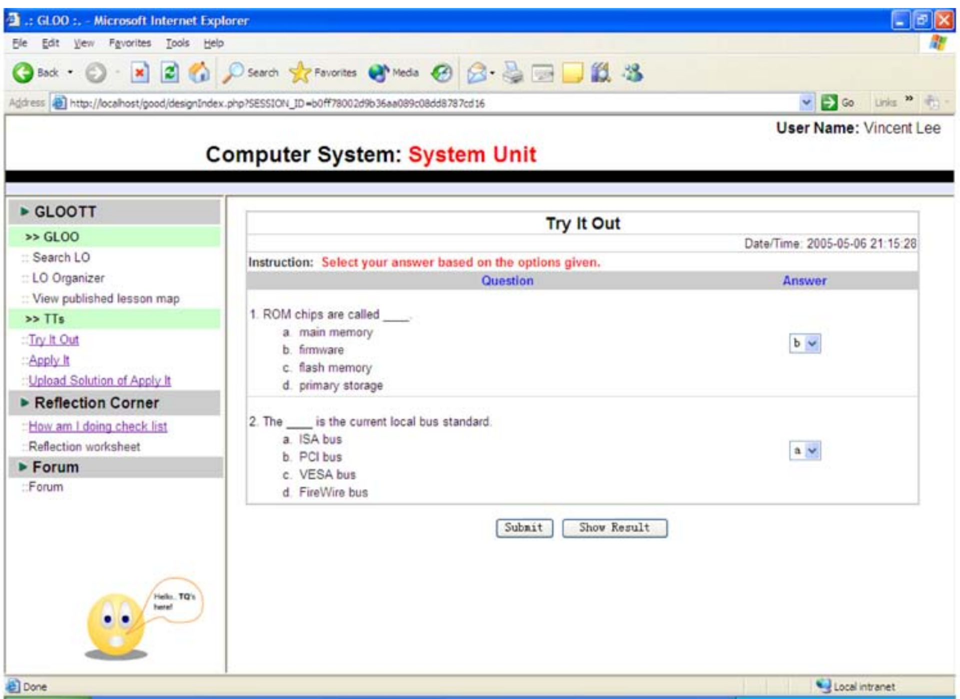
This approach supports the integration of information into the students' knowledge structure (Jonassen & Wang, 1993). In the hypertext design, the information is organized into a network that contains links to various multimedia nodes that engages students with generative activities. Barab, Young, and Wang (1999) highlight that hypertext is a generative learning strategy. This concept fits well with the design of lesson map. This learning environment enables the students to decide which learning objects should be accessed. When using the hypertext design approach in the design of lesson maps, learners are able to control the navigation of the lesson maps. As this occurs, the students are elevated from passive learners to authors or designers, controlling their learning rather than receiving program-controlled instruction.

A study from Liu and Pedersen (1998) demonstrates that engaging students in the design of their learning could support the development of knowledge construction and HOTS. In addition, Jonassen and Reeves (1996) note that people who learn the most from the design of instructional materials is the designer themselves and this will engage them in HOTS. Hence, Learning Object Organizer which is in hypertext design fits well with the pedagogical design principles in promoting HOTS.

Lesson mapping involves the creation of hyperlinks to the learning objects. Learners design the lesson map that contains hyperlinks to certain learning objects to represent relationships among the ideas. The outlines form of concept maps used in the lesson mapping provide a hierarchical structure of concept maps based on the relationships of links to various learning objects. As the learning objects and links become interrelated in the lesson map, a structural knowledge representation depicts the understanding of the lesson. The process of lesson mapping engages the learners to identify the key concepts and relate them in a more meaningful way. The learners actively construct knowledge as they form the lesson maps that contain hyperlinks to various learning objects.

When the students design the lesson map, they organize the learning objects, generate the relationship among the learning objects, and assimilate the new learning objects into their existing lesson map as shown in Figure 5. This process involves generating links, relating learning objects, adapting the existing learning objects to the new learning objects, and correcting any misconceptions in the existing lesson map based on the feedback of the instructors and the thinking tasks in the system. Besides, as the students progress in the learning process, they can modify their lesson maps by adding new nodes, refining and reorganizing the relationships among the nodes.

Figure 6. Try it out



This assists the students to learn the concepts in a meaningful way and engages themselves with HOTS.

In short, GLOO involves learners in the construction of knowledge as they actively generate knowledge in the form of lesson maps that hyperlink to the multiple forms of learning objects design. They not only use but also contribute to the shared knowledge by designing and uploading their learning objects. This engages the learners with HOTS as they socially interact contribute and shared their learning and thus giving them ownership of their learning.

In the "Try it out" part of the TT (see Figure 6), the learners need to solve the multiple choice questions and the system will assess their answers. The students are required to solve the problems in Apply IT (see Figure 7) and upload their solutions to the system. The instructor would then assess the answers and give relevant feedback to the students using face to face discussion or forum in the system.

The Reflection Corner acts as a self-assessment tool to help the learners in monitoring their engagement with HOTS and reflecting their learning. Students fill in the "How am I doing" checklist to reflect their engagement with HOTS (see Figure 8). The instructor will give relevant feedback to the students based on their self-assessment. A chart showing the percentage of the use of HOTS will be displayed in the system (see Figure 9). The frequency of the responsea to the "Yes" and "No" is calculated in a percentage based on the questions of each cognitive operation.

In addition, the students need to fill in the self-assessment questions in the reflection worksheet (see Figure 10). The reflection worksheet, which has been modified from Parry and Gregory (2003), allows students to undertake self-assessment of their progress. Students need to answer the ques-

Figure 7. Apply "IT"

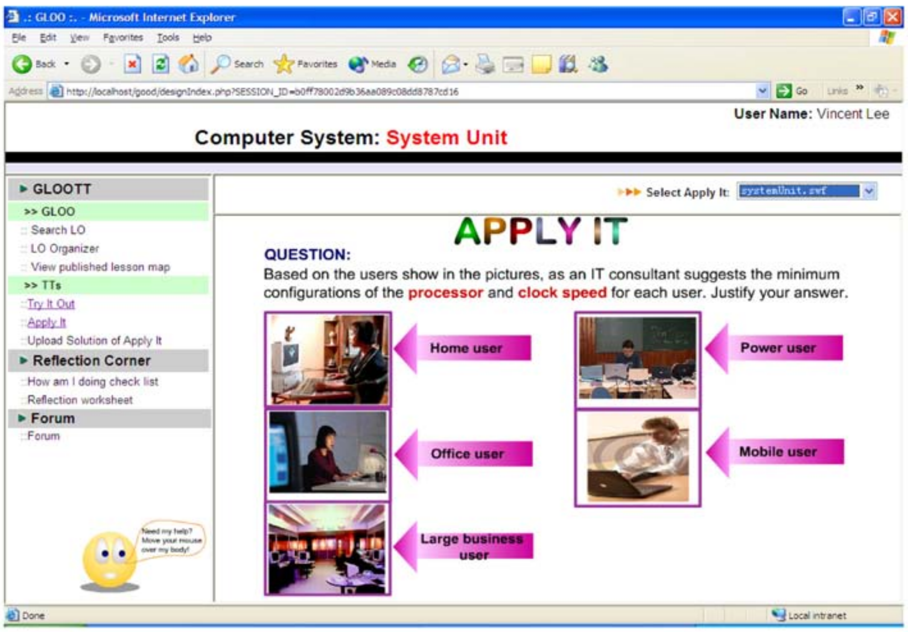


Figure 8. "How am I doing" checklist

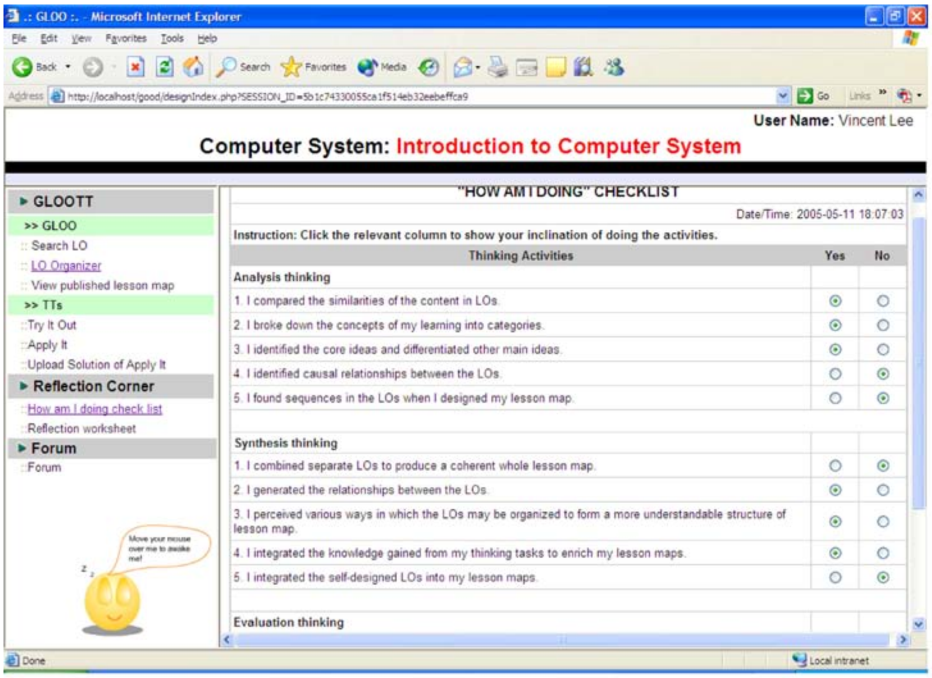


Figure 9. Chart of "How am I doing" checklist

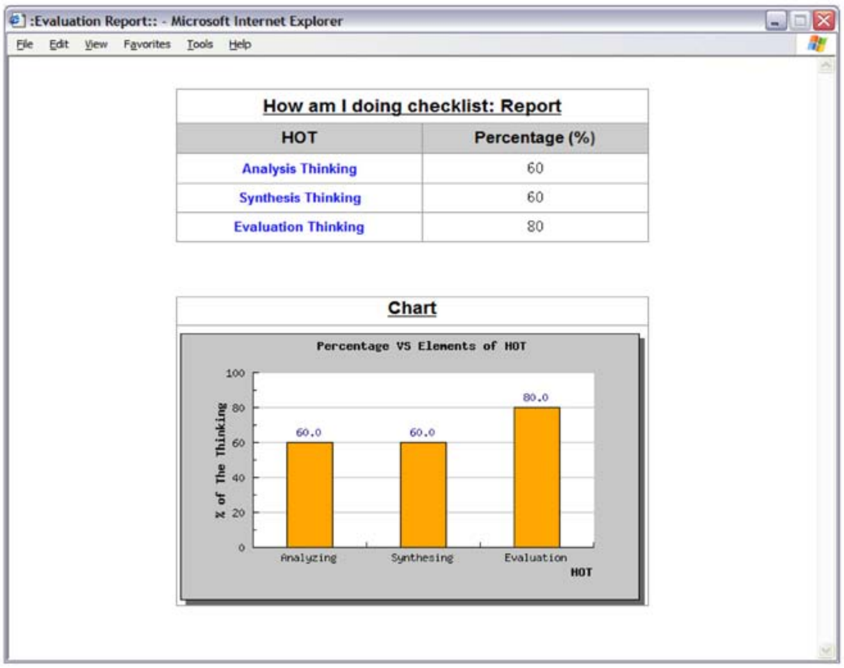
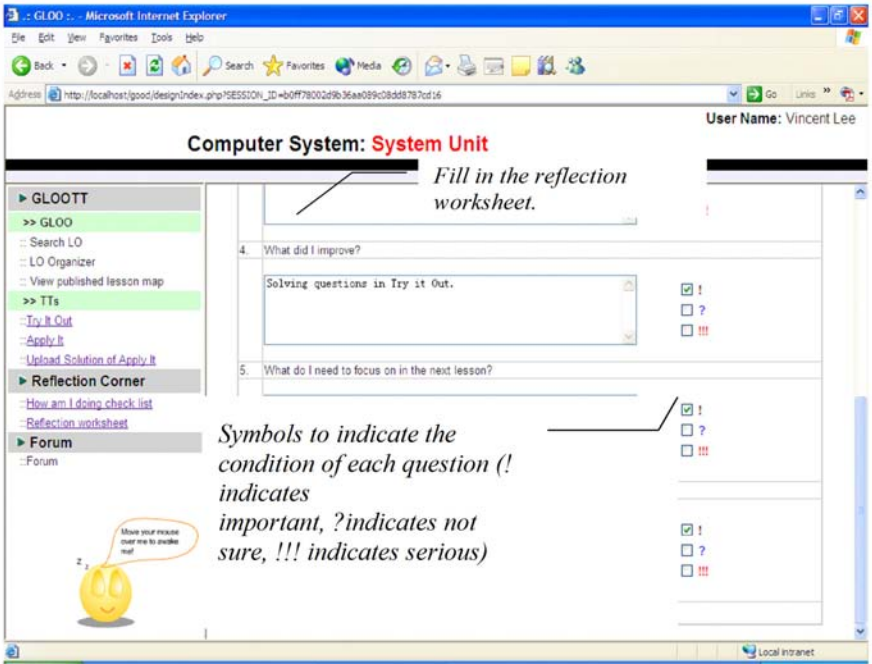


Figure 10. Reflection worksheet



tions in the reflection worksheet to reflect on what they have done and learned in order to project and decide how the learning can be incorporated for the next learning. These questions are as follow:

a. What did I learn?
b. What are my strengths and weaknesses?
c. What did I improve?
d. What do I need to consider after this lesson?
e. What do I need to focus on in the next lesson?
f. What do I need to improve?

The Web-based learning system designed based on GLOOTT model is learner-centered and the learning environment is generative-oriented. The system is not only a knowledge acquisition tool but also a mind tool that promotes HOTS. It also guides learners to be "learning designers." The system engages learners in the construction of knowledge as they actively generate knowledge in the form of lesson maps that are hyperlinked to the learning objects. Besides, learners can upload their self-designed learning object to the system. They not only use but also contribute to knowledge sharing by designing and uploading the learning objects.

STUDY ON THE EFFECTIVENESS OF THE WEB-BASED LEARNING SYSTEM

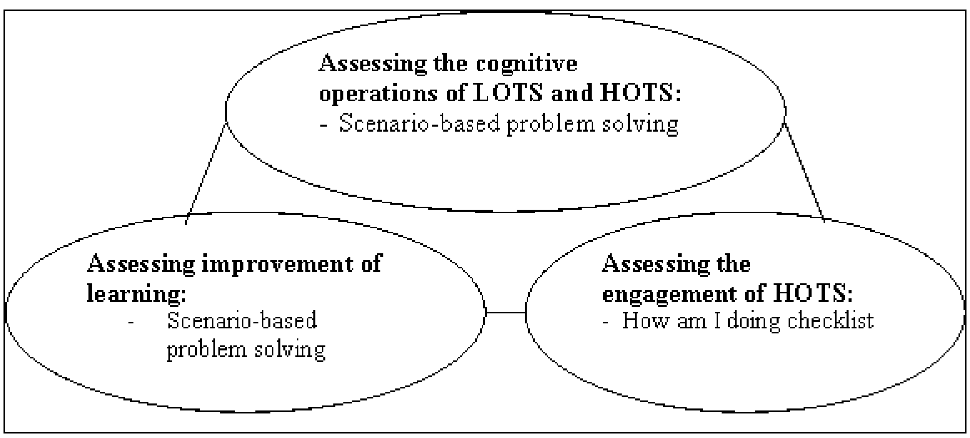
A comprehensive study was conducted to evaluate the effectiveness of GLOOTT model in improving HOTS among the diploma-level Computer Science students. Quantitative and qualitative methods were employed in the evaluation of the effectiveness of the Web-based learning system, while multiple assessment techniques were used in the assessment of LOTS and HOTS. The assessment of LOTS and HOTS in this research was modified from the thinking skills assessment design framework proposed by Costa and Kallick (2001). In order to strategize a balanced assessment, triangulation method was used in the design framework of HOTS assessment. Figure 11 depicts the design framework of the assessment in this research.

The framework contains:

1. Assessment of the cognitive operations of LOTS and HOTS
   In this study, the assessment of the cognitive operations of LOTS and HOTS was based on the cognitive operations from the Bloom's Taxonomy of thinking. Pretests and posttests were designed to assess the cognitive operations of LOTS and HOTS.
2. Assessment of the learning improvement
   The test was designed as a thinking task that consisted of scenario-based problems to assess students' improvement of learning. The problems in the test were based on the problems design that engage LOTS and HOTS with below characteristics proposed by Weiss (2003):
   a. Must be appropriate for students' current content knowledge and the problems are designed slightly beyond their knowledge to avoid the regurgitation of knowledge.
   b. Ill-structured problems that possess several solutions or no solution.
   c. Authentic in which the problems are designed based on students' experience or related to their expected career.
   d. Promotes life-long and self-directed learning through the authentic problems that require students to further analyze their solution or to seek for alternative solutions to the problems.

The problems for LOTS and HOTS in the tests required students to give their argumentation in order to defend their answers. According to Jonassen (1992), giving argumentation will require the students to utilize their HOTS. In addition, Jonassen (1992) further points out that the process of giving argumentation in the problem solving engages the students with HOTS.

Figure 11. Design framework of HOTS assessment (adapted from Costa & Kallick, 2001)



3. Assessment of HOTS engagement

   The assessment of HOTS engagement aims to determine if the students were aware of their own thinking and to identify their thinking during the learning process. According to Chapman (2003), the students' engagement is an indicator of their willingness to participate in learning activities. Chapman (2003) further points out that analysis of the students' engagement can show their willingness to persist with cognitive tasks by regulating their learning behavior and their inclination in using the cognitive. This would indicate the level of the students' engagement in certain cognitive tasks.

   The analysis of the HOTS engagement was based on the students' records of "How am I doing" checklists. The checklist was designed to examine the engagement of HOTS when the students are learning with Web-based learning system. It is a self-assess checklist that needs to be filled out by the students, which serves as a method to assess the students' engagement of certain cognitive tasks (Chapman, 2003). The checklist was adapted from the cognitive operations of analysis, synthesis, and evaluation thinking by Bloom et al. (1956), Bloom, Hasting, and Madaus (1971), Jonassen (2000), and Beyer (1988). The checklist aims to facilitate the self-assessment of the students for the improvement of HOTS in their cognitive activities. The frequency of responds in the form of "Yes" and "No" to the questions of each cognitive operation was calculated in percentage.

The research design was based on the pre-experimental design, one group pretest-posttest design (Campbell & Stanley, 1963) with quantitative approaches. The sample was randomly selected from the Computer Science class in the college. There were two sample groups in the study. The first group was the sample for the evaluation of effectiveness of Web-based learning system. The second group was the sample for the evaluation of HOTS engagement when the students work with the Web-based learning system.

The first sample group sample consisted of 30 students from a class who had taken the Computer System (CS) subject. Random cluster sampling method was used by choosing a class of students arranged by the college. Stratified sampling was used for the second sampling group to select sample from the first sample group. The second sample group was divided into three groups, namely the less active group, the active group, and the very active group based on the number of lesson maps designed by the students when they were learning with the Web-based learning system. The division of the groups was based on the calculation of standard deviation (σ) of the distribution for the number of lesson map. The active group was classified as $\pm 0.5\sigma$ of the mean, very active group as above 0.5σ and less active as below 0.5σ of the mean. The samples were then drawn randomly based on proportional stratified sampling from each group. One third of the students from respective group were eventually selected for the analysis of the HOTS engagement. There were 10 students in this group.

A pretest and posttest were used to identify the improvements in learning through the score and the level of cognitive operations of LOTS and HOTS. The pretest was conducted before the use of the Web-based learning system, while the posttest was administered after, in which the questions were designed based on the characteristics of problems design to engage students in LOTS and HOTS proposed by Weiss (2003). A rubric was been used as to assess the levels of LOTS and HOTS as well as the students' scores in the tests. The rubric of HOTS evaluation was modified with permission from Hansen (2001), the original instrument designer. The modification was based on the taxonomy of thinking from Bloom et al. (1956) and Bloom et al. (1971), which Hansen had validated its suitability in the HOTS assessment.

There are five scores in the rubric that represent different criteria of the assessment answers. The maximum score is 4 and the minimum is 0 for Knowledge (K), Comprehension (C), Application (App), Analysis (Ana), Synthesis (S), and Evaluation (E).

The results from the study show the improvement of learning among the students. Table 1 shows the difference of mean scores for pretest and posttest. The mean score of the pretest (38) is lower than that of the posttest (65).

The results in paired-samples T test showed the significant differences between the mean scores of LOTS and HOTS in the pretest and posttest at α=0.05. Due to the display limitation of the software, the significance value was shown to be 0.000.

Analysis of paired-samples T test was used to study the improvement of HOTS between pretest and posttest. The scores of both tests were analyzed based on each cognitive operation of Bloom's Taxonomy. Table 2 shows the results of the analysis.

Comparison of the mean score of each cognitive operation for pretest and posttest showed the improvement of students in both LOTS and HOTS. The mean score of each cognitive operation for the posttest was significantly higher than the pretest, implying positive improvement in HOTS and LOTS.

The improvement of the students' HOTS engagement was demonstrated through the analysis of the progressive change of the HOTS engagement throughout the learning process with the Web-based learning system from the records of "How am I Doing" checklist. The results show that each individual's HOTS engagement significantly improved throughout the learning process with the Web-based learning system. Table 3 depicts an example of the data analysis for two students from the group that shows similar pattern of progressive improvement. However this self-report method could be quite subjective as it is strongly dependent on the students' own perceptions against their progress.

Table 1. Mean scores of pretest and post-test

Test	N	Mean
Pre	30	38
Post	30	65

Table 2. T-test analysis of mean scores for each cognitive operation in pretest and post-test

Cognitive operation / Test	K	C	App	Ana	S	E
Pretest	2.50	1.99	1.46	1.31	1.17	0.66
Posttest	3.43	3.04	2.76	2.54	2.13	1.71
Significance value	0.000	0.000	0.000	0.000	0.000	0.000

N = 30; Confidence Interval = 95%

The GOOD learning system that was designed and developed based on the conceptual GLOOTT model has taken into the considerations of pedagogical designs, namely, the generative learning, the reusable learning object, and learning activities that encourage HOTS. In the conventional education, students learn through the passive way that hardly engages them with construction and reflection on their learning, which are essential for the development of HOTS. In contrast, the GOOD learning system provides an environment that helps to engage students with higher order thinking activities, to encourage learners to construct their learning, and to reflect on the consequence of their own thinking.

The conceptual GLOOTT model represents a multifaceted theoretical framework that integrates important components such as learning object, generative learning, the elements that engage students in HOTS, and Web-supported learning environment. The results of the study show that the features of generative learning and learning object design fit well in enhancing learning. This supports the argument from Bannan-Ritland, et al. (2000) that the unique attributes of the learning object design could be incorporated with generative learning from constructivism. Hence, it might be useful for other researchers to investigate this means of integrating learning objects to improve learning.

SUGGESTIONS FOR FURTHER RESEARCH

The lesson map designed in the system was confined to outline form. Thus, the lesson mapping design tool could be extended to network form. This provides options for the students to design their lesson maps according to their own learning styles. The data tracking from the study shows that the students employed various strategies in

Table 3. An example of students' HOTS engagement

Student	Chapter	Checklist Filled	Analysis	Synthesis	Evaluation
P12	1	1st	100%	80%	60%
		2nd	100%	100%	80%
		3rd	100%	100%	100%
	2	1st	100%	100%	80%
		2nd	100%	100%	100%
	3	1st	100%	100%	100%
	4	1st	100%	100%	100%
	5	1st	100%	100%	100%
P29	1	1st	100%	40%	40%
		2nd	100%	80%	80%
		3rd	100%	100%	100%
		4th	100%	100%	100%
	2	1st	100%	80%	60%
		2nd	100%	100%	100%
	3	1st	100%	100%	100%
	4	1st	100%	100%	100%
	5	1st	100%	100%	100%

exploring the system. Such as design lesson map before completing the thinking tasks or vice-versa. Thus, further research could be conducted to determine what and which strategies would yield better learning outcomes. Such a study is useful for instructors to determine how to guide the students. It is also important for the students to know their learning strategies so that they are more alert in their learning. Besides, it also shows that the learning object system could be designed for various learning styles.

The advent of the technology and features of the World Wide Web has spurred the growth of collaborative learning. Hence, the learning object system could be extended to a collaborative learning tool. Such a system would be useful to examine the effectiveness of the system in supporting collaborative learning in achieving the desired learning outcomes.

CONCLUSION AND SUMMARY

The reusability and flexibility of learning objects make them an appropriate instructional design for e-learning. Furthermore, the dynamic features of learning object with the incorporation of pedagogical aspects such as generative learning reveals its potential in supporting learning. It is hoped that this chapter has extended the thinking in regard to the design of learning systems with reusability and flexibility of learning objects in generative learning environments rather than merely the technical aspects of the learning object system design. Technological design alone does not guarantee effective transformation of learners into active learners. Therefore we hope the proposed model can provide a theoretical framework for those who would like to design and develop a technology-supported learning application with learning object towards a more learner-driven and learner-oriented interactive learning environment. Learning experiences that improve HOTS of the students will soon become a common practice in a rapidly changing technological society as the development of information technology has become ubiquitous in higher education.

The proposed conceptual model is useful in designing a learning object system that supports learning. We advocate incorporation of the pedagogical and instructional theories for application into learning object systems. It is hoped that this approach would be resourceful in offering an alternative for technology-supported learning, especially for those instructors who intend to improve HOTS among learners.

In summary, to incorporate generative principles, a learning objects system must generally be able to:

a. Afford reuse of the learning objects.
b. Assist in relating and consolidating the reusable learning objects.
c. Provide an approach to note-taking, which is different from the conventional note-taking by using concept mapping as illustrated in the lesson map of the Web-based learning system.
d. Provide a way of relating, reviewing, and understanding of the content in the learning objects.
e. Provide a tool for construction of existing information by developing the new linkages among the learning objects.
f. Provide an approach to sharing and linking the students' self-designed learning objects.
g. Assist in flexible, constructive, and self-directed learning.
h. Provide a multiple representation of knowledge to illustrate learners' conceptual understanding.
i. Allow the artifacts designed and created by the learners to be shared in the learning.

REFERENCES

Alpert, S.R., & Grueneberg, K. (2000). Concept mapping with multimedia on the Web. *Journal of Educational Multimedia and Hypermedia, 9*(4), 313-331.

Bannan-Ritland, B., Dabbagh, N., & Murphy, K. (2000). Learning object systems as constructivist learning environments: Related assumptions, theories and application. In D.A. Wiley (Ed). *The instructional use of learning objects: Online version*. Retrieved March 31, 2008, from http://reusability.org/read/

Barab, S.A., Young, M.F., & Wang, J.J. (1999). The effects of navigational and generative activities in hypertext learning on problem solving and comprehension. *International Journal of Instructional Media*. Retrieved March 31, 2008, from http://www.findarticles.com/p/articles/mi_qa3756/is_1999901/ai_n8839530/pg_1

Beyer, B.K. (1988). *Developing a thinking skills program*. Boston, MA: Allyn and Bacon.

Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H., & Krathwohl, D.R. (1956). *Taxonomy of educational objectives: The classification of educational goals*. New York: David McKay Company.

Bloom, B.S., Hasting, J.T., & Madaus, G.F. (1971). *Handbook on formative and summative evaluation of student learning*. New York: David McKay Company.

Bonn, K.L., & Grabowski, B.L. (2001, January). *Generative learning theory: A practical cousin to constructivism*. Paper Presented at the Joint Meeting of Mathematics. New Orleans, LA.

Campbell, D.T. & Stanley, J.C. (1963). *Experimental and quasi-experimental designs for research*. Boston, MA: Houghton

Chapman, E. (2003). Assessing student engagement rates. *ERIC Digest*. (ED482269). Retrieved March 31, 2008, from http://www.ericdigests.org/2005-2/engagement.htm

Collis, B., & Strijker, A. (2003). Re-usable learning objects in context. *International Journal on E-Learning, 2*(4), 5-17.

Costa, A.L., & Kallick, B. (2001). Building a system for assessing thinking. In A.L. Costa (Ed), *Developing minds: A resource book for teaching thinking* (3rd ed.). Alexandria, VA: Association for Supervision and Curriculum Development (pp. 517-527).

Dabbagh, N. (2001). Concept mapping as a mindtool for critical thinking. *Journal of Computing in Teacher Education, 17*(2), 16-24.

Dori, Y.J., Tal, R.T., & Tsaushu, M. (2003). Teaching biotechnology through case studies-can we improved higher order thinking skills of nonscience majors? *Science Education, 87*(6), 767.

Fogarty, R. (2002). *Brain compatible classroom* (2nd ed.). IL: Skylight Professional Development.

Hansen, D. (2001). *Effective practices for gifted education in Kansas*. Retrieved March 31, 2008, from http://www.kansped.org/

Harrigan, A., & Vincenti, V. (2004). Developing higher-order thinking through an intercultural assignment. *College Teaching, 52*(3), 113-120.

Jonassen, D.H. (1992). Evaluating constructivist learning. In T.M. Duffy & D.H. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation* (pp. 137-148). NJ: Lawrence Erlbaum Associates.

Jonassen, D.H. (1996). *Computers in the classroom: Mind tools for critical thinking*. Columbus: Merrill/Prentice Hall.

Jonassen, D.H. (2000). *Computers as mindtools for schools* (2nd ed.). NJ: Prentice Hall.

Jonassen, D.H., & Reeves, T.C. (1996). Learning with technology: Using computers as cognitive tools. In D.H. Jonassen (Ed), *Handbook of research for educational communications and technology* (pp. 693-719). New York: Macmillan.

Jonassen, D.H., & Wang, S (1993). Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction, 20*(1), 1-8.

Lim, T.M. (2000). *Prototyping hypercal for exploratory learning of quadrating function*. Unpublished Doctoral dissertation, University Technology of Malaysia, Malaysia.

Liu, M. & Pedersen, S. (1998). The effects of being hypermedia designers on elementary school students motivation and learning of design knowledge. *Journal of Interactive Learning Research, 9*(2), 155-182.

Morgan, T. (1996). Using technology to enhance learning: Changing the chunks. *Learning and Leading with Technology, 23*(5), 49-51.

Parry, T., & Gregory, G. (2003). *Designing brain compatible learning* (2nd ed.). Illinois: Skylight Professional Development.

Reigeluth, C.M., & Nelson, L.M. (1997). A new paradigm of ISD? In R.C. Branch & B.B. Minor (Eds.), *Educational media and technology yearbook* (pp. 24-35). Englewood: Libraries Unlimited.

Resnick, L. (1987). *Educating and learning to think*. Washington, DC: National Academy Press.

Snow, R. (1989). Toward assessment of cognitive and conative structures in learning. *Educational Researcher, 18*(9), 8-14.

Tan, W.C. (2006). *Development and evaluation of a Web-based learning system based on learning object design and generative learning to improve higher-order thinking skills and learning.* Unpublished doctoral dissertation, University Technology of Malaysia, Malaysia.

Tan, W.C., Aris, B., & Abu, M.S. (2006). GLOOTT model: A pedagogically-enriched design framework of learning environment to improve higher order thinking skills. *AACE Journal, 14*(2), 158-171.

Weiss, R.E. (2003). Designing problems to promote higher-order thinking. *New direction for teaching and leaning, 95*, 25-31.

Wiley, D.A. (2000). *Learning object design and sequencing theory.* Unpublished doctoral dissertation, Brigham Young University.

KEY TERMS

Generative Learning: Generative learning is a type of instruction developed by constructivists. The generative learning activities involve the creation of relationships and meanings of the learning. In the generative learning, students are active in the knowledge construction. Experts and researchers advocate that concept mapping and problem solving are activities of generative learning. Concept mapping and problem solving will engage students in analysis, synthesis, and evaluation skills. Thus, it is important to integrate these skills into learning in order to promote HOTS. In the generative learning environment, students are active in constructing meaningful understanding of information found and generating relationships among the information.

GLOOTT Model: GLOOTT refers to Generative Learning Object and Thinking Tasks. It is a pedagogically-enriched conceptual model that consists of learning object, generative learning, and HOTS.

HOTS: HOTS is the abbreviation of Higher Order Thinking Skills. The cognitive operations of HOTS are Analysis, Synthesis, and Evaluation (Bloom et al., 1956; Bloom et al., 1971). Table 4 describes the features of the Bloom Taxonomy of Thinking used in this research (Bloom et al., 1956).

Learning Object: A learning object is a self-contained, flexible, and reusable chunk of instruction that can be assembled with other objects to facilitate the learning.

Lesson Mapping: Lesson mapping is the concept mapping in GOOD learning system. It is the generative learning activity designed in the Web-based learning system that aims to engage students in HOTS. It is an outline form of concept map suggested by Alpert and Grueneberg (2000) and Dabbagh (2001).

Reflection Corner: According to Fogarty (2002), reflective thinking is the foundation of HOTS. Students are self-aware and they plan, monitor, and evaluate their thinking and learning when they engage in reflective thinking. Thus, Reflection Corner acts as a self-assessment tool to help the learners in monitoring their engagement with HOTS and reflecting their learning. It consists of a checklist, called "How am I doing" checklist to enable learners to reflect their engagement with HOTS.

Thinking Tasks: Thinking tasks in this chapter are the scenario-based problems that involve learners with HOTS. Thinking tasks aim to test their understandings as well as to reinforce and practice HOTS as mentioned by Costa and Kallick (2001). There are two parts in thinking tasks, namely Try It Out and Apply It. Try It Out contains multiple-choice questions uploaded by the instructor to assess the students' understanding. Apply It consists of scenario-based problems that engage learners with HOTS.

Table 4. Bloom taxonomy of thinking (from Bloom et al., 1956; Bloom et al., 1971)

Bloom Taxonomy of Thinking	**Features**
Knowledge	Knowledge is defined as the remembering of previously learned material. This involves the recall of specific elements in a subject matter. Knowledge represents the lowest level of learning outcomes.
Comprehension	Comprehension is the ability to grasp the meaning of material. It is described in three different operations: translating material from one form to another, interpreting material, and estimating future trends. These learning outcomes represent the lowest level of understanding.
Application	Application is the ability to use learned material to new problems and situations. For examples, the application of rules, methods, principles, and theories. The learning outcomes represent the higher level of understanding than knowledge and comprehension.
Analysis	Analysis is the ability to break down material into its constituent parts into the relative hierarchy of ideas with the relations between the ideas. This includes the identification of parts and the hierarchical organization, and analysis of the relationships between the parts. Learning outcomes are higher than knowledge, comprehension, and application. Analysis is recognized as an element in HOTS.
Synthesis	Synthesis is the ability to put parts together to form a whole. This involves the process of arranging, combining, and working with parts in such a way as to constitute a new pattern or structure. The learning outcomes emphasize the formation of new patterns or structures and creative behavior. Synthesis is recognized as an element in HOTS.
Evaluation	Evaluation is defined as the ability to judge the values of materials for some purposes or solutions. The judgments are based on definite criteria, either those determined by the students or those given to them. The learning outcomes are at the highest cognitive hierarchy. Evaluation is recognized as a cognitive operation in HOTS.

Chapter XXXV
Applying Learning Object Libraries in K-12 Settings

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ABSTRACT

The author describes the work of Dr. Mary Budd Rowe and the establishment of an early learning object databases. Extensive training with K-12 educators left two lingering issues about learning object library implementation: the question of granularity, and the perceptual chasm between developers of learning object libraries and the practitioners who will ultimately retrieve the objects. An examination of Dr. Rowe's projects, including Science Helper K-8, Culture & Technology, and Enhanced Science Helper provides insight into possible barriers to success when teachers use learning object libraries as a tool for lesson planning. An intelligent lesson-planning tool that populates a student-centered learning environment is proposed as a possible solution to overcome such barriers.

INTRODUCTION

Learning objects libraries have been around for well over 15 years and a great deal of effort has been put into their formalization. Indeed, it may be said that more attention is currently being directed towards the formation of such libraries than ever before. Planning groups, pilot programs, industrial libraries, and standards committees across the globe have been implemented and in some cases are running successfully. It is not altogether clear, however, if learning object libraries will ever be successful in mainstream K-20 educational settings. A "learning object is any entity, be it digital or nondigital that may be used for education and training" (IEEE, 2002, p. 6). A learning object library is a collection of such objects, along with facilities to retrieve them. Learning object libraries are the perfect computer application. They take the work of many and share it globally, make access to the materials simple and straightforward, catalog the materials by universally accepted standards, keyword, process themes, content themes, experience type, suitable learning style, and so on. It is a match made in Heaven: a world full of educational material, and a high speed, networked computer system. The merits of such a system are so obvious most advocates never even ask a very basic question. Unfortunately, we have learned that this question must first be asked: "If we build it, will they come?" Why wouldn't they come? As it turns out, there may be many reasons.

Learning object libraries, like all database systems, have an inherent bias: they are categorical. They maintain information in very specific ways. And teachers do not necessarily think so categorically about their curricula. Even simple databases are rarely used professionally by teachers:

Database design can help users to think relationally, in a detailed fashion, and in an inductive (in aggregating data) and deductive (in disaggregating information) manner. Yet, the conceptual and technical difficulty of databases renders them invisible in terms of classroom use….Complex software such as spreadsheets, databases, simulation software, statistical programs, or "mind tools," (so called because of their ability to promote higher order thinking) are most obvious in US classrooms by their absence. In tracking software use by 300 teachers with whom I worked over a four-year period, only about 12% reported spreadsheet use (mostly among math teachers and for purposes of creating graphs). When math teachers were removed from the equation, spreadsheet use fell to 2%. In eight years of classroom-based work with teachers, I have never witnessed database, GIS, simulation or statistical software use. (Burns, 2005, p. 3)

Apparently, problems with database use are not limited to teachers. In a study of collegiate business students researchers, Chen and Ray (2004) investigated the students' ability to solve a realistic business problem using a database software application. Students made a variety of mistakes applying the database in their work. For example, "the majority of queries were unnecessary queries," "6 of 11 individuals and 5 out of 9 teams performed no planning" (p.15) when using the database, and only one team and two individuals were able to make good conclusions" (p. 16). The researchers reported that "After exposure to numerous demonstrations and exercises involving database tasks such as creating queries, creating reports, and using online help facilities, students were not able to use these procedures to solve a business problem" (pp. 18-19). This suggests that understanding how to use database search facilities is not adequate preparation for solving problems that involve the use of the database.

In the United States, most curricula are aligned with national standards of one sort or another. Most science curriculum developers are well versed in the National Science Education Standards. Individual states have developed their own standards, sometimes deviating from the national standards and sometimes remaining relatively close to them. Teachers are aware of the standards and know they are teaching the appropriate standards for their grade level. However, and this is important, do the teachers really think about the standards when preparing their lessons for the following day? Our experiences indicate that they rarely do, but rather, focus on specific content. This may not matter, since in the United States at least, the textbook companies have taken care of the application of the standards for them. The standards compliance requirements that states and districts demand of textbook companies are systemic enforcers of "best practice" or "expert thinking." Even when states and districts develop curricula, the instructional designers seldom consider the full potential of teachers as codesigners of curriculum materials. Traditionally, curriculum designers view teachers as either transmitters of the intended curriculum or as active implementers of the curriculum materials (Connelly & Ben-Peretz, 1997).

If we consider the categories most learning object designers would use to categorize lessons, including the established learning object category standards put forth in IEEE committees (IEEE, 2002), we find that although they are appropriate identifiers of lessons, they may not be on the mind of most practitioners. Wiley (1999) viewed the lack of an instructionally grounded approach to learning object libraries as encouraging "Clip-Art Instruction," where learning objects simply embellish online lessons. In the European Union sponsored CELEBRATE Project (McCormick, Scrimshaw, Li, & Clifford, 2004), for example, evaluators found that metadata created by an indexer related to the learning resource type may not always reflect how a resource will really be used in classrooms by experienced teachers. A subsequent project called MELT (MELT, 2007) attempts to remedy this situation by using "folksonomies" and "social tagging" facilities (Guy & Tonkin, 2006) that allow teachers to add their own metadata to the system. Whether this strategy is successful remains to be seen, but based on our experience with tagging, which was done by content experts, we would expect a high degree of variation in such a tagging system. That is, multiple tags will be entered to identify the same concept.

In projects directed at K-12 science and social science settings under the leadership of Dr. Mary Budd Rowe, thousands of lessons were catalogued, abstracted, categorized in many ways, and delivered to thousands of teachers. As early as 1983, Dr. Rowe was building learning object databases for use by science teachers across the United States. In these applications, called *Science Helper K-8* and *Culture & Technology*, the learning objects stored on CD-ROM and retrieved by the system were actually lessons, experiments, games, readings, or teacher materials that could "stand-alone." Over 2500 such objects were included in the projects. After her passing in 1996, I led a team of her colleagues to rework some of the material so that it would address the main concerns of previous users of the system. In the newer version additional objects were added, including short videos illustrating certain science concepts. We published the updated version of those materials, entitled *Enhanced Science Helper* in 2000. The Enhanced Science Helper projects contained 1350 objects. Many of us had worked on these projects for more than a decade.

Working with in-service teacher training using our categorically based search engines, my colleagues and I have found that most teachers think about their lessons in fairly straightforward ways, often associated with keywords rather than more global thematic or discipline-centric ways. Preservice teachers, being trained to consider standards and best practices, also rely on topic oriented approaches to their lesson planning. In a dissertation focusing on our work with Science Helper K-8, Dwyer (1998) trained preservice teachers in the use of the Science Helper K-8 CD-ROM and its search engine for at least 6 hours, with the goal of creating a mini-unit (three or four lessons) on a science topic of their choosing. Even after training, only 34% of the subjects used content and process themes appropriately, with others indicating that they simply scanned through the topics or applied randomly selected criteria (11%).

Unfortunately, not all teachers are likely to use materials outside their textbook and day-to-day experiences to help them compose lessons. Needles (1991) found that beginning primary teachers tend to be more concerned with in-school experiences such as lesson content and classroom management, while Hodson (1993) found that even teachers with a coherent understanding of science do not plan lab activities aligned with that understanding. Instead these teachers also focus on more immediate issues such as classroom management and student development.

No matter how learning objects are categorized, categorization schemes themselves are subject to temporal bias. For example, consider the field of educational technology. Winn and Snyder (1996) have argued that as educational technology was established as a discipline when behavioral principles dominated psychology, behaviorism initially provided the most common perspective on instructional design. As theories of learning have developed and educators have gained more experience of using computer-based technology, there has been a shift of emphasis from the behaviorist paradigm to a constructivist view. That is, over the years, the role of the learner has taken precedence over the strict behaviorally-based design aspects of learning artifacts in the research. Although it is easy to imagine a learning objects library developing over several years, it is difficult to imagine perspectives on categorization being constant over time.

The second question we must ask is about granularity. Granularity refers to the *size* of a learning object. What size should a learning object be? Should it narrowly address a specific concept, or contain a *combination* of concepts that support the understanding of each? Unfortunately, there is not necessarily a correct level of granularity for a learning object. In a well-crafted learning experience there is a great deal of symbiosis between lesson parts. To some extent, the way one describes the context of an object helps define the object. While instructional developers may find it useful to move from the course level to the concept level when designing (South & Manson, 2000), teachers may remain focused on course goals when assembling objects. A report issued by the Wisconsin Online Resource Center on their ultimately successful Learning Objects Project (Chitwood, May, Bunnow, & Langan, 2004) illuminates these issues:

As learning objects began coming into the technical team in early May of 2000, reviewers realized that what was coming in was often an entire learning activity complete with delivery instructions rather than a chunk of learning information that might or might not be interactive for students. Some developers were working under the impression that learning objects were developed solely for faculty so had to be redone completely. Other developers created highly innovative activities but did so by creating them thematically rather than looking at each as an independent, self-contained chunk of learning; many in this collection needed to be re-adapted for use as learning objects that could stand alone. Still other developers sent in ideas with no supporting information such as what a student might need to do to activate the learning object or how they might interact with it once inside, so they needed to add detail to their submissions.

In the majority of cases, developers who initially believed they had a clear idea of what a learning object is actually submitted ideas and information that was far enough off the mark that they needed major revision before they went to the programmers. (p. 20)

South and Monson (2000) have defined a "context threshold" on a spectrum that ranges from objects that are "too intertwined in the material that precedes and follows it to be efficiently extracted and reused" (p. 4) and those that have such a lack of context to be simply "unassociated media" (p. 4). At some point on the spectrum, objects also cross a "learning threshold" (p. 4) in which it "no longer retains enough internal structure to be recognizably oriented to a learning purpose and loses its embedded instructional utility" (p. 4). Wiley (2003) has noticed that many "instructional designers of learning objects problematically focus on removing as much context as possible in order to maximize the reuse of the learning objects they create" (p. 2). For example, in the MELT project (MELT, 2007), partners concluded that content that travels well (is reusable across countries and languages) has a strong visual element with just a few text labels. In use, however, teachers (and students) may need tightly related background material to explain the significance or application of the visuals. While breaking down resources into many smaller units may help them become reusable across borders, it increases the effort required for "discoverability" (Wiley, South, Bassett, Nelson, Seawright, & Monson, 1999). The burden of recontextualizing the objects falls on the user of the learning object library. This recontextualization adds significantly to the cost of a learning resource and in some case may prohibit its use altogether (Downes, 2003). Although component reuse has been successful in military and NASA settings (Agresti & Evanco, 1992), it is not necessarily the case that every teacher is capable of such work. Spalter (2002) reported that:

Our feeling is that the answer for the lack of success in the creation of reusable component building blocks for education cannot be ascribed solely to software engineering issues…The social issues, platform problems, and severely limited funding and time-scales preclude the application of many software engineering recommendations, including, say, establishment of reuse teams in addition to regular programmers [Poulin 1999]. To add to these difficulties, there are a great many complex and poorly understood issues that affect educational software, making it difficult to analyze in terms of components. These issues include topics such as pedagogy, assessment, and classroom implementation. Even if a set of successful components is created for a given domain, the problems of interoperating with components from other subject areas, or within the same subject area but at different levels of sophistication and abstraction, are formidable. (p. 5)

Shulman's (1986, 1987, 1992) concept of pedagogical content knowledge separates content and "deep" understanding of a subject from knowledge of curricular development. This type of knowledge is seen as craft knowledge or "integrated knowledge" that represents teacher "accumulated wisdom" (van Driel, Verloop, & De Vos, 1998, p. 674). It is unlikely that beginning teachers have an adequate pedagogical content plus the programming knowledge to judge and assemble lessons from a variety of disaggregated units with varying sizes and applied purposes, even though they may be able to disassemble and rearrange single resources (Reigeluth & Nelson, 1997). Duffin (2004) reports that:

While some aspects of development that previously were done by a programmer have been made accessible to teachers, others have not. Despite the components and other approaches to reuse most teachers are not creating interactive online materials. (pp. 19-20)

When decisions about granularity are made, the question of whether or not an object can stand-alone is often a trade-off. In two of our projects, *Culture & Technology* and *Enhanced Science Helper*, we divided formal lessons into subcomponents that we determined to be reusable. We found that although these subcomponents could stand alone, they were strengthened by their original context to such an extent that we developed a way of linking such objects to their original lessons. This is consistent with the work of Laleuf and Spalter (2001) who found a tradeoff between "too many features and not enough flexibility, or having so fine-grained a set of components that a great deal of work still needed to be done to create the final product" (p.3). Their solution was to "produce a complete set of subcomponents, thus providing objects at all levels of granularity" (p. 3). Of course, having variation in granularity leaves the work of sorting out the integrative value of the objects to the end-user of the repository, in this case the teacher. For example, consider the Nardoo River simulation. In this simulation, a number of investigations are presented to the learner(s). A learner, or team of learners, can carry out a single investigation and become immersed in a "real" situated process (Harper, 1996). However, because the entire set of investigations has been carefully constructed, much is lost when students work only one individual investigation. Teams of students working different investigations view different perspectives on the same problem, thus strengthening the lessons learned in the simulation. To some extent, every well-crafted lesson has background information or support materials that make the lesson more robust or meaningful. Who should provide this information? Who is best qualified to provide it? Who has time to provide it? Of course there are systematic ways to group or link lesson objects in meaningful ways, but there is still a question about how to best make a lesson more than the sum of its parts.

BACKGROUND

The launching of Sputnik in the 1950s sent shock waves through the educational system of the United States. Fearing that the United States was not prepared to handle future challenges in science and mathematics, the National Science Foundation and other agencies began to fund a plethora of curricular initiatives in the fields of math and science. Some of the most well researched science and math curricula ever made (SCIS, SAPA, ESS, COPES, USMES, MINNEMAST, ESSP) were developed as a result of this funding (see http://www.coe.ufl.edu/esh/index.html for a description of these projects). For the first time, the development of what we have come to call scientific literacy beginning with the youngest pupils was the focus of national attention in the United States (see Bruner, 1960). By the late 1970s however, many of the curricula and text materials developed were no longer being used. Textbook companies of the day "borrowed" many of their activities from funded projects, but the projects themselves had ceased to be funded. Dr. Mary Budd Rowe had been engaged in discussions with educators who were worried about losing these extraordinary curricular materials, which had been created by the best American science educators in top universities and tested in diverse classroom settings. The advent of the personal computer and its increasing role in education gave Dr. Rowe an idea. What if all of the materials funded by NSF in the post-Sputnik era could be archived using computer technology? In typical Mary Budd Rowe fashion, she began investigating archival tools and developing her idea. A visit to the Library of Congress led her to believe that laser disc technology was the best approach. She applied for funding from the Carnegie Foundation and began assembling a team at the University of Florida.

While discussing her idea with colleagues in Washington, D.C., she was told that the U.S. Navy had a new device for information storage that might be more suitable for her needs, though details of the device were sketchy. She was soon to find that although the Navy had such a device, she would need top-secret clearance to see it. By Dr. Rowe's accounts, it took her several weeks to obtain the clearance necessary to see the new device. Once she saw it, she was convinced that the device, called a CD-ROM drive, was the way to archive the information. She procured the funding from the Carnegie Foundation of New York and began the *Science Helper K-8* project at the University of Florida. Her plan was to use CD-ROM technology to archive the post-Sputnik curricular materials. Unfortunately, no one knew how to store, archive, and retrieve such information. One member of her team, a young graduate student from Australia named Bob Melczarek, was very interested in the newly acquired computer technology and accepted the challenge to write a database application that would access the lesson material. To "capture" the pages of curricular information, the pages were photographed at a newspaper publishing center, 12 pages at a time. Melczarek developed a means to "cut up" the page images and a compression scheme to store the pages. He also set out to explain the concept of a computerized database to the team.

As Dr. Rowe and the less technical team members working on the Science Helper K-8 project began understanding the power of a database retrieval system, they began to see an opportunity. Dr. Rowe had always believed that teachers (and students) spent too much time on the minutia of science, but failed to see what she called the "pillars of the discipline," the "big-picture" ideas that form the framework for science inquiry. A major task of the project was to develop a "meaningful" search facility that would provide teachers a way to find learning resources quickly and easily. The opportunity, which became the team's hidden agenda, was to create a tool that would, through use, help teachers become familiar with the major organizing processes and themes that experts use to describe their disciplines. The team hoped that by interacting with a well developed search facility a teacher would actually learn to identify and ultimately organize their thinking around the processes and themes presented as choices in the search tool. Around this time, Pea (1985) had noted that pragmatic systems "may have the peripheral consequence of pedagogic effects, that is, they may contribute to understanding but not necessarily" (p. 84). The team decided that the key to the entire search process, that is, the key to promoting the transfer of pedagogic information such as content and process themes to the teachers and other users of the system was in the organization of the information. A good search facility was dependent on intelligent organization. Although this seems trivial to proponents of learning object libraries today, it was light years away from archiving the materials as books using a table of contents. In those early days of personal computers, developing a set of organizing parameters that would transcend the data and encompass all the instructional material being archived was beyond the ken of teacher educators.

Table 1. Categorization scheme for science helper series

Project	Where did the resource come from?
Book	Title of the book in which resources where found
Resource Type	Lesson, Experiment, Game, Reading, and so forth.
Lesson Title	Actual Title
Resource Title	Meaningful name assigned by abstracter
Suggested Grade Level	Found in the resources themselves
Rated Grade Level	Abstracter's opinion of appropriate grade
Subject	Example for science: Astronomy/Space science, Botany, Chemistry, Earth Science/Geology, Ecology/Environment, Engineering/Technology, General Science, Human Science, Life Science/Biology, Mathematics/Statistics, Physical Science
Process Themes	Applying/Problem solving, Classifying, Communicating, Controlling variables, Experimenting, Hypothesizing, Inferring, Interpreting data, Measuring, Modeling, Observing/Recording, Operationally defining
Content Themes	Energy, Instruments, Interaction/Change, Patterns in nature, Space/Time relationships, Statistical view, Structure of matter, Systems, Tradeoffs
Keywords	Words identified by abstractors as being central to the lesson
Precautions	Abstracter's view of safety hazards, dated material, appropriateness, and so forth.
Links	The names of other resources which relate to this resource.

It should be noted that similar procedures were followed in all projects the team undertook in the 17 years that followed. These projects included Science Helper CD-ROM (the first project), Culture & Technology (15,500 objects in science and social science), the Science Helper Video Series, and the Enhanced Science Helper CD-ROM. A few additional categories were added to the search engine to accommodate the social science materials in Culture & Technology, and National Science Education Standards were added to the Enhanced Science Helper CD-ROM). Following is a brief description of how the team organized the information.

First, highly qualified readers (scientists, science experts, and original authors) became familiar with the learning object, that is the lesson, experiment, educational game or other resource by reading it, viewing it, playing it, or otherwise engaging in the activity. The reader would critically examine the object denoting themes, processes, keywords, and so forth. Then, the reader would categorize the lesson according to criteria that were painstakingly developed over several months (see Table 1).

Finally, the reader would write a brief *abstract* describing the resource. The abstract insures that a searcher will be able to quickly determine the scope of the lesson and its appropriateness for a particular application.

The above process was carried out for every lesson. When many readers work on a project, a great deal of communication is necessary to assure consistency. Moreover, discussions often came down to the semantic level concerning process themes, content themes, and even keywords.

Central to the development of the search facility was the idea that humans had categorized all of the information that was to be searched. When a person used our system to search for a keyword, they were directed to a lesson that included the keyword in a meaningful way as judged by the abstractors, even if the word *did not appear in the content* of the lesson. This lies in sharp contrast to a computer-based word search, which returns every lesson mentioning the word in any context. Of course when humans categorize items their categorizations are subjective, so human error is possible. In other words, there are tradeoffs related to each method (Foti, 2004a).

Once the abstracting process was complete, the team entered the information into the database and massaged it into a consistent form by multiple review iterations through the data. Multiple forms (plurals, etc.) of the same keyword, for example, had to be eliminated. In a database containing thousands of keywords, this is a formidable task. Some processes can be automated while many cannot. Database management involving multiple views of the data, or multiple layouts and several hundreds of iterations through the data were required (Foti, 2005).

It is important to point out that in the case of the Science Helper K-8 project (and our similar subsequent projects) the development team was constructing the *entire* library of objects. Foremost in our minds as developers were issues of accessibility and clarity. We found it difficult, even with a limited number of very knowledgeable reviewers, to insure that criteria were applied in the same manner by all. This is a significant point since today's learning object libraries invite contributions from a variety of sources. While much attention is given to ensuring the proper form for submissions, it is highly unlikely that sufficient attention can be given to consistency of submissions with respect to how well certain attributes map to the objects. For example, suppose a reviewer is given the task of deciding which process themes apply to a given learning object. Suppose that the learning object is a virtual dissolved oxygen experiment with a graphing feature. Further, process themes have been itemized as: Applying/Problem solving, Classifying, Communicating, Controlling variables, Experimenting, Hypothesizing, Inferring, Interpreting data, Measuring, Modeling, Observing/Recording, and Operationally defining. Some reviewers might claim that all of the themes apply, others might insist that only a subset of the themes apply. During our projects we had lengthy discussions about whether only highly related themes should be recorded or whether we should be more liberal and provide "looser connections" into the data. Of course, how reviewers evaluate and categorize objects has a significant effect on the user. Should the user expect to be given more or fewer choices to scan? To some extent, the answer depends on the size of the repository and the variation between entities stored in the library. Unfortunately, these parameters are always in flux in a learning object library that is growing, that is, in operation. Reviewers' rating assessments related to the strength of a map between the object and a given theme or standard affects the interoperability and effectiveness of the library itself. To overcome this problem, we developed a strength parameter that allowed reviewers to quantify the strength of the map between the object and the theme being rated. We found, however, that there was enough rater bias to make composite ratings meaningless. We ultimately dropped the use of the strength parameter from our search algorithm. There is reason to believe, therefore, that in a learning object library that allows open submission of objects a wide degree of variation might exist between descriptors such as themes, standards, and even content addressed by the submissions.

During the course of our projects, we ran training seminars for a variety of audiences. For example, in the original Science Helper K-8 project, Dr. Rowe invited State Science coordinators from all 50 U.S. states to participate in training. Over the years we trained in-service teachers, pre-service teachers, district science coordinators, and conference participants at a variety of conferences. After several years of such training, our formal and informal observations have produced a consensus among team members about how individuals react when introduced to our system, and how they ultimately use the system.

LEARNING OBJECTS AND THE TEACHER

Currently, many learning object practitioners envision a future where students will have direct access to learning object lessons. Systems will allow proactive learners to search for and find their own learning objects and engage in self-directed learning. While applications that focus on individual learners may indeed proliferate, we focus here on a model in which teachers are lesson developers and learning object tools are used primarily by teachers and curriculum developers. Even though teachers are trained in pedagogical theories, accessing objects using categorical descriptions may still cause confusion. According to Hodgins (2004):

Metadata will be derived that can adequately describe every piece of data, every object, every event, and every person in the world. Objective metadata, most of which can be generated automatically, describe physical attributes, date, author, operational requirements, costs, identification numbers, and ownership and so on. Subjective metadata are the more varied and valuable attributes of a learning object, and are determined by the person or group who creates the metadata… It is especially the subjective attributes or metadata that create the ability to capture what is otherwise tacit knowledge, context, perspectives, and opinions. (pp. 79-80)

Hodgins describes a perspective on learning objects that begins to uncover the difficulties in their widespread use. Objective metadata embodies the characteristics that illustrate the "perfect fit" between learning objects and computer retrieval, between instruction and automated delivery systems. Instructional strategies that assume traditional cognitive processing models such as Driscoll's (1994) Cognitive Information Processing (CIP) model or Merrill's (1999) ITT theory perfectly support a straight-forward view of learning object library applications in that they separate process and content. The assumption is that one can organize instruction into meaningful teaching by providing a variety of activities for the student that will result in the student having developed an appropriate cognitive framework and the necessary knowledge to *understand*. In this model, the designer is in complete control, prescribing what is made available to the learner, even if the learner functions in an inquiry-based learning environment. Many intelligent tutoring systems are based on such instructional strategies, and many educators subscribe to viewing instructional design as a series of properly sequenced learning activities. When introduced to learning object libraries, teachers with little learning object experience also embrace this idea, searching in relatively simplistic, de-contextualized ways. For example, a teacher might search for a lesson by using the keyword *caterpillars*, promoting content mapping over pedagogical mapping. While separating process and content works well for skill building, it may not be appropriate for all teaching modalities.

In a comprehensive national U.S. study, Becker (1998) reported that teachers with a constructivist orientation were much more likely to use the Internet for instructional purposes. A more student-centered view of learning is more likely to elevate the role of situated cognition, cognitive flexibility theory and inquiry-based models in the teacher's mind. To adequately address these issues a learning object library has to be very robust in its application of subjective metadata. Identifying the context in which a particular learning object was used effectively, and precisely how the outcomes were achieved may provide teaching practitioners with a deeper understanding of the object's value. It can also provide the teacher with a better understanding of how to employ the object in a more generative student experience. Unfortunately, it is time consuming to submit a robust description of the subjective metadata associated with a learning object, and perhaps more difficult to quantify results in any consistent way in a learning object library. For example, pedagogical theories that practitioners might apply and submit to a library could involve complex vocabulary that may not be used consistently in the research. Even the term *learning object* means different things to different people! In addition, the complexity of pedagogical theories confounds their use as descriptors. Moreover, to be used effectively, teachers would have to be familiar with the terms being used by authors of each learning object and understand which aspects of the related theory were being applied in the object. Alternatively, those maintaining the learning object repository would have to refine submission data to make it more consistent and understandable. In our experience, we found this type of refinement to be difficult and unreliable across multiple reviewers. If machines were to provide this maintenance function they would have to be programmed by teams that understood both content and pedagogy at a very deep level and would be willing to frequently update the code to accommodate theory building. This is an expensive undertaking. Many computer scientists addressing the technical problems associated with building a comprehensive learning object library underestimate the intricacies of including practitioner-centric subjective metadata. However, to effectively augment user performance, this type of data is essential particularly in curriculum development efforts.

While different educational practitioners may approach learning object libraries in different ways, they will all use learning object libraries during lesson development. At this point, teacher needs are fairly well defined (see Figure 1). The appeal of the learning object library as a reference is never clearer than it is at this point. What if teachers could simply enter a few criteria and be presented with a "perfect" lesson?

However, as we have seen, developing a categorization scheme for educational materials is a complex undertaking. Indeed, creating *any* database that accurately describes its content is difficult. The developers of a learning object library and international standards committees painstakingly review categories and identifiers iteration after iteration. In time, a fairly accurate description of the learning material is reached, complete with pedagogical references, sources, grade level appropriateness, readability, and so forth. The description may include content themes, process themes, related national, state or provincial standards, and so on.

Unfortunately, it is likely that many teachers who will ultimately access the library will not think in those terms. Our work with teachers indicates that given a sophisticated search engine, teachers request information at a fairly rudimentary level. Rather than asking for materials related to *hypothesizing* or *patterns in nature* for example, they ask for materials related to *frogs* or *salamanders*. In fact, keyword searching was the most common way teachers requested information (Dwyer, 1998). Many of our studies were undertaken before Internet search engines were common, and we often provided preliminary instruction on the power of using meta-level searching. Still, teachers gravitated towards keyword searching, presumably because their internal organization scheme consisted of topic-related information. In other words, teachers do not often focus on curriculum and specific lessons at the same time, and since curriculum development is often done at the school district, state, provincial, or national level, many teachers do not think about global curricular issues at all. According to Ben-Peretz (1990), curriculum designers and teachers have little or no regular conversations with one another. This means that if a learning object library is based on curriculum standards and meta-level processes, there will automatically be a chasm between the library and the implementation of its elements (see Figure 2).

Teachers work in a highly contextual environment where local classroom concerns often trump more theoretical issues. Lesson plans are not often categorical descriptions of what the lesson will address. Even with the intense push

Figure 1. The great promise of learning object libraries

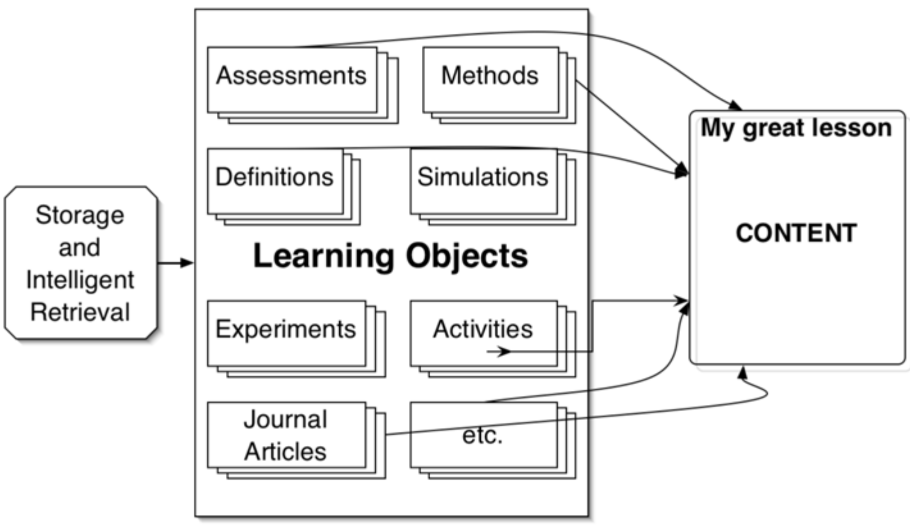
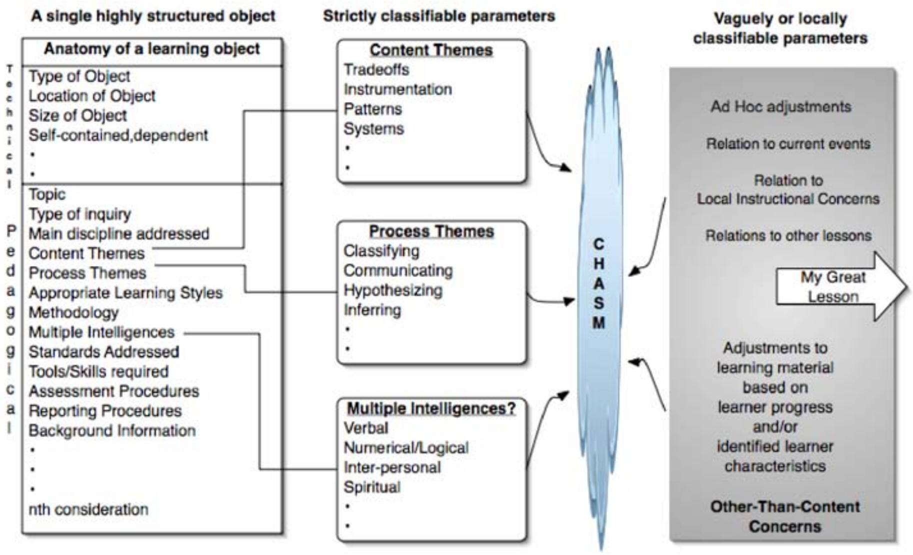


Figure 2. The chasm between the repository and the teacher's needs



towards standards-based testing, most teachers' concerns are with events related to the classroom and student needs.

The problem is amplified by the concerns of those attending to the issues on the opposite side of the chasm. Library developers, and ultimately standards committees, view learning objects as n-dimensional objects where the number of dimensions is limited only by the awareness of the cataloging agency. Curriculum developers could create hundreds of descriptors to help teachers identify and locate objects that meet complex pedagogical needs. Methods and procedures associated with the library may be self-referential and relational. However, from a teacher's point of view, methods associated with a specific learning activity are often dependent on learner knowledge, behaviors, situation, and preferences (Foti, 2004b).

THE FUTURE

It is clear that the concerns of educational practitioners are somewhat detached from the categorical descriptions in a sophisticated learning object repository. What is needed is a system that will conflate the requirements of the user and the computerized repository while identifying the needs of the user and isolating objects that would augment user performance. How would such a system work? Can it be designed to preserve the integrity of the learning object library? Can it cross the bridge between teaching as an art and teaching as a science?

A logical place to augment the performance of an educational practitioner would be during a lesson planning activity. To truly augment performance an artificially intelligent system would be in place that would determine teacher needs based on an analysis of a teacher's lesson plan narrative. As a teacher types a lesson plan, the system monitors the teacher's writing and searches a knowledge base for associated concepts. The knowledge base, which is context sensitive to the grade level, subject and other parameters related to the teacher's task, contains appropriate information for the particular search at hand.

For example, suppose a middle school teacher begins writing a lesson plan that includes the words *inclined plane*. The intelligent processor constantly monitors the teacher's plan as it is being written and "decides" that since the narrative contains words like *sliding* and *abrasion*, and not *rolling* and *wheels*, the lesson is probably about friction rather than acceleration. The

Figure 3. Basic implementation components

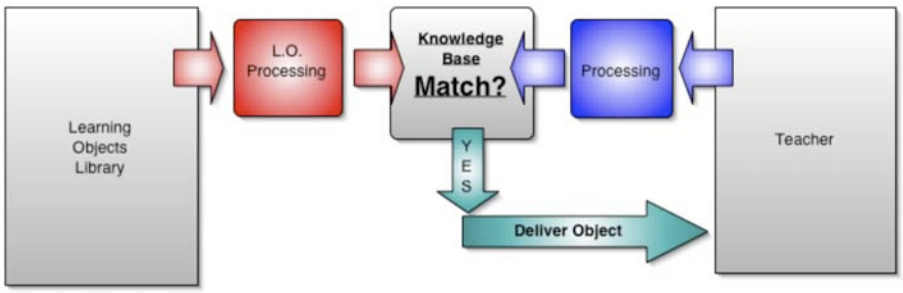
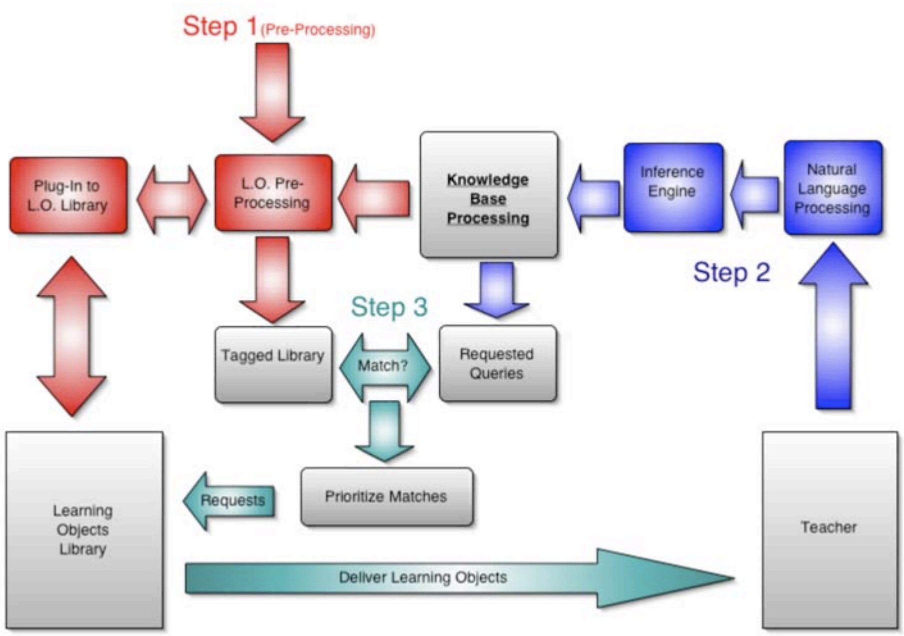


Figure 4. Bridging the chasm between repositories and teachers



system refines the search as the teacher expands the lesson plan. Notice that the narrowing of the search relies heavily on the context of the lesson, namely middle school science. A simplistic view of such a system appears in Figure 3. Processing occurs on both sides of the diagram, with the interpretation of teacher needs being processed on one side and the matching of appropriate learning objects happening on the other. The set of concepts contained in the knowledge base is context sensitive. In other words, a teacher with a different profile would instantiate a different knowledge base component.

The Knowledge Base is essentially a database that contains a set of finely grained organizational parameters for a specific content domain. In fact, this implementation is based on a knowledge base that is strictly related to a limited educational sphere. To apply this model in a universal context, a variety of knowledge bases would be used, switching out the knowledge bases for a specific application. In the example above, a knowledge base designed for middle school science was applied. The Knowledge Base module, since it is designed to address a narrow content area, contains an extensive set of lesson related concepts organized at a level of granularity that generally exceeds the level of national science standards and similar standards. The Knowledge Base will interface with the strictly classifiable parameters of the learning objects library as well as with the teacher requests. Natural language processing and an inference engine are used to refine and generate Knowledge Base requests from determinations of teacher intent. The teacher intent processor also strives to map issues related to structure (definitions, facts, examples, non-examples), concept types required (procedure, process, principles), and media type (animation, illustration, video) (Foti, 2005).

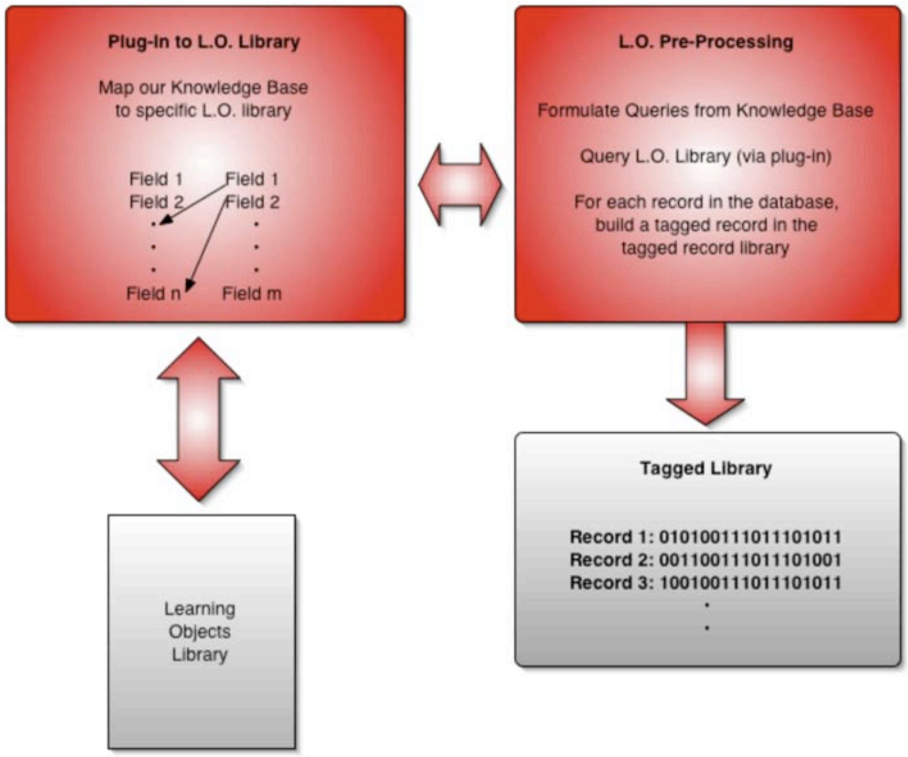
A more detailed view of such a system is provided in Figure 4. Step 1 in the process involves synchronizing the learning objects library with the knowledge base. Since the knowledge base applied to an inquiry is specific to the content domain, the knowledge base will have its own internal knowledge representation configuration and categorization scheme. The system assumes that the knowledge base can be mapped to any given learning objects repository. In practice, a robust system might employ several decentralized libraries. A plug-in mechanism is used to carry out the synchronizing of the knowledge base to a given learning objects library. Creation of the plug-in will require an understanding of the knowledge base structure and the library structure in order to establish a "handshake" between the components, and human intervention may be necessary. Figure 5 illustrates the remapping of a particular knowledge base to a particular learning objects library. Since the knowledge base contains a finite set of specific search parameters, a binary string can be constructed to represent each request. These requests may then be mapped to corresponding records in the library.

In Step 2, a nontrivial natural language processor is applied to the teacher narrative that interprets the teacher lesson-building. The user-processing module infers the needs of the user related to a user profile and maps the processed requests to the knowledge base, building a query list. For example, a teacher narrative by an eighth grade teacher indicating the need for background information related to a pendulum experiment might generate a query list for the content, such as Periodic Motion, Simple Pendulum, Length of Pendulum, Suspended Weight; the content themes of Patterns in Nature, Systems; the appropriate Science Standards; and so on.

Finally, in Step 3 the system matches the query list from Step 2 with the plug-in processed records mapped to the knowledge base in Step 1. The prioritized list of objects from the library is presented to the teacher for approval and/or incorporation into the lesson.

One can envision a learning environment that would readily receive such objects and allow construction of the student-based learning

Figure 5. Preparing to compare requested data to library data



module as part of the planning process. Along with my colleagues at The Athena-Group, Inc. in Gainesville, Florida, we designed and built such a learning environment. Through funding from The National Institutes of Health in the U.S., we built a learning environment that allowed lessons to be composed using a wide variety of data types. In other words, the learning environment is a container in which the teacher/designer can compose a lesson by assembling learning objects in a meaningful way.

Central to the learning environment's functionality was the PSI Tool, a Personal Study Instrument. Teachers can create learning modules that are composed of various learning objects by building a module's PSI Tool, that is, by placing linked buttons or button sets in the PSI Tool. Figure 6 shows the PSI Tool.

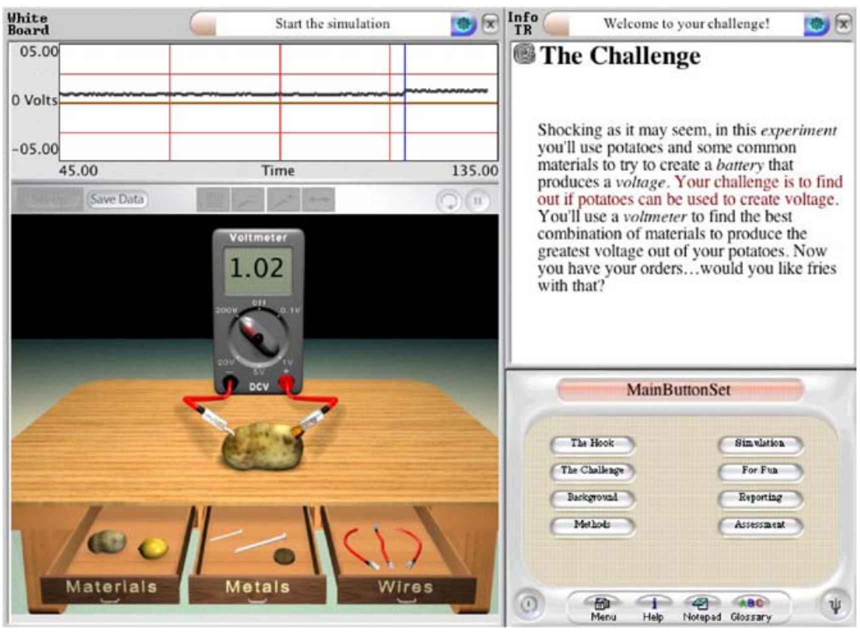
Figure 6. The personal study instrument (PSI tool)

Components of the lesson, such as background material, local context issues, assessment requirements, simulations, and reporting templates may be organized by the teacher to create multiple lessons with the same material. In our lessons, for example, we created different PSI Tool representations for different student learning preferences: Directed (step-by-step), Guided, or Inquiry. The system contains local and global glossaries, a notepad and video help (Neelands, Ledbetter, Foti, & Alkazemi, 2003).

The presentation of the module allows content objects to slide in and out of the screen under the control of the student. Real-time interaction and virtual activities are possible (see Figure 7). A key issue here is that the teacher *composes* an experience that may be much greater than the collection of material in the learning environment. When creating a lesson, the instructor is working at the level of the lesson, making decisions about content, context, and learning styles of the student. The instructor can create multiple paths to the knowledge, and temporally control the presence of buttons. Since this type of lesson development may involve objects with varied pedagogical orientations, teachers will have to understand more about the effectiveness and appropriate use of various instructional and media types. This has implications for teacher training institutions that focus on the teacher as consumer rather than the teacher as developer.

The containers used in a learning environment such as the one shown in Figure 7 are extremely important in that they allow the student to access the various learning objects in exactly the same way. In addition, lesson components, that is, individual learning objects, may have a high degree of fidelity between them. Although each object might stand alone, together the components have added value. Consider background information and a simulation, for example. The simulation may help a student understand background material

Figure 7. The learning environment with PSI tool and other containers



that was unclear, since it may be easier to express a process using interactive elements rather than in a narrative.

Although the size of a learning object "unit" may be defined by a project, there is still a question about how to deal with lessons that are well constructed assemblages of learning objects. Should the composed lesson shell be considered an object, while its components are also objects? If a categorical descriptor in a learning object could specify a list of each learning objects parents, the search facility could reassemble lessons on the fly. Since a given learning object might be a component of several such "lessons," operationally the descriptor would need to be a list. For example, if I am looking at a learning object that addresses the coefficient of friction, I would be able to browse through some previously composed lessons in which the learning object I'm viewing appeared. While the storage of these larger lesson compositions would seem counter to the self-contained idea of primitive learning objects, it would go a long way in helping novice teachers in their lesson planning. The IEEE metadata standards address these issues in Aggregation Level and Structure descriptors, but issues of lesson ownership, or at least lesson "parents" when lessons are repurposed may still be problematic.

The *lesson browser* might be a separate application that imports learning objects from the library as lessons are called up by a user or the user's inference engine. Ultimately, the facilities that are built around a learning object library should be judged on their ability to add value to the users of the system. While many of the features and facilities associated with a robust learning object library will grow organically, based on the needs and requests of users, it seems likely from our past experience that issues of granularity and lesson composition will need to be addressed in a meaningful, practical way. It is logical to assume that mass acceptance of learning object libraries will occur only after the process has become completely supported electronically, from lesson inception to the completion of a learning environment that is ready to apply to the learning task at hand.

CONCLUSION

Historically, learning object repositories were created using set of categorical descriptors developed by a team of database engineers and content experts. Even though international standards have been established to increase the interoperability of learning objects, there is no compelling evidence that educational practitioners will embrace learning object methods and models that are being developed. This is due to the fact that teachers engaged in lesson planning may not feel inclined to browse through a number of learning objects trying to verify that someone else's learning object will suit their immediate needs. Furthermore, they may not use or even understand the same pedagogical descriptors that the library creators applied to categorize the objects. Our experience indicates that teachers will not embrace any learning object retrieval system that makes it necessary for them to evaluate the granularity of each of a set of objects, or to spend a great deal of time mapping the objects to their envisioned lesson. It seems likely that teachers will not truly embrace the integration of learning objects into their routines until the process of lesson planning and lesson building is integrated. This process entails a much more automated way of accessing learning objects and a well-defined, flexible, easy-to-use learning environment in which objects can be placed for immediate dissemination to students. In the years since our work with the Science Helper series, we have created a learning environment that allows teachers to call up objects for inclusion in lessons, but our tests show that a system with more automation is required. We propose a model for such a system that requires a high degree of automated expert intelligence applied to a variety of components within the system. A lesson plan editor in which teachers can access a variety of objects predetermined to relate to their immediate needs and place them within a robust learning environment that they can craft for their students may have widespread appeal. We can only hope that if we build it, they will come.

REFERENCES

Agresti, W., & Evanco, W. (1992). Projecting software defects. *Analyzing Ada Designs in IEEE Transactions on Software Engineering, 18*(11), 988-997.

Becker, H.J. (1998). *Internet use by teachers: Conditions or professional use and teacher-directed student use.* Teaching, Learning, and Computing, 1998 National Survey. Report #1. National Science Foundation, Arlington, VA. Washington, DC: Office of Educational Research and Improvement (ED)

Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts.* Albany: SUNY Press.

Bruner, J. (1960). *The process of education.* New York: Vintage.

Burns, M. (2005, March 8-15). Just right: Rethinking the how and why of technology instruction. *Ubiquity, 6*(8). Retrieved April 1, 2008, from http://www.acm.org/ubiquity/views/v6i8_burns.html

Chen, C., & Ray, C. (2004, Spring). The systematic approach in teaching database applications: Is there transfer when solving realistic business problems? *Information Technology, Learning, and Performance Journal,* 22(1). Retrieved April 1, 2008, from http://www.osra.org/itlpj/chenray-spring2004.pdf

Chitwood, K., May, C., Bunnow, D., & Langan, T., (2004). *Battle stories from the field: Wisconsin online resource center learning objects project.* Retrieved April 1, 2008, from http://reusability.org/read/chapters/chitwood.doc

Connelly, F.M., & Ben-Peretz, M. (1997). Teachers, research, and curriculum development. In D.J. Flinders & S.J. Thornton (Eds.), *The curriculum studies reader* (pp. 178-187). New York: Routledge.

Downes, S. (2003). Design and reusability of learning objects in an academic context: A new economy of education? *USDLA Journal*, *17*(1). Retrieved April 1, 2008, from http://www.usdla.org/html/journal/JAN03_Issue/article01.html

Driscoll, M.P. (1994). *Psychology of learning for instruction.* MA: Allyn and Bacon.

Duffin, J.W. (2004). *Theory for authorizing tools that support teachers adaption of mathlets.* Doctoral Dissertation, Utah State University, Logan, Utah. Retrieved April 1, 2008, from http://matti.usu.edu/duffin/diss/jd-diss.pdf.

Dwyer, W. (1998). Conceptual changes arising from the use of a search interface developed for an elementary science curriculum database. Unpublished Doctoral Dissertation, University of Florida, Gainesville, Florida.

Foti, S.L. (2004a, June). *The relationship between technical and pedagogical aspects of learning object libraries.* Paper presented at the Partnership for Global Learning Conference on Learning Objects, Orlando, Florida.

Foti, S.L. (2004b, February 1). *Learning objects: Closing the gap between the technical and the academic.* Paper presented at the SSCCII 2004 Symposium of Santa Caterina on Challanges in the Internet and Interdisciplinary Research, Amalfi, Italy.

Foti, S.L. (2005, March 17). *Evaluating learning object libraries.* Paper presented to the Grant Review Conference on European Union Funded Learning Objects Projects, Porto, Portugal.

Guy, M., & Tonkin, E. (2006). Folksonomies: Tidying up tags? *D-Lib Magazine*, *12*(1). Retrieved April 1, 2008, from http://www.dlib.org/dlib/january06/guy/01guy.html

Harper, B. (1996). *Using cognitive tools in interactive multimedia*. Paper presented to the AUC Academic Confrenece From Virtual to Reality, The University of Queensland, 1996. Retrieved April 1, 2008, from http://www.auc.edu.au/conf/Conf96/Papers/Harper.html

Hodson, D. (1993). Philosophic stance of secondary school science teachers, curriculum experiences, and children's understanding of science: Some preliminary findings. *Interchange*, *24*(1, 2), 41-52

Hodgins, H.W. (2004). The future of learning objects. In J.R. Lohmann & M.L. Corradini (Eds.), *E-technologies in engineering education: Learning outcomes providing future possibilities [2002], P1*(11).

IEEE Standard for Learning Object Metadata. (2002). Approved publication of IEEE. Designation: 1484.12.1-2002, July 15, 2002. Final Draft. Retrieved April 1, 2008, from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

Laleuf, J.R., & Spalter, A.M. (2001, June). A component repository for learning objects: A progress report. In *Proceedings of the ACM/IEEE Joint Conference on Digital Libraries.*

McCormick, R., Scrimshaw, P., Li, N., & Clifford, C. (2004). CELEBRATE evaluation report. Retrieved April 1, 2008, from http://celebrate.eun.org/eun.org2/eun/en/index_celebrate.cfm

MELT: Learning Resources for Schools. (2007). *Audit report on MELT content - version 2 Part II: Folksonomies – state-of-the-art, requirements and use cases for the MELT social tagging tool.* Retrieved April 1, 2008, from http://eunbrux09.eun.org/shared/data/melt/MELT_D5P2_Part2_final.pdf

Merrill, M.D. (1999). Instructional transaction theory (ITT): Instructional design based on knowledge objects. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory*. Mahwah, NJ: Lawrence Erlbaum Associates.

Needles, M.C. (1991). Comparison of student, first-year, and experienced teachers' interpretations of a first-grade lesson. *Teaching and Teacher Education*, *7*, 269-278.

Neelands, K., Ledbetter, R., Foti, S., & Alkazemi, E. (2002, Summer). Using DHTML and Java to synergistically combine text-based and interactive instructional materials. *Journal of Interactive Instruction Development*, *15*(1), 19-26.

Pea, R.D. (1985). Integrating human and computer intelligence. In E.L. Klein (Ed.), *Children and computers* (pp. 75-96). San Francisco: Josey-Bass.

Reigeluth, C.M., & Nelson, L.M. (1997). A new paradigm of ISD? In R.M. Branch & B.B. Minor (Eds.), *Educational media and technology yearbook* (pp. 24-35). Englewood, CO: Libraries Unlimited, Inc.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review,57*(1), 1-22.

Shulman, L. (1992). Ways of seeing, ways of knowing, ways of teaching, ways of learning about teaching. *Journal of Curriculum Studies*, *28*, 393-396.

South, J.B., & Monson, D.W. (2000). A university-wide system for creating, capturing, and delivering learning objects. In D.A. Wiley (Ed.), *The instructional use of learning objects: Online version*. Retrieved April 1, 2008, from http://reusability.org/read/chapters/south.doc

Spalter, A.M, (2002). Problems with using components in educational software. In *ACM SIGGRAPH 2002, Proceedings, Conference Abstracts and Applications*. Retrieved April 1, 2008, from http://www.cs.brown.edu/people/ams/pub/components.pdf

Van Driel J.H., Verloop N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, *35*, 673-695.

Wiley, D.A. (1999). *Learning objects and the new CAI: So what do I do with a learning object?* Retrieved April 1, 2008, from http://wiley.ed.usu.edu/docs/instruct-arch.pdf

Wiley, D. (2003). *Learning objects: Difficulties and opportunities*. Retrieved April 1, 2008, from http://opencontent.org/docs/lo_do.pdf

Wiley, D., South, J.B., Bassett, J., Nelson, L.M., Seawright, L.L., Peterson, T., et al. (1999, December). Three common properties of efficient online instructional support systems. *The ALN Magazine*, *3*(2). Retrieved April 1, 2008, from http://www.sloan-c.org/publications/magazine/v3n2/wiley.asp

Winn, W., & Snyder, D. (1996). Cognitive perspectives in psychology. In D.H. Jonassen (Ed.), *Handbook for research for educational communications and technology* (pp. 112-142). New York: Simon & Schuster Macmillan.

KEY TERMS

Granularity: Granularity refers to the size of the components that make up a system. There is often discussion in learning object library circles about the ideal granularity of learning objects. The IEEE standards suggest several size ratings for objects from small media fragments to courses (or nested courses).

IEEE Standards: The Institute of Electrical and Electronics Engineers Standards Association is a developer of industry standards for a broad range of industries. The IEEE has created Learning Object Metadata standards which are referred to herein.

Inference Engine: An inference engine is a computer program that applies artificial intelligence to try to obtain answers or responses to queries from a knowledge base.

Knowledge Base: A knowledge base is a database that is used to manage knowledge. The information in the knowledge base can be accessed using logical operators to determine appropriate retrieval items. Often a knowledge base uses an ontology or data model to define its classification scheme. As applied here, the knowledge base is a highly contextualized set of classifications and relationships related to a focused core of content knowledge.

Metadata: Metadata is essentially data that describes data. In a learning object library, a database of metadata is used to "tag" each learning object for subsequent retrieval.

Natural Language Processing: Natural language processing refers to the ability of computers to translate computer database information to natural sounding language or vice-versa (as is described in this discussion).

Science Helper Project: The Science Helper Project was a project funded by Carnegie Foundation of New York to archive curricular materials created in the post-Sputnik era in the United States. During this time, the U.S. National Science Foundation and other agencies funded several innovative science projects in the U.S. Ultimately, the project produced several products:

- *Science Helper K-8*: a CD containing what would be called a Learning Object Library with a level-2 Aggregation Level (Lessons) by IEEE standards. The project contained 990 lessons.

- *Science Helper Video Series*: A series of science videos focusing on elementary science methods for use by teachers, teacher's aides, and interested parents.
- *Culture & Technology*: A set of 3 CDs containing over 15,000 pages of searchable lesson material and 1550 lessons. Culture & Technology was the same type of learning object library as Science Helper K-8, but included social science curricula as well as science curricula.
- *Enhanced Science Helper*: A revision of the original Science Helper CD with added learning objects including video clips. This library contained 1370 *editable* lessons and a more robust search engine.

Chapter XXXVI
Guidelines for Developing Learning Object Repositories

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ABSTRACT

We present guidelines for designing and developing a repository for the storage and exchange of instructional resources, as well as considerations for the development of the resources to be included in the repository. We elaborate on the constraints that design teams may typically face and the tradeoffs they make to ensure that users utilize the system. The guidelines and decision points we present center around common issues discussed in the learning object literature as problematic and salient to the design, development, and implementation of learning objects and object repositories. These themes are terminology, granularity, reusability, and object sharing. The guidelines we present stem from the creation of an online shareable content support system for faculty within a department of early childhood education. The types of issues and solutions we illuminate are applicable across varied educational contexts and content areas.

With the increasing implementation of learning objects in higher education contexts, the spectrum of repositories developed to house these objects ranges from large-scale collections open to the public to relatively small-scale in-house collections with restricted access (Bannan-Ritland, Dabbagh, & Murphy, 2000; Campbell, 2005; Carnevale, 2001; Malcolm, 2005). Some repositories allow any user to add objects to the collection while others limit who can contribute. Objects included in some collections are developed, maintained, and published by individual contributors without common design specifications across contributors, while other collections contain objects created using a guided design process and published through a structured workflow. Across repositories, the range of media types stored as well as the search options afforded by the interface and structure of the repository also vary. Examples of repositories across the spectrum include Wisc-Online (Wisconsin Online Resource Center, 2007), Penn State Multimedia Teaching Object (MTO) Repository (The Pennsylvania State University, 2007), Multimedia Educational Resource for Learning and Online Teaching (Merlot, 2006), Learner.org (Annenberg Media, 2007), and Integrating New Technologies into the Methods of Education (INTIME, 2001). Typically, the intent of these collections is to make objects available to other users to integrate into the teaching and learning process, to provide exemplars, and/or to assemble an organization's knowledge. The extent to which these repositories are utilized can be determined by a number of factors, including ease of retrieval and use of objects, the type and nature of content available, and the quality of the objects (Bratina, Hayes, & Blumsack, 2002; Collis & Strijker, 2004; Parrish, 2004), all of which should be addressed when designing a repository.

In this chapter, we offer guidelines for designing and developing a repository for the exchange of instructional resources, as well as considerations for the development of the resources to be included in the repository. The guidelines we present, which stem from the creation of an online shareable content support system for faculty within a department of early childhood education, illuminate the constraints the design team faced and compromises made to promote full utilization of the system. At the crux of the project was a departmental vision for an online repository for full-time and adjunct faculty to use when developing and teaching on-campus, online, and blended courses. The driving force was to promote intradepartmental sharing of instructional objects and resources among faculty and develop a system that faculty could use to collectively store, explore, and retrieve resources for customization and reuse. When the project was initially proposed, the department was undertaking several initiatives that would increase offerings of blended and online courses, and would likely increase the need for hiring adjunct faculty. The department sought to alleviate the faculty burden of developing online content for courses and to provide instructional support to adjunct faculty, while at the same time maintaining high-quality content and continuing the department's tradition of enriched student learning experiences. Access to the repository was restricted to departmental faculty; however, anyone with access to the repository could add objects or retrieve them.

The issues and solutions presented in this chapter are applicable across varied educational contexts and content areas in which learning objects and repositories are utilized. The learning object literature provides a beginning framework for the design of all types of objects and repositories, but designers using only this guidance must make pivotal decisions based on limited prescriptions. The objectives of this chapter are to: (a) identify and expand on common themes identified in the learning object literature as most salient to the design, development, and implementation of learning objects and object repositories; (b) illuminate the design decisions that emerge in mapping these themes to the creation of a learning object repository and learning objects to meet specified goals and objectives; and (c) provide guidelines that illuminate the constraints and affordances of the decisions.

A broad range of educational practitioners can use these guidelines to help ensure that their ideas are grounded in realistic expectations, practical considerations, and empirical research. Individuals who serve in planning, implementation, support, and oversight roles for educational technology (such as e-learning managers and administrators) can use these guidelines to proactively identify and address issues that can influence the scope of a project, support or obstruct project implementation and outcomes, and promote collaboration and academic exchange. Individuals serving in design and development roles (such as instructional designers, multimedia developers, and faculty members) can use these guidelines to shape the ways in which they design learning objects for reuse and customization. Individuals serving in instructional roles (such as faculty members and instructional designers) can use these guidelines to inform the development of educational resources that they can and will use and reuse.

BACKGROUND

While the utilization of learning objects is generally considered to be positive, their development and implementation can pose challenges for designers, creators, managers, and users. How designers address these challenges can impact the use of the repository (Malcolm, 2005). In this section, we briefly present some of the themes represented in the literature that have accompanied the emergence of learning object repositories. Our discussion is not exhaustive of all themes but highlights the ones that were most salient to our context. These central themes relate to terminology, granularity, reusability, and object sharing.

Terminology

In the context of developing learning objects and repositories, agreement and shared understanding among the specified group of developers and users of terminology is a necessity. The meaning assigned to a term can have different implications for different organizational contexts and can determine the direction of design and development efforts. Nuances in the use of terminology within the field encourage inconsistent and sometimes confusing use of terms that serve to hinder communication about the purpose and intent of objects and repositories. One example of inconsistent use of terminology relates to what *is* and *is not* a learning object. As Parrish (2004) points out:

There are as many definitions of learning objects as there are people offering them, which suggests that maybe they are defining the wrong thing. Most have attempted to define learning objects as entities of particular kinds of artifacts, and have inevitably failed in the attempt to make the term both broad enough to encompass all that they might be and at the same time eliminating what they are not. (p. 52)

Another example of a term that sometimes requires clarification in the realm of learning objects is *user*. In some applications of learning object repositories, the user is a faculty member seeking to integrate an object into instructional materials; in other cases, the user is a learner searching for an object to enhance his or her own learning. The design team may explicitly or implicitly specify who the intended or prospective users are. If the repository is housed on an Intranet and access to it is restricted to authorized faculty and staff, the repository has been explicitly positioned for faculty use. If the repository is publicly available on the Internet, it may be explicitly positioned for both faculty and learner users but implicitly designed for faculty use or learner use (based on interface design, search tools, language, etc.).

Granularity

Collis and Strijker (2004) note that *granularity* is another concept within the literature that people apply differently depending on their context. Barritt and Alderman (2004) refer to granularity as the size and shape of a learning object and leave further definition to the organization and context of the project (as determined by the needs, tools, processes, and goals of the organization). For example, one organizational project may require learning objects to be delineated as very small assets (e.g., a picture, a paragraph of text, an assessment item) to be connected together with other assets to create a complete, self-contained, educationally useful learning object, while a project that may not require this level of granularity (given the intent and purpose of the creation and use of the learning objects) will define learning objects at different levels. Some projects adopt a schema from existing literature (see Duncan, 2003) while others create their own schema and terminology at the outset of the project based on their goals and objectives. These cases illustrate Malcolm's (2005) point that granularity is an important factor in determining the reusability and reuse of learning objects.

Granularity can be recognizable from the metadata assigned to a particular learning object. The design and development of a learning object repository often requires the use of metadata for search and retrieval functions, and the granularity of the objects in the repository likely determines the types of metadata by which an individual can search for objects. In this sense, metadata provides a framework for describing the granularity of the object itself and metaphorically its size and shape. Given appropriate metadata for an object, a user can also assess the object's potential for reuse. Yet metadata and the requirement of specifying it for each learning object is a problematic issue discussed frequently in the literature (Bennedsen, 2004; Collis & Strijker, 2004; van Merriënboer & Boot, 2005). In discussing the importance of adding metadata to describe learning objects to ensure that enough information is provided to facilitate searching and retrieval of desired objects, Bennedsen (2004) also evaluated the minimum amount of metadata required in an attempt to balance the need for metadata with the limited time an object creator or sharer may have to add such metadata. The five metadata elements determined to be sufficient for users to find the object desired were title, description, keyword(s), date, and uniform resource locator (URL).

Reusability

Two of the main goals that drive the use of learning objects center on enhancement and reusability. The enhancement of learning is often the primary goal of integrating these tools into the curriculum and instructional materials. For example, an interactive learning object that allows a learner to click on an area of a baby's body (simulating a human touch) and demonstrates the appropriate reflex (simulating a human baby's reflex) can help the viewer assimilate the concepts of infant reflexes (The Pennsylvania State University, 2007) perhaps better than what would be afforded by a mere textual description of the reflexes, thereby enhancing the learning experience. In the context of reusability, the goal for implementing learning objects is often to reduce the need to repeatedly "reinvent the wheel" during course design and development. For example, an instructor who wants an audiovisual demonstration of a principle can often locate and use a particular learning object more expediently than he or she would be able to create an original object.

Related to this goal of reusability, customization of instructional resources is also fundamental to learning objects. While striving to alleviate the perceived burdens of design and development tasks, instructional designers and educational technologists strive to enable faculty to exercise academic freedom in personalizing learning objects. The skills, abilities, and available tools of intended users who want to customize the learning objects often limit the designer's options. Users who are frequently asked to design or create their own learning objects when developing and delivering online courses are often novice instructional designers and may not be well-versed in applying specific learning theory and instructional strategies to design effective instruction (Frizell & Hübscher, 2002a).

Object Sharing

At the core of the purpose of any repository is the ability to share information with a specified set of users. Some repositories have specific requirements that must be met for an object to be shared (included in the repository) while other repositories allow users to contribute a wider variety of objects. The retrieval and use of objects contained in the repository are the complement to sharing objects. A repository that is full of rich objects that have been shared and are ready for use but has a limited number of users who actually retrieve and reuse the objects has only met one part of the goal of the repository. Factors discussed previously (such as granularity and reusability) affect the level of object sharing as well as object retrieval and use in any repository. Among the reasons that users may not utilize learning objects are a lack of awareness that objects exist, a lack of perceived benefit of using others' materials, and a lack of fit between the resource and the need (Parrish, 2004). Van Merriënboer and Boot (2005) refer to this issue as an exchange problem, stating that people may not want to use materials created "out of house" or by other people. Other reasons that may limit retrieval and use relate to difficulties in searching for and identifying desirable objects, inability to easily view or try out objects, or inability to easily customize objects. As design teams create learning object repositories and learning objects they must consider these issues in an attempt to address as many barriers to object sharing, retrieval and use as possible within the designs.

MAIN FOCUS OF THE CHAPTER

The exemplar presented in this section stems from a departmental project initiated to create an online shareable content support system for faculty. The project team combined a vision to promote the sharing of instructional objects and resources among faculty with a need to develop a system that faculty could use to collectively store, explore, and retrieve resources to support their reuse and potential customization. The design team's attempt to apply learning object literature to the design and development of the system revealed a lack of published discussion surrounding the decision points that emerge in implementing similar systems. In this section, we will examine several decision points that were salient in the design, development, and implementation of the system.

Within the discussion of these decisions points, we present guidelines for consideration when making similar and related decisions:

1. Terminology guideline: Define key terms and gain consensus on what they mean.
2. Granularity guideline: Determine desired levels of granularity for objects in the repository.
3. Reusability guideline: Consider the users' technology tools and skills for reusing and repurposing objects.
4. Object sharing guideline: Anticipate how users are likely to interact with the repository.

The interdisciplinary and cross-context nature of these guidelines should convey the idea that there may not be a single "best" solution to address a particular issue. For each guideline, we present the central issue, the decisions made in the context of the project, and the constraints imposed and affordances associated with the decisions. To provide the context for the issues and decisions made, we first provide a brief overview of the object repository on which the decisions are based.

Context for the Repository

The development of the repository was part of a departmental initiative to provide faculty with resources to expand student engagement in integrated and active learning experiences across all courses in the department's programs. The repository, which was dubbed *ECE SHARE* (Early Childhood Education Searchable sHareable Academic Resource Exchange), is a Web-based application hosted on one of the university's Web servers. Access to share and edit content within the repository is restricted to authorized faculty and other individuals. The current structure of ECE SHARE provides an opening screen that prompts the user to search for resources, share resources, or learn more about the repository (see Figure 1).

Faculty can search for resources (see Figure 2) using the metadata that was assigned to each resource when it was added to the repository (refer to Table 1). Faculty can also search for resources by the name of the individual who shared the resource or by the date a resource was uploaded into the repository.

From the search results (see Figure 3), faculty can view and download all resources, as well as edit the metadata of any resource they have shared.

To share objects with other individuals, faculty can use the share tool (see Figure 4), which requires the faculty member to identify the metadata associated with the resource (which other faculty will then use to search for the object). The only situation in which a faculty would not upload a file to share would be if the resource was a URL. Providing this method for sharing URLs affords faculty the ability to generate resource lists or webliographies.

While the repository has been implemented, we continue making formative revisions based on data collected from faculty and other users. For example, faculty members have identified changes needed in metadata, search functions, and instructions. As course development efforts ensue, we continue to populate the repository

Figure 1. Screen capture of opening page in ECE SHARE

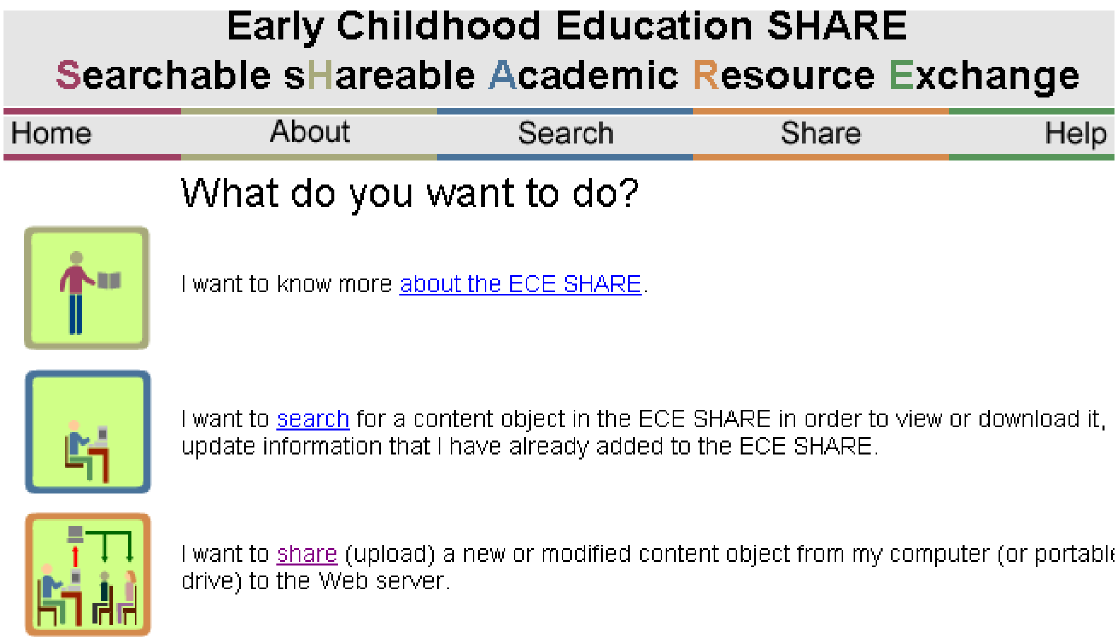


Figure 2. Screen capture of search page in ECE SHARE

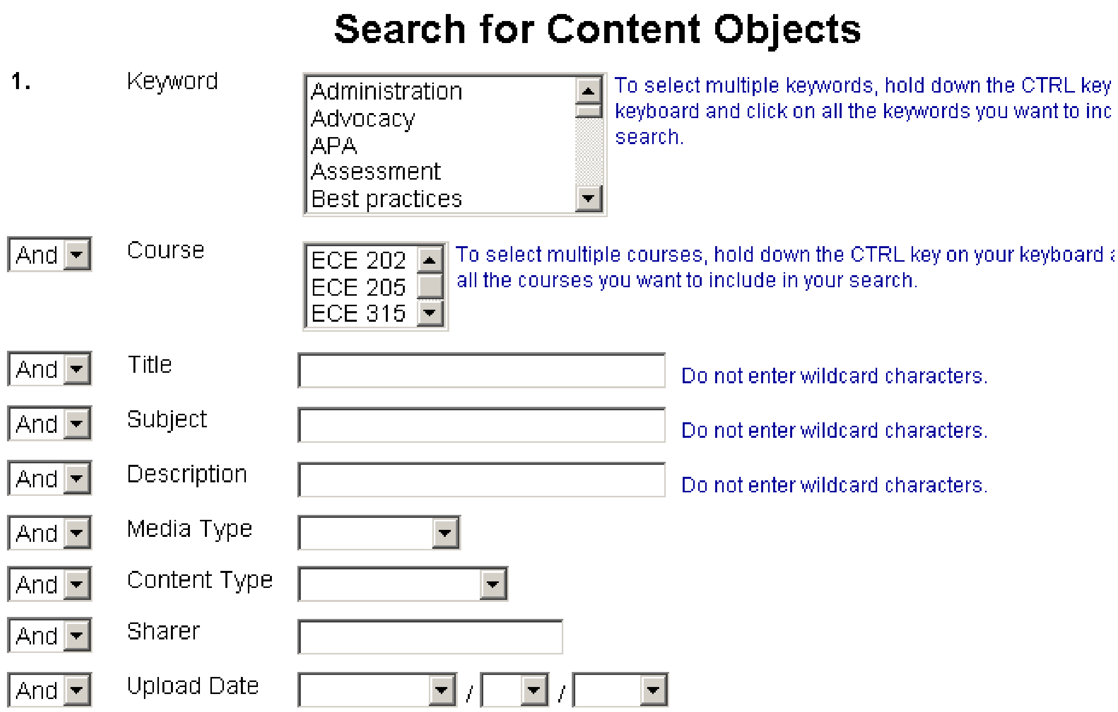
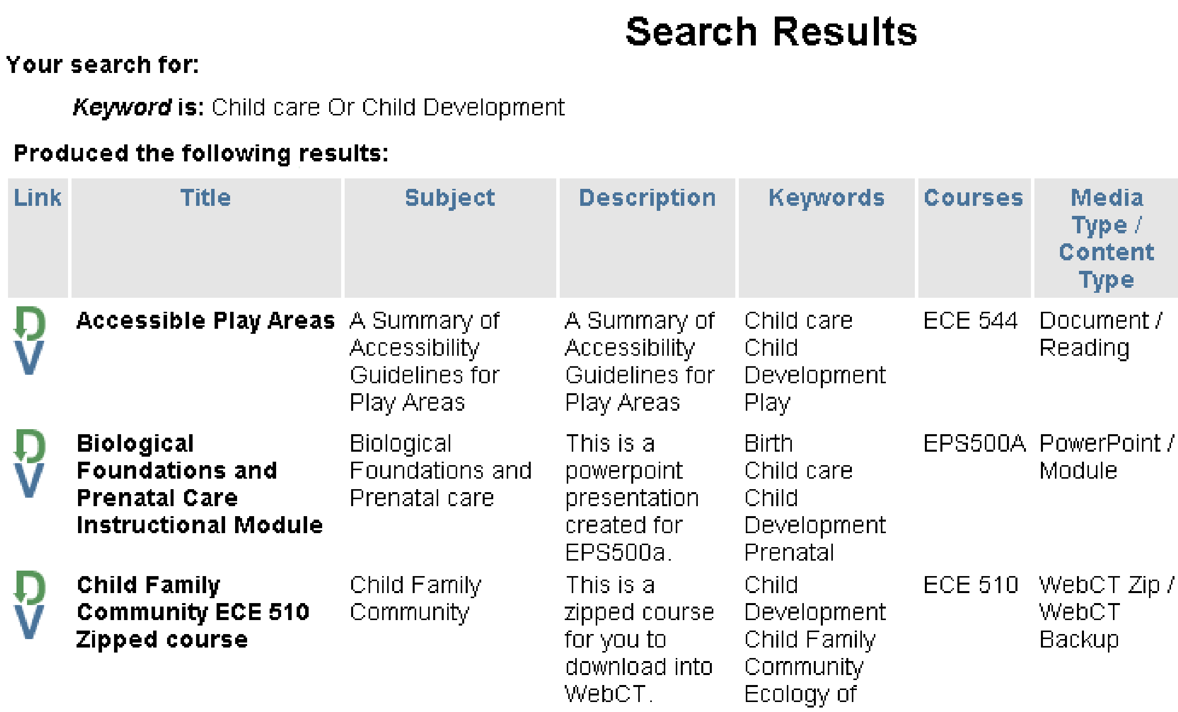


Figure 3. Screen capture of search results in obtained in ECE SHARE



Search Results

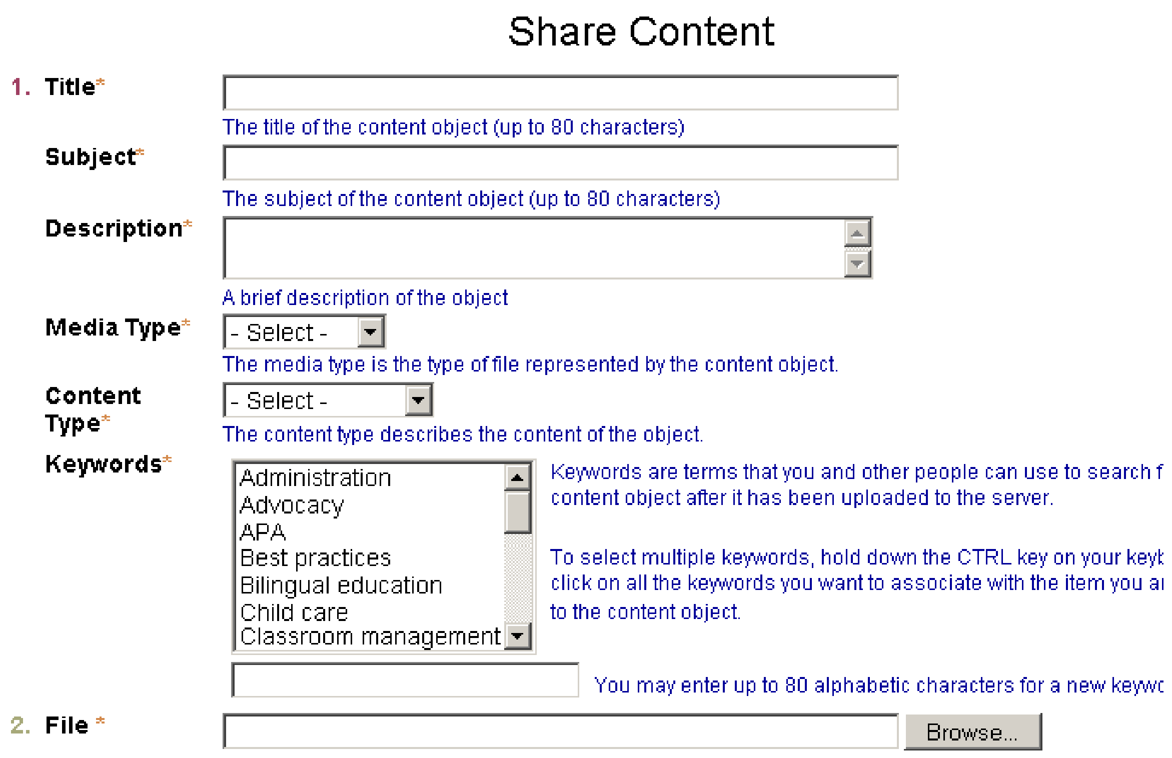
Your search for:

***Keyword* is:** Child care Or Child Development

Produced the following results:

Link	Title	Subject	Description	Keywords	Courses	Media Type / Content Type
D V	**Accessible Play Areas**	A Summary of Accessibility Guidelines for Play Areas	A Summary of Accessibility Guidelines for Play Areas	Child care Child Development Play	ECE 544	Document / Reading
D V	**Biological Foundations and Prenatal Care Instructional Module**	Biological Foundations and Prenatal care	This is a powerpoint presentation created for EPS500a.	Birth Child care Child Development Prenatal	EPS500A	PowerPoint / Module
D V	**Child Family Community ECE 510 Zipped course**	Child Family Community	This is a zipped course for you to download into WebCT.	Child Development Child Family Community Ecology of	ECE 510	WebCT Zip / WebCT Backup

Figure 4. Screen capture of share page in ECE SHARE (used to add objects to the repository)



with all of the resources concurrently being developed, and we add to our knowledge of how we must balance design and user considerations in the development of the repository to promote successful implementation. From our efforts we present the decisions we made when designing and building the repository to guide others as they embark on related projects.

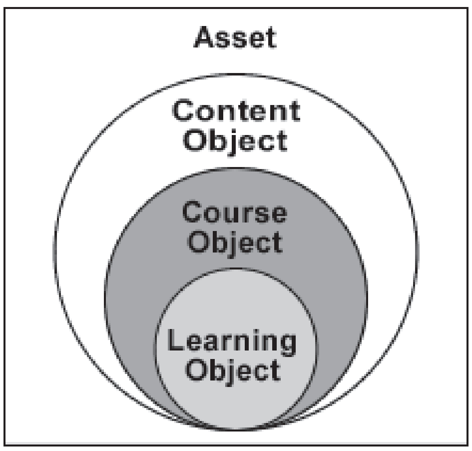
Terminology Guideline: Define Key Terms and Gain Consensus on What They Mean

One of the initial issues faced by the design team was inconsistent use of terminology among the members of the design team, other faculty members, and relevant literature. If terminology is not agreed upon at the onset of a project, it can hinder communication within the design team. Some designers and faculty may have a narrow vision of learning objects that precludes them from understanding how particular resources might be used, precipitates a bias against the use of learning objects, or shapes a misconception of the goals of resource exchange. To some degree, all of these cases manifested themselves during our development efforts.

At the onset of the project, some members of the design team used the term *learning object* to refer to any resource included in the repository while others argued that certain resources required finer distinctions. Upon recognizing how terminology was becoming an obstacle to the development process, the design team critically examined the terminology they were using. This action enabled the team to gain consensus and refine their terminology to fit the context of the project. The nomenclature that was adopted for the project is graphically depicted in Figure 5. The design team distinguished between three types of objects (learning objects, course objects, and content objects) but considered all of them as *assets*. An asset was defined as any digital resource that could be reused or repurposed to support course development or learning. Essentially, an asset was any type of object, and over time it became synonymous with the term *object* without any descriptors.

Some of the assets to be stored in the repository were specifically labeled as *learning objects*, which were defined as any digital resource that could be reused or repurposed to support learning *and* could stand alone as an instructional lesson. An example of a learning object created during course development is an interactive Flash® animation designed to demonstrate how individuals attend to some stimuli and filter out others when completing a cognitive task. Another example is

Figure 5. Nomenclature used to distinguish between types of objects in the repository



a tutorial developed using PowerPoint® to teach students how to create the electronic portfolio required by all students in the department.

Other assets were labeled as *course objects* and defined as digital resources packaged as an entire course that could be reused. Unlike learning objects, which could vary in usage and in terms of file format, a course object was a WebCT course backup file. These objects were created within the WebCT interface and exported in a proprietary zipped WebCT format. The objects could then be restored inside a WebCT course shell for customization and reuse by a faculty member. Once an online course was fully developed, the design team would create a course object and upload it to the repository for other faculty members and adjunct faculty to be able to access it.

The third type of object that the design team identified was a *content object*, which was defined as any digital resource that could be reused or repurposed to support learning. Based on this definition, a learning object and a course object were considered to be content objects. However, a content object was often neither a learning object nor a course object. Examples of a content object include a course syllabus or outline, a course schedule, a Web resource, and a handout. By virtue of the wide range of resources that could be classified as content objects, the ways in which content objects can support learning are quite diverse. In the case of a course syllabus or outline, the content object supports learning by specifying learning outcomes, content topics, expectations, and requirements for a particular course. The object can be reused by an adjunct instructor or another faculty member reviewing or revising the course, as well as for designing a similar course. Similarly, a course schedule can support a learning context through its ordered sequence of course topics, listing of relevant readings, and list of assignments to enhance or assess learning.

The design team's conceptualization of assets, learning objects, course objects, and content objects, which evolved during the initial stages of the project, was precipitated by misalignment between the term *learning object* and the project vision for the repository. The initial use of the term was problematic because it unnecessarily limited faculty's vision for the repository, and it complicated the schema proposed for identifying objects. For example, faculty members who viewed the repository as a collection of interactive objects to be used in online teaching did not recognize how it could be used outside of this purpose.

There were several affordances enabled by the adopted object hierarchy. First, it facilitated communication among the design team in that members had a firmer grasp of what was meant when someone referred to a particular type of object. Use of the hierarchy also facilitated discussions with other faculty members because it helped establish a common language referent. The hierarchy also enabled faculty to envision using the repository for more than "just finding graphics" as they recognized how it could help streamline the course development process. This notion became a base for formulating the next guideline centering on the granularity of the content for the repository.

This guideline is applicable across contexts, even those beyond higher education. In applying this guideline to other contexts, the recommendation to gain consensus on terminology used within a project should be considered early in the planning process. We do not recommend that a team attempt to create a unique set of terms and definitions to apply to the project. Instead, we advocate identifying existing terms and definitions that align with the views of the team and intent of the project. Citing and using terminology from the existing literature can facilitate communication with other professionals and can help you situate your project within the context of other projects. Further refinement of such existing terminology may be necessary to make distinctions clearer among team members as was the case within our project. When such refinements are made, it is critical that they are documented and used consistently.

Granularity Guideline: Determine the Desired Level of Granularity for Objects in the Repository

There are many ways to position an object repository based on the range of the objects to be stored within it, and the impact of the decision affects the design and development of the repository, the retrieval of objects from the repository, as well as the design and development of the objects themselves. For example, if the repository is envisioned solely as a collection of learning objects that instructors can use to support single learning objectives, the design implications may differ from the case where the repository is to host a variety object types (ranging from learning objects to course- or content-level objects). It is important to not only determine what the repository will be used for but to communicate that information to the prospective faculty members. If faculty members perceive that the repository will contain all types of resources, but they discover that it only contains learning objects that target specific objectives, they may not use the repository to its full potential or they may not use it at all. The converse may also be true; if the range of objects in the repository is not clear, faculty members may think the contents are not applicable to what they do (especially if they do not teach online and do not envision how learning objects can supplement classroom activities). In this case as well, faculty may not be inclined to even explore what the repository has to offer.

Another reason that it is important to consider the granularity early in the design stage is that it affects how items will be tagged for retrieval. It affects the overall metadata schema as well as the specific fields within the metadata categories. For example, the descriptors used to describe or identify an object that is intended to be used as a handout may differ in structure and content from the descriptors used to describe or identify a tutorial. Early in the design process of our repository, the design team considered a variety of metadata schema. Our intent was to balance minimalism and adequacy, which could often present a challenge as suggested by the literature (Bennedsen, 2004). The metadata schema we adopted was the same across all types of objects. This decision was made primarily for the sake of simplicity and because we considered the schema to be adequate to cover all of the item types to be stored in the repository. The metadata fields that we used to identify objects are listed in Table 1.

One of the initial challenges that the design team faced was in determining the best way to distinguish between the *type* of item and the *content* of the item. The resolution was to use two fields: media type and content type. The media type allowed users to describe the physical nature of the file using terms such as animation, audio clip, document, graphic, PowerPoint, video clip, WebCT zip, and Web site. The content type related more to the nature of what was represented by the object. The list of content types represented terms to describe the intended roles of the object, such as activity, module, reading, resources, rubric, schedule, template, tutorial, and WebCT backup.

In developing this schema, it was important to consider both what the objects represented and how users might search for them. By separating the physical type from the usage of the content, it was possible to accommodate the needs of users who tended to view objects in terms of what they were (file types) as well as users who viewed objects in terms of how they might use them (roles). However, there is an artificial constraint that can be imposed by classifying objects based on usage. Suppose that instructor *A* creates an activity to help students learn a particular concept and shares an electronic version of the activity. Since he or she used the object as an activity, the most likely content type that he or she would select when tagging the object is *activity*. Instructor *B*, who wants to provide students with samples of activities that they can use in their classrooms, searches the repository for handouts. Since instructor *A* did not envision his or her file to be used as a handout, it was not tagged this way, and consequently would not be retrieved in a search for handouts (unless it met other search criteria). Hence, the retrieval of objects could be limited by how the person who shares the object views its utility.

As with the terminology guideline, our recommendation is one that design teams should follow early in the project. The vision and goals for a given learning object repository project should provide clear direction in defining the scope of what the repository will and will not contain and the intended uses of the repository. Clear identification of intended users of the repository will encourage the design team to remain cognizant of

Table 1. Metadata used to identify objects in the repository

Metadata	Usage
Keyword	A list of one or two-word phrases used to categorize the object
Course	A list of courses for which the object might be applicable
Title	The title of the object
Description	A description of the content and/or nature of the item
Subject	An extension of the title
Media Type	The physical type represented by the object
Content Type	The nature of the intended usage of the object

faculty roles and the likely knowledge and skills faculty members possess that could impact the design, implementation, and use of the repository. Further consideration of potential faculty can extend the utility of the repository beyond its initial launch. The intent of this guideline is not to prescribe a specific scope but to suggest that the scope must be clearly communicated to the intended faculty. The terminology guideline also applies given that choosing the metadata by which objects are identified and tagged requires careful attention to terminology and definition, and clear communication of the intended meaning of metadata labels. Just as there is existing terminology to apply to your own project, there are also existing metadata schema that your team might be required to use (e.g., SCORM) or might choose to use given the fit of the scheme with your project.

Reusability Guideline: Consider the Users' Technology Tools and Skills for Reusing and Repurposing Objects

Related to the use of learning objects are the notions of reusability and repurposing. Designing learning objects to allow for repurposing, customization, and personalization is an oft-cited issue for design teams. If not properly addressed, this issue can result in underutilization of the resources and the repository. The sources of common constraints relate to technology, as well as user access and abilities. Within the past several years, there has been considerable increase in the number and types of tools available for creating animations, graphics, and other formats common to learning objects. Some of these programs are free for public use and are designed to eliminate the need for people to have sophisticated technology skills to design and create learning objects.

Given the plethora of tools available for creating various types of objects, one of the key decisions to be made is what tools to use in creating objects for the repository. This decision can have a significant impact on whether and how objects in the repository are used and repurposed and reused. Consider the following possible scenarios: (a) items in the repository are highly customizable, but special software and special skills are required to customize most of the items; or (b) very few of the items in the repository support any degree of customization. For faculty who find the exact item that they need, it may be inconsequential whether the items are customizable or not. Faculty members who find an object that is "close" to what they want but is not a perfect match, though, may become frustrated in either case if they are not able to customize the objects.

The way that we addressed reuse and repurposing was to first anticipate the types of faculty who might use the repository. We created profiles for the faculty and identified their roles, the types and levels of technology skills they were likely to have, and the types of tools they were likely to have access to and familiarity with using. While the profiles were not of specific individuals, they represented the range of faculty that we expected to use the repository—from the high-end technology-savvy faculty who actively seek out new tools and innovations to use to the technologically challenged faculty who can perform simple word processing tasks but are not likely able to create or alter objects. A table like the one shown in Figure 6 is helpful for organizing the faculty profiles, especially when the user pool is large or complex.

The design team created another table from the object perspective. This table, like the one shown in Figure 7, profiled the types of skills that would be needed to customize certain types of objects.

By using these tables, we were able to refine the format of objects and identify the proficiencies required and tools needed for creating, repurposing, and customizing objects. During this review process, the design team considered tradeoffs between optimal design and ease of

Figure 6. Faculty profiles table

Type of User	Technology Skills	Access to Tools	Comments

Figure 7. Table of the types of objects and factors related to customization

Type of Object	Skills Needed	Tools Needed	Comments

use, repurposing, customization, personalization, and maintenance. For example, there were several cases in which specific software was the designer's preferred tool for creating course materials. Upon recognizing that few faculty members had access to the software, though, the designer used an alternative tool to encourage use and customization of the objects.

In combination with faculty skills and access to tools, the design team also had to consider the format of the objects they or faculty would create in order to promote repurposing and customization. Within the range of objects that could be created and shared, it was beneficial for the designers to create templates in collaboration with faculty to provide a convenient means for faculty to develop and customize their own content. The implementation of templates has become a common method to support novice designers by capturing and integrating design experience, pedagogical principles, and design strategies (Frizell & Hübscher, 2002a, 2002b; Jones, 2005). By sharing the templates (content objects) in the repository, faculty members could access them as needed. Examples of the types of templates we included in the repository are (a) tutorial templates to teach technology skills, (b) case templates to present information about a problem to be solved (patterned after Wiley, Waters, Dawson, Lambert, Barclay, & Wade, 2004), and (c) guided discovery templates to engage learners in observations and investigations that will lead to the discovery of principles. The application of these templates as well as others resulted in multiple finished learning objects being included in the repository.

A decision made by the design team to create some templates using PowerPoint illustrates the simultaneous consideration of many elements that can impact the reusability and repurposing of objects within a repository. For several of the templates, PowerPoint was selected as the software tool, because most of the identified faculty members were relatively proficient at creating presentations, and the University had a site license for the software. It also accommodated a range of faculty skills. Faculty with limited PowerPoint knowledge could open a template and insert their text into the placeholders without having to change the formatting or layout. Faculty with advanced PowerPoint skills could alter the file according to their proficiency and needs.

While there were advantages to both the template approach and the use of typical productivity tools for developing instructional materials, there were also constraints imposed by this approach. For example, one of the decisions that was made was to retain the files in native PowerPoint format (rather than converting them to Web format) to facilitate uploading and downloading from the repository as well as integration into course materials (i.e., it was considered easier for users to download and upload a single encapsulated file rather than a zipped file that then had to be uncompressed and all the components placed in the correct location). Consequently, some of the file sizes were rather large depending on the quantity and nature of graphic elements embedded in the file. There were additional challenges in integrating some of the materials into the university's learning management system (which was an older version of WebCT).

Within this guideline, we revisit the idea of carefully considering the intended and potential users of the repository, which is applicable across all repository contexts. However, the intended use of objects and the extent to which objects housed within a repository are customizable are context dependent and should be determined as part of the vision and goals for the repository. Regardless of the intended extent of object customization envisioned, the recommendation of clearly identifying users, their knowledge and skills, and the tools available is also relevant to this guideline. We recommend that design teams examine literature on design patterns to determine the utility of their application within the context of the project.

Object Sharing Guideline: Anticipate How Users Are Likely to Interact With the Repository

Designers should not assume that intended users will be automatically drawn to using the repository when it is implemented. The full adoption of a resource repository, and subsequently the extent to which sharing actually occurs, is influenced by a number of factors, one of which is usability. The notion of usability encompasses interface design, as well as the ease of searching and retrieving resources. If users have difficulty navigating the repository, they may curtail their use of it. Similarly, if users have difficulty locating resources or if search results repeatedly return more unrelated or undesired items than desired items, it may also have a negative impact on use of the repository. The extent to which objects are tagged, as well as the types of tags assigned to objects, is a key factor in whether and how users can retrieve them from the repository. The metadata scheme that we used (a simplified form of which is presented in Table 1) was derived by brainstorming the types of objects that the repository was likely to contain (using the table shown in Figure 5).

Another method used by the design team to anticipate how faculty would likely interact with the repository was to create process flow documents to represent a faculty member's actions when using the repository for different purposes. Among the purposes considered were faculty members who wanted to reuse and customize a ready-made WebCT course, to faculty wanting to develop their own online or blended course utilizing various assets within the repository, to faculty who wanted to identify helpful resources to enhance classroom instruction. By thinking through the processes that the range of faculty would employ, we were able to refine both the interface of the repository as well as the fields used to search for and share objects.

The recurrence of some recommendations within prior guidelines indicates their applicability across guidelines and emphasizes their significance. Within this guideline we again note the importance of identifying the users and anticipating their capabilities and desired interaction with the repository. This knowledge informs multiple decisions across the project and can ultimately impact on the adoption of the repository. Here it informs the design of the interface as well as the metadata scheme employed.

FUTURE TRENDS

From our ongoing documentation of decisions made in developing the repository, the most prevalent user considerations have been the technology skills of faculty and the strategies required to customize and reuse content within the university's learning management system. As Wirski, Oliver, Hingston, and Omari (2002) indicated, "developers tend to build new instructional resources before they look for shareable ones [which] tends to center around the need to have some form of control and influence over their own materials" (p. 2). In addition, they noted that widespread resource sharing without consistent systems makes a shareable content model a difficult goal to achieve. Many of the design decisions made within this project were focused on minimizing these specific issues and creating a repository that provides a consistent format that allows users to easily share and modify objects. Analysis of (a) utilization of the repository; (b) use, reuse, and customization of objects; and (c) user experiences and attitudes will continue to inform our design and development efforts. The results from these analyses will also guide future development efforts as the pool of users extends beyond the initial faculty group envisioned to use the repository.

The types of issues we have discussed in this chapter are not all-encompassing. Other issues relating to access, security, and copyright have become increasingly discussed in the literature. Other lines of research that we believe would be particularly fruitful are case studies that focus on the processes involved in designing and developing repositories in higher education and other contexts, especially noting where decision points and guidelines might differ considerably.

CONCLUSION

Central to the notion of learning objects and repositories is the need to create shareable and reusable content (Wiley et al., 2004). Users seek viable solutions for the design, development, reuse, and customization of online content. In this chapter, we have presented several decision points framed by the exemplar of an object repository in a higher education context. There are a variety of initiatives and activities in the field of learning objects and this chapter describes aspects of one such project. We imagine that the group of faculty for which the repository was developed is not unlike many faculty groups (as well as faculty support teams) that are seeking workable solutions to the design, development, reuse, and customization of online content without being technology or instructional design experts themselves. For implementation of learning objects and learning object repositories to be fully successful, design and user considerations must be balanced throughout the design and development process. Educational technologists commonly perform this balancing act when translating the initial design of a system into a user-friendly product while still meeting the goals of the system. Managing user expectations and abilities while designing a system that works as intended is rarely an easy task, but it is often the key to ensuring that the system goes beyond development and is actually implemented and fully adopted by the intended users. We have made connections between decision points, decisions, and practice to demonstrate ways to help designers, faculty members, and e-learning managers balance these needs. Learning objects, repositories, and related models are relatively young concepts in instructional technology (Wirski et al., 2002), and we expect continued definition of contextually-sensitive design principles through documentation of projects such as ours.

REFERENCES

Annenberg Media. (2007). *Annenberg media learner.org*. Retrieved April 2, 2008, from http://www.learner.org/

Bannan-Ritland, B., Dabbagh, N., & Murphy, K. (2000). Learning object systems as constructivist learning environments: Related assumptions, theories, and applications. In D.A. Wiley (Ed.), *The instructional use of learning objects: Online version*. Bloomington, IN: Association for Instructional Technology & Association for Educational Communications and Technology. Retrieved April 2, 2008, from http://www.reusability.org/read/

Barritt, C., & Alderman, F.L. (2004). *Creating a reusable learning objects strategy: Leveraging information and learning in a knowledge economy*. San Francisco: John Wiley & Sons.

Bennedsen, J. (2004). Learning objects in use. In K. Morgan & J.M. Spector (Eds.), *The Internet society: Advances in learning, commerce, and security* (pp. 61-68). Southampton, Boston: WIT Press.

Bratina, T.A., Hayes, D., & Blumsack, S.L. (2002). Preparing teachers to use learning objects. *The Technology Source*. Retrieved April 2, 2008, from http://technologysource.org/article/preparing_teachers_to_use_learning_objects/

Campbell, L. M. (2005). Repository issues…from a teaching and learning perspective. *Joint Information Systems Committee*. Retrieved April 2, 2008, from http://www.jisc.ac.uk/uploaded_documents/repos_issues_cetis_feb05.pdf

Carnevale, D. (2001, May 3). Some online educators turn to bit-sized instruction. *The Chronicle of Higher Education*. Retrieved April 2, 2008, from http://chronicle.com/free/2001/05/2001050301u.htm

Collis, B., & Strijker, A. (2004). Technology and human issues in reusing learning objects. *Journal of Interactive Media in Education, 4*. Retrieved April 2, 2008, from http://www-jime.open.ac.uk/2004/4/collins-2004-4-disc-paper.html

Duncan, C. (2003). Granularization. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning*. London: Kogan Page.

Frizell, S.S., & Hübscher, R. (2002a). Aligning theory and Web-based instructional design practice with design patterns. In G. Richards (Ed.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2002* (pp. 298-304). Chesapeake, VA: AACE.

Frizell, S., & Hubscher, R. (2002b). Supporting the application of design patterns in Web-course design. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2002* (pp. 544-549). Chesapeake, VA: AACE.

Integrating New Technologies into the Methods of Education. (2001). *About INTIME*. Retrieved April 2, 2008, from http://www.intime.uni.edu/about/New_about/about.html

Jones, R. (2005). Designing adaptable learning resources with learning object patterns [Electronic version]. *Journal of Digital Information, 6*(1).

Malcolm, M. (2005). The exercise of the object: Issues in resource reusability and reuse. *British Journal of Educational Technology, 36*(1), 33-41.

Multimedia Educational Resource for Learning and Online Teaching. (2006). *About the MERLOT collection*. Retrieved April 2, 2008, from http://taste.merlot.org/merlotcollection.html

Parrish, P.E. (2004). The trouble with learning objects. *Educational Technology, Research, and Development, 52*(1), 49-67.

The Pennsylvania State University. (2007). *About this repository*. Retrieved April 2, 2008, from http://tlt.its.psu.edu/mto/about.html

van Merriënboer, J.J.G. & Boot, E.W. (2005). A holistic pedagogical view of learning objects: Future directions for reuse. In J.M. Spector, C. Ohrazda, A. Van Schaack, & D.A. Wiley (Eds.), *Innovations in instructional technology: Essays in honor of M. David Merrill* (pp. 43-64). Mahwah, NJ: Lawrence Erlbaum Associates.

Wiley, D.A. Waters, S., Dawson, D., Lambert B., Barclay, M., & Wade, D. (2004). Overcoming the limitations of learning objects. *Journal of Educational Multimedia and Hypermedia*, *13*(4), 507-521.

Wirski, R.M., Oliver, R., Hingston, P., Omari, A., & Brownfield, G. (2002). Considerations for a digital repository. *The Knowledge Tree, 1*. Retrieved April 2, 2008, from http://knowledgetree.flexiblelearning.net.au/edition01/html/_download/Learning_Objects_Paper.pdf

Wisconsin Online Resource Center. (2007). *About Wisc-Online*. Retrieved April 2, 2008, from from http://www.wisc-online.com/about.asp

KEY TERMS

Granularity: Refers to the metaphorical size, shape, and scope of a learning object.

Learning Object: Any digital resource that can be reused or repurposed to support learning *and* can stand alone as an instructional lesson.

Object Repository: A collection of instructional resources housed in a central location (such as a database) from which users can retrieve information about the objects as well as the objects themselves.

Reuse: Refers to the process of retrieving an object from a repository and using it for a purpose similar to the original purpose for which the object was designed.

Repurpose: Refers to the process of retrieving an object from a repository and using it for a purpose quite different from the original purpose for which the object was designed.

Chapter XXXVII
Reusability of Online Role Play as Learning Objects or Learning Designs

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ABSTRACT

This study tracks the uptake of online role play in Australia from 1990 to 2006 and the affordances to its uptake. It examines reusability, as one affordance to uptake, from the perspective of two often polarized constructs: learning object and learning design. The study treats "reuse" in two ways: reuse of an existing online role play and reuse of an online role play as the model for another role play. The first type of reuse implies the online role play is a learning object and the second type implies the online role play derives from a learning design. Online role play consists of a scenario and a set of roles that students adopt in order to collaboratively solve a problem, create something, or explore an issue via e-mail or a combination of e-mail and Web-based threaded discussion forum. Thirty-six role plays of this type were identified in Australian universities of which 80% were reuse of a learning design. Only three examples of role play as a learning object were found, suggesting that learning design is a useful concept for understanding how to support reusability in universities. Other affordances to uptake of role play were also tracked. This indicated that the contribution of educational developers far outweighed that of academic colleagues, conferences, journals, and engines. The results have implications for the work practices of educational developers and for managers of learning object repositories.

INTRODUCTION

It is not yet clear whether the learning designs movement will take off with the same momentum as the learning objects industry. This chapter compares the two by focusing on online role play as the example of courseware. Role play is deliberately chosen because it is a learning design that does not have its pedagogical basis in a content transmission model of teaching. Instead it presents a constructivist learning environment, and as such it may better challenge the current conceptualisation of learning objects. By discussing learning objects and reusability in the concrete teaching and learning context of online role play, it is anticipated that recommendations might be more meaningful to teachers than theoretical papers on computer science aspects of learning objects.

This chapter describes a study conducted by the authors which tracked the uptake of online role play in Australian higher education from 1990 to 2006 and investigated the affordances to uptake. Our use of the word "uptake" overlaps with other terms like "reuse," "adoption," "adaptation," "modification," and "dissemination" (McKenzie, Alexander, Harper, & Anderson, 2005). Online role play is an area of teaching activity in Australian universities that is small enough that it can be investigated in detail via interview and case study rather than broad-brush survey methods. This case study approach to research provides richer and more appropriate detailed data as well as information on individual differences which could be lost in surveys.

The study treats "reuse" in two ways: reuse of an existing online role play and reuse of an online role play as the model for another role play. In the context of this book, the first type of reuse implies the online role play is used as a learning object and the second type implies the online role play derives from a learning design.

It is usually assumed that learning objects are small, having a low level of granularity that means they are easy to reuse and easy to customise to individual needs. However it is also possible to aggregate learning objects into a larger learning object (Duncan, 2003) such as a whole online role play. Whether larger learning objects hinder reuse is an interesting question but it was not one specifically addressed by this study, which focused instead on university teachers who have chosen to reuse rather than looking at why teachers chose *not* to reuse. The second question on obstacles to uptake has been covered by other studies (McKenzie et al., 2005; McNaught, 2003).

BACKGROUND

Role Play and Online Role Play

Role plays are situations in which learners take on the role profiles of specific characters or organisations in a contrived setting. Role play is designed primarily to build first person experience in a safe and supportive environment. Role play is widely acknowledged as a powerful teaching technique in face to face teaching (van Ments, 1989) and role play online is also powerful, with some added benefits (Bell, 2001). Online role plays are conducted via e-mail or a combination of e-mail and Web-based threaded discussion forum.

Online role play provides a scenario and a set of roles that students adopt in order to collaboratively solve a problem, create something, or explore an issue. An online role play is a type of simulation in which students interact with each other via the computer rather than the traditional simulation in which students interact with a computer model.

In Australia there has been pioneering work in online role plays in university-level subjects in politics by Vincent and Shepherd (1998), Linser, Naidu, and Ip (1999), and Kinder, Fardon & Yasmeen (1999); economics by Freeman and Capper (1999); psychology by Chester and Gwynne (1998); engineering by McLaughlan, Kirkpatrick,

Figure 1. Screen capture of online role play at University of Western Australia (Yasmeen & Fardon, 2002) showing threaded discussion by students in role as national delegates for UK, China, Syria, Russia, Pakistan, Egypt. © 2002 Samina Yasmeen & Mike Fardon. Used with permission

Maier, and Hirsch (2001); education by Bell (2001, 2002); geography by Brierley, Hillman, Devonshire, and Funnell (2002); and history by Wills and Ip (2002).

According to the taxonomy of simulations developed by Gredler (1992), these Australian examples fall into the category of multi-agenda/social-system/social-process simulations because:

participants assume roles in a hypothesized social group and experience the complexity of establishing and implementing particular goals within the fabric established by the system. The differences and potential conflicts among the roles set in motion the dynamics. (p. 22)

Although all of the examples stress the academic theory and content of their university-level discipline area, they also stress the generic learning outcomes, for example negotiation skills and communication skills, as the main outcomes of a social-process simulation. As participants work towards their social or political goals, they may experience a range of emotions such as pride, frustration, anger, rejection, acceptance, or conflict, therefore debriefing activities are an important part of any role play.

Following a definition adopted by Project EnRoLE (Encouraging Role Based Learning Environments, Carrick Institute Project, 2007[a]), the online role-based learning environments tracked by this study are all designed to increase understanding of real life human interaction and dynamics. Participants:

- Assume a role in someone else's shoes or in someone else's situation
- to do authentic tasks in an authentic context
- Involving in-role human interaction such as collaboration, negotiation, debate
- Interacting between roles substantially in an online environment.

Learning outcomes are assessable and generate opportunities for student reflection.

Online role play can add to face to face role play in two ways: asynchronicity and anonymity (Bell, 2001, 2002; Chester & Gwynne, 1998; Freeman & Capper, 1999). If online role play is conducted asynchronously it provides time for players to consider and research alternatives and use "out of role" discussions before making a "move." Role playing is a good environment in which to test and play with possibilities, establish strategies, promote confidence and evaluate consequences of any response. Face to face role play is usually of short duration and demands spontaneous action. While it may be of value to some training situations (e.g., sales presentation), it offers little opportunity for reflection. In contrast online role play can take weeks. This provides more opportunity for reflection, consolidation, and internalization of the actions taken.

Unlike a face to face role play, online role play can be anonymous, which provides distinctive features to support learners who may be intimidated, shy, or otherwise unable to participate fully in a face to face situation, especially impromptu face to face role play. It has an added value for participants whose first language is not the language in which the role play is conducted. In some cases it may enable participants to be more creative and imaginative. For example, gender swapping is a common outcome of anonymity and one that is not as plausible in face to face situations. Online role play can provide practice leading into face to face role play if needed.

TRACKING USE OF ONLINE ROLE PLAY IN AUSTRALIAN UNIVERSITIES

The growth of online teaching has been very rapid in the past 10 years, yet implementation of role play in an online setting is growing more slowly. In a previous national study, the essence of effective online role play was distilled into a learning design from analysis of seven exemplar case studies and interviews with fifteen role play designers (Hedberg, Oliver, Harper, Wills, & Agostinho, 2002; Wills & Ip, 2003). Since that study, the authors have tracked the growth of new designers and found additional designers who were missed in the first study because they had not published about their work or were not available for participation in the project at the time. The current study identified role play designers in Australian universities via literature review, searching of university teaching and learning Web sites, a follow-up e-mail survey with the original designers, new interviews with some of those designers, and personal approaches.

Some role plays have stopped after running three to four times either because the designer has moved universities and not yet restarted the role play in a new context or because the curriculum has changed and the role play has not yet been re-purposed for the new learning objectives. In Table 1, in the first interval there was a quadruple increase. In the second interval, as the Internet

Table 1. Growth of online role play in Australian Universities 1990–2006

Growth in…	1990-4	1995-9	2000-4	2005-6
Number of **role plays** developed	2	7	22	36*
Number of **role play designers**	2	11	35	48

** 10 of these 36 role plays are not currently running but most anticipate running again in the future*

began to gain credence in teaching, there was a three fold increase. There is only a small increase in the last interval but this covers two years so far rather than five years.

LEARNING OBJECTS

Wiley provides the following broad definition of a learning object:

any digital resource that can be reused to support learning. This definition includes anything that can be delivered across the network on demand, be it large or small. Examples of smaller reusable digital resources include digital images or photos, live data feeds (like stock tickers), live or prerecorded video or audio snippets, small bits of text, animations, and smaller Web-delivered applications, like a Java calculator. Examples of larger reusable digital resources include entire Web pages that combine text, images and other media or applications to deliver complete experiences, such as a complete instructional event. (Wiley, 2000, p. 23)

It is assumed that uptake and adoption of educational technology in teaching will be faster if teachers reuse educational courseware developed by other teachers rather than reinventing the wheel. In the past it has been assumed that one hurdle to teachers reusing other teachers' courseware is that the courseware is a closed package that has been too large a chunk to implement as a whole in another context because they want to modify it for their own unique context. One strategy by which university teachers use educational materials, digital or otherwise, is by breaking the materials into constituent parts, reusing those parts that are relevant to their subject, context, and perspective, and reassembling those parts from the original package along with parts from other packages to form a new set of educational materials. It is assumed that systems which mirror teachers' natural instinct to reuse chunks in their own preferred order for their own context will assist uptake and adoption of educational technology. These assumptions have underpinned the learning objects movement. Associated movements are the repository and metadata industries aimed at providing assistance to teachers in finding and reviewing these chunks or learning objects.

Australian university teachers are not yet exposed to the learning objects approach, although there has been some sector-level activity in Australian schools (Learning Federation[b]) and the vocational sector (ANTA ToolBox[c]). Recently the Carrick Institute for Learning and Teaching has initiated the Carrick Exchange for universities but at the time of writing it had not been launched.[d] Perhaps it is early days but also perhaps sharing is not part of the academic teaching culture which in general does not seem to reward time spent on teaching. Academics also value their intellectual property in different ways from school and vocational teachers as publication is a major part of promotion processes. There is some indication in our case studies that centres for teaching and learning, whose role is to support university teachers, are interested in learning objects and digital content repositories. Presumably this is because of the potential for gaining efficiencies in central courseware development.

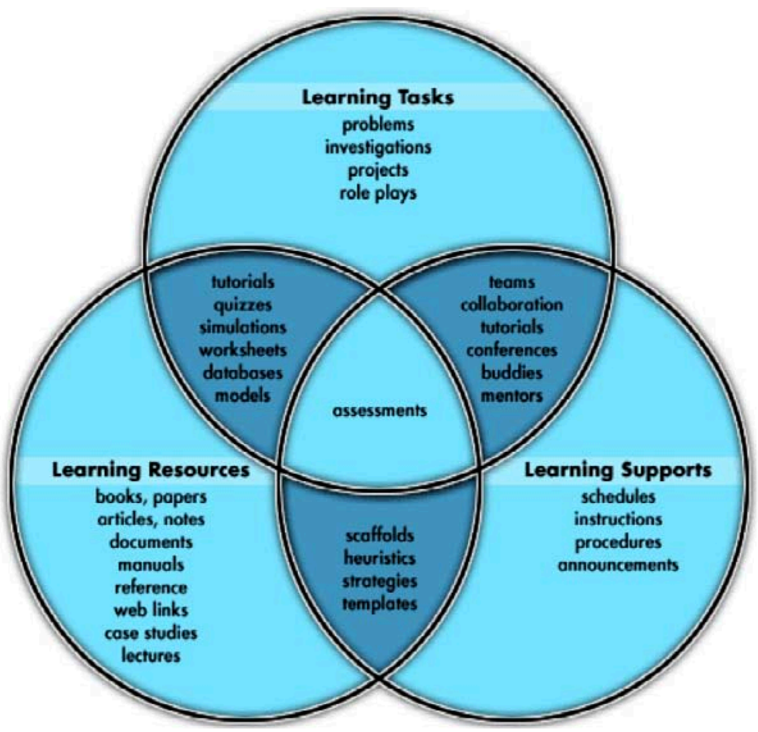
Meanwhile others in the educational technology scene are philosophically opposed to the learning objects movement, fearing that it does not provide teachers with a quality pedagogical basis for reuse of the learning objects (Mayes, 2003). They fear it will escalate a cut and paste "clip art" approach to teaching based on a content transmission model and hinder the growth of high quality online learning environments based on constructivist pedagogy. So alongside the learning objects movement has developed the learning designs movement which posits that in education a more useful "reusable chunk" is not a piece of content but rather a generic design for a sequence of learner-centred activities, resources and supports.

LEARNING DESIGNS

Based on a UK project called SOURCE for Software Use, Reuse and Customisation in Education,[e] the Australian Universities Teaching Committee (AUTC) proposed a similar project:

In a climate where individual institutions are experiencing increased costs at the same time

Figure 2. Key elements of a learning design, based on Oliver (1999) ©2008 Ron Oliver. Used with permission



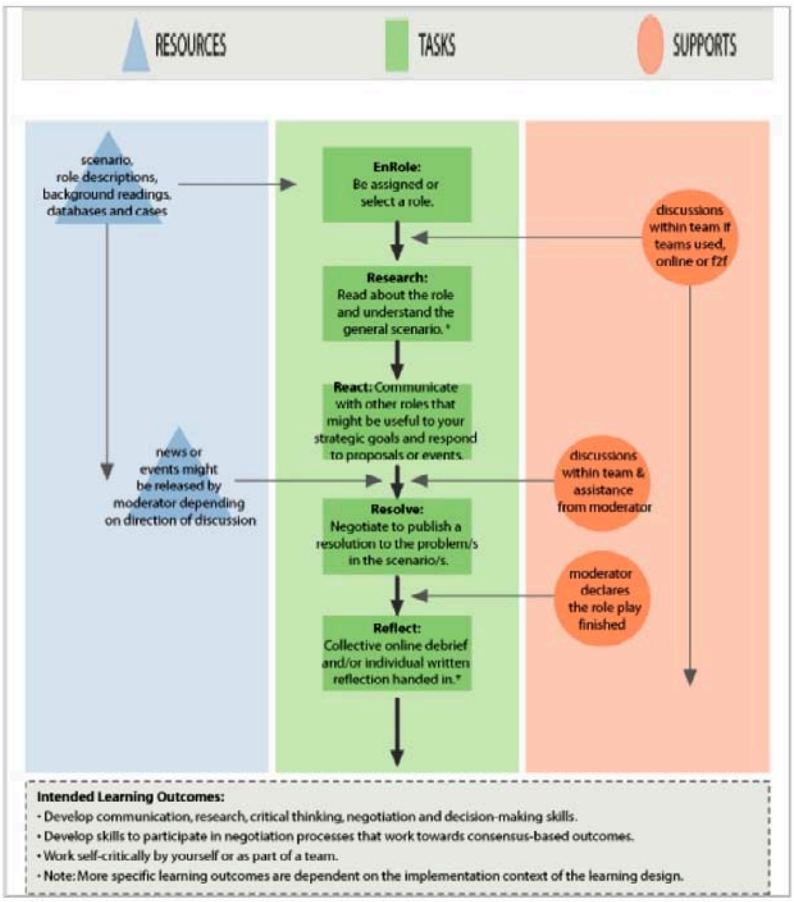
as they face increased demand for more flexible approaches to learning, AUTC considers there is benefit to be gained in developing shared resources and disseminating successful, generalisable templates between institutions.[f]

The University of Wollongong and Edith Cowan University won the bid for this major project on learning designs for ICT-based teaching. The aim of this project was to assist dissemination of the best online and multimedia projects previously funded by Australian government by distilling the essential learning design behind the project (Hedberg et al., 2002). The three year national project (2000-2003) culminated in a Web site which is available to all and contains exemplars, guides, and tools for supporting high quality online learning in universities (www.learningdesigns.uow.edu.au). The categories of learning design in the site include online role play.

The project proposed that quality learning comprises the following key elements (see Figure 2):

- Tasks that learners are required to do.
- Resources that support learners to conduct the task.

Figure 3. Learning design sequence for a generic online role play (Wills & Ip, 2003) © 2007 Sandra Wills and Albert Ip. Used with permission



- Support mechanisms that exist from a teacher implementing it.
- Assessment tying these elements together.

The term "learning design" as applied in this project describes the various frameworks that can be used to guide the design and choice of these four elements in the development of a learning experience for students, particularly ICT-mediated learning experiences. The project evolved a graphical representation mechanism to describe and document the generic learning design foci in terms of the tasks, resources and supports that would be required in the learning setting. A "Learning Design Sequence" representation uses the following graphical notation: Squares represent Tasks, Triangles represent Resources, Circles represent Supports, and Asterisks represent assessable tasks.

Learning Design as a Means for Facilitating Reuse of Online Role Play

The rationale behind the AUTC Learning Designs project was that effective description of online role play as a learning design would facilitate uptake of the teaching technique. The Learning Design Sequence developed for generically describing online role play is enRole, Research, React, Resolve, Reflect (see Figure 3).

The project team considered that the Learning Design Sequence construct could be a form of documentation to serve as a "standard" or "common" communication mechanism to explain and illustrate different kinds of learning designs. Most generic guides and exemplar descriptions housed within this Web site use the mechanism, supported by additional documentation. This documentation typically includes a description of key features of the learning design and the nature of the tasks, resources, and supports required. The role of ICT in the implementation of the learning design is also explained.

REUSABILITY OF ONLINE ROLE PLAYS

Because online learning has become a large investment for universities and is now a concern of Information Technology Services and Finance Directors as well as Educational Development Centres, "reusability" has become a topic of high interest. In tracking the uptake of online role play in Australia from 1990 to 2006, this current study treats "reuse" in two ways: the first type of reuse implies the online role play is a learning object and the second type implies the online role play derives from a learning design. Laurillard and McAndrew (2003) take a similar approach to terminology in an unpublished presentation titled "A pedagogic focus for R&D: Generic e-learning activities as learning objects?" at an AUTC Learning Designs conference in Sydney, 2002, and in Chapter 7 of *Reusing Online Resources* (Littlejohn, 2003).

Table 2. Reuse of learning object and reuse of learning design

Reuse by…	different teacher **same** discipline	different teacher **different** discipline
of **same** role play: Learning Object	6	0
of **same** role play **design**: Learning Design	5	18

Of the 36 role plays developed during the 15-year period, 29 role plays (80%) were a reuse of another role play. Table 2 analyses the 29 role plays using the framework of learning objects and learning designs.

Before the analysis it had been predicted that most role plays would fall into the category of "Reuse of same role play design by different teacher in same discipline" as this is the lesser "distance" to transfer. However results show substantial uptake of the learning design by different teachers in different disciplines. That 23 of the 36 role plays are reuse of a learning design supports the value of the original learning designs project: in a university context, learning design is currently a more useful concept than learning object.

Possibly, reusability in the form of learning objects is less likely in a university context because university role play designers are highly expert in the discipline area of the role play, such as politics or geography, and bring a wealth of knowledge into the moderation of the role play which is difficult to duplicate in another university. Course outlines are often closely aligned to the research strengths of the academics employed in the department. Reuse of comprehensive teaching materials is therefore less common in universities than in schools and post-secondary education. Academics are more likely to adopt a learning design than a learning object, unless the learning object is small and can be incorporated into their own learning design.

Our motivation for tracking and analysing the role plays was to chart whether a role play can become a learning object in the same manner as packaged print-based simulations such as *BaFa BaFa* or educational software such as *SimCity*. However, only three role plays in this study have been reused by others.

Three Role Plays that have become Reusable Learning Objects

Middle Eastern Politics

The first known university-level online role play developed in Australia, Andrew Vincent's Middle Eastern Politics at The University of Melbourne (Vincent & Shepherd, 1998) is a powerful example as it has been successful both as a learning object and as a learning design. Many of the 36 role plays now developed can track their ancestry back to Vincent's original learning design.

When Vincent moved to Macquarie University in another state and reused the role play there, the role play continued, and flourished, at The University of Melbourne. Middle Eastern Politics therefore counts twice as a learning object under the definition of reuse in this chapter. Figure 4 is a brief description of the role play.

Figure 4. Excerpt from description of Middle Eastern politics role play on project EnRoLE Web site

> *The simulation, which is set two or three weeks in the future, generally runs for three to four weeks and is played in the students' own time. It concludes with a real-time conference of three to four hours which addresses the issues that the students have been discussing in the preceding weeks. Once students are assigned to a team, and before the simulation begins, with the release of a scenario, they write a short profile of their character which is placed on the Web site and is accessible to all. The main role play proceeds in response to the scenario. Once the scenario has been released, the simulation is largely student driven, although all messages are monitored by controllers for grading purposes and to ensure that the students remain "in character."*

Figure 5. Screen capture from Middle Eastern politics[g] (Vincent & Shepherd, 1998) showing media roles. © 2007 Andrew Vincent & John Shepherd. Used with permission

At Macquarie University, the online role play has been reused in schools and may be released as a part of a textbook, although we have not included these two examples in Table 2 which counts only university examples.

Pain Management Roundtable Discussion

Elizabeth Devonshire (2006) at the University of Sydney has likewise had success with both a learning design and learning object.

Her original learning design for a roundtable discussion (RTD) in geography at Macquarie University (see Brierley et al., 2003) has now been reused twice at the University of Sydney (Devonshire, 2006) as the design for a RTD on pain management and for a RTD on animal ethics.

Her University of Sydney Pain Management online role play has recently been licensed to two international universities and therefore counts as a learning object twice in Table 2.

Idontgoto University

Likewise Maureen Bell's online role play, Idontgoto University (Bell, 2001), is reused by other teachers at the University of Wollongong for the same subject and by teachers at the University's Dubai campus, thus scoring twice as a learning object in the table above. Her learning design is described on the Learning Designs Web site as Quick Start Role Play #2.[h]

Only 3 online role plays of the 36 tracked in this study have been reused by other teachers. Investigating factors which contributed to the success and sustainability of these three role plays will help identify strategies for guiding future designers.

Reusable Learning Objects within Online Role Plays

Bennett, Lockyer, and Agostinho (2004), who were all involved in the original national project, have looked at learning designs from a different angle than the study reported here. They investigated how university teachers make use of generic learning designs as a framework for incorporating learning objects into their subjects. A learning design can incorporate learning objects and if an online role play is built as a learning object then it is feasible that it could contain learning objects within it too. Scenarios, role descriptions, and resources produced for an online role play could all become reusable learning objects if developed appropriately. For example, a project at The University of Melbourne is currently investigating

Figure 6. Excerpt from description of pain management roundtable discussion on project EnRoLE Web site

> *The RTD role play is built around the interactions of a multidisciplinary team (four health professionals), who are meeting regarding the management of a complex patient case. Each team member is represented by a small group of participants. These small "consultant" groups prepare a position statement about the case. Then, one player from each group participates in the (online) team meeting, with external support/advice from their "consultant" group. The team meeting enables exploration of the clinical decision making process within an interprofessional team context.*

Figure 7. Excerpt from description of Idontgoto University role play on project EnRoLE Web site

> *At a mythical university, IDONTGOTO UNIVERSITY, a lecturer has used criterion-referenced assessment in a subject and all of the students have received 100%. This has scandalised some of the academics in the faculty and the story has hit the local paper, The Daily View. A debate on criterion-referenced vs. normative assessment unfolds in the letters to the editor pages.*

issues with reusing cases, developed for business school case-based learning, as scenarios in role-based learning.

In this study, we found two instances where a component of a role play may be handed on as a learning object: *Save Wallaby Forest* by Kristin Demetrious[i] and *A Different Lunch* (Linser, Waniganayake, & Wilks, 2004). In the first, a scenario in video format is being considered for reuse in a different department in the same university. In the second, a video-based scenario is being considered for reuse in a different department in another university.

It is interesting that in both cases the learning object is in video format because there is a significant investment in high quality video production, thus perhaps it is worth trying to find other uses for it. In both cases the video is a very powerful trigger for the role play. However, according to one of the designers, a video format can constrain reuse because the actors portray roles with real gender, age and ethnicity which cannot be modified for a different context, unlike a text-based scenario. The video scenario written for *A Different Lunch* is based in an early childhood setting. The role play issues have equal validity in a primary school setting but the video scenario precludes reuse in this new setting.

These are the type of design issues that affect reuse of low granularity learning objects. The second part of this study, still underway, will investigate the design issues for high granularity learning objects, that is, an entire online role play, by further analysing the three role plays already identified as learning objects in the previous section.

Other Affordances to Uptake of Online Role Play

In tracking the growth of online role play, this study was looking for *reuse* as an affordance to uptake but it also noted other affordances (shown in Table 3):

- Seeing a colleague using role play or hearing them talk about it
- Seeing a presentation about role play at a conference or reading a relevant journal paper
- Being guided and supported into the use of role play by an educational developer
- The availability of a role play engine to guide and support their design work
- Following the guidelines for designing online role plays on the Learning Design Web site of the AUTC project.

The first 10 years of role play designers depended on a mix of the first three affordances. It was anticipated that after 2003 the AUTC Learning Design Web site would have impact,

Table 3. Affordances for uptake of online role play in Australian universities

Affordance (in some cases more than one affordance)	**1990-4**	**1995-9**	**2000-4**	**2005-6**
1. Personal Handover as Learning Object	1	1	0	4
2. Colleague	1	1	1	3
3. Conference Presentation/Journal Paper		1	3	0
4. Educational Developer			10	12
5. Engine			7	5
6. AUTC Learning Design Web site				5

because that is what it was funded to do; however, interviews indicate that although the Web site has been counted five times as an affordance to five new role plays, the other affordance for each of these five role plays is an educational developer. It is the educational developer, not the academic, who accesses the Web site.

There are a further five instances where the Learning Design Web site is starting to have impact but they have not been counted above as the role play has not yet been finished and not yet used with students. In addition, there are four instances where the Learning Design Web site has led to the development of a simplified template or guide for online role play at a particular university. Slowly the Web site is beginning to be one of the influences on the design of online role play.

Another affordance is the availability of tools and engines. In many of the examples a role play generator called *Fablusi*[j] was an affordance. In six examples, *Simulation Builder*[k] was an affordance and in one example it was *WebQUEST.*[l] In the future, it is possible that *LAMS*,[m] the Learning Activity Management System, may become an additional affordance or other toolkits as described by Conole and Oliver (2002). These tools are an exemplification of the particular role play learning design followed by the tool developer.

CONCLUSION

Outcomes from the study reported in this chapter, which tracks over 20 years the use and reuse of online role play as an example, imply that strategies for facilitating reusability must encompass learning designs and not just learning objects.

Repositories and content management systems must be able to handle learning designs as well as traditional learning objects. The previous Australian national project on learning designs suggested that learning designs currently require multiple formal descriptive systems such as visual sequences, templates, exemplars, and guides. All these need cross-referencing in any educational repository making it more than the usual index of learning objects.

Strategies for facilitating reusability of learning objects must operate at many levels of granularity:

- The stereotypical notion of video clips as learning objects, as well as
- Entire role plays packaged as learning objects, and
- Learning objects within learning objects.

Learning objects, repositories, and content management systems have been presented as being solutions to reuse, however they are really only underpinning technologies to support a university's explicit approach to facilitating reuse. A university's approach must build on existing affordances and provide reward and recognition for both *contribution* to repositories as well as for *reuse* of learning objects and learning designs retrieved from them. For example, a national project approved since this current study concluded (Project EnRoLE) will provide funds for a national repository of online role plays and introduces peer review as a reward structure for contribution to it. The project does not provide funds for building new role plays but it does reward reuse by funding collaboration between existing role play designers and potential new users:

Project EnRoLE builds a community of university teachers who are using online role play and develops a repository of sharable/reusable role play learning designs with an associated peer review process. In two years it aims to double the number of role play designers by scaffolding beginners and establishing national and international role play partnerships.

Support for teachers adopting learning designs must be provided. Support could include learning design toolkits, templates, and engines as as well as cultural change strategies such as recognition for sharing learning designs using peer review processes.

The finding that educational developers are currently one of the main affordances for uptake of learning designs and learning objects implies that position descriptions for educational developers need to clearly articulate their role in identifying opportunities for reuse and designing for reuse. The indispensable role of educational developers in mediating and facilitating reuse and reusability also impacts the design of repositories: decisions need to be made as to whether the repository is designed for use by educational developers or for use by university teachers, as the interfaces will be very different.

In conclusion, the concepts of learning object and learning design are both useful in understanding and facilitating reusability; however, in the university context more attention should be paid to supporting the uptake of learning designs.

REFERENCES

Bell, M. (2001). A case study of an online role play for academic staff. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the crossroads.* In *Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education*, The University of Melbourne, (pp. 63-72).

Bell, M. (2002). Online role play: Anonymity, engagement and risk. *Educational Media International, 38*(4) 251-260.

Bennett, S., Lockyer, L., & Agostinho, S. (2004). Investigating how learning designs can be used as a framework to incorporate learning objects. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.) *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference*, Perth (pp. 116-122). Retrieved April 2, 2008, from http://www.ascilite.org.au/conferences/perth04/procs/bennett.html

Brierley, G., Hillman, M., Devonshire, E., & Funnell, L. (2003). *Description of round table exercise: Environmental decision-making about water resources in physical geography* Retrieved April 2, 2008, from http://www.learningdesigns.uow.edu.au/exemplars/info/LD26/index.html

Chester, A., & Gwynne, G. (1998). Online teaching: encouraging collaboration through anonymity. *Journal of Computer Mediated Communication, 4*(2).

Conole, G., & Oliver, M. (2002). Embedding theory into learning technology practice with toolkits. *Journal of Interactive Media in Education*, *8*, 1-28. Retrieved April 2, 2008, from www-jime.open.ac.uk/2002/8

Devonshire, E. (2006). Re-purposing an online role play activity: Exploring the institutional and pedagogical challenges. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds.), *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who's Learning? Whose Technology?* (pp. 205-208). Sydney: Sydney University Press. Retrieved April 2, 2008, from http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p36.pdf

Duncan, C. (2003) Granularization. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* London: Kogan Page (pp. 12-19).

Freeman, M., & Capper, J. (1999). Exploiting the Web for education: An anonymous asynchronous role simulation. *Australian Journal of Educational Technology, 15*(1), 95-116.

Gredler, M. (1992). *Designing and evaluating games and simulations: A process approach*. Houston, TX: Gulf Publishing Company.

Hedberg, J., Oliver, R., Harper, B., Wills, S., & Agostinho, S. (2002). Implementing generic learning designs based upon quality ICT exemplars.

In *Proceedings of the International Conference on Computers in Education* (pp. 1011-1016). Copyright IEEE. Retrieved April 2, 2008, from http://ro.uow.edu.au/edupapers/5

Kinder, J., Fardon, M., & Yasmeen, S. (1999). Offline or online? A simulation exercise in a first year international politics unit. In J. Winn (Ed.), *Responding to Diversity: Proceedings of ASCILITE Conference* (pp.181-189).

Laurillard, D., & McAndrew, P. (2003). Reusable educational software: A basis for generic e-learning tasks. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to eLearning.* London: Kogan Page (pp. 81-93).

Linser, R., Naidu, S., & Ip, A. (1999). Pedagogical foundations of Web-based simulations in political science. In J. Winn (Ed.), *Responding to diversity, Proceedings of ASCILITE Conference* (pp. 191-198).

Linser, R., Waniganayake, M., & Wilks, S. (2004). Where is the teacher? E-learning technology, authority and authorship in teaching and learning. *EDMEDIA-2004*, Switzerland. Retrieved April 2, 2008, from http://www.simplay.net/papers/where_is_the_teacher.html

Littlejohn, A. (Ed.). (2003). *Reusing online resources: A sustainable approach to eLearning.* London: Kogan Page.

Mayes, T. (2003). Introduction to Part 1. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning.* London: Kogan Page (pp. 9-11).

McKenzie, J., Alexander, S., Harper, C., Anderson, S. (2005). *Dissemination, adoption & adaptation of project innovations in higher education.* Report for the Carrick Institute of Learning & Teaching, Australian Universities Teaching Committee. Retrieved April 2, 2008, from http://www.carrick-institute.edu.au/carrick/webdav/site/carricksite/users/siteadmin/public/dissemination_dissemi-nationadoptionandadaptation_report_2005.pdf

McLaughlan, R., Kirkpatrick, D., Maier, H., & Hirsch, P. (2001). Academic and institutional issues related to the planning and implementation of a multi-disciplinary roleplay-simulation involving collaboration across institutions. In G. Kennedy, M. Keppell, C. McNaught, & T. Petrovic (Eds.), *Meeting at the crossroads. Proceedings of the 18th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 407-415). Melbourne: The University of Melbourne.

McNaught, C. (2003). Identifying the complexity of factors in the sharing and reuse of resources. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning.* London: Kogan Page (pp. 199-211).

Oliver, R. (1999). Exploring strategies for online teaching and learning. *Distance Education*, *20*(2), 240-254.

van Ments, M. (1989). *The effective use of role play.* UK: Kogan Page.

Vincent, A., & Shepherd, J. (1998). Experiences in teaching Middle East politics via Internet based role play simulations. *Journal of Interactive Multimedia in Education*, *98*(11). Retrieved April 2, 2008, from http://www-jime.open.ac.uk/98/11/vincent-98-11-t.html

Wiley, D.A. (2000). *Learning object design and sequencing theory.* Doctoral dissertation, Brigham Young University, Utah. Retrieved April 2, 2008, from http://opencontent.org//docs/dissertation.pdf

Wills, S., & Ip, A. (2002). Online role play as a complementary learning design for the first fleet database. In *Linking Learners: ACEC 2002 Conference Proceedings*. Hobart: Australian Council for Computers in Education. (ISBN 0-9581188-0-9)

Wills, S., & Ip, A. (2003). Research, react, resolve, reflect: Developing and using online role play learning designs. Retrieved April 2, 2008, from http://www.learningdesigns.uow.edu.au/guides/info/G1/index.htm

Yasmeen, S., & Fardon, M. (2002). *Description of political science simulation exercise*. Retrieved April 2, 2008, from http://www.learningdesigns.uow.edu.au/exemplars/info/LD25/index.html

KEY TERMS

Educational Developer: Academic developer, instructional designer, or learning designer in a university education centre that supports and develops university teachers.

Learning Object: "Any digital resource that can be reused to support learning" (Wiley, 2000).

Learning Design: Generalisable template for a learning activity describing the sequence, tasks, resources, and supports.

Online Role Play: A scenario and a set of roles that students adopt in order to collaboratively solve a problem, create something, or explore an issue via e-mail or a combination of e-mail and Web-based threaded discussion forum.

Repository: An indexed collection of learning objects supported by a Content Management System.

Reuse: Overlaps with other terms like "uptake," "adoption," "adaptation," "modification," and "dissemination."

ENDNOTES

[a] http://cedir.uow.edu.au/enrole/

[b] http://www.thelearningfederation.edu.au/tlf2/

[c] http://toolboxcentral.flexiblelearning.net.au

[d] http://www.carrickinstitute.edu.au/carrick/go/home/rin/pid/381

[e] http://www.source.ac.uk/

[f] www.learningdesigns.uow.edu.au

[g] http://www.mq.edu.au/mec/sim/index.html

[h] http://www.learningdesigns.uow.edu.au/guides/info/G1/Downloads/QuickStartRolePlay_2.pdf

[i] Online Teaching & Learning Fellows Case Study on Deakin University website: http://www.deakin.edu.au/teachlearn/cases/files/2003oltf/case06.htm,

[j] www.fablusi.com

[k] http://www.mmc.arts.uwa.edu.au/student-projects/staff/simulations

[l] http://webquest.sdsu.edu/

[m] http://www.lamsinternational.com/

[n] http://cedir.uow.edu.au/enrole/

Chapter XXXVIII
An Analysis of Learning Designs that Integrate Patient Cases in Health Professions Education

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ABSTRACT

Health professional education is changing to meet the demands of a limited workforce and a focus on community-based clinical training. The change requires a focus on technology-supported learning in order to reach students and teachers who are separated by significant distances. The use of patient cases as reusable learning objects has received considerable attention in the sector and many support the use of such resources, but in order to do so the cases must be meaningfully integrated into the learning experience. This chapter reports the results of an analytical study that has developed eight generic case based learning designs categorised into three broad approaches supported by research evidence from the literature. These learning designs document common patterns in case based learning that could be adapted by teachers and designers to the specific requirements of different contexts. In closing, the authors consider how learning designs might be used as a vehicle for effectively integrating patient cases.

INTRODUCTION

Globally, health professional workforce demands have led to the establishment of new schools and the expansion of existing schools (Howe, Campion, Searle, & Smith, 2004; Lau & Bates, 2004; Lawson, Chew, & Weyden, 2004). Such increases in both supply and demand for nursing and medical education, and the necessary relevant clinical experiences, have caused educators to rethink curriculum foci and delivery models. As such, there is increasing emphasis on community-based and distributed education models. Technology-facilitated teaching and learning has been an essential component of this reconceptualisation of health professional education.

One initiative in this area has been in the development of learning object repositories with a health education and/or professional education focus (Chandler, Uijtdehaage, & Dennis, 2003; Harden & Hart, 2002; MedBiquitous Consortium, n.d.; Ward & Hartley, 2006). One important type of learning object is the patient case, which details the condition of a health service client. The context of a case may be a hospital setting, a community health clinic, or even the patient's home environment. A clinical case may be brief in only providing patient presenting information (i.e., the problem for which the patient seeks health care), or be extensive and include full medical records, investigations and reports, and case notes of one or more health care providers. Depending on how they are used in educational settings, clinical cases may allow students to analyse and reflect on real-world problems and/or apply reasoning and decision making skills in a contextualised manner.

While the value of learning objects (including patient case learning objects) to support such distributed education programs has been widely recognised, there is concurrently a call to investigate how they can be integrated into the curriculum (Ruiz, Mintzer, & Issenberg, 2006). This chapter presents the findings of an analytical study that sought to identify a set of generic learning designs to document common patterns used in case based learning in a way that can be communicated to other teachers and designers. The aim of the project was to consider how learning designs might support pedagogically meaningful integration of patient case learning objects in health profession education.

BACKGROUND

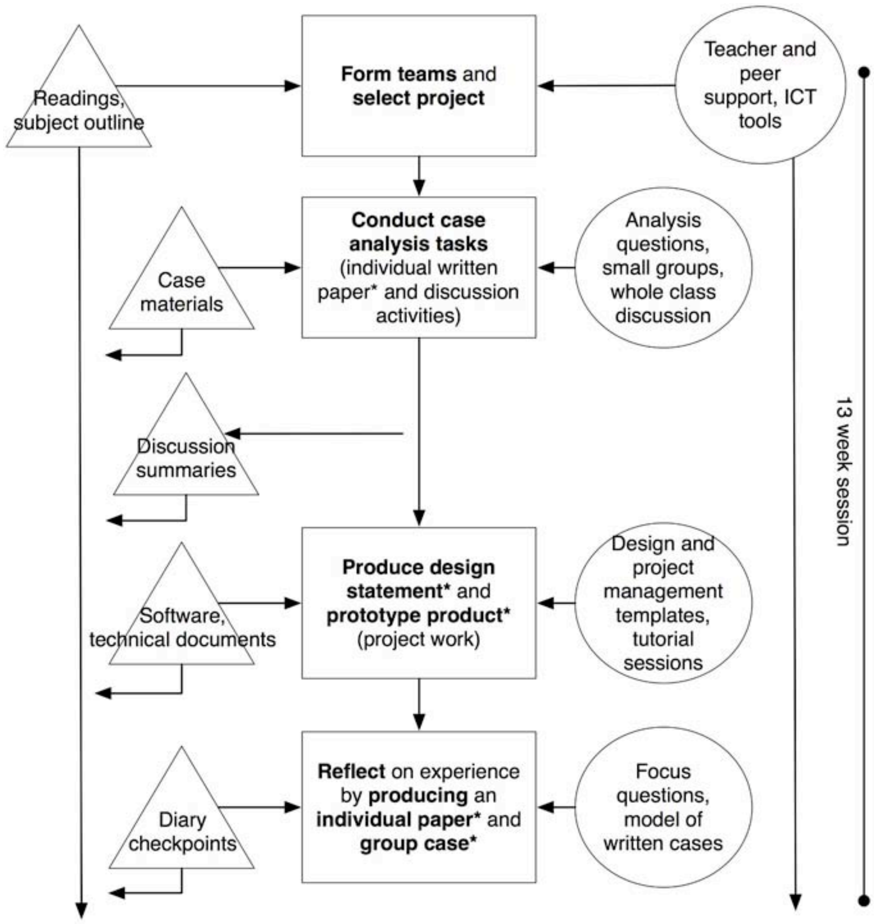
Case Based Learning

Case based learning has been used extensively in education—particularly in professionally-focused disciplines such as medicine, law, business, and teacher education (Bennett, Harper, & Hedberg, 2002; Crang-Svalenius & St. Jernquist, 2005; Golich, 2000; Kim, Hannafin, & Kim, 2004; Tarnvik, 2002; Tomey, 2003). Case based learning refers to a suite of approaches that seek to engage students in analysis of specific, usually real-world, situations (or cases). This is usually achieved through individual and/or group analysis of a case description in which students develop an understanding of the events depicted and consider possible interpretations or resolutions. The role, structure, and application of cases in educational environments vary greatly depending on the intended purpose, which has led to a great diversity in case based learning approaches. Research across the these disciplines has shown the power of using cases in their various forms to create vicarious or pseudo experience for learners that promote the development of knowledge and skills through a situated approach to learning (Bennett et al., 2002; Conyers & Ritchie, 2001; Floyd & Bodur, 2005; Malloy & DeNatale, 2001; Thomas, O'Connor, Albert, Boutain, & Brandt, 2001).

LEARNING DESIGNS

A significant body of literature has emerged in the past decade about the concept of learning designs (see the Agostinho chapter in the Learning Designs section of this Handbook, for an in-depth review of this work). One area of learning design research that has been initiated and further developed in Australia has become known as the Learning Design Framework. This framework comprises both a representation of learning design, the Learning Design Visual

Figure 1. Example of a case based learning design using the learning design visual sequence. Source: Adapted from Bennett (2002)



Intended Learning Outcomes:
- Enhance understanding of the design, process and project management issues that arise in multimedia product development.
- Have the ability to design and develop interactive multimedia packages in collaborative teams.
- Develop an understanding of the roles and responsibilities of the members of a multimedia development team.
- Reflect on the team experience and articulate the lessons that can inform future practice.

Sequence (LDVS), and a theoretical model for how learning designs and their representations support teachers in planning and implementing teaching and learning experiences.

The representation aspect of this framework was initially informed by the work of Oliver (1999) and Oliver and Herrington (2001), which defined the main structural components of a learning design to consist of the *tasks* students engage in, the *resources* available to the students, and the *supports* provided to assist the students through the learning process. The concept of these learning design components was further developed in a large-scale project that undertook an extensive evaluation of examples of the use of flexible learning in the Australian higher education context. The products of that project include a Web site (www.learningdesign.uow.edu.au) containing generic and contextualised learning designs derived from the evaluated examples. These learning designs are represented using the Learning Design Visual Sequence (Agostinho, Harper, Oliver, Hedberg, & Wills, in press) which comprises a graphical representation and supporting textual description documenting the design.

One example of a learning design that involves case based learning is illustrated using the LDVS in Figure 1. This particular design represents a subject that is available to students over a 13-week teaching session.

The tasks (represented by a series of rectangles arranged vertically in the centre) form the focus of the diagram. For this learning design, students form groups and select a project which involves the development of educational multimedia software. As a group, students analyse learning objects comprised of cases of other multimedia design projects, produce a design statement and prototype for their own project, and then reflect on their experience by developing their own case. Assessable tasks, indicated by an asterisk (*), include the design statement, prototype and new group case.

In the LDVS, resources (represented by triangles) and supports (represented by circles) are illustrated alongside the tasks which they facilitate. Resources comprise the content material provided to help learners work through a task, or which learners create to contribute to the content as part of the learning process. For this learning, students are provided with case materials technical documentation related to the software development, and create discussion summaries and diary entries to share with the class. The diagram indicates that the resources are sequentially released to students as they progress through the tasks and then are available for the remainder of the session. In the LDVS, supports refer to the strategies a teacher implements or facilitates to help learners engage with and complete each task. In this design, the teacher and fellow students (within and outside of each group) support each other through focused online discussion pertaining to each task.

PROCEDURE USED TO DEVELOP CASE BASED LEARNING DESIGNS

The initial step in the process of developing evidence based, high quality learning designs required an in-depth exploration of the literature. This began with a comprehensive search of key education and health/medicine bibliographic databases (such as Ed/ITLib Digital Library, ERIC, Expanded Academic Index, Proquest education, Medline), which focussed on health professional education. Keywords including "case-based learning," "case methods," and "case study" directed the identification of relevant literature in education broadly and within the professional education literature specifically. Given the increasing use of online technologies to facilitate the various health profession education programs, specific emphasis was placed on identifying examples of case based learning that had used Internet and/or multimedia technologies in some way, particularly to deliver patient case or other learning objects.

However, wholly face-to-face implementations were not excluded from the analysis. From the literature found, examples of case based learning that appeared in peer reviewed publications and included empirical evidence were given prioritised for review. Within this subset, articles that provided sufficient detail about how cases were used in teaching and learning were identified and selected as the basis for the development of learning designs for case based learning. An LDVS was developed to document the learning processes as it was explained in each article. Each learning design was then analysed for common themes such as granularity, structure, and purpose. From this further analysis, the set of generic case based learning designs were categorised in terms of the conceptual literature of case based learning.

CASE BASED LEARNING DESIGNS

Kim et al. (2004) provide an in-depth discussion of case based approaches through their discussion of three varied designs, each of which is defined by the pedagogical design, the main purpose and the role of the cases in learning. Thomas et al. (2001) also describe three approaches to case based instruction, though they have distinguished these according to the delivery method used—written, standardised patient or Web-based. An analysis of this and other literature has informed the development of Figure 2, which illustrates three general types of case based learning strategy.

Figure 2 attempts to capture and classify the multitude of variations of case based learning by distinguishing between three broad approaches—the case method, case study, and case based project approaches. The case study and case method approaches can, but do not always, exist in isolation. The case based project approach is derived when qualities of both the case study and case method approach are evident in the one learning design. The diagram also indicates the outcomes and the case structure for each approach. The specific generic learning designs for each approach are listed in Table 1.

While there are commonalities across all three approaches in that each includes a case and a clear link to intended student learning, understanding the differences between approaches and their correct application depending on desired outcomes and learning contexts is critical to deriving the benefits of a case based learning approach (Thomas et al., 2001). This requires understanding of the case structure and outcomes, which define the fundamental differences between each approach. To gain a better appreciation of the differences, each approach and one of the generic designs exemplifying the approach is discussed in detail in the following sections.

CASE METHOD APPROACH

The case method approach incorporates a structured approach to problem solving, whereby only a problem in the form of a "real-life" event is put forward to trigger students to devise hypotheses and diagnoses to solve the case. Through exploration of the problem and research into treatment, this approach encourages the development of clinical reasoning, clinical decision-making, and problem solving skills. This approach is used within the traditional and adapted problem based learning curricula. Problem based learning in medical education is well documented in terms of its many variations (Davis & Harden, 1999; Lockyer & Patterson, 2005).

An analysis of the literature describing case method approaches has led to the development of four generic learning designs that typify the common variations. The main differences in the designs arise from the extent to which the traditional problem based approach is followed or adapted in terms of individual student activity, the level of student autonomy in the identification of their necessary learning materials, and the degree of student involvement in the identification and/or negotiation of learning objectives.

Figure 2. Overview of case based learning approaches

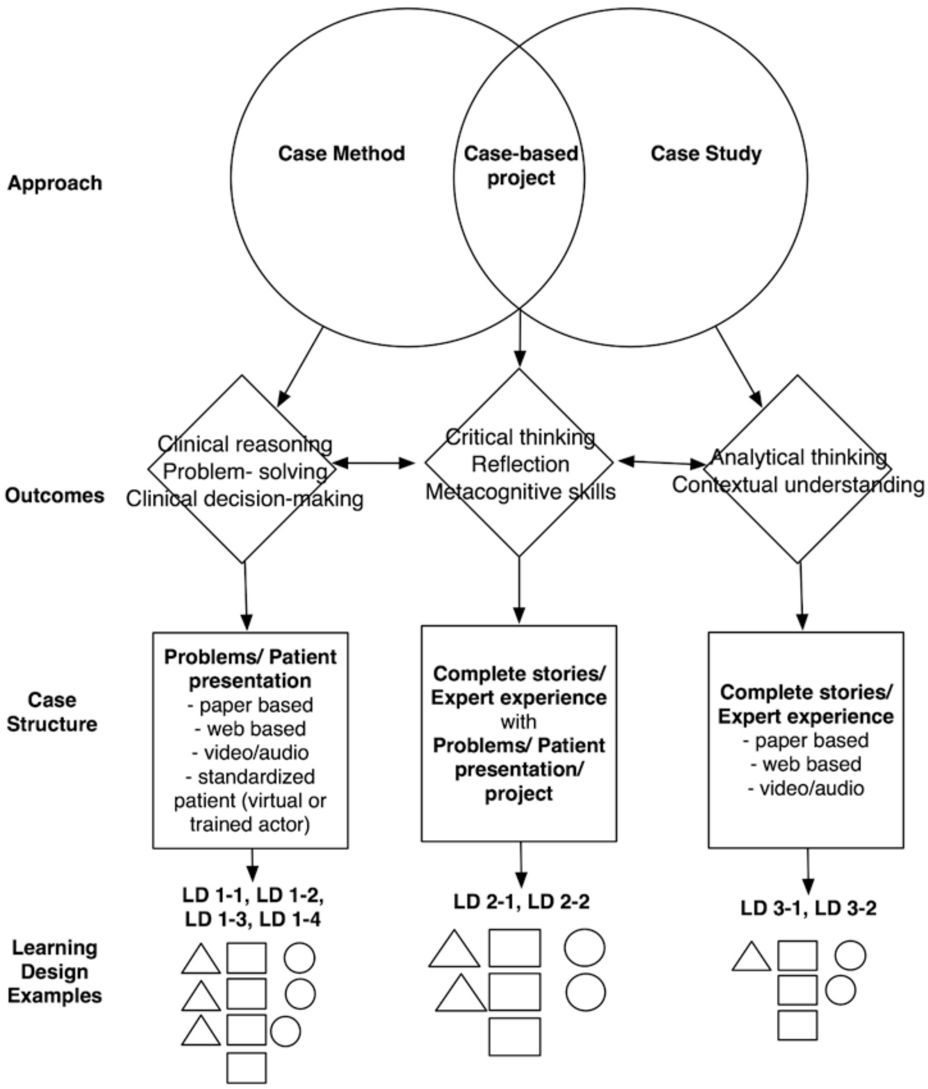
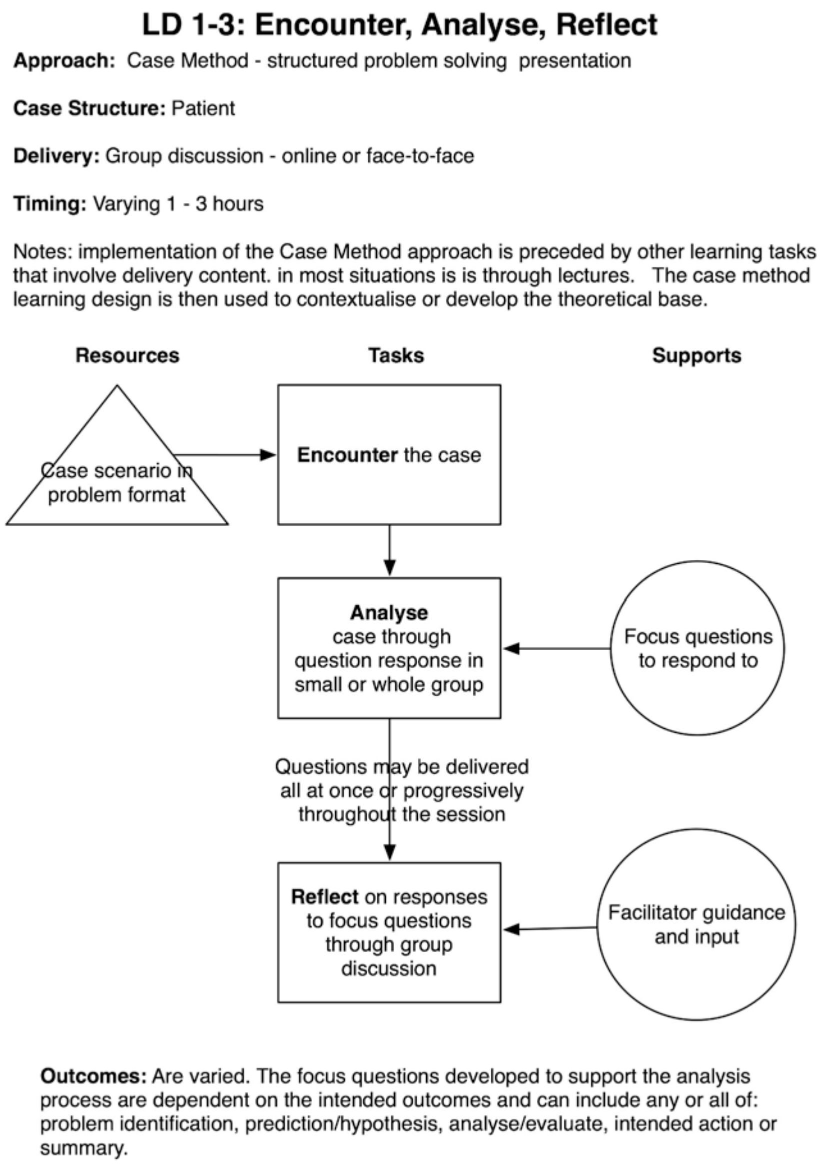


Table 1. Case based learning designs categorised by case based learning approach

Approach	Identifier	Case Based Learning Design Name
Case method	LD1-1	*Review, Explore, Examine, Solve*
	LD1-2	*Review, Diagnose, Plan, Reflect*
	LD1-3	*Encounter, Analyse, Reflect*
	LD1-4	*Encounter, Clarify, Identify, Solve*
Case based project	LD2-1	*Analyse, Apply, Reflect*
	LD2-2	*Analyse, Discus, Write, Share*
Case study	LD3-1	*Interprofessional Perspectives*
	LD3-2	*Analyse, Discuss*

Within the *Encounter, Clarify, Identify, Solve* learning design (LD 1-4), the patient case provides an authentic setting within which students clarify the terms and issues that are unfamiliar to them, identify their learning objectives, and engage in active individual inquiry to meet those objectives with resources that may or may not have been preselected by teachers. The individual inquiry process is supported through student group meetings facilitated by a clinical expert and/or a tutor who is well trained in the problem based learning process. Less traditional applications of problem based learning often involve the integration of individual and small group inquiry with lectures

Figure 3. Learning design visualisation sequence for the Encounter, Analyse, Reflect generic design



and other learning activities (see, for example, Roberts, Lawson, Newble, Self, & Chan, 2005).

Two of the other generic learning designs encapsulate common variations on this approach worthy of inclusion as separate designs. The *Review, Explore, Examine, Solve* learning design (LD 1-1) involves small group problem solving activity involving the use of a standardised patient (a person trained to act as a patient) to present a clinical problem (Srinivasan, Wilkes, Stevenson, Nguyen, & Slavin, 2007). The *Review, Diagnose, Plan, Reflect* design (LD 1-2) involves an individual, problem solving activity in which students experience a clinical problem (usually presented in a multimedia learning object delivered within an online environment) and work through to explore the problem, create an action plan for treatment, and reflect upon their plan (Brearley Messer, Kan, Cameron, & Robinson, 2002; Naidu, Oliver, & Koronios, 1999) .

The fourth generic learning design based on the case method approach, *Encounter, Analyse, Reflect* (LD 1-3), was derived from a range of medical and nursing education literature (Cliff & Curtin, 2000; Conyers & Ritchie, 2001; Crang-Svalenius & St. Jernquist, 2005; Gilboy & Kane, 2004; Hoag, Lillie, & Hoppe, 2005; Katsikitis, Hay, Barrett, & Wade, 2002; Schlenker & Sullivan Kerber, 2006; Tarnvik, 2002; Tomey, 2003) and is illustrated in Figure 3.

The *Encounter, Analyse, Reflect* design involves student discussion about issues pertaining to a clinical problem presented by an incomplete patient case. In the initial *encounter* task, students read the patient case scenario that has been provided. The case resource may be made available to students in printed form and/or via a subject Web site. Then, in small groups or as a whole class, students *analyse* the case by discussing and responding to a set of focus questions set by the facilitator. As with the case study approach, focus questions should be clear, concise, appropriate to the learning outcomes, and intended to guide individual analysis and promote discussion. The facilitator may choose to deliver all questions at once or progressively. In the final *reflect* task, students discuss their responses to the focus questions with facilitator guidance and/or expert input. To support this, the facilitator maintains the focus of the discussion and provides feedback to students' reflections. The facilitator may also wish to disclose how the case was dealt with in real life and the consequences that resulted.

CASE STUDY APPROACH

The case study approach involves students engaging in the analysis of a complete patient case. A complete case consists of a description of an authentic scenario, process, and solution, often including thoughts, actions, and consequences experienced by the people involved. The case study approach aims to promote the development of analytical thinking and contextual understanding, and can be used to assist students in developing an understanding of a variety of perspectives on an issue.

Within the case study approach two generic learning designs have been extracted from the literature. Both centre on analysis and discussion tasks with variation in the way the case resources, expert advice and focus questions that support the tasks are unfolded for students through the course of the learning experience. The main difference between these two designs is the focus and scope for case analysis.

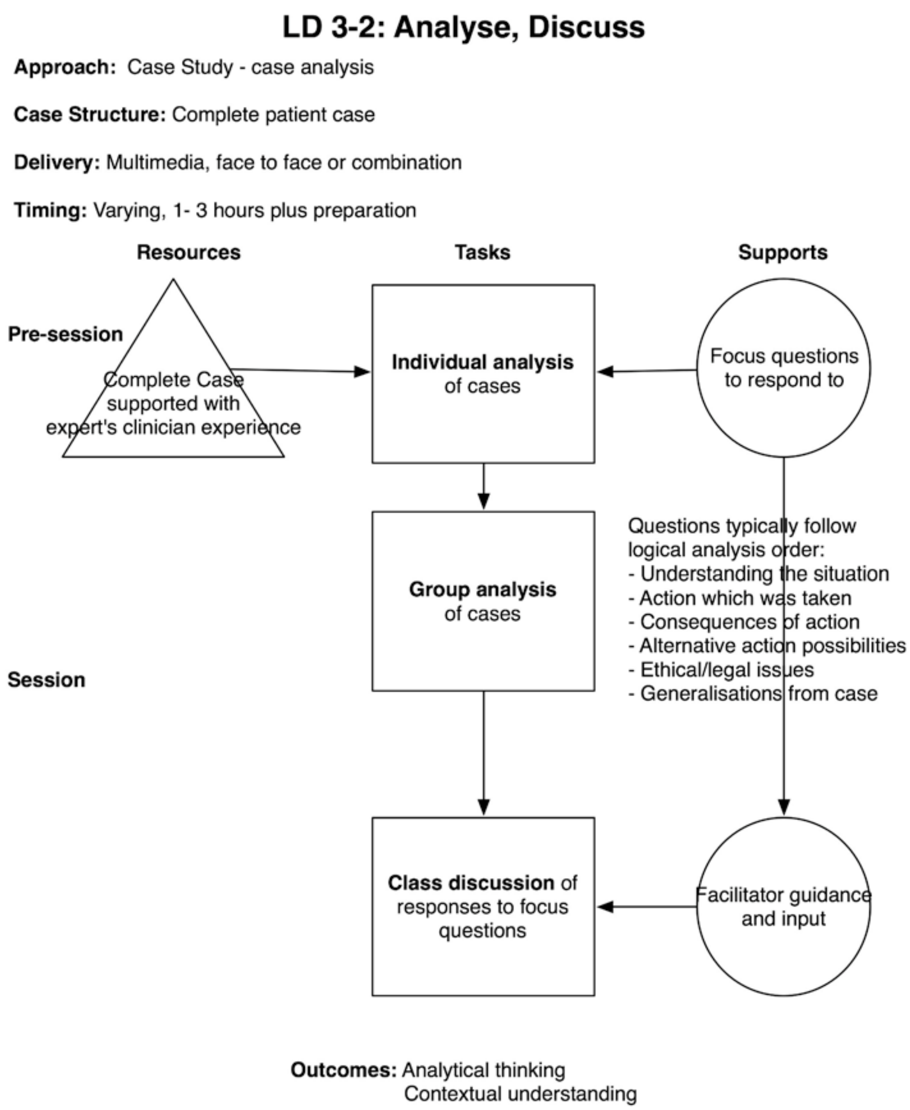
In the *Interprofessional Perspectives* learning design (LD 3-1), students analyse a complete scenario which offers viewpoints from two or more perspectives in order to gain an understanding of different approaches to the same situation. Focus questions lead analysis of the various perspectives and assumptions which such ideals are based (O'Brien Quinn, 2005).

The *Analyse*, *Discuss* learning design (LD 3-2), derived from a range of professional education literature (Golich, 2000; Lind, 2001; Malloy

& DeNatale, 2001), illustrated in Figure 4, is an example of one of the generic designs that was categorised under this approach.

This learning design requires students to respond to focus questions relating to a complete patient case through which they analyse how the situation was dealt with in one particular instance. Prior to students meeting as a group, they are presented with a full patient case. This may be provided in a printed course pack or online in the format of a text-based or multimedia learning object. Students are expected to individually *analyse* the case by responding to a set of focus questions pre-defined by the teacher or designer. The questions should be clear, concise, and intended to encourage analytical thinking and to promote discussion in the later group session. The facilitator may choose to present all questions at

Figure 4. Learning design visualisation sequence for the Analyse, Discuss generic design



once or progressively unfold them over a period of time. The questions would typically follow logical analysis order through which the learner develops an understanding of the situation, the action that was taken and the consequences of the action. This is followed by questions that encourage learners to consider possible alternative actions, reflect on ethical and/or legal issues, and identify generalisations that could be drawn from the case. The focus questions are provided to keep students on track throughout the analysis and should be directly related to the intended learning outcomes. Thus, it is necessary for the facilitator to develop the focus questions prior to the implementation of the learning design.

During a scheduled class session, students work in small groups to share their responses to the focus questions and further explicate their understanding of the case. After the groups have had time to work through the focus questions, they report back as a whole class to *discuss* an overall summary with the teacher facilitating and providing expert input. Facilitation of this session ensures that all relevant issues related to the particular case study are addressed.

CASE BASED PROJECT APPROACH

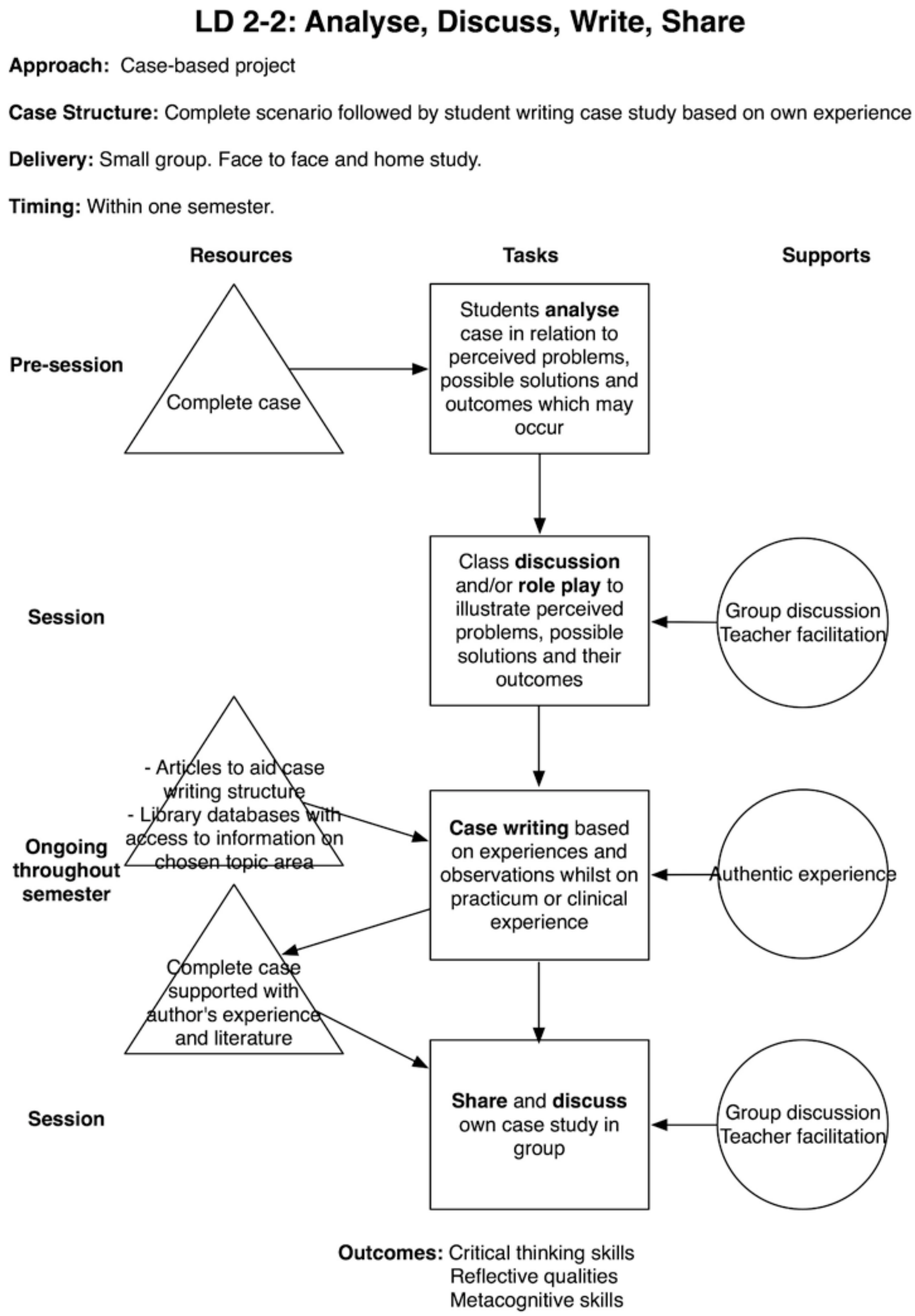
Case based projects integrate the case study and case method into one learning experience. Regardless of the particular design, the use of the two methods promotes the development of critical thinking, reflection, and metacognitive skills. The literature informing case based project approaches formed the basis of two generic learning designs. Each design involves students analysing a complete case then applying this knowledge to their own situation. The designs differ in the context in which this knowledge is applied.

Learning design *Analyse, Apply, Reflect* (LD 2-1) students work in either a small group or individually to analyse a complete, authentic case scenario in the form of an example of and commentary pertaining to an actual situation. After discussing the case, students work in groups to apply their new and existing knowledge to develop a solution or action plan for treatment for a case project/problem presented to them as an incomplete case (Bennett et al., 2002; Kim & Thomas, 2004)

The second case based project learning design is *Analyse, Discus, Write, Share* (LD 2-2), illustrated in Figure 5.

In the *Analyse, Discuss, Write, Share* learning design, prior to a class session, students are provided with an authentic case scenario that details an event as it actually occurred within practice. These cases are learning objects that have been written by previous students and may be presented using text, audio, and/or video format and delivered in hardcopy or online as appropriate. Students *analyse* the case to identify problems occurring within the situation, suggest ways of solving or treating the problem, and consider the possible outcomes that may result if the suggested actions are taken. During class, students *discuss* their responses to the case in light of the problems, solutions and outcomes that they developed during the initial analysis. The development of understanding and insight into multiple perspectives is supported through collaborative discourse, which the facilitator guides through effective questioning techniques. Subsequent to this discussion, students engage in practical placement activities to experience professional practice in context. During this time students identify an issue that has arisen which they would like to write up as a case. Information is provided to instruct students on case writing and library databases are made available for students to research their chosen issues. Students use these resources and their practical experience to *write* their own cases. Once prepared, students *share* their cases with others in the class and respond to questions posed by classmates about the case situation. Group discussion with teacher facilita-

Figure 5. Learning design visualisation sequence for the Analyse, Discuss, Write, Share generic design



tion allows students to engage vicariously in the experience of others.

DISCUSSION

This analysis of the case based literature related to professional learning has revealed three overall categories of approach—case study, case method, and case based project. Within these approaches, generic learning designs that describe common overall case based learning patterns have been extracted. Each of these has been derived by analysing reports of actual case based learning implementations which were clearly described in the literature and whose effectiveness was supported by evidence. Despite significant variation between the implementations, it was possible to identify consistencies in the nature of the authentic patient case and analysis tasks that are characteristic of an approach. Across all approaches, the use of some kind of facilitated discussion is a common supportive activity.

Of the three broad approaches identified, the case study and case method are those that have most often been used in health professional education, particularly in medicine and nursing. The case based project approach has been effectively used most often in pre-service teacher and teacher professional development contexts. However, the increased and early clinical exposure that students in medicine and nursing are now benefiting from other opportunities to use the case based project approach in these professional education settings. Increasingly, students have access to varied and vast amounts of clinical material from which they can research and write their own patient case that can be shared with other students and their teachers and be available in a repository as reusable learning objects for future use.

The outcomes of this project in identifying the broad approaches and generic learning designs characteristic of case based learning demonstrates the utility of the learning design concept as a tool that allows extraction of teaching and learning processes for analysis. Documenting the various approaches using the learning design formalism enabled each to be expressed in a consistent "language," thus facilitating comparison and the extraction of similarities and differences.

The key practical benefit of identifying these generic learning designs is in their use with educators. Generic designs serve to document the characteristics of a learning sequence and identify the tasks, resources and supports important to effective use. The strength of these learning designs is that they are not prescriptive and "leave room" for educators to apply their professional knowledge to adapt the design for their particular learning contexts. Thus, learning designs can be used to guide the design process. For example, by understanding the way resources are used, educators can plan the integration of reusable learning objects, in this case patient cases integrated with analysis and discussion tasks.

To advance educational research and practice in case based learning designs, issues of how to disseminate learning designs, how to make them easily accessible, and how to ensure that educators use them effectively must be addressed. Although the concept of learning designs is growing, questions remain about whether and how such a framework can support the design, planning and implementation activities of health professional educators. For example, it can be argued that the most common practice of health professional educators, and educators in general, is to share their teaching ideas through personal professional contact and through the literature. With this in mind, how could the case based learning, learning designs best be communicated to health professions educators? An online repository of learning designs may be one option. However, if this were to be actioned, it could not be done in isolation of the patient case learning objects, the key resources vital to the design of health professional education. Given the expansion of learning object repositories containing patient cases, a support system that brings these two concepts together would appear to offer great potential.

CONCLUSION

This chapter has described the outcomes of an analytical study that sought to identify common approaches reported in the case based learning literature and develop a set of generic learning designs that document these characteristics. This has served to identify three broad approaches and eight generic designs that could be applied to health professional education. The generic designs describe successful patterns whose effectiveness is supported by research evidence which could be used to assist educators in planning and developing learning experiences that integrate reusable learning objects. Further research is needed to determine how to best disseminate such designs and facilitate their use in supporting teachers' design processes.

REFERENCES

Agostinho, S., Harper, B., Oliver, R., Hedberg, J., & Wills, S. (in press). Visual learning design representation to facilitate dissemination and reuse of innovative pedagogical strategies in university teaching. In L. Botturi & T. Stubbs (Eds.), *Handbook of visual languages for instructional design: Theories and practices.* IGI Global.

Bennett, S. (2002). R*eal life cases in multimedia*. Retrieved April 3, 2008, from http://www.learningdesigns.uow.edu.au/exemplars/info/LD1/more/03Context.html

Bennett, S., Harper, B., & Hedberg, J. (2002). Designing real life cases to support authentic design activities. *Australian Journal of Educational Technology, 18*(1), 1-12.

Brearley Messer, L.B., Kan, K., Cameron, A., & Robinson, R. (2002). Teaching paediatric dentistry by multimedia: A three-year report. *European Journal of Dental Education, 6*(3), 128-138.

Chandler, C.S., Uijtdehaage, S.H., & Dennis, S.E. (2003). Introducing HEAL: The health education assets library. *Academic Medicine, 78*(3), 249-253.

Cliff, W.H., & Curtin, L.N. (2000). The directed case method: Teaching concept and process in a content-rich course. *Journal of College Science Teaching, 30*(1), 64-66.

Conyers, V., & Ritchie, D. (2001). Case study class tests: Assessment directing learning. *Journal of Nursing Education, 40*(1), 40-42.

Crang-Svalenius, E., & St. Jernquist, M. (2005). Applying the case method for teaching within the health professions - teaching the teachers. *Medical Teacher, 27*(6), 489-492.

Davis, M.H., & Harden, R. (1999). AMEE medical education guide No. 15: Problem-based learning: A practical guide. *Medical Teacher, 21*(2), 130-140.

Floyd, D.M., & Bodur, Y. (2005). Using case study analysis and case writign to structure clinical experiences in a teacher education program. *The Educational Forum, 70*(1), 48-60.

Gilboy, N., & Kane, D. (2004). Unfolding case based scenarios: A method of teaching and testing the critical thinking skills of newly licensed nurses. *Journal of Emergency Nursing, 30*(1), 83-85.

Golich, V.L. (2000). The ABCs of case teaching. *International Studies Perspectives, 1*(1), 11-29.

Harden, R.M., & Hart, I.R. (2002). An international virtual medical school (IVIMEDS): The future for medical education? *Medical Teacher, 24*(3), 261-267.

Hoag, K., Lillie, J., & Hoppe, R. (2005). Piloting case-based instruction in a didactic clinical immunology course. *Clinical Laboratory Science, 18*(4), 213-220.

Howe, A., Campion, P., Searle, J., & Smith, H. (2004). New perspectives - approaches to medical education at four new UK medical schools. *British Medical Journal, 329,* 327-331.

Katsikitis, M., Hay, P.J., Barrett, R.J., & Wade, T. (2002). Problem- versus case-based approaches in teaching medical students about eating disorders: A controlled comparison. *Educational Psychology, 22*(3), 277-283.

Kim, H., Hannafin, M., & Kim, M. (2004). Online case-based learning: Components, applications, and assessment. *Distance Learning, 1*(5), 23-31.

Kim, H., & Thomas, G. (2004). *Web-enhanced case methods for preservice teachers.* Paper presented at the Proceedings of Society for Information Technology and Teacher Education International Conference 2004.

Lau, F., & Bates, J. (2004). A review of e-learning practices for undergraduate medical education. *Journal of Medical Systems, 28*(1), 71-87.

Lawson, K.A., Chew, M., & Weyden, M.B.V.D. (2004). The new Australian medical schools: Daring to be different. *The Medical Journal of Australia, 181*, 662-666.

Lind, V.R. (2001). Designing case studies for use in teacher education. *Journal of Music Teacher Education, 10*(2), 7-13.

Lockyer, L., & Patterson, J. (2005). Scaffolding clinical problem based learning within an online collaborative environment. In T.C. Montogomerie & J.R. Parker (Eds.), *Proceedings of the IASTED International Conference on Education and Technology* (pp. 236-241). Calgary: ACTA Press.

Malloy, S.E., & DeNatale, M.L. (2001). Online critical thinking: A case study analysis. *Nurse Educator, 26*(4), 191-197.

MedBiquitous Consortium. (n.d.). *MedBiquitous - enabling collaboration fo health care education*. Retrieved April 3, 2008, from http://www.medbiq.org

Naidu, S., Oliver, M., & Koronios, A. (1999). Clinical decision making in nursing practice with case-based reasoning. In P. Kommers & G. Richards (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 1999* (pp. 692-697). AACE.

O'Brien Quinn, S. (2005). Artificial sanity: A case study for a class in introductory psychology. *Journal of College Science Teaching, 35*(2), 15-17.

Oliver, R. (1999). Exploring strategies for online teaching and learning. *Distance Education, 20*(2), 240-254.

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Edith Cowan university.

Roberts, C., Lawson, M., Newble, D., Self, A., & Chan, P. (2005). The introduction of large class problem-based learning into an undergraduate medical curriculum: An evaluation. *Medical Teacher, 27*(6), 527-533.

Ruiz, J.G., Mintzer, M.J., & Issenberg, S.B. (2006). Learning objects in medical education. *Medical Teacher, 28*(7), 599-605.

Schlenker, E.C., & Sullivan Kerber, C.H. (2006). The CARE case study method for teaching community health nursing. *Journal of Nursing Education, 45*(4), 144.

Srinivasan, M., Wilkes, M., Stevenson, F., Nguyen, T.a., & Slavin, S. (2007). Comparing problem-based learning with case-based learning: Effects of a major curricular shift at two institutions. *Academic Medicine, 82*(1), 74-82.

Tarnvik, A. (2002). Advantages of using the multiple case method at the clinical stage of medical education. *Medical Teacher, 24*(4), 396-401.

Thomas, M.D., O'Connor, F.W., Albert, M.L., Boutain, D., & Brandt, P.A. (2001). Case-based teaching and learning experiences. *Issues in Mental Health Nursing, 22*(5), 517-531.

Tomey, A.M. (2003). Learning with cases. *Journal of Continuing Education in Nursing, 34*(1), 34-38.

Ward, K., & Hartley, J. (2006). Using a virtual learning environment to address one problem with problem based learning. *Nurse Education in Practice, 6*(4), 185-191.

KEY TERMS

Cases: Descriptions of events and the factual evidence relating to and/or perspectives of people involved in the event. Cases may include the outcomes that eventuated from the event.

Case Based Learning: Encompasses any education situation in which cases are used as resource material for a learning activity.

Health Professional Education: Used in this chapter to encompass the initial and or continuing education of any type of health professional. This includes, but is not limited to, medical doctors, nurses physiotherapists, and psychologists.

Patient Cases: Documented examples of real or fictitious persons who present for health services. Patient cases may be made available staff and students in print or electronic format and use a range of media (text, images, video, sound).

Problem Based Learning: Involves presentation of a problem which triggers students to define their learning needs in terms of the knowledge and skills that will help them address the problem. Various implementations of problem based learning involve sequences of student self-directed inquiry; teacher-directed instruction; and informal and/or formal discussion with peers and teacher.

Chapter XXXIX
Reconceptualisation of Learning Objects as Meta-Schemas

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ABSTRACT

The shift in the way we visualise the nature of mathematics and mathematics learning has presented educational technologists with new challenges in the design of rich and powerful learning environments. Against this background, the design and use of learning objects in supporting meaningful mathematical learning assumes increased significance. I argue that learning objects need to be sufficiently pliable such that both teachers and learners could engage in knowledge construction that provides further avenues for growth and sophistication of mathematical schemas. In this chapter, the author aims to show the limitations of current views about mathematical learning objects and the need to reconceptualise these in terms of generic meta-schemas. A meta-schematic framework would provide the mathematics community with powerful pedagogical tools to support and assess mathematics learning. Two examples of these meta-schemas for geometry are described.

INTRODUCTION

Practitioners' and academics' views about the nature of mathematics and mathematics learning have undergone radical changes. Traditionally, mathematical knowledge was perceived as a collection of facts and symbols that needs to be committed to memory and retrieved at a later time to solve problems. However, the current dominant epistemological perspective is that the body of mathematical knowledge is not a static entity. Collectively its principals, concepts, codes, procedures,and conventions constitute cultural tools that have been invented and used by communities in order to interpret and function in an environment that has changed as human civilization has developed. As human thinking advanced, people had to invent more advanced mathematical tools and new ways of representing mathematical ideas that have in turn helped them solve more sophisticated problems. Thus, at a macro level, mathematical knowledge undergoes continuous changes in order to keep pace with the demands of the environment. The above shift in the way we view mathematics and its functions from immutable truths to ever knowledge that provides powerful tools to make sense of one's environment is beginning to pose new questions and challenges for teachers and educational technologists.

BACKGROUND

There are at least two major implications of the aforementioned change in the way mathematics is understood by learners for the teaching of mathematics and the kind of technological tools that can be used to support the learning process. The ever changing and malleable nature of mathematical knowledge calls for novel ways of conceptualising the design and development of mathematical learning environments. Designers need to focus on helping learners acquire mathematical structures that embody a collection of concepts, symbols and procedures. Further, these structures must be flexible enough to assimilate new information and accommodate new mathematical understandings. This structural view of mathematical knowledge and its development addresses the issue of *inert* knowledge that has been highlighted by Bransford (1979). Knowledge is considered to be inert when its is not accessed and used when in fact it can be shown that that knowledge is stored in memory.

The notion of mathematical structures connotes the existence of relations among various components or entities. Cognitive psychologists, in their analysis of knowledge, have identified two major factors that could impact on the quality of knowledge: strength and spread (Anderson, 2000). The starting point for my attempt to represent the quality of mathematics teachers' knowledge of content and pedagogy is Mayer's (1975) notion of knowledge connectedness. Mayer (1975) described the accumulation of new information in long-term memory as adding new nodes to memory and connecting the new nodes with components of the existing network. He identified two types of knowledge connectedness: *internal* and *external*. *Internal connectedness* refers to the degree to which new nodes of information are connected with one another to form a single well-defined structure or schema. This sense of connectedness refers to both the presence of nodes related to a schema and the quality of the relationships established among those nodes. The broad notion of quality here can be related, in part, to what Anderson (2000) refers to as the strength of a memory trace. Seen in this way, the stronger the connections among the nodes in a particular schema, the better the quality of that structure. Mayer (1975) referred to *external connectedness* as the degree to which newly established knowledge structures are connected with structures already existing in the learner's knowledge base. For example a teacher might be expected to relate a schema for proportion with schemas for ratio or fraction.

Identification of what connections are present in a knowledge structure is one important dimension related to the quality of that structure. Other things being equal, the more comprehensive the connections in a knowledge structure, the more "rich" or more elaborated the structure, the more useful it will be in problem solving (Anderson, 2000). However, it is also apparent that the nature of the connections within a knowledge structure, not just the number of connections, is also important. Some time ago Bruner (1966) referred to knowledge representations as having degrees of "power," and Wittrock (1974) has described both student and teacher understandings as having "generative" capacity. Both power and generative capacity draw attention to the quality of the connections in a knowledge structure. The more powerful and more generative a structure the more widely it can be applied in problem solving (Bruner, 1966). So we might expect different individuals to have connections between proportion and ratio or fraction that differ in power. In a similar vein we might expect a student's new schema for proportion to have both a certain quality in its internal structure (internal connectedness) and a certain quality in its connections to related schemas (external connectedness). This analysis of connectedness was a central feature in Chinnappan's (1998) argument that the linking of the different pieces of knowledge of geometry and trigonometry reflect deeper and richer understandings.

KNOWLEDGE CONNECTEDNESS AND PROBLEM REPRESENTATION

Representational studies of mathematical problem solving emerged from the desire to explain the nature of students' problem comprehension, and what role, if any, previously-learned content knowledge plays during the construction of a particular representation. The consensus is that we need to examine how the structure of prior mathematical knowledge influences students' problem representation which in turn helps students become competent at solving problems. Consequently, the last decade has witnessed considerable investments research studies concerning two different but related factors that influence mathematical problem representation: quality of prior mathematical knowledge and use of that knowledge for problem representation. Prawat (1989) suggested that higher levels of problem-solving performance require students to develop a rich store of content knowledge and that patterns of use of the knowledge during problem representation could be influenced by the state of organisation of that knowledge.

KNOWLEDGE ORGANISATION AND MATHEMATICAL ACTIVITY

There is a growing body of evidence to support the view that qualitative aspects of students' mathematical content knowledge could exert a major influence on the deployment of prior knowledge and outcome of students' problem-solving effort. The quality of mathematical content knowledge can be interpreted in terms of the degree of organisation of the different bits of mathematical information. Network models of knowledge organisation (Rumelhart & Ortony, 1977) provide a useful framework that allows us to visualise how mathematical knowledge could be organised. According to these models, well-organised knowledge can be characterised as that which has many components that are built around one or more core ideas. Connections exist between core ideas and their components and among the components. The components could comprise mathematical definitions and rules, as well as knowledge about how to deal with a particular class of problems. That is, organised mathematical knowledge encompasses both declarative and procedural knowledge (Anderson, 1995). Winne (1997), in his analysis of tactics for handling mathematics and other tasks, used the notion of "generic script" to refer to knowledge structured in this manner.

Interest in organisational aspects of content knowledge in human memory and performance has led to the development of a key psychological framework called *schemas*. A schema can be defined as a cluster of knowledge that helps students understand and represent a problem, and provides cues for the activation of relevant strategies. Marshall (1995) identified four primary components of schemas: feature recognition knowledge, constraint knowledge, planning knowledge, and implementation knowledge. The more tightly connected these components are the easier it is for the parts to be accessed. In a similar vein, Mayer (1992) suggested that schemas are involved in any successful mathematical problem-solving effort, and that these knowledge forms have been neglected in studies of mathematics instruction and problem solving.

Studies of the performance of experts and novices in domain rich areas have generated several hypotheses concerning the role of schemas and similar knowledge structures. For example, in a study involving sorting of problems, Chi, Feltovich, and Glaser (1981) found that experts use schemas that were more elaborate and built around principles underlying the problems compared to novices whose schemas focused on superficial elements of problem statement and associated diagrams. The results led Chi et al. (1981) to conclude that qualitative differences in prior knowledge could explain why novices respond to the "surface structure" of a problem while experts respond to its "deep structure." Likewise, Chi, Glaser, and Rees (1982) ascribed expertise at problem solving to features of the individual's knowledge base that are indicative of the existence of connections with related information. To become an expert problem solver, one has to acquire a great deal of domain-specific declarative and procedural knowledge that is linked in meaningful ways. Newell (1990) argued that an extensive and well-connected knowledge base drives search in the problem space.

Similar investigations in mathematics led to the conclusion that experts develop schemas that allow them to classify a given problem as belonging to a particular category, which in turn assists them in the retrieval of appropriate solution strategies. Owen and Sweller (1989) pursued the question of the importance of organising content knowledge in their study of trigonometry. The results of this study showed that students who produced correct solutions in the least amount of time tended to access and use previously acquired schemas that were built around properties of right-angled triangles and knowledge of how to deal with problems involving right-angled triangles, that is students invoked schematised knowledge of trigonometry that was relevant to right-angled triangles. The investigators concluded that in order to become competent problem solvers, students must acquire an extensive body of domain-specific knowledge schemas. The development of domain-specific knowledge schemas of the type to which Sweller and colleagues were referring could be characterised as involving the establishment of linkages between principles, rules and concepts within and between the various mathematical topics.

The foregoing discussion indicates that high-achieving students can be expected to utilise schemas that are more complex and better assimilated than their low-achieving peers during the solution process. Thus, the identification and characterisation of these schemas is an important issue for designers of mathematic learning objects that are aimed at developing knowledge that can subsequently be accessed to interpret mathematical phenomena.

SCHEMA ACTIVATION AND PROBLEM REPRESENTATION

It is clear that performance in mathematical tasks is to a large measure dependent on using prior knowledge that is organised in the form of schemas. A major advantage of having knowledge stored in memory in clusters of schemas is that they facilitate retrieval of the required knowledge from the long-term memory into the working memory during information processing. Let us now examine this advantage by turning our attention to the function of schemas in mathematical tasks.

In problem-solving contexts, schemas play an influential role during the construction of representations for a given problem, and cognitive psychologists argue that students' ability to solve mathematics problems can be greatly enhanced if they are taught to construct useful representations of the given problem (Frederikson, 1984).

Building a problem representation is a complex process in which students attempt to establish meaningful links between information in the problem statement and knowledge embedded in their schemas about that problem. The components of individual problem schemas could include: (a) knowledge of procedures and strategies associated with tackling a group of problems that are similar to the problem in question; (b) knowledge of mathematical concepts; and (c) knowledge about previous experiences with similar problems. Hence, building a representation of the problem involves constructing links between the above parts of the schema and information located in the problem. This interlinking of information is highlighted in Hayes and Simon's (1977) comment that "the representation of the problem must include the initial conditions of the problem, its goal, and the operators for reaching the goal from the initial state" (p. 21).

Thus, the process of representation requires the construction of solution-relevant relations between elements of what is given in the problem with components that are present in the relevant schema that is accessed from memory. It follows that the more elaborate a schema, the greater the likelihood that a student will be able to construct useful and multiple representations of the problem. The richness of the problem schema plays a significant role in helping a student filter irrelevant information from given information and attend to information that would be relevant to working out the solution. Instructional strategies that foster the development and deployment of schemas can be expected to enhance the quality of search activities invoked by students during the course of their solution attempts.

The role of schemas in the modelling process was investigated by Chinnappan (1998, 2003), in a study of problem solving within the domain of geometry. The principal aim of the study was to examine the relationship between the schemas activated by students and how these schemas were deployed during the construction of models. The results of this study revealed that: (a) students accessed a range of schemas relevant to the problem; (b) the successful students were able to align the schemas in ways that suggested an understanding of the problem structure; and (c) high-achieving students tended to build more complex mental models of the problem resulting in novel paths to the solution than low-achievers. For example, students gain experience in solving unknown angles or sides of a right-angled triangle using knowledge about trigonometry. In doing so, they acquire schemas that are built around right-angled triangles. Such schemas could consist of knowledge about the properties of right-angled triangle, the solution of equations, and the use of trigonometric ratios. In a new problem that contains a right-angled triangle and other figures, students might have to use or generate information from the right-angled triangle in order to make progress towards the problem goal. However, this solution of a subproblem involving the right-angled triangle is unlikely to be achieved if the solver does not have, or fails to activate, right-angle triangle schemas from the long-term memory. In other words, a search in problem space involves the accessing and use of relevant schemas in order to generate new information that in turn could be used to solve other subproblems. The solution and management of these subproblems constitutes an important activity of the solution process and can be argued to reflect an understanding of the structure underlying the problem in question.

The above interpretation of schema-driven problem representation and modelling activities suggests that the study of schemas constitutes an important area if we are to extend current levels of understanding about mathematical learning and problem solving. Specifically, instructional strategies that utilise learning objects can be expected to enhance the quality of search activities invoked by students during the course of their solution attempt.

REUSABLE LEARNING OBJECTS IN MATHEMATICS LEARNING AND TEACHING

The general recognition that abstract mathematics concepts are difficult and complex for young children to grasp has motivated some teachers and researchers to consider how best to utilise reusable learning objects (RLOs) in scaffolding the development of understanding. The term "learning objects" is used to refer to any entity, digital or nondigital, that can be used, re-used, or referenced during technology-supported learning (Duval, 2002). The pedagogical use of RLOs in classroom mathematics is well documented and covers a range of mathematics topics and age groups. For example, in K-6 mathematics, children are encouraged to interact with software that assists them make the transition from whole numbers to fractions. The assumption is that a dynamic learning environment that is provided by computer software assists children exhibit their understanding more flexibly. This issue was taken up by Hunting, Davis, and Pear (1996) who conducted a teaching experiment with 8- and 9-year old children with a software program called *Copycat*. They reported that the environment was suitable for externalising children's prior understanding of whole numbers and fractions. More recently, a team of researchers from the University of Georgia has been investigating children's understanding of fractions with the aid of a computer program known as *Javabars* (Olive, 2000). In both the environments, children are able to construct and manipulate shapes. This involves partitioning a whole into an equal number of predetermined parts and naming the fractions. The same shape can be reused to examine relationships between different parts and wholes.

In secondary mathematics, teachers have been encouraging their students to construct and analyse graphs. Maple (2007) is one of the most commonly used RLOs in such activities. *Maple* allows students to conjecture and evaluate their visual and analytical representations of functions. Once a function is plotted on the screen, students can move the graphs and examine changes in the algebraic notation. Similar LOs also help students to collect data, tabulate the data and examine relationships among variables that were abstracted from real-life problems contexts. Likewise, E*xcel* is an LO that can be used to test linear and other forms of relationships.

While there is a high level of interest in integrating RLOs in the teaching and learning of mathematics, teachers tend to make limited use of these tools in the assessment of student learning and to inform their practice. That is, RLOs do not provide the teacher and the learner with data about their evolving understanding of a particular mathematics topic. I take up this issue below by suggesting that we reconceptualise LOs.

MATHEMATICAL UNDERSTANDING AND LEARNING OBJECTS

In a constructivist learning environment, mathematics teachers and learners are expected to build on understandings by accessing content knowledge and reorganising that content into new forms of representation that reflect a deeper understanding of mathematics concepts and the teaching of those concepts. The accessing and assimilation of new information need to be supported by schemas, as discussed in a prior section. Depending on their function, schemas could be specific to a mathematics concept or they may assume a macro shape. For example, learners could have developed a schema for general problem solving as well one for solving algebra problems. The former can that has the macro configuration be used to understand and make progress with a range of problems but it does not contain sufficient domain information for the solution of algebra problems.

The purpose of the present chapter is twofold. First, I will develop a rationale for the case that the acquisitions of elaborate schemas indicate a deep grasp of mathematical knowledge. The assessment and development of instructional support for the continued growth of mathematical schema ought to be a primary aim of the design of mathematics learning objects. Secondly, I will attempt to demonstrate this point in reference to two learning objects that have been the foci of Chinnappan and Lawson's (2005) recent work in learning and teaching geometry.

MATHEMATICS META-SCHEMAS

As I have described, there is an increasing acceptance of pedagogical value of learning objects in scaffolding mathematics teaching and learning. By and large, this enthusiasm for technology-driven learning is not underpinned by a clear vision of what it is that teachers would like their children to learn. This is not to say that teachers do not have a goal when they invite children to interact with learning objects. The act of engaging students via learning objects in a collaborative manner and having fun in the process could be seen to be a legitimate learning outcome by some teachers, while others may regard such actions as "doing mathematics." In both instances, there is less focus on the quality of mathematical learning that children can participate in.

While learning objects provide novel and interesting ways to seek children's attention and participation in the mathematics learning, we need a more robust rationale for our justification for the design and inclusion of these tools in the mathematics curriculum (Lesh, 2006). Surely, the development of solid mathematics understandings among the children must be a central goal of instruction. But how do we characterize these understandings? There are two possible avenues for teachers to demonstrate the richness and depth of mathematics understandings, both of which require a clear articulation of the evolving schemas.

One of the features of learning objects is that learners can reuse the artefacts embedded therein. As the cycle of use-reuse continues, a parallel system could be set up that captures the emerging schema. This latter system constitutes a second layer of learning objects. Henceforth, I will refer to these as Embedded Learning Objects (ELOs) and argue that these objects should occupy a critical layer that girds the overall design and evaluation of one or a series of learning objects. An ELO can be visualised as overarching schema or a meta-schema. ELOs provide an importance source of information for teachers and learners as to the result of their interactions. An ELO is a schema and can be visualised as being generic in that it acts as a template with slots to be filled in as learning objects are activated by students of mathematics. RLOs and ELOs are related but they are also differences between the two. An RLO, with respect to learning a specific mathematics concept, allows learners to acquire that concept and, may, through repeated actions, help them consolidate their grasp of the concept in question. The RLO, however, does not scaffold the learner construct multiple connections with between the focus concept with other concepts. Further, RLOs do not provide information to the learner about the wider implications of the focus concept. An ELO, on the other hand, builds into its structure information about a mathematics concept, its multiple representations and connections, and the learning trajectory of that concept in relation to a learner.

EMBEDDED LEARNING OBJECT 1: ANGEL (A NONLINEAR GEOMETRY ENVIRONMENT FOR LEARNING)

ANGEL was developed at the University of Wollongong as a learning object that could be used to scaffold high-school students ability to construct proofs for given geometric statements (Ekanayake, Brown, & Chinnappan, 2003). The development of proofs is a complex problem-solving activity in mathematics, particularly in geometry. Students need to construct cycles of logical arguments and assemble relevant declarative geometric information in order for the process to continue. The reasoning processes underlying this cognitive activity draws heavily on content as well as a series of higher order metacognitive actions that could control the progress of the solution process.

Our development of ANGEL was guided by the above schema which is an example of an ELO. Figures 1-5 show a series of reusable learning objects that constituted an ELO. Figure 1 shows the problem statement that the student is invited to solve. The Progress bars indicate how well the student has advanced during his or her problem-solving attempt. Each bar will be shaded from left to right as the student works his way through the problem. When a student completes the problem-solving sequence of moves all the bars will be shaded.

Figures 2-4 illustrate the scaffolds provided in the software, prompting student to check the progress that was made in the solution attempt. Students can use each of these scaffolds differently by providing multiple points of entry. In Figure 2, students are provided with assistance as to how to develop a visual model of the problem. For the problem that is given in Figure 1, students are given two diagrams that translate the word problem into an appropriate diagram. Figure 3 is a further development of the diagram this identifying the given information and the goal of the problem. In Figure 4, students are shown the reasoning moves and the arrival at the statement that is to be proved. Thus, Figures 1-4 show increasing levels of details and help that are provided to the student. Students are encouraged to use help at level 1 (Figure 2) and to continue working on the problem without further assistance. If they are unable to proceed, the level 2 (Figure 3) scaffolding is provided, and so on. The aim here is to provide a series of graded prompts to help students access relevant prior knowledge. After students have completed their solution attempt (or failure to make any start despite all levels of assistance), they are able to view the Process Guidance information (Figure 5). This set of information reflects the overall set and sequence of moves and associated geometric information that has to be accessed and integrated into their reasoning process.

When the student progresses to Step 4 (Figure 5), students are given further guidance that can be used to check their solutions or reflect on why his solution was not complete. The statements (process guidance) are all meta-cognitive in nature.

Figure 1.

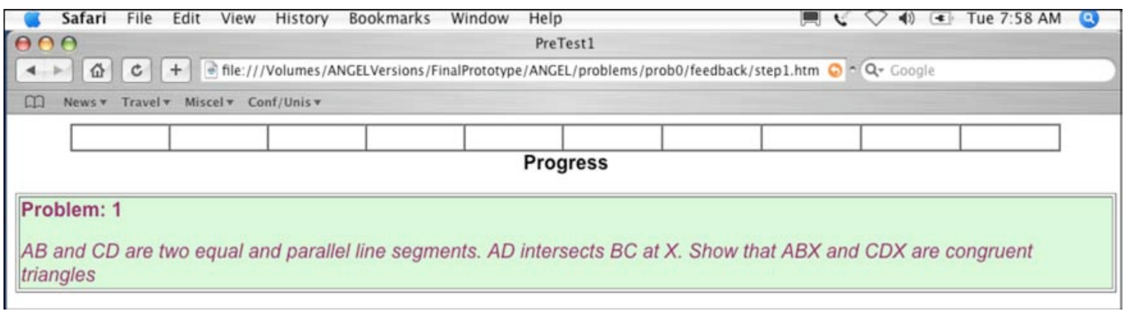


Figure 2.

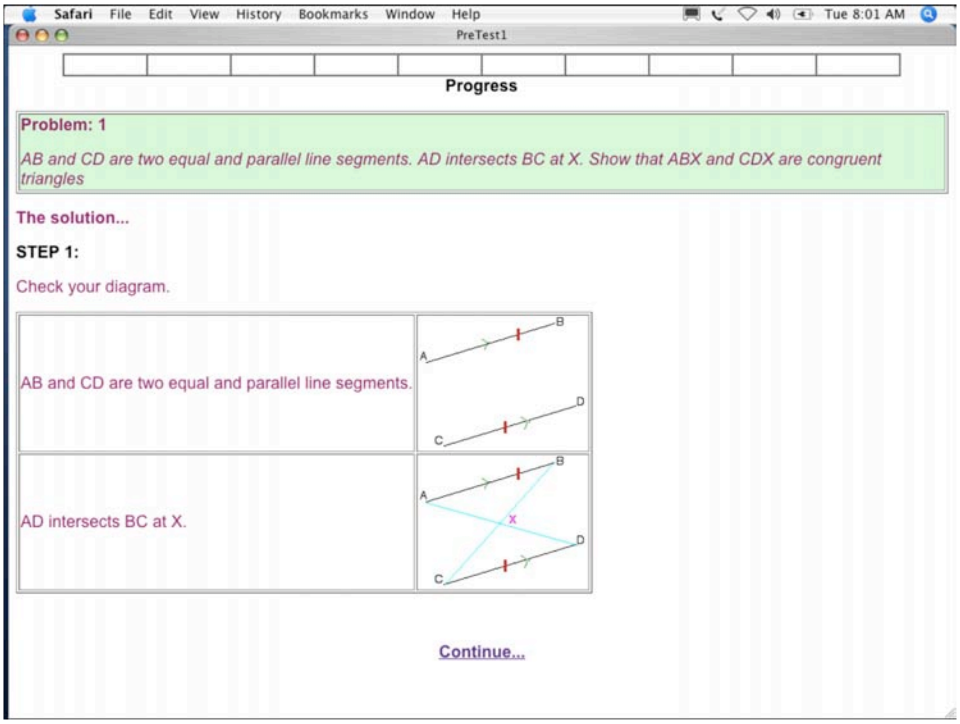


Figure 3.

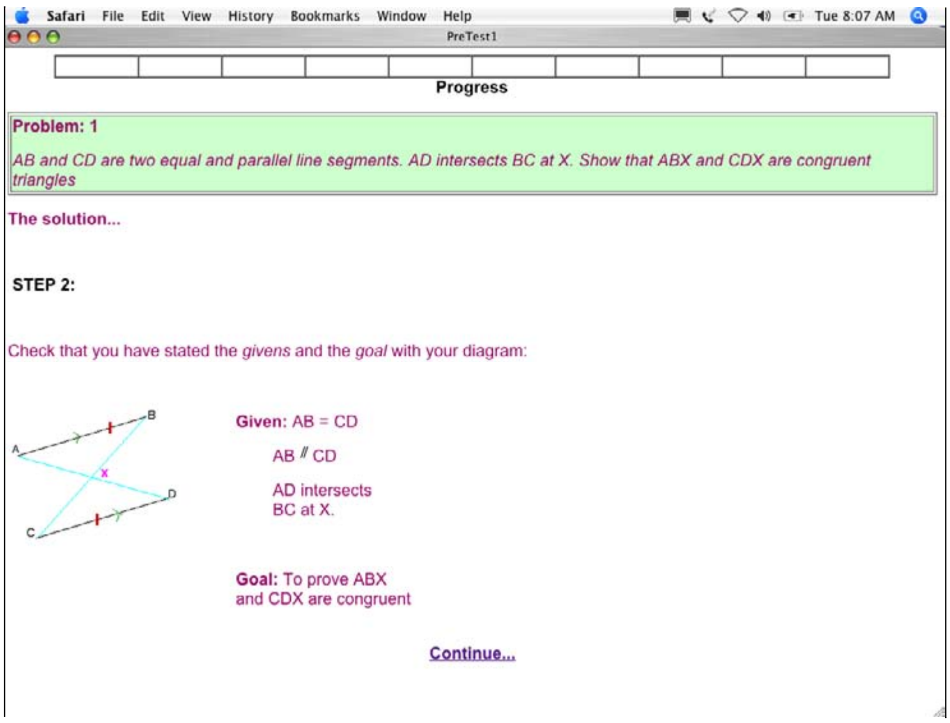


Figure 4.

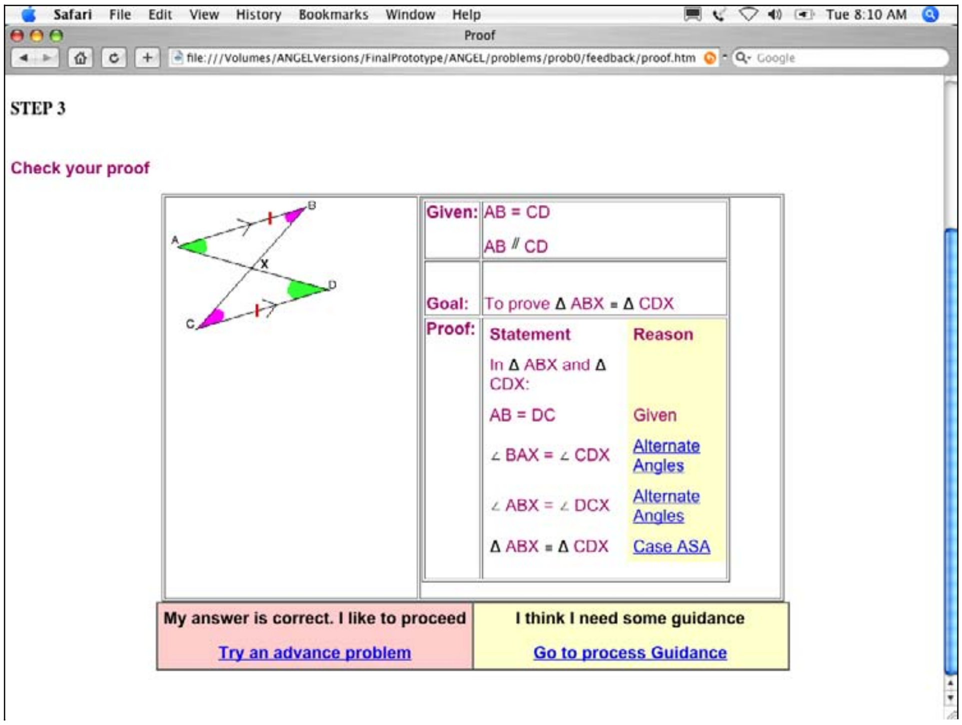
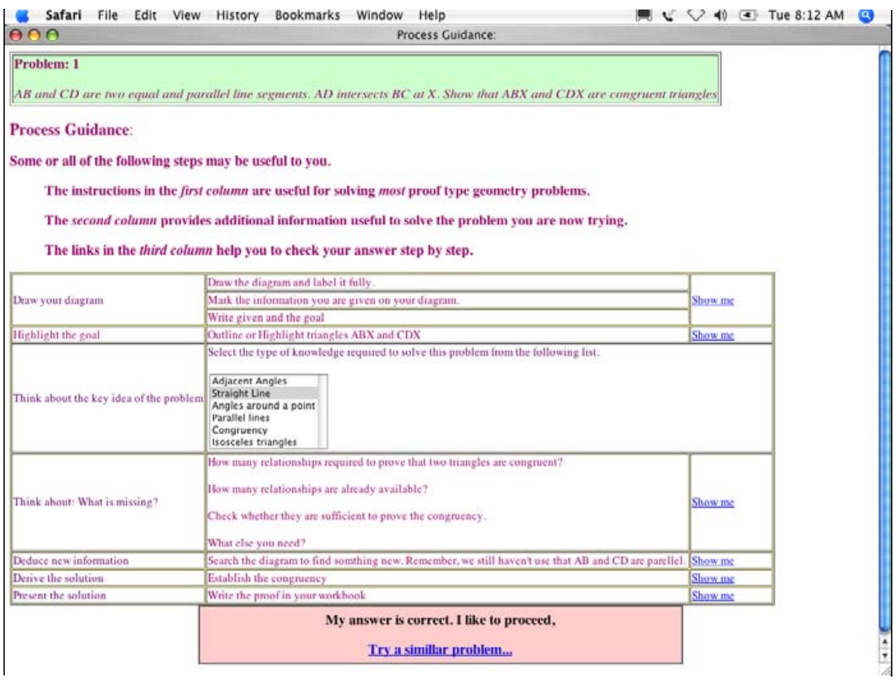


Figure 5.

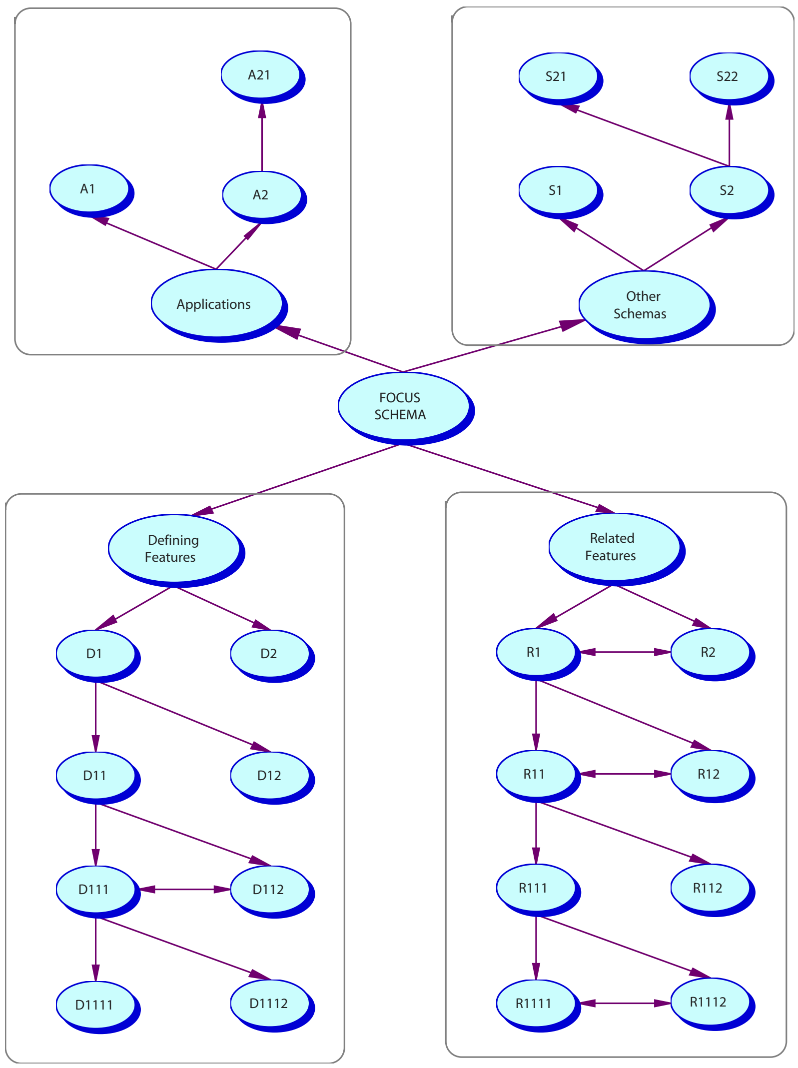


Collectively, ANGEL is an example of a meta-schema, the structure of which is based on a systematic analysis of core mathematics knowledge components and processes that are required for geometric proof development. These components and processes were identified and verified via an empirical study of actual proof development actions demonstrated by a cohort of high school students and with inputs from teachers, curriculum experts and mathematicians.

EMBEDDED LEARNING OBJECT 2

The second example of an ELO provided here was part of larger study in which we investigated the quality of teachers' knowledge of geometry and their knowledge of teaching geometry (Chinnappan & Lawson, 2005). The study was aimed at unpacking the content and pedagogical knowledge that teachers need in order to provide better learning support for students. The meta-schema

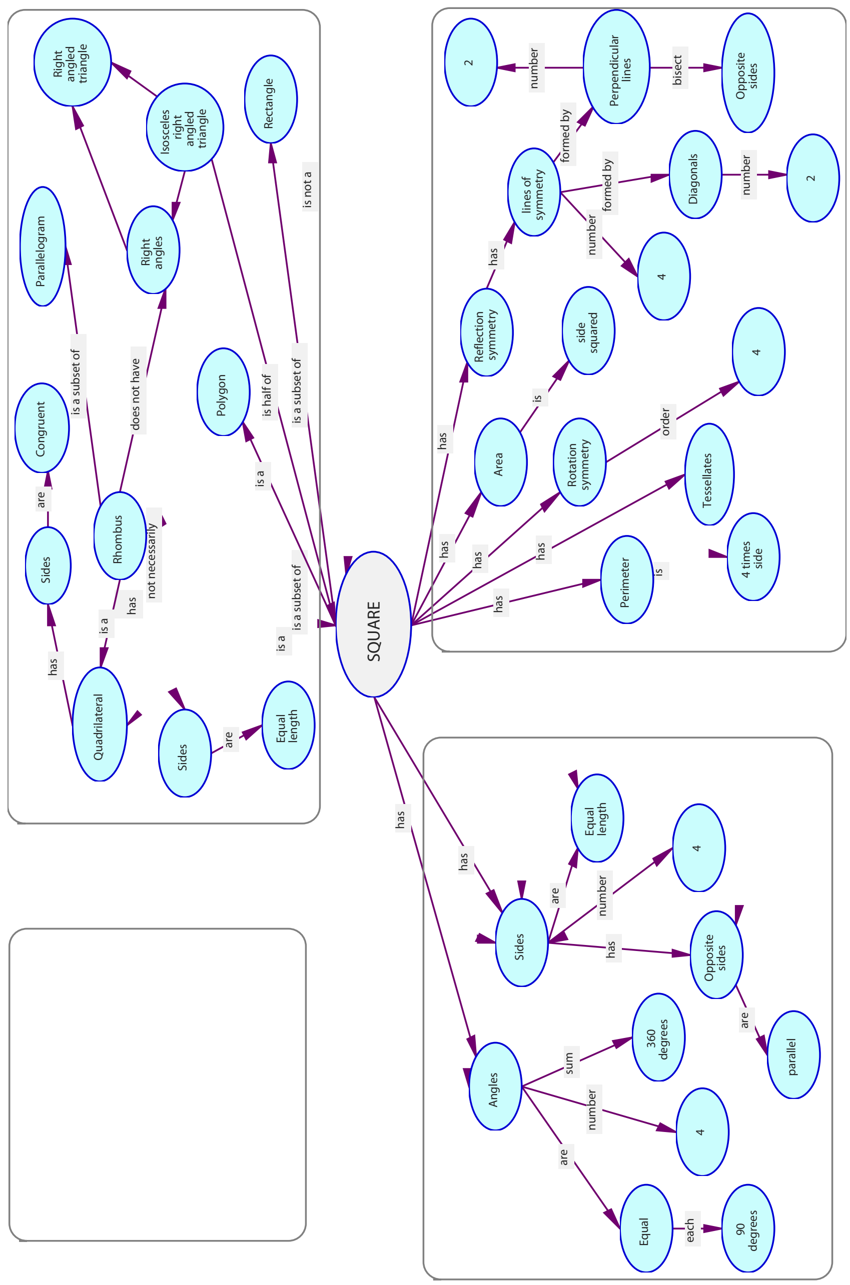
Figure 6.



is presented in Figure 6 illustrates within- and between-schema links that need to be established by teachers and students when they study a geometric figure such as square.

Thus, the focus schema could be a square or a pentagon. The within-schema links refer to connections among the *defining features* and those among the *related features* of a square. The

Figure 7.



between-schema links refer to links between the focus schema and *other* schemas. The following measures were derived for each map. We interpreted quantity as having two sub-categories: (a) number of nodes; and (b) number of links, including cross links. Figure 6 shows how the above meta-schema could be translated if one is analysing concepts that are built around square as the focus schema. Figure 6 shows a concept map that we generated by interviewing and observing one teacher's geometry class over a period of time. This particular teacher did not make any links that belonged to the *applications* category of this ELO but he had considerable knowledge and relational understanding that are relevant to the *defining* and *related* features categories.

From the perspective of meta-schemas as learning objects, the template in Figure 6 is the kind of structure that designers need to use in order to guide the development of simple learning objects, such an animation in which students could rotate a square and examine its properties or be able to construct a number of, say, pentagons, and explore their tessellating properties.

Both examples highlight two important features of meta-schemas as ELOs. First, such objects need to grounded in a mathematical concept that allows students to engage and explore that concept. Secondly, information about the growth of students understandings need to be provided *in situ* so that the learner is supported to make judgement of what has been learnt and what has not.

FUTURE TRENDS

The uptake of learning objects in mathematics teaching and learning is a recent development, but it is gaining momentum as we place greater emphasis on new pedagogies that bring focus to the cognitions and actions of the learner in the learning process. At the K-12 schooling levels, teaching methodologies area still predominantly teacher-driven with sporadic use of learning objects. Whenever children are given the opportunity to interact with learning objects, the objective and learning outcomes tends to be peripheral to the primary aims of mathematics lessons (Goos & Bennison, 2007; Zevenbergen, & Lerman, 2007). It is encouraging that teachers perceive learning objects as important in mediating the understanding of mathematics concepts. However, teachers' decisions need to be grounded in solid pedagogical rationale (Kennewell, 2001; Chinnappan, 2006). If we are to support teachers so that they are able to make informed decisions about when and how to use learning objects, designers, researchers and mathematics teachers need to work as community in order to examine potential advantages for the learners.

Three areas are ripe for productive inquiries on the pedagogical use of learning objects by mathematics teachers and learners. First, we need to examine more closely how and under what contexts teachers actually employ learning objects in the mathematics classroom or elsewhere. The limited evidence that we have suggests that these objects are used on an ad hoc basis and primarily as a second or third choice as teaching aids. Data on this issue has the potential to inform students, teachers and designers of learning objects.

A second line of research in this area should focus on the characterization of the growth of learners' understanding of mathematics as they interact with learning objects. The research aim here could be to map learners' changing understanding with the use of concept maps or similar tools. The maps could be analysed to reveal the general pattern of growth shown by a learner over a period. Long-term investigations of this nature are useful for developing trajectories of learning (Simon, 2004) and clarifying the particular contributions from the learning objects that are used to scaffold learning.

Thirdly, teachers in collaboration with researchers could develop schemas that provide clear illustrations as to the components and links that are pedagogically important for a deep understanding of core topics in school mathematics such as basic algebra, numbers and space. These schemas could be designed as a second level of learning objects (ELOs) that are placed online with the Level 1 learning objects such as the one provided by the New South Wales Department of Education and Training (2007). The schemas must have a basic structure in the form of a template such as the one described above for fractions and square. How teachers choose to expand or draw upon a given template can also provide alternative angles of insight into teachers' cognitions about a mathematic topic and the teaching of that topic.

The above point about the limitations of pedagogies that are over dependence on Level 1 learning objects and the need for a more encompassing and powerful ELO that provides the conceptual buttress for the Level 1 objects indicates that future work in this area could look at the type of parallel processing that goes on when learners and teachers are engaged with mathematics learning objects.

CONCLUSION

Learning objects are likely to gain wider acceptance among the mathematics teaching community and they hold great promise as tools that could drive future classroom pedagogies. The learner can easily modify these objects individually or with assistance from peers and teachers, and reuse them. The iteration of actions by learners and teachers can provide important insights into the children's quality of learning. However, children's interactions with learning objects need to be constrained by a second layer of learning objects, that is, a solid base schema that embodies the macro structure that teachers would like their children to develop. This presupposes that teachers have a clear understanding about the structure of that schema. I have outlined two such schemas at varying levels of specificity but more work needs to be done in these areas with collaboration among teachers, mathematicians, and researchers.

REFERENCES

Anderson, J.R. (1995). *Learning and memory: An integrated approach*. John Wiley.

Anderson, J.R. (2000). *Cognitive psychology and its implications* (5th ed.). New York: Worth Publishers.

Bransford, J.D. (1979). *Human cognition: Learning, understanding, and remembering.* Belmont, CA: Wadsworth.

Bruner, J.S. (1966). *Toward a theory of instruction*. New York: Norton.

Chi, M.T.H., Feltovich, P.J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, *5*, 121-152.

Chi, M.T.H., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R.J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 1, pp. 7-76). Hillsdale, NJ: Lawrence Erlbaum.

Chinnappan, M. (1998). Schemas and mental models in geometry problem solving. *Educational Studies in Mathematics*, *36*(3), 201-217.

Chinnappan, M. (2003). Schema cConstruction among pre-service teachers and the use of IT in mathematics teaching: A case study. *Mathematics Teacher Education and Development*, *5*, 31-43.

Chinnappan, M. (2006). Using productive pedagogies framework to build a community of learners online in mathematics education. *Distance Education*, *27*(3), 355-370.

Chinnappan, M., & Lawson, M. (2005). A framework for analysis of teachers' geometric content knowledge and geometric knowledge for teaching. *Journal of Mathematics Teacher Education*, *8*(3), 197-221.

Department of Education and Training, NSW. (2007). Retrieved April 4, 2008, from http://www.curriculumsupport.education.nsw.gov.au/primary/mathematics/k6/learningobjects/index.htm

Duval, E. (2002). 1484.12.1 IEEE standard for learning object metadata. IEEE Learning Technology Stan- dards Committee. Retrieved April 4, 2008, from http://ltsc.ieee.org/wg12/

Ekanayake, M.B., Brown, C., & Chinnappan, M. (2003). Development of a Web-based learning tool to enhance formal deductive thinking in geometry. In L. Bragg, C. Campbell, G. Herbert, & J. Mousley (Eds.), *Proceedings of the 26th Conference of the Mathematics Education Research Group of Australasia Vol. 1* (pp. 302-308). Geelong, VIC: Mathematics Education Research Group of Australasia.

Frederiksen, N. (1984). Implications of cognitive theory for instruction in problem solving. *Review of Educational Research*, *54*, 363-407.

Goos, M., & Bennison, A. (2007). Technology-enriched teaching of secondary mathematics: Factors influencing innovative practice. In J. Watson & K. Beswick (Eds.), *Proceedings of the 30th Conference of the Mathematics Education Research Group of Australasia, Vol. 1* (pp. 315-324). Adelaide: MERGA.

Hayes, J.R., & Simon, H.A. (1977). Psychological differences among problem isomorphs. In N.J. Castellan, D.B. Pisoni, & G.R. Potts (Eds.), *Cognitive theory* (Vol 2.). Hillsdale, NJ: Lawrence Erlbaum.

Hunting, R.P., Davis, G., & Pearn, C.A. (1996). Engaging whole-number knowledge for rational-number leaning using a computer-based tool. *Journal for Research in Mathematics Education*, *27*(3), 354-379.

Kennewell, S. (2001). Using affordances and constraints to evaluate the use of informal and communications technology in teaching and learning, *Journal of Information Technology for Teacher Education*, *10*, 101-114.

Lesh, R. (2006). New directions for research on mathematical problem solving. In P. Grootenboer, R. Zevenbergen, & M. Chinnappan (Eds.), *Proceedings of the 29th Conference of the Mathematics Education Research Group of Australasia, Vol. 2* (pp. 15-33). Adelaide: MERGA Inc.

Maple. (2007). Maple Student Edition 11, Retrieved April 4, 2008, from http://www.maplesoft.com/students/index.aspx

Marshall, S.P. (1995). *Schemas in problem solving*. NY: Cambridge University Press.

Mayer, R.E. (1975). Information processing variables in learning to solve problems. *Review of Research in Education*, *45*, 525-541.

Mayer, R.E. (1992). The psychology of mathematical problem solving. In F.K. Lester, & J. Garofalo (Eds.), *Mathematical problem solving: Issues in research*. Philadelphia, PA: The Franklin Institute Press.

Newell, A. (1990) *Unified thoeries of cognition*. Cambridge, MAs: Harvard Univeristy Press.

Olive, J. (2000). *JavaBars: Computer tools for interactive mathematical activity in the elementary school*. The University of Georgia.

Owen, E., & Sweller, J. (1989). Should problem solving be used as a learning device in mathematics? *Journal for Research in Mathematics Education*, *20*, 322-328.

Prawat, R. (1989). Promoting access to knowledge, strategy and disposition in students. *Review of Educational Research*, *59*, 1-42.

Rumelhart, D., & Ortony, A. (1977). The representation of knowledge in memory. In R. Anderson,

R. , & W. Montague (Eds.), *Schooling and the acquistion of knowledge*, Hillsdale, NJ: Erlbaum.

Simon, M.A. (2004). Raising issues of quality in mathematics education research. *Journal for Research in Mathematics Education, 35*(3), 157-163.

Winne, P.H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology, 89*(3), 397-410.

Wittrock, M.C. (1974). Learning as a generative process. *Educational Psychologist, 11*(2), 87-95

Zevenbergen, R., & Lerman, S. (2007). Pedagogy and interactive whiteboards: Using activity theory to understand tensions in practice. In J. Watson & K. Beswick (Eds.), *Proceedings of the 30th Conference of the Mathematics Education Research Group of Australasia, Vol. 2* (pp. 853-862). Adelaide: MERGA.

KEY TERMS

Learning Object: A learning object is defined as any entity, digital or nondigital, that can be used, re-used, or referenced during technology-supported learning (Duval, 2002).

Numeracy: The ability and disposition of children to use mathematics effectively to meet the demands of life at home and work.

Chapter XL
Designing Learning Objects for Generic Web Sites

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ABSTRACT

This chapter provides an in depth discussion of the issues involved in integrating learning design and learning objects into generic Web sites. It has a dual focus and consists of two parts: the first part outlines and critiques the notion of the Net Generation and its implications for learning design, while the second part is based on a case study of a generic academic learning support Web site and allows for the testing of some of the theoretical assumptions about the Net Generation. Informed by empirical research, this chapter concludes by offering suggestions on ways to exploit convergent possibilities of integrating learning design and learning objects in a Web environment, while paying careful attention to divergent capabilities of students targeted in such an environment.

INTRODUCTION

This chapter is concerned with working towards a tighter fit between the possibilities that new technologies provide for learning design and learning objects on the one hand, and an increasingly diverse student body on the other. When it comes to applying new technologies in an educational context, the emphasis tends to be on the potential that these technologies offer, often accompanied by a brief disclaimer that these technologies also facilitate fragmentations with greater disparities between the information-haves and have-nots. Not surprisingly, this simultaneous movement between possibilities and the skills/knowledge required to capitalise on those possibilities, presents the biggest challenge for an e-education environment.

The notion of the Net Generation (Oblinger & Oblinger, 2005) attempts to capture the apparently fast changing skills/ knowledge sets of a "new generation," and ascribe specific characteristics to that generation such as ability to read visual images, visual-spatial skills, digital literacy, and connectedness, amongst others. These kinds of characteristics would have major implications for the area of learning design and learning objects, particularly in terms of their applications. But just as with earlier attempts to define generations, the boundaries between them are porous, and the concept should thus be approached with appropriate caution. This applies in particular to a tertiary e-education environment which is increasingly characterised by a highly diverse student population, not only culturally but also in terms of "techno literacy." In this context, the challenge for e-education becomes one of balancing convergent possibilities of integrating learning design and learning objects in a Web environment with divergent capabilities of diverse student cohorts. As Hughes (2004, p. 364) argues, "the ability and potential (of e-learning) to enhance access to education, particularly higher education, is largely determined by the potential learner's circumstances, which in many ways define the learning environment." Thus, the challenge is one of designing effective learning experiences in an increasingly diverse tertiary education context.

This chapter addresses the above challenge in a general sense in the first instance, before applying the resultant insights to an empirical case study of an academic learning support site at the University of Southern Queensland (USQ), to forge links between theory and practice. USQ is well placed to conduct such a study because as a regional Australian university, it has both a highly diverse and a geographically dispersed student population, with more than 75% of its students studying in distance education mode. The case study involves a Web site called ALSOnline (Academic Learning Support Online), which is currently in the process of being redeveloped, and the study was designed to provide insights into what would make it more "user friendly," both with regards to learning objects and the convergent possibilities of presenting and designing those objects.

The study consists of a survey of first year students from five large first year courses in five different faculties, and a follow-up series of in-depth interviews, conducted through MSN Messenger. The online survey asked questions about learning objects, accessibility, navigation, and organisation of content. The interviews paint a more in-depth picture of learner needs and capabilities and in particular the needs and capabilities of a diverse student population. This in turn raises questions about how to (re-)design a generic site like ALSOnline. For example, to what extent do we incorporate multimodal design? This would take advantage of convergent possibilities by incorporating and combining a variety of different media, which the Internet is ideally placed to accommodate. In addition, it would be tailored to the Net Generation with its "visual-spatial" skills, its "attentional deployment" (ability to shift attention rapidly from one task to another) and its "experiential preference" (prefer to learn by doing rather than by being told what to do). At the same time however, it raises questions about Internet access, and about the assumptions of the Net Generation's skills themselves.

Possibilities afforded by new technologies should be capitalised on, and be informed by changing characteristics that students bring to the tertiary learning environment, but at the same time they should carefully take increasingly diverse needs, skills, and lifestyles into account, and have a clear focus on desired outcomes. This chapter will address these potential outcomes through a theoretical discussion of current expectations of and about a new generation of students combined with a theoretical discussion of current practice and developments in learning design and learning objects. Aligning these two is important as their integration can potentially satisfy the objective of creating both stimulating and student-centred learning designs and objects. This would not be such a daunting task if the student body was reasonably homogenous, but there is increasing evidence that this is not the case.

Despite its merits in identifying changing characteristics of a generation that has grown up immersed in new technology, a notion like "the Net Generation" tends to reinforce a perception of homogeneity amongst a new generation of students, by ascribing a specific set of skills to these "new students." Through its theoretical discussion of "the Net Generation," this chapter will debunk some of the myths surrounding this perception. This will in turn be reinforced by the case study outlined above. The question of diversity makes this case study particularly relevant as it concerns learning design and learning objects for a generic Web site, which by definition needs to address a diverse student population rather than a course-specific student cohort. Taken together, this will then inform a set of suggestions for a framework on which to base learning design and learning objects.

THE NET GENERATION

The notion of the Net Generation is part of an attempt to come to grips with fast changing technology and the related changes in a generation that has grown up in an environment saturated by technology. With regards to education, it is an attempt by a generation for whom information technology was something to be "learned" or "taught," to understand the implications of dealing with a new generation of students for whom technology has been an integrated and ubiquitous part of their everyday environment. As a result, the Net Generation does not think "in terms of technology; they think in terms of the activity technology enables" (Oblinger & Oblinger, 2005, p. 2.10). This has major implications for the way in which they are taught or should be taught, because their resulting characteristics differ significantly from those of earlier generations. In response, educational institutions are currently thinking through different ways to address this generation in an educational context.

Oblinger & Oblinger (2005, p. 2.5) define the Net Generation's characteristics as follows:

- Ability to read visual images—intuitive visual communicators
- Visual-spatial skills—related to their expertise with games
- Inductive discovery—better learning through discovery rather than being told
- Attentional deployment—ability to shift their attention rapidly between tasks
- Fast response time—ability to respond quickly and expectations of rapid responses in return.

In addition, they are digitally literate, connected, immediate, experiential and social (pp. 2.5-2.6). These characteristics imply a major shift in the way students learn or could potentially learn, and it is thus vital for educational institutions to engage with these characteristics in learning design, curriculum design and approaches to teaching. At the same time this should be approached with appropriate caution. Hughes argues for example that "the learning enterprise is not about us as educators: the focus should be placed on the learning, not the teaching. We should focus on what the learner needs, not on what we want to or are able to supply" (2004, p. 368).

But to focus on what the learner needs requires an in depth knowledge of precisely what that means. One of the dangers with a concept like the Net Generation is that it creates an impression of an unproblematic break with what came before on the one hand, and that it invites an easy generalisation on the other. In other words, with its emphasis on common characteristics, it easily leads to the impression that a singular or generic approach is needed to address this generation. But Sankey and Nooriafshar warn that "it would be difficult, if not impossible, to design a learning environment to cater for the 'generic' learner, who in reality does not exist" (2005, p. 161). Furthermore, Ramaley and Zia usefully caution that "it is helpful to realise that not everyone is a member of the Net Generation—not because of age but because of access to technology" (2005, p. 8.1). This raises some important questions. For example, is the Net Generation really a *generation*? Are its characteristics purely related to age, or is it more directly linked to level of engagement with technology? And how do we deal with an educational context increasingly characterised by diversity in terms of student skills and characteristics?

These are important questions to ask before embarking on a complete overhaul of educational approaches in response to Net Generation characteristics, and they should be informed by more fundamental considerations. As Kellner notes, "it is a time to reflect on our goals and to discern what we want to achieve with education and how we can achieve it" (2000, p. 259). In other words, convergent possibilities through learning design and learning objects in educational contexts should be informed by clear objectives and desired outcomes. They should also be flexible enough to allow for engagement with divergent capabilities. As Laurillard (2002) reminds us:

> *At the heart of a university is the iterative dialogue between teacher and learner, nurturing the ideas and skills that constitute understanding. As we imagine the future forms of universities, that dialogue should remain the salient feature, with the delivery of infrastructure always in support of it, never in the foreground.* (p. 241)

In short, possibilities should be capitalised on and be informed by changing characteristics that students bring to the learning environment, but at the same time they should carefully take increasingly diverse needs into account and have a clear focus on desired outcomes. This may require a wide variety of delivery modes to ensure an inclusive educational experience. There is no doubt that developing these is highly resource intensive, particularly if this task is approached in fragmented ways by individuals working in isolation. However, as Conole and Fill suggest, "the increasing availability and use of online, digital resources to support teaching and learning is stimulating a convergence between the fields of learning design and learning object technologies" (2005, p. 5), and there are increasing possibilities to capitalise on this convergence primarily through the sharing of learning objects to inform different learning designs.

Within this context, learning design is defined as "an application of a pedagogical model for a specific learning objective, target group and a specific context or knowledge domain" (Conole & Fill, 2005, p. 5). In aligning these, the target group is the most problematic in this case, as it is often difficult to define its characteristics. Therefore, definitions of learning objects that place an emphasis on flexibility and particularly reusability and interoperability are most useful, as they are geared towards the ideal of sharing resources with all its potential benefits, both in terms of economical use of resources and in terms of pedagogy. Reusability is taken to mean "reusable ideas, not fixed, prepackaged solutions" (Goodyear, 2005). While there is considerable debate about what constitutes 'learning objects' (McGreal, 2004), Downes usefully argues that learning objects should be "defined by the problems they solve" (2004, p. 28). Thinking about them in this way opens up a myriad of convergent possibilities with regards to tailoring learning objects to specific learning designs which target specific cohorts of students.

CONVERGENT POSSIBILITIES

As mentioned above, combining the characteristics of the Net Generation with the available technology offers many new possibilities in terms of learning design, and it potentially requires a different approach to the relationship between "teacher" and "learner." Kehrwald argues for example that the role of teaching staff has changed "from that of provider and controller of information to mentor and facilitator in the learning process" (2005, p. 143). Similarly, Albion notes that "it is anticipated that courses will adopt knowledge building approaches that depend more upon the ability of staff to guide student development through a course than to provide extensive prepared materials" (2005, p. 122). Such approaches, Albion (2005) argues, are consistent with "the desire for students to own their own learning agenda" (p. 122).

This is particularly significant in a learning environment that is apparently increasingly informed by ubiquitous access and connectivity. The Net Generation is said to be both highly mobile and always connected. If we combine that with the possibility that they are experiential learners (they prefer to learn by doing rather than by being told what to do), and social (prolific communicators), we are presented with many opportunities, and perhaps a duty, to enhance their learning experiences. As Brown suggests, "Net Gen students, using a variety of digital devices, can turn almost any space outside the classroom into an informal learning space" (2005, p. 12.3). He then goes on to argue that "educators have an important opportunity to rethink and redesign these nonclassroom spaces to support, encourage, and extend students' learning environment" (p. 12.3). Of course this redesign should carefully consider the potentially highly diverse skills that students bring to their learning environments.

At the same time however, the redesign must be informed by the carefully rethought outcomes of the learning process. For in Kirkwood and Price's words, "it is not technologies, but educational purposes and pedagogy, that must provide the lead, with students understanding not only *how* to work with ICTs, but *why* it is of benefit for them to do so" (2005, p. 257, original emphasis).

To date and in a general sense, higher education institutions have introduced new technology into the learning environment mostly as a supplement to existing teaching and learning practices. And as Kirkwood & Price note, "there is still much to be done in terms of exploiting ICT for rich pedagogical use (i.e., enhanced forms of teaching and learning), and for serving learners in different target groups" (2005, p. 259). However, some examples are surfacing of institutions beginning to explore the possibilities of enhanced forms of teaching and learning.

One example of this is the work of MIT's Comparative Media Studies Program, which is engaged in the design of games for educational purposes. According to Squire and Jenkins, "games promise to stimulate the imagination, spark curiosity, encourage discussion and debate, and enable experimentation and investigation" (2003, p. 10). This creates many exciting opportunities that fit the characteristics of the Net Generation very well. For example, it directly engages with the Net Generation's craving for interactivity through an immediate response to their each and every action, and "traditional schooling provides very little of this compared to the rest of the world" (Oblinger & Oblinger, 2005, p. 2.13). In addition, it potentially feeds directly into the social nature of net geners, as games can be played not only on an individual level but also in teams. Windham, who considers herself a "net gener," notes that "we tend to learn things ourselves, to experiment with new technology until we get it right, and to build by touch rather than tutorial" (2005, p. 5.6). In short, "we are a generation of learners by exploration" (p. 5.6). And this is precisely what the Squire and Jenkins led MIT-Microsoft Games-to-Teach Project, which consists of 15 games concepts at this stage, is geared towards.

Games are inherently based on exploration. "At their best, games are imaginary worlds, hypothetical spaces where players can test ideas and experience their consequences" (Squire & Jenkins, 2003, p. 8). This does not mean that they replace older media like books, but rather that they offer different ways to engage with older media and in particular to stimulate interest in them. The results to date in this project suggest that "students are motivated to return to those media to do better in the games. They don't memorise facts; they mobilise information to solve game-related problems" (Squire & Jenkins, 2003, p. 14). Not only does this perfectly suit the Net Generation's craving for interactivity, making the approach very much learner-centred, but it also fits with the earlier identified need for an outcomes-based approach, where outcomes relate to an emphasis on students' ability to apply acquired knowledge, rather than merely reproduce it.

If games successfully simulate the "real world" then it also makes them inherently transdisciplinary, which is an increasingly important skill in the contemporary work place. Moreover, they have the potential to teach and develop the ability to apply knowledge in different contexts, through different scenarios. "These scenarios cut across different game genres, different academic fields, different pedagogical models, and different strategies for integrating games into the classroom" (p. 10). In this context, Green and McNeese, interpreting Salomon, draw attention to the important recognition that "accessing information from technology is different from constructing knowledge. The process of constructing knowledge from information gathered is an active process in which technology plays a minor role" (2007, p. 8). The former is relatively easy to achieve, while the latter requires a carefully thought out learning design and carefully selected learning objects, for example educational games.

Overall then, developments like these offer exciting opportunities with which to respond to the specific learning needs of Net Geners. The development of educational games also offers a wide range of convergent possibilities, not only in terms of educational content, disciplines and genres, but also with regards to the increasing mobility of the Net Generation. Games can increasingly be accessed through different media platforms, which provides an opportunity to significantly extend students' learning environments in terms of time and place. However, the MIT example is at the higher end of the development scale, and it is based on a commercial partnership with Microsoft and it is thus backed up by significant capital. Squire and Jenkins (2003) argue that this is necessary because the Net Generation has grown up on highly sophisticated entertainment titles. They note that "the secret of a video game as a teaching machine is its underlying architecture, and few educational games keep pace with contemporary entertainment titles and thus fail to achieve this potential" (Green & McNeese, 2007; Squire & Jenkins, 2003, p. 8).

Herein lays one of the dilemmas of smaller institutions, which do not always have the funding levels required to keep up with the technology that is commercially available. Building relationships with commercial partners is one solution to this, but there are other, more modest, ways of developing educational applications of new media technologies, which still engage with the characteristics of the Net Generation, for example interactive quizzes, CD-ROMs, and multimodal power point presentations, to name a few (Sankey, 2006). However, a more fundamental issue is the assumption of the Net Generation as a homogeneous group with the same characteristics and level of skills across the board, and the often unproblematic equation of the Net Generation with "new students" (Abram & Luther, 2004). For at the same time that we identify "the Net Generation," educational institutions are also confronted by an increasingly diverse student population with potentially highly divergent capabilities, skills and characteristics, as suggested by a recent First Year Experience in Australian Universities report (Krause, Hartley, James, & McInnes, 2005).

DIVERGENT CAPABILITIES

In their general overview of the Net Generation's characteristics, Oblinger and Oblinger (2005) concentrate overwhelmingly on the ways in which education should engage with and address this generation. There is very little space in their analysis for words of caution in this respect, except for acknowledging that "the Net Gen may need to be encouraged to stop experiencing and spend time reflecting" (Oblinger & Oblinger, 2005, p. 2.7). This follows the assertion that "they often choose not to pay attention if a class is not interactive, unengaging, or simply too slow" (Oblinger & Oblinger, 2005, p. 2.7). In short, the literature about the Net Generation often implies a one-dimensional transaction whereby educational institutions either need to engage with the Net Generation's characteristics or risk becoming irrelevant to this generation. Of course this makes sense to some extent, especially for universities keen to position themselves on the cutting edge. At the same time however, it is important to carefully question the claims and generalisations about the Net Generation on the one hand, and the extent to which they define the overall student body on the other. In addition, even if the characteristics are taken as a given, there is a need to carefully consider appropriate educational outcomes. For as Brown (2005, p. 12.7) suggests:

It may well be that Net Gen students' strengths are also their weaknesses. The expectation for fast-paced, rapidly shifting interaction coupled with a relatively short attention span may be counter-productive in many learning contexts. Repetition and steady, patient practice-key to some forms of mastery- may prove difficult for Net Gen students. Designing courses for them necessitates balancing these strengths and weaknesses.

Similarly, Kvavik notes that "some students are so conditioned by punch-a-button problem solving on computers that they approach problems with a scattershot impulsiveness instead of methodically working them through. In turn, this leads to problem-solving difficulties" (2005, p. 7.8). Kvavik (2005) sounds this warning in the context of an empirical study on how students use technology, which shows some interesting results. In this study, 95% of students were 25 years old or younger, and "technologically saturated" in terms of ownership, which firmly positions them in the Net Generation. The study found that students report using technology first for educational purposes (such as writing documents and e-mails, surfing the Internet, and classroom activities), followed by communication. But while the highest reported computer use was in support of academic activities, students reported strong use and skill levels in support of communications and entertainment. Men were more likely to spend more hours playing computer games, surfing the Net, and downloading music, while women spent more time communicating.

The most interesting part of the study, and the most relevant for my purposes here, relates to the discrepancies between student perceptions of their own technology use, and their actual skill levels. The qualitative data suggest that generally students have very basic office suite skills as well as e-mail and basic Web surfing skills. However, "moving beyond basic activities is problematic. It appears that they do not recognise the enhanced functionality of the applications they own and use" (Kvavik, 2005, p. 7.7). The study concludes by debunking the expectation that Net Gen students require less training with technology. The findings suggest that "many necessary skills had to be learned at the college or university and that the motivation for doing so was very much tied to the requirements of the curriculum" (p. 7.17). And as Kvavik argues, "undergraduate students need to develop two types of skills: information literacy or fluency and the technical skills needed to use the tools" (p. 7.5). It is therefore vital to get a clear picture on how the Net Generation's characteristics translate into skills, and moreover where these skills are potentially lacking and in need of development.

Kvavik's (2005) study puts the buzz surrounding the Net Generation into some much needed perspective, and his findings were more recently echoed by a University of Melbourne report about first year students' experiences with technology, which questions whether "they really are digital natives" (Kennedy, Krause, Judd, Churchward, & Gray, 2006). Of course this is not to say that we should not pay any attention to the different characteristics and skills that some of the new generation of students bring to the classroom. But it does suggest a need to carefully consider the pedagogical foundations which underlie our learning design to engage with these differences. In short, it demands a careful balance between student needs and expectations on the one hand, and desirable and relevant educational outcomes on the other.

This concludes the theoretical context, and provides the conceptual foundation on which the next section of this chapter is based. Kvavik's (2005) study, and the literature on the Net Generation in general, are based on experiences with students from relatively affluent backgrounds. As mentioned before, USQ is a regional university with a highly diverse student cohort, and increasingly so. "New" students at USQ are thus not necessarily "young" nor from affluent backgrounds. And while a certain proportion of the student cohort could be called "Net Geners," this certainly does not apply across the board. The main challenge is thus to cater for highly diverse needs, keeping in mind the balance as outlined above. The empirical part of this chapter is based on a small study regarding the use of an academic learning support site (ALSOnline) at USQ, which is primarily targeted at first year students. ALSOnline is presently going through a redevelopment phase which has necessitated an evaluation of its current use.

ALSOnline: RESEARCH FRAMEWORK AND CONTEXT

ALSOnline (Academic Learning Support Online) was initially developed in a typically hasty fashion and could therefore be characterised by what is sometimes called "shuffle ware," that is, the wholesale "dumping" of off-line resources in an online repository. The site is currently in the process of being redeveloped, and this pilot study was designed to provide insights into what would make it more "user friendly," with regards to the overall learning design of the site, the learning objects that together comprise the overall learning design, and the convergent possibilities of presenting these learning objects.

The study consists of a survey of first year students from five large first year courses in five different faculties and a follow-up series of interviews, conducted through MSN Messenger. The online survey asked questions about content, accessibility, navigation, and organization of content. The follow-up interviews provide a more in depth picture of the needs and capabilities of a diverse student population. This diversity in turn raises questions about how to (re-)design a site like ALSOnline. For example, to what extent do we incorporate multi-modal design? This would take advantage of convergent possibilities by incorporating and combining a variety of different media, which the Internet is ideally placed to accommodate, and it would be tailored to the Net Generation's "visual-spatial" skills and its "attentional deployment." At the same time however, it would raise questions about Internet access, both in terms of physical access and access as it relates to skill levels, and about assumptions of the Net Generation's skill levels.

The recent usage data for the ALSOnline site (2005 and 2006) is presented in Table 1, showing the total page views figure which represents the total number of "clicks" on any page on the site. While this information gives some idea about the overall traffic on the site, it tells us very little about the reasons for these visits, nor about the ways in which the visitors use the available information.

The number of "hits" per page, as broken down in months, can give us an idea about overall site traffic and allow us to identify increased activity on the site, clustered around semesters and busy periods where many assignments are due. However, this information is limited in that it only shows that there is activity, rather than what type of activity. Similarly, it does not provide us with information about repeat visits or the length of time for each visit.

The project described in this chapter aimed to evaluate the uses and applications of ALSOnline. While a lot of effort goes into developing online learning support resources in tertiary education, particularly in a USQ context where distance education makes up a highly significant part of its core business, the information on how students use it and how it helps them learn is sketchy at best, as mentioned above. This project therefore aimed to evaluate ALSOnline in more depth and develop an informed foundation for the impending redevelopment of the site. To achieve this central aim, the project had the following sub-aims:

- To identify, through a survey, what types of students use ALSOnline, what they use it for, and how they use it;
- To investigate in depth, through a number of interviews, what the strengths and weaknesses of ALSOnline are;
- To identify how ALSOnline could be improved and become more student centred;
- To develop, through a combination of analysis of data gathered and relevant literature, a foundational framework for the redevelopment of ALSOnline.

To address the first subaim of this project, a structured online survey with targeted questions was distributed in five first year courses. Access to the survey was provided in a link that was e-mailed to all students in these courses with an explanation of the project. The rationale for the selection of the sample was to target students who would most benefit from ALSOnline, therefore only first year courses were chosen, and to potentially get as wide a sample of first year students as possible, which explains why introductory core courses from each of USQ's five faculties were targeted.

Table 1. Number of individual page views per month on ALSOnline, based on information available up until July 2007

Month	**Number of page views 2006**	**Number of page views 2007**
January	11484	8467
February	16485	12211
March	7079	17929
April	6838	14125
May	5579	10609
June	7675	12045
July	6874	-
August	9348	-
September	7079	-
October	7735	-
November	6695	-
December	6249	-
TOTAL	**99120**	**75386**

SURVEY RESULTS

Demographics

Total USQ enrolment in 2006 was 25,868 students, out of which approximately 14,000 were commencing students, and approximately 19,000 studied in distance mode. Out of a total of 2,058 students enrolled in first year courses who were asked to participate, the survey had a 10.6% response rate, of which 53.9% was female, and 46.1% was male.

The results in Table 2 indicate that at least 40% of respondents fit into the age range commonly used to identify the Net Generation (Kennedy et al., 2006; Kvavik, 2005). In addition, respondents were asked in an open ended question about their cultural and linguistic backgrounds, and while 63% identified as White Australian or Australian, the other 37% indicated a wide variety of backgrounds. This was thus a highly culturally diverse cohort which reflects the overall USQ student population.

Table 3 gives a clear idea of study modes, showing that a majority of USQ students are studying off campus. These data were collected before the first cohort had commenced on the new Springfield campus, which explains why Springfield campus is not included in the table.

While the data in Table 3 provide an idea about modes of study, the next section of the survey was designed to get a sense of how students balance study with work, particularly because there are high numbers of mature age and returning students at USQ, as the age table above shows. This in turn has an impact on the number of courses

Table 2. Age groups of survey respondents as percentage of overall respondents

Age	Percentage of respondents
Under 20	15.1%
20 to less than 25	24.7%
25 to less than 35	30.1%
35 to less than 45	16.0%
45+	14.2%

Table 3. Study modes of respondents as percentage of overall respondents

Off Campus/Distance (includes mailed study packages)	64.2%
On Campus (in an overseas location)	5.5%
On Campus (Toowoomba)	24.3%
On Campus (Fraser Coast)	2.3%
Online (all study materials provided online)	3.7%

Table 4. Number of hours of paid work per week as compared with percentage of respondents

No paid work	10.6%
1-10 hours of paid work per week	23.7%
11-20 hours	12.3%
21-30 hours	10.1%
31-40 hours	19.6%
More than 40 hours	23.7%

that students take per semester: 15.6% took one course per semester; 50.5% took two courses; 14.7% took three courses; and 19.3% took more than three courses per semester. Table 4 indicates how many hours of paid work these students do per week.

If we combine the results in Table 4 with the number of courses that these respondents take per semester, the reasons for the perception that students are increasingly 'time poor' becomes very obvious. While the vast majority of students take at least two courses per semester, more than half also work more than 20 hours per week with almost a quarter working more than 40 hours. This may mean they study in weekends and evenings, which is in fact frequently mentioned in the interview data. In addition, this does not appear to be faculty-specific, as the data was fairly evenly spread across USQ's five faculties in terms of students' enrolment and study patterns with the largest cohort attached to the Business faculty (34.2%) and the smallest to Education (11.9%).

Academic Learning, Study Skills and Support

The next section of the survey was designed to gain insight into student perceptions of study skills requirements for their courses and availability of support at USQ. The first question of this section asked respondents in what mode they preferred to access academic learning support: 15.2% had a preference for e-mail; 5.5% preferred the phone; 40.6% face to face; and 38.7% preferred online support.

This shows a fairly balanced split between a preference for face-to-face support and online support, with e-mail and phone much less preferred. Given that most of these respondents are distance students, for whom face-to-face support is often inaccessible for logistical reasons, online support becomes a vital component of academic learning support.

ALSOnline

This part of the survey focused specifically on the learning design of ALSOnline. Significantly, 91.1% of respondents indicated that they were unaware of the existence of ALSOnline, which presents a major problem as the site offers many resources that are potentially very useful. This indicates a potential problem with the overall learning environment on the Web and issues with navigation to the site, as well as problems with creating awareness among students about available resources. The above data clearly indicate that providing a link from the main student page is not enough to ensure students accessing these resources. This is reinforced by the response of

Table 5. Suggestions for improvement categorised as a percentage related to themes

Better advertising and exposure	36%
Not aware of it	36%
Make it more interesting/less boring/shorter	8%
Separate hardcopy material	4%
No suggestions	4%

students who did not access ALSOnline to a survey question that asked them why not: 2% did not think it was useful; 6.9% indicated that they had no need for it; and 91.1% was not aware it existed. Creating pathways for the integration of much of this generic material into discipline-specific courses may be one solution to this, which will be explored in more depth later in this chapter.

Further analysis of the results also indicated that respondents were quite specific and targeted in their use of the site, with relatively even percentages across different subject areas of the site. Respondents were asked to tick a "yes" or "no" box for every topic category on ALSOnline, and analysis of the percentages thus acquired implied that most respondents visited ALSOnline irregularly, and mostly to access a specific topic category. This thus implies that students visit for specific reasons, rather than using the site as a complete study and learning aid. This in turn focuses our attention on the relationship between the overall learning design of the site and the learning objects that make up its constitutive parts. Since this is a generic site that students access for specific reasons, this may mean that individual learning objects on the site should be designed to be self-contained to some extent, so that they can be more easily "lifted" from the site and integrated into discipline-specific courses, even if they have a similar "look and feel" in relation to the overall learning design of ALSOnline.

Those who have visited ALSOnline (18.3%) generally had a positive response to it with 60.9% rating the overall site as either useful (45.7%) or very useful (15.2%). Asked for any suggestions for improvement, 11.4% offered suggestions, as shown in Table 5.

Interestingly, only the third answer in Table 5 could be explicitly linked to a Net Generation characteristic, but this is a very small overall percentage. Furthermore, there are no spontaneous responses that imply a lack of interactive and/or multimedia elements. If we relate that to Kvavik's findings as outlined earlier, it could be inferred with appropriate caution given the relatively low response rate, that these students simply do not use ALSOnline in a manner expected of Net Geners, or indeed that the site does not attract Net Geners. The final question asked whether respondents would be willing to participate in a follow-up interview/ focus group about ALSOnline, to which 26.5% agreed.

FOLLOW-UP INTERVIEWS AND RECOMMENDATIONS

The follow-up interviews were conducted through MSN Messenger and each interview ran for approximately one hour. MSN Messenger was chosen as a way to conduct these interviews, after initial attempts to organise face-to-face focus groups were unsuccessful, partly due to many survey respondents studying off campus. MSN Messenger was chosen because it is widely available, easily accessible and user-friendly, so that interview participants who had never used it before could quickly familiarise themselves with it. Six students is a very small sample, and it is therefore difficult to make valid generalisations based on the responses that follow. However, some interesting trends emerged from the interview data. The names in the following interview data have been changed to protect the privacy of the participants. Some of the recommendations, based on the theoretical discussion and the survey and interview data presented in this chapter, are already in the process of being developed while others are still in the planning stages.

DEMOGRAPHICS

Of the six participants, five were female and one male. All of them were distance students and studying part time, enrolling in one or two courses per semester. The time devoted to study by respondents ranged from about 16 hours to more than 30 per week. While some worked full time or ran a business which equates to a full time job, others worked part time. Almost all, particularly the women interviewed, juggled a busy family life as well. As Vicki put it, "there just isn't enough hours in the day to go with my five children!" Ruth paints the following picture:

On a good week I put in about 16 hours - closer to exams I have a strict discipline with study and a chaotic household - 4am study till 6, work and then two hours at night. I study on Friday and part time Saturday, usually early in the day with the rest of the household asleep.

All of the interview participants were also mature age students, with some explicitly identifying themselves as "baby boomers."

ALSOnline USAGE

A resource like ALSOnline would be particularly useful for the type of students outlined here, as it provides easily accessible information on many aspects of study, from the academic to the administrative. However, only one of the participants had accessed it before, one was not sure, and the rest had never accessed it. Helen, who was the only one who had accessed ALSOnline had used it for information about learning styles, maths support and academic writing strategies, and she used it mainly during the semester. Vicki noted quite rightly that "it's great to have this [ALSOnline], but if no one knows it's there, they can't use it," a response that echoed the survey data.

A specific recommendation to address this overall lack of accessibility is to work towards a two-step solution. The first step would be to create learning objects for ALSOnline that are reusable, adaptable and interoperable. In terms of reusability (and adaptability), this would mean moving beyond the provision of information in a static manner to the design of *interactive* exercises that could be used as stand alone exercises or can be appropriated as templates, which would allow for the opportunity to insert course-specific content. This would not only specifically address the Net Generation characteristic of preferring "inductive discovery" (learning through discovery rather than by being told), but it would at the same time address the learning needs of many mature aged students for whom factors of time, and thus relevance, are of major importance.

In terms of interoperability, USQ has decided to move away from WebCT in 2008, which will be replaced by Moodle as its Learning Management System (LMS), and the expectation is that this will make it more feasible for ALSOnline to function as a learning objects repository, from which learning objects can be "lifted" and adapted to specific courses. This relates directly to the second step in the process, which entails a move towards embedding academic learning skills into the curriculum. For instance, if we take "question analysis" as an example, the idea would be for course designers (or students for that matter) to "lift" an exercise from ALSOnline, and insert their own assignment question into it. This could in turn be directly inserted into the course materials in the appropriate place. This scenario could be duplicated for most of the learning support topics on ALSOnline, and it would overcome the apparent difficulty for students to find online support. In addition, a generic version would still be available on ALSOnline.

DISCUSSION OF EXPECTATIONS ABOUT ACADEMIC LEARNING SUPPORT ONLINE

The participants were also asked to indicate what they expected to find on an academic learning support site, and what they wanted to find on such a site. Ironically, John, who didn't think ALSOnline would be of any use to him, mentioned suggested study methods (time management), approaches to assignments (including essay writing skills), and exam preparation, all of which are already available on ALSOnline. In addition, he said he would like to see anecdotes from students who have had problems but have succeeded, and suggested study plans for core courses, for example something on "how not to panic." The latter points to a common anxiety, which is specifically pressing for distance students: the lack of face to face contact and immediate feedback. While this can be specifically related to Net Generation characteristics such as "immediacy" and "social connectedness," the data here suggest that these characteristics extend well beyond a narrow definition of the Net Generation. In response, it is recommended that a number of learning objects that facilitate peer interaction be integrated into ALSOnline, for example chat facilities, discussion forums and/or blogging facilities. Again, while these should be available in a generic form on ALSOnline, it is envisaged that these learning objects will also be reusable in different courses, as part of the course materials, especially in courses that are offered in distance mode.

In terms of other expectations, Vicki mentioned referencing and essay writing saying, "I love learning. I am motivated but my marks suffer because I struggle with how to put it on paper." Beth listed planning tools, scheduling, note taking tips, study strategies, essay/report/short answer writing skills, a guide to Harvard referencing, and step-wise methods for using the library. This foregrounds two interrelated issues: the available learning support appears to address perceived student needs, but this support frequently does not reach its targets because students are simply not aware of its existence. The next interview question was therefore designed to gain a sense of appropriate ways to bridge this gap in communication channels.

ACCESS IN THE USQ ONLINE ENVIRONMENT

Some students said that they go through the homepage to access the USQ online environment, while others have bookmarked USQ*Connect*, which is part of USQ's WebCT learning environment. Students who access USQ through the homepage need to click on a number of links to find ALSOnline, and therefore need to know what they are looking for to locate it. The chances of "accidently" stumbling upon it are slim. This is a key reason for the relatively low number of hits that ALSOnline receives. Isolating specific learning objects that address academic learning skills and embedding these into course design and materials (possibly including assessment) is therefore the main recommended strategy to come out of this project as a potential solution to this.

NAVIGATION

With regards to navigation, John, who designs his own Web sites, argued for page lengths of two to three "scrolls" and no more than two links. In his view, too many links can be frustrating, as can too long a page where one can get lost. Vicki stressed the importance of clear headings, as did Alisha, and the ALSOnline home page has already been modified in this respect. Another strategy, linked to the embedding agenda outlined above, will be to provide specific links to appropriate exercises and information within course materials.

Also referring to navigational design, Beth preferred internal links to scrolling, "where you may miss something if you get impatient," which could be seen as a typical "Net Generation" response despite Beth's baby boomer affiliation. At the same time however, she identified herself as a "great reader" who likes the idea of a clear contents page, which "would save a lot of unnecessary searching." Because of responses like Beth's, it is important not to simply replace the current static learning materials, but rather to enhance it by adding a variety of learning objects, which are reusable and adaptable.

MODES OF CONTENT PRESENTATION

Moving away from the structure and organisation of ALSOnline, the questions that followed asked about the overall learning design in terms of formats and ways in which students would like to see the content presented. John suggested an area that links to faculty groups for specific subjects which would include a facility to ask faculty members questions. This again points to the potential of an embedded approach in collaboration with faculty staff. He also suggested step by step pages ("scaffolded") for certain help topics, saying:

I like interactive quizzes and sound files are good too. Videotaped lectures are just as snoozie as the real ones (kidding); these are a good idea, but the impact can be lost; server size and transfer rates may inhibit this one. A student self support chat area would be good too, because often students find it encouraging to chat to others who are experiencing the same things.

Vicki also liked videotaped lectures, saying "the video lectures please, please, please- I am begging!" One of her majors was Anthropology, which she loved, but explained, "what I don't love is trying to pronounce some of the terminology; without lecturer input this is difficult." She mentioned Macromedia Breeze presentations as well as being very helpful. The learning design team for ALSOnline is currently developing a whole suite of Breeze presentations for incorporation into the site. The multimedia nature of these presentations specifically addresses Net Generation characteristics such as the "ability to read visual images" and "visual-spatial skills." Again however, the responses here suggest that these kinds of characteristics may by no means be limited to the Net Generation.

Vicki further expressed her feelings about distance study in a more general sense: "I love studying externally; I get a great deal of satisfaction out of it. But sometimes it really is like being on your own." This echoes John's comments above, and was reiterated by others. Ruth hinted at this as well, via her suggestion to incorporate quizzes. "Quizzes are a great boost to self-confidence when studying alone (if you're on the right track)." Alisha, who is an ESL student, expressed concern about her difficulties with understanding material when presented the first time around. She felt she needed to discuss concepts and ideas to gain an understanding, which again points to the perceived need for discussion forums (either synchronous or asynchronous) for distance students. As noted above, these will be developed as part of ALSOnline (along with chat and blogging facilities), but they will need to be specifically linked to course materials to ensure a meaningful learning experience. Again, this relates to relevance and immediacy, as the timeframes and structures of courses would allow for immediate and relevant discussion and peer interaction about specific learning skills, which is much harder to achieve in a generic environment.

Finally, Beth had frequent Internet service issues and expressed great frustration with that, as it prevented her from listening to lectures for example, which is another reason to retain the static materials as they can be easily accessed, even in a dial-up context. "If I had broadband all the time I think videotaped lectures, Power Point with sound, and quizzes would all be great, especially quick tests to check progress throughout the semester." And again, she would also greatly appreciate "interactive sessions, maybe a bit like this one [MSN Messenger chat]; gives us distance bods a feeling of actually being involved in Uni life."

FUTURE TRENDS, DIRECTIONS, AND CONCLUSIONS

Despite being small in scale, the main insight gained from the above data is that the current student population can be characterised by one word: diversity. The relatively small sample for this particular study, and its limitation to a single institution, means that caution needs to be exercised in terms of the conclusions drawn. So while the results in many ways confirm the earlier posed questions about the Net Generation, particularly the problematic notion that this is a generation which can be defined by relatively uniform characteristics, a larger cross-institutional study would allow for firmer conclusions in this regard.

However, the results of this study do show similarities to other research conducted at single institutions. As Kennedy et al. (2006, p. 13) note for example, there is "little empirical support for the stereotypical depiction of the digital native-wired and wireless 24/7." They conclude that

> *the critical point is that while first year students might use technology in a range of ways and may, apparently, be digitally literate, we cannot assume that being a member of the Net Generation is synonymous with knowing how to employ technology-based tools strategically to optimise learning experiences and outcomes in university setting.* (Kennedy et al., 2006, p.16)

They come to this conclusion via their study of first year students at the University of Melbourne, who according to their age should be closely aligned with Net Generation characteristics. They strongly advocate the need for more empirical research to inform learning design in general, and they argue that the main challenge for universities is "how to cater for the broad range in students' levels of access to, familiarity with, and preference for different technologies and technology-based tools" (Kennedy et al., 2006, p.14).

Recognising this broad range is even more urgent in the context of a regional university such as USQ with large numbers of distance students, and whose student population may be even more diverse than that of a 'big eight' institution like the University of Melbourne. Thus, the study discussed in this chapter is a first step in taking up the challenge outlined above and it provides some useful initial insights, but it needs to be followed up by a more detailed and larger scale study, and rigorous evaluation once recommendations have been implemented, that can then inform learning design and learning objects in more meaningful ways.

Recognising the importance of increasingly diverse student cohorts, and the dangers of assuming neat characterisations (as in the "Net Generation"), Sankey (2006) advocates what he calls a "neomillennial learning approach," which uses a multimodal learning environment. This approach maintains "a balanced environment for more traditional learners, while at the same time integrating a range of multimedia based enhancements for those who learn in non-traditional ways" (Sankey, 2006). Examples of learning objects that provide such enhancements are video interviews, interactive exercises, formative quizzes, animated and narrated sample assignments, use of visually attractive images and Breeze presentations.

However, these learning objects are part of a course based learning design, whereas designing learning objects for a generic learning environment creates its own challenges. On the other hand, it also creates potential opportunities. As mentioned earlier, Downes (2004) usefully emphasises "sharability" (composed of reusability and interoperability) in his definition of learning objects. Moreover, given that learning objects are resource intensive to design and create, he further advocates the creation and use of what he calls "learning object repositories" (2004, p. 29). These can either be stand alone or included in another service. As a generic skills learning environment, ALSOnline could potentially serve this purpose in the future. All discipline-based courses require a certain amount of generic skills and if these could be cooperatively designed and stored in a central repository (in the form of ALSOnline), they could be directly integrated into specific courses where needed. This would be in line with Brown's assertion that:

Learning environment design is less likely to remain the activity of an individual academic. The quality emphasis has prompted more distributed team responsibility for curriculum design with selection and integration of components such as graduate attributes or professional skills in subjects or modules relative to their position within a broader course. (2006, p. 10)

CONCLUSION

Overall, this chapter has been concerned with debunking certain myths about the notion of the Net Generation both theoretically and empirically. This is an important exercise as it focuses our attention on the increasing diversity of the students that we target when employing our learning designs and learning objects. The possibilities afforded by rapidly changing technologies should be capitalised on, but should also be centrally informed by the changing characteristics that students bring to the tertiary learning environment, taking into account their increasingly diverse needs, skills, and lifestyles and maintaining a clear focus on desired learning outcomes. In short, a balance needs to be struck between convergent possibilities and divergent needs.

REFERENCES

Abram, S., & Luther, J. (2004, May 1). Born with the chip. *Library Journal*, *129*(8),34-37.

Albion, P. (2005). Along the continuum: From print to simulated experience. In J.B. Son & S. O'Neill (Eds), *Enhancing learning and teaching: Pedagogy, technology and language* (pp. 119-131). Flaxton: Post Pressed.

Brown, M. (2005. Learning spaces. In D.G. Oblinger & J.L.Oblinger (Eds), *Educating the net generation* (pp.12.1-12.22). Boulder, CO: Educause.

Brown, C. (2006). Developing familiarity with learning design tools through subject analysis. *Journal of Learning Design*, *1*(2), 10-20. Retrieved April 4, 2008, from http://www.jld.qut.edu.au/

Conole, G., & Fill, K. (2005). A learning design toolkit to create pedagogically effective learning activities. *Journal of Interactive Media in Education*, 08. Retrieved April 4, 2008, from jime.open.ac.uk/2005/08

Downes, S. (2004). Learning objects: Resources for learning worldwide. In R. McGreal (Ed), *Online education using learning objects* (pp.21-31). London & New York: RoutledgeFalmer.

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology*, *21*(1), 82-101.

Green, M., & McNeese, M.N. (2007). Using edutainment software to enhance online learning. *International Journal on E-Learning*, *6*(1), 5-16.

Hughes, J.A. (2004). Supporting the online learner. In T. Anderson & F. Elloumi (Eds), *Theory and practice of online learning* (pp.367-384). Canada: Athabasca University.

Kehrwald, B. (2005). Learner support in networked learning communities: Opportunities and challenges. In J.B.Son & S. O'Neill (Eds), *Enhancing learning and teaching: Pedagogy, technology and language* (pp.133-148). Flaxton: Post Pressed.

Kellner, D. (2000). New technologies/new literacies: Reconstructing education for the new millennium. *Teaching Education*, *11*(3), 245-265.

Kennedy, G., Krause, K., Judd, T., Churchward, A., & Gray, K. (2006). *First year students' experiences with technology: Are they really digital natives?* (Preliminary Report of Findings). Melbourne, Australia: University of Melbourne, Centre for Study of Higher Education.

Kirkwood, A., & Price, L. (2005). Learners and learning in the twenty-first century: What we know about students' attitudes towards and experiences of information and communication technologies that will help up design courses? *Studies in Higher Education*, *30*(3), 257-274.

Krause, K., Hartley, R., James, R., & McInnes, C. (2005). *The first year experience in Australian universities: Findings from a decade of national studies*. Melbourne, Australia: Centre for the Study of Higher Education, University of Melbourne & DEST.

Kvavik, R. (2005). Convenience, communications, and control: How students use technology. In D.G. Oblinger & J.L.Oblinger (Eds), *Educating the net generation* (pp.7.1-7.20). Boulder, CO: Educause.

Laurillard, D. (2002). *Rethinking university teaching: A conversational framework for the effective use of learning technologies* (2nd ed.). London & New York: Routledge/Falmer.

McGreal, R. (2004). Introduction. In R. McGreal (Ed), *Online education using learning objects* (pp.1-16). London & New York: Routledge-Falmer.

Oblinger, D.G., & Oblinger, J.L. (2005). Is it age or IT: First steps toward understanding the net generation. In D.G. Oblinger & J.L.Oblinger (Eds), *Educating the net generation* (pp.2.1-2.20). Boulder, CO: Educause.

Ramalay, J., & Zia, L. (2005). The real vs. the possible: Closing the gaps in engagement and learning. In D.G. Oblinger & J.L.Oblinger (Eds), *Educating the net generation* (pp.8.1-8.21). Boulder, CO: Educause.

Sankey, M.D. (2006). A neomillennial learning approach: Helping nontraditional learners studying at a distance. *International Journal of Education and Development using ICT*, *2*(4). Retrieved April 4, 2008, from http://ijedict.dec.uwi.edu//viewarticle.php?id=224&layout=html

Sankey, M., & Nooriafshar, M. (2005). Multiple representations in multimedia and e-learning materials: An issue of literacy. In J.B.Son & S. O'Neill (Eds), *Enhancing learning and teaching: Pedagogy, technology and language* (pp. 149-171). Flaxton: Post Pressed.

Squire, K., & Jenkins, H. (2003). Harnessing the power of games in education. *InSight*, *3*, 7-33.

Windham, C. (2005). The student's perspective. In D.G. Oblinger & J.L.Oblinger (Eds), *Educating the net generation* (pp.5.1-5.16). Boulder, CO: Educause.

KEY TERMS

ALSOnline: ALSOnline stands for Academic Learning Support Online. It is a generic academic support Web site designed by the Learning and Teaching Support Unit (LTSU) at USQ. URL: http://www.usq.edu.au/learningcentre/alsonline/

Edutainment: Edutainment is a hybrid game genre that relies heavily on visuals and narratives or game formats but also incorporates some type of learning objective (Green & McNeese, 2007).

Convergence: As with learning objects, there are many different definitions of convergence and not much consensus. It is often used with a specifying adjective (as in "media convergence" or "technological convergence"). In the context of this chapter, it refers to blurred boundaries between previously separate elements, particularly the potential that technological convergence offers with regards to "sharability" and "reusability" of learning objects, as well as the potential convergence between generic and course-specific learning objects.

Generic Academic Skills: Generic academic skills are academic skills that are not course-specific. Examples include essay and report writing, question analysis, numeracy skills, critical analysis, and so on.

Learning Design: An application of a pedagogical model for a specific learning objective, target group, and a specific context or knowledge domain. The learning design specifies the teaching and learning process, along with the conditions under which it occurs and the activities performed by the teachers and learners in order to achieve the required learning objectives (Conole & Fill, 2005).

Learning Object: On a basic level, learning objects are educational resources that can be employed in technology-supported learning (McGreal, 2004). However, there are many different definitions that run from the very general to the very specific, with little consensus. This chapter follows Downes' (2004) approach who advocates that learning objects should be defined by the problems they solve.

Learning Styles: Learning styles reflect the diversity of the ways in which students study and learn, and academics teach and learn.

Neomillennial Learning Approach: A neomillennial learning approach is concerned with designing learning materials to cater to learners with a range of different learning modalities and backgrounds. Designing for multimodal learners may reduce the impact of providing course materials to a very diverse and an increasingly nontraditional student body (Sankey, 2006).

The Net Generation: The Net Generation (also called "Digital Natives," "Y Generation," "Next Generation," and "Millennials") is a group of individuals, born roughly between 1980 and 1994, who have been characterised by their familiarity with and reliance on information and communication technologies (ICTs) (Kennedy et al., 2006).

The University of Southern Queensland (USQ): The University of Southern Queensland (USQ) is a dual-mode institution with "triple-option" teaching modes (on-campus, distance education, and online). It is currently the second largest distance education provider in Australia, with 75% of its students studying in this mode, with almost 90 nationalities represented (Sankey, 2006). URL: http://www.usq.edu.au/

Chapter XLI
Standards for Learning Objects and Learning Designs

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ABSTRACT

E-learning standards are a contentious topic amongst educators, designers, and researchers engaged in the development of learning objects and learning designs. There is disagreement regarding the relative benefits and limitations of standards, while the relevance of standards to some education and training contexts has been questioned. It may be difficult for designers and educators to be sure that they need to implement standards, let alone to choose the most appropriate one from the plethora available. This chapter aims to provide individuals involved in the design and development of learning objects and learning designs with a wide-ranging critical overview of e-learning standards. It first traces the evolution of standards, and then examines their application in the present day. Finally, the chapter considers some of the limitations and criticisms of current standards, and suggests some possible directions for future development.

INTRODUCTION

Opinions vary regarding the importance and relevance of e-learning standards for learning objects and learning designs. Some view standards as nothing more than buzz words, and have difficulty seeing the relevance to K-12 and tertiary education of standards that have, so far, been used to support a limited range of pedagogical models in commercial and military training contexts. Others consider standards to be pivotal in facilitating sharing, reuse, and interoperability of resources across all training and education sectors. Whatever your opinion, it is clear that standards are difficult to avoid.

So, what are the most commonly used e-learning standards and why have standards become so important? How do standards benefit instructors, education providers and students? Should "standards compliant" e-learning be the "Holy Grail" for the e-learning developer? How should one select the "correct" standard(s) from the plethora available? How much time and effort does the designer or educator need to invest in order to apply e-learning standards correctly? This chapter examines standards related issues relevant to current and future development of learning objects and learning designs. It aims to provide both the novice and more experienced standards implementer with a wide-ranging overview of e-learning standards by:

- Outlining the history and evolution of standards, in which we consider the rationale for the development and application of standards, provide definitions of the most prevailing standards, and outline the evolutionary process behind each one. Standards are categorised as part of this process.
- Detailing, with the aid of case studies, the present use of standards in a variety of education and training contexts.
- Explaining how the various standards are applied by offering practical advice for practitioners involved in selecting and deploying standards.
- Outlining recommendations for the future directions of standards. In particular, we examine some of the limitations and criticisms of current standards and discuss the applicability of today's standards in future e-learning contexts in which a wider range of technologies and pedagogical approaches are likely to be employed.

EVOLUTION OF STANDARDS

E-learning standards originated in the military and commercial training domains in the early 1990s, in order to allow learning objects produced by different vendors to operate on different technical platforms. More recently there has been interest in the possibilities offered by e-learning standards for enabling the sharing and reuse of learning objects and designs in K-12 and tertiary education contexts.

Today's e-learning standards typically strive towards achieving economies of scale, by facilitating the reuse of e-learning content and activities in different education and training domains, subject areas, and geographical regions. The allure of cost savings and efficiency gains has resulted in a number of countries investing in organisations responsible for the promotion of e-learning standards, for example the UK's Centre for Educational Technology Interoperability Standards (CETIS) and Canada's EduSpec initiative.

Standards apply not only to learning objects and designs, but also to learning management systems (LMSs) or Virtual Learning Environments (VLEs). Compatibility must be present such that content and designs conformant to a particular specification or standard can interoperate with an LMS that also conforms to the standard. This interoperability is of great importance for the sharing of resources and materials, allowing, for example, an organisation to "mix and match" content developed by a range of vendors with resources developed in-house and deliver these via a common LMS. A standard may also describe how units of learning material should be compiled as single file. Such file formats allow content to be easily migrated from one LMS to another.

Metadata standards that describe learning material objects and designs (for example the subject classification or technical format of the resource) are crucial in enabling discovery—and hence reuse—of resources. Some standards focus solely on metadata, while others are used for a range of purposes, including metadata. By requiring the addition of metadata to content, the opportunity for retrieval and reuse is amplified allowing educators and students to search for learning objects and designs through a range of search terms. This is of particular importance when the learning material is to be made available via a digital repository.

Some standards offer tracking or reporting functionality, and thus allow certain types of information about a learner's interactions with a learning object or design—for instance a set of scores—be stored. The format of this information is standardized, allowing it to be represented and used in every LMS that conforms to the standard in question. Similarly, some standards address the order in which learning material should be presented to the learner. This tracking and sequencing information is in-built into the package, and so can be moved and used with considerable ease.

E-learning specifications and standards are not simply born into existence; they evolve via an iterative process of drafting and redrafting. A *specification—*defined as a precise and detailed declaration of the requirements and characteristics, both technical and functional, necessary for a particular system or element of a system—is developed in the first instance. The very nature of the evolution process means that a specification may be incomplete and in need of refinement. A specification that has been made complete and robust may receive approval from an official standards body, and thus become a *standard*, defined by the International Organization for Standardization (ISO) as "a document, established by consensus, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (ISO/IEC, 1996, p. 4).

There is often confusion as to whether content is compliant, conformant or certified to a specification or standard. Indeed, the words compliant and conformant are often conflated. "Conformant" is preferred over "compliant" by many of the standards organisations (e.g., SCORM conformant), while others choose to use "designed for" (e.g., designed for AICC). Test suites are often available with which developers can test their conformance to a particular standard. However, certification can only be acquired if the standard/specification producing organisation or an independent test lab has completed this conformance testing and has given official certification.

Generally accepted software related definitions of specifications and standards are often complex and technically oriented (Marshall, 2004). Reference is given to precision and detail, requirements, and guidelines, but there is often little mention of pedagogical issues, which in the e-learning context, are as, if not more, important, than technical issues. We therefore review specifications and standards in this chapter by analysing both their technical and educational strengths and weaknesses.

STANDARDS TODAY

The terms "specification" and "standard" are often used interchangeably. This has led to inevitable confusion over what a standard is and how it differs from a specification. This complexity is compounded by the existence of *de jure* and *de facto* standards. A standard can only be certified by an official standards body, such as the ISO or the IEEE. Such standards are referred to as *de jure*, meaning "according to law." However, specifications produced by non-official standards organisations may be standards in their own right—called *de facto* standards—due to their general acceptance by a majority within a particular community or communities, despite not existing with a place in law. Indeed, a standard may be recognised by both in law and by the majority, and thus be both a *de jure* and a *de facto* standard.

Commonly used e-learning specifications and standards, and their associated originating organisation, are given in Table 1. We place these standards and specifications into four categories: *packaging, communication, metadata,* and *instructional.* Some may also be applicable to more than one category; we deem these to be *multicategory* standards.

PACKAGING STANDARDS

Packaging standards outline how learning content can be aggregated, allowing explicit description of the order that learning material should be presented. These standards also specify the representation of information and the method by which it

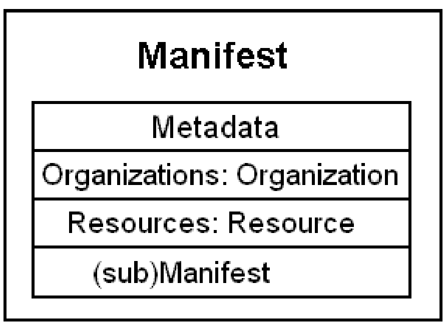
Table 1. Specifications and standards in common use

Category	**Organisation**	**Associated specification or standard**
Packaging	IMS Global Learning Consortium	Content Packaging (CP)
	IMS Global Learning Consortium	Question and Test Interoperability (QTI)
	Aviation Industry Computer-Based Training Committee (AICC)	Packaging
	Advanced Distributed Learning (ADL)	Sharable Content Object Reference Model (SCORM)
Communication	AICC	Computer Managed Instruction (CMI)
	ADL	SCORM
Metadata	Dublin Core Metadata Initiative (DCMI)	Dublin Core Metadata Element Set
	IEEE Learning Technology Standards Committee (LTSC)	Learning Object Metadata (LOM) standard
	Association of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE)	Metadata
	ADL	SCORM
Instructional	IMS Global Learning Consortium	Simple Sequencing
	IMS Global Learning Consortium	Learning Design
	ADL	SCORM

can be transported from one learning environment to another, thus playing an important role in the use of digital learning repositories.

The *IMS Global Learning Consortium*, established in 1997, is a nonprofit global organisation that produces standards to meet interoperable learning technology requirements. The widely adopted *IMS Content Packaging* (IMS CP) specification outlines the manner in which learning content can be combined and organised, and how this larger unit of instruction can be moved from one learning environment to another (IMS, 2005). Central to IMS' CP standard is the *manifest* (Figure 1), an XML file that outlines the order in which elements of a unit of learning—such as content or exercises—should be delivered. The manifest organises the delivery order of learning objects in a hierarchical fashion, thus information will be presented to the student in a step-by-step manner. Consequently, in the absence of in-built logic within a lesson, the student will experience a pre-defined course, regardless of their performance for each lesson within the course. However, the instructor can change the organisation section of the manifest at any stage and re-package the content. This allows new learning objects to be added, learning objects to be removed, or courses structures to be changed for different groups of students.

Figure 1. IMS CP manifest (adapted from ADL, 2004a)



It should be possible to move a CP from one learning environment, conforming to the CP standard, to another with relative ease. Content packaging is also proving to be particularly important with the increasing use of digital learning repositories. The IMS CP standard has been incorporated into SCORM, which we discuss later.

The *IMS Question and Test Interoperability* (IMS QTI) specification seeks to facilitate the exchange of tests and results between learning environments. According to the IMS QTI Overview (IMS, 2006), the specification is designed to:

- Document a format to facilitate the storage and exchange of questions and tests, regardless of the authoring tool with which they were created.
- Enable the consistent reporting of test results within a range of systems.
- Aid with the setting up of question repositories.

QTI uses XML to record learner data. The specification is centred on a number of documents, including:

- The Assessment Test, Section, and Item Information Model, which provides detailed information regarding the format of assessment tests and questions (e.g., information to be presented to the student and the way this information should be scored), and the necessary requirements for learning environments.
- Results Reporting, which outlines information that can be reported, such as score and number of attempts, and the way in which a series of related questions can be grouped together to form an individual assessment section.
- Metadata and Usage Data, which are of particular importance to those using ques-

tion repositories. QTI uses a profile of the IEEE LOM standard.
- The Integration guide, which describes the relationship between QTI and other IMS specifications.

The *Aviation Industry Computer-Based Training Committee (AICC)* was established in 1988 to provide sustainable and cost-efficient training for the aviation industry, achieved via the development and delivery of computer-based training technologies. An AICC package is based on seven files: the mandatory course description file, assignable unit file, descriptor files and course structure files; and the optional objective relationship files, prerequisites files, and completion requirements files (AICC, 2006). This specification has been described as difficult to implement (Horton, & Horton, 2003), and it appears to be less widely applied than the IMS CP standard—a standard that performs essentially the same function—perhaps due to the incorporation of IMS CP in SCORM.

COMMUNICATION STANDARDS

Communication standards allow the sharing of learner-centred data, such as personal details, language preferences, or level of knowledge (score, completion status, for example). To facilitate this sharing of data, a communication standard specifies the manner in which the learning environment should start and end learning content, and communicate with it in the interim.

The AICC's *Computer Managed Instruction* (CMI) specification (AICC, 2004), first released in 1993, allows information to be shared among courses created by various developers. Specifically, the CMI specification details the communication between a lesson and the learning environment, the storage of the data communicated, and the movement of a course between multiple learning environments. Thus, CMI conformant learning environments handle both students and the learning material with which the students are working. The specification describes the CMI components that facilitate this as:

- The development of course structures.
- A testing component, for the development and administration of tests.
- A student rostering component, for the management of student names and demographic information.
- A student assignment management component, for the functioning of daily training procedures, the rule-based control of student assignments, and the initiation and logging onto lessons.
- A data collection component, for the collection and maintenance of student performance data. Student performance data is composed of, for instance, attempt number, lesson time, score, pass/fail status, amongst others.

While the focus of the specification was originally on aviation-related training—a focus which still remains to a considerable degree—the AICC feels that it is important "to promote interoperability standards that software vendors can use across multiple industries" (Hodgins & Conner, 2000, AICC Section, para. 3).

METADATA STANDARDS

Metadata is structured data about data. For example, in a library, the information recorded on an index card that references a particular copy of a book is its metadata. It is used for labelling, identifying, and discovering material, and is vital to ensure that digital learning repositories can be searched effectively. Metadata for learning objects and learning designs include: administrative metadata (such as information detailing the creator of the resource, or copyright details);

subject classification metadata (for example a description of the resource, or a description of its educational purpose); and technical metadata (information about the format of the resource, for example Flash file, audio clip, etc.). Metadata standards detail the most important pieces of metadata and specify accepted vocabulary for a particular context or a range of contexts, thus allowing content developed by different authors to be described in a consistent manner. Usually, within a particular metadata scheme, there are compulsory and optional metadata elements.

The *Dublin Core Metadata Initiative* (DCMI), an open forum organisation, was established in 1995. The organisation aims to develop metadata standards for online environments and non-electronic resources existing in libraries and commercial companies. DCMI cites its major characteristics as (DCMI, 2006):

- Independence—not biased towards a particular commercial or domain interest
- International—participation is sought from the international community
- Influenceable—DCMI is an open organisation without any prerequisites for participation.

Dublin Core metadata usually refers to the fifteen elements of the Dublin Core Metadata Element Set (DCMES) (DCMI, 2006), first published in 1998. This metadata is then used, for the most part, to aid the discovery of Web-based resources. DCMI metadata's advantages include its transferability across domains (that is, its elements are relevant to a range of disciplines), along with its simplicity and international background (Hodgins & Conner, 2000).

The *IEEE Learning Technology Standards Committee* (LTSC) has produced the *Learning Object Metadata* (LOM) standard (IEEE, 2002). This standard, which specifies 77 elements, focuses specifically on the syntax and semantics of digital or non-digital learning objects. The standard aims to provide the minimum set of attributes required to allow for the management and location of learning objects. The purpose of the LOM project is (IEEE, 2002):

- To enable the searching, evaluating, acquiring and utilising of learning objects
- To enable the sharing of learning objects across technology-based learning systems
- To enable the creation of pieces of learning, so that units can be aggregated to form other meaningful units of instruction
- To enable the collection and sharing of comparable data by researchers
- To define a simple but extensible standard that can be applicable to a range of domains.

ARIADNE is an association also concerned with the development and use of metadata. A specification submitted by ARIADNE to the IEEE in 1998 was harmonised with a similar specification submitted by the IMS to form the basis of the IEEE LOM standard. More recently, ARIADNE has been working on the Educational Recommendation (ARIADNE, 2004), which is related to the IEEE LOM standard. This metadata scheme is primarily for use in the educational context, but can also be applied to skills training in general. It aims to solve two practical problems that may arise as a result of using metadata, namely:

- The creation of metadata by humans should be made as easy as possible; and
- Users searching for and discovering material should do so as easily and efficiently as possible with the help of metadata.

INSTRUCTIONAL STANDARDS

Instructional standards, which often focus on pedagogical strategies, define the manner in which learning content should be presented to participants, and, for group activities, they define how participants will interact with each other.

The *IMS Learning Design* (IMS LD) specification was released in February 2003 (IMS, 2003a). Based on the Educational Modelling Language (EML) developed at the Open University of the Netherlands (OUNL), it aims to enable the sharing and support of a range of pedagogical approaches. A significant difference between IMS LD and the standards discussed thus far is that IMS LD supports collaborative approaches to learning. IMS LD can utilize or be used in conjunction with a number of additional IMS specifications as well as SCORM.

IMS LD allows a self-contained unit of learning (UoL), such as a lesson or module, to be described via a generic language. Koper (2005) uses the metaphor of a play to describe how a UoL encoded via IMS LD unfolds. As in a play, a learning design is composed of one or more *acts* that are played out in sequence. When one act is completed, the next one begins. The learning design is complete after the last act is finished. Participants in a UoL each assume a *role* and carry out a series of *activities* during each act. In the same way that a play can be staged many times with different actors in different theatres, a learning design can be run time and again with different participants on alternative systems.

The LD specification has three levels:

- Level A incorporates the core LD elements.
- Level B builds on Level A and facilitates personalization by allowing the content and activities presented to participants to be modified according to their interactions with the LD.
- Level C builds on Level B and adds an event-driven messaging system. Notifications can be sent to both to human participants and to elements of the design. For example, if a learner asks a question, the tutor can be notified that a response is required.

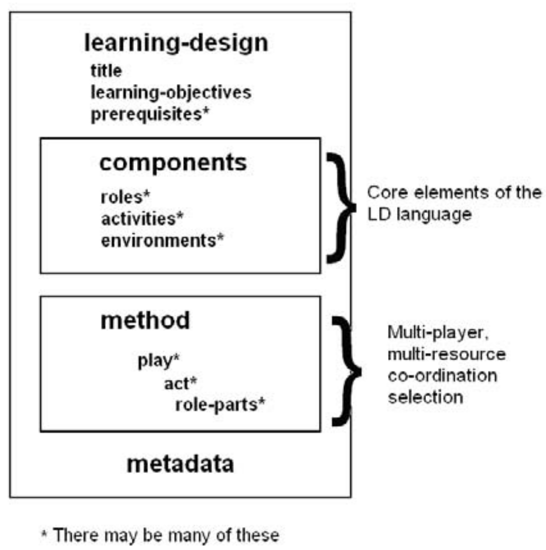
Each UoL content package contains (Figure 2):

- An XML manifest that describes the components, method, properties, conditions and notifications specification, and points to the associated files or resources.
- The set of files or resources described in the XML manifest.

When an IMS LD UoL is "played" in an IMS LD-aware application—such as a VLE or dedicated IMS LD player—the application makes the appropriate activities and environments available to each of the participants playing the various roles. At the beginning of each act a new set of activities and resources can be released to each of the participants.

IMS Simple Sequencing (IMS SS)—which is not, as the name suggests, a "simple" specification (Mackenzie, 2004)—outlines the route a learner can take through a particular unit of instruction, based on previous actions. This allows a course to be adapted based on the needs of the learner.

Figure 2. LD UoL content package (reproduced from Koper & Tattersall, 2005)



Simple Sequencing's central concept is that of a learning activity. This is intended to be a "pedagogically neutral unit of instruction, knowledge, assessment, etc." (IMS, 2003b, Learning Activity Section, para. 1), and is usually associated with a piece of learning. Activities are arranged as an activity tree. Based on rules assigned to each activity by the instructor, the LMS traverses the tree choosing appropriate learning content to deliver to the student. For example, achieving below a certain score for a particular learning object might lead to learner to a remedial learning object, whereas achieving above a certain score will allow the student to progress to new material. IMS claim that the specification is neutral with regards to pedagogy and instructional strategies. While it has the potential to add richness to the learning experience, it still remains focused on the single-student learning model and operates on a tree-based/hierarchical structure.

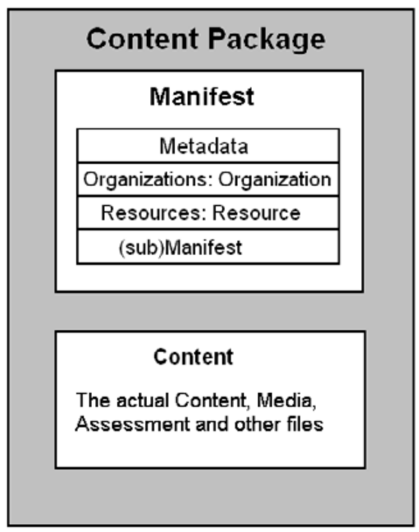
MULTICATEGORY STANDARDS

Multicategory standards are those which fit a number of the above categories.

The *Sharable Content Object Reference Model* (SCORM), developed and maintained by the U.S. Department of Defense Advanced Distributed Learning (ADL) initiative, is perhaps the most commonly used multicategory standard, and is fast becoming a *de facto* standard within the community. Rather than being a completely new standard, SCORM brings together pre-existing packaging (IMS Content Packaging), communication (AICC CMI), and metadata (references IEEE LOM) specifications and standards as an integrated multi-purpose specification. The latest version of SCORM, SCORM 2004 (ADL, 2004a, 2004b, 2004c), builds on its predecessor, SCORM 1.2 (ADL, 2001). SCORM 2004 contains a Content Aggregation Model (CAM) document, a Run-Time Environment (RTE) document and a Sequencing and Navigation (SN) document:

- The CAM specification (ADL, 2004a) details how learning content should be structured and described. Individual chunks of learning content are referred to as learning resources, and are either assets or sharable content objects (SCOs). An asset is the smallest and simplest piece of content described by SCORM. A SCO, usually a group of assets, is a single standalone piece of information or learning, which can be combined with other SCOs to form a course; it is essentially a SCORM conformant learning object. A content aggregation structures learning resources into a single unit of instruction. Here, the sequence in which learning resources are delivered to the student is determined. Learning content that is ready for delivery must be packaged in a particular manner. Such a content package should contain metadata, an organization section that defines content structure and behaviour, a list of references to the resources in the package, and all required physical files (Figure 3).

Figure 3. SCORM content package (adapted from ADL, 2004a)



The CAM specification draws on the IMS Content Packaging standard and the IEEE LTSC LOM standard.

- The RTE specification (ADL, 2004b) describes the way in which content interacts with the LMS. Specifically, this specification provides "a common way to launch and manage content objects, a common mechanism for content objects to communicate with an LMS and a predefined language or vocabulary forming the basis of the communication." (ADL, 2004b, p. 17). The RTE therefore defines three mechanisms: a common way for the LMS to start a learning resource, a means of communication between the learning resource and the LMS, and a set of information that an LMS can track for every SCO. The RTE specification is largely based on work done by and with the AICC. SCORM uses CMI to communicate between the learning resource and the LMS.
- The SN specification (ADL, 2004c) defines how content can be sequenced through a set of system-initiated or learner-initiated navigation events. The sequencing and navigation specification is considerably complex. It outlines: sequencing concepts and terminology; sequencing definition model; sequencing behaviour model; navigation control and requirements; and a navigation data model.

SCORM is useful due to its multifunctional offering. It allows content to be organised and transported between learning environments; provides a standard method for the LMS to start the learning resource and to note student data; and the latest version moves towards enabling adaptive and personalised learning experiences. SCORM is aimed at a single learner working through material at his or her own pace, however, which may not be ideal for all learners or courses.

STANDARDS IN PRACTISE

The majority of organisations that develop standards and specifications aim to address issues in a range of contexts. In order to address standards in practise, we outline a sample of projects and opinions concerning the impact of standards on K-12, commercial, military and tertiary contexts. We then explore the application of one particular standard, SCORM, within the tertiary sector with the aid of an extended case study.

K-12 Education Contexts

A search for the use of e-learning standards within the K-12 context yielded limited results. This suggests that either standards are not commonly applied to K-12 content or that, if standards-conformant K-12 lessons do exist, they have not made a great impact. The fact that, in general, standards organisations seem to refer to the K-12 environment almost as an afterthought could mean that existing standards can only be of limited use to those teaching at primary and secondary levels. The lack of suitability of SCORM to K-12, for example, has been recognized by Daniel Rehak, a codirector to the Workforce ADL Co-Lab, who notes that SCORM "is essentially about a single-learner, self-paced and self-directed. It has a limited pedagogical model unsuited for some environments" (Rehak & Mason, 2003). He also acknowledges that SCORM "has nothing in it about collaboration. This makes it inappropriate for use in HE and K-12" (Kraan & Wilson, 2002, para. 4). However, in March 2006, ADL announced their collaboration with Florida Virtual School (FLVS), an online public high school in the USA (ADL, 2006). In the same year, a selection of elementary school teachers in California moved towards using digital resources rather than relying solely on traditional textbooks. It was expected that both initiatives would incorporate SCORM (Ascione, 2006).

Commercial Contexts

E-learning standards have made a certain impact on the commercial sector. Indeed, 93% of corporate and government e-learning developers surveyed by Macromedia indicated that they considered standards to be important (Heins & Himes, 2002). Companies developing software to adhere to standards are keen to promote their conformance. We can presume that standards are therefore important to customers, as it is often the customers that are the driving force behind such company decisions. This is compounded by Kevin Oakes who, during his term as president of SumTotal Systems, asserted that:

Many of our… enterprise customers continue to demand better return on their learning investment, including trackable content with a lengthy shelf-life and learning assets that can be used in any environment, across disparate technologies. This need has driven our efforts to provide solutions with deep integration for standards-based content and other technical functionalities. (SkillSoft press release, 2004, para. 7)

Occasionally, when a commercial company gains official certification for a particular standard, it includes statements from the certification body in its press release. Such statements may, for example, pronounce the importance of standards compliance in the commercial sector and express the hope that certification will be achieved by other commercial companies (SkillSoft press release, 2004, para. 5). This begs the question: who is this publicity for—the commercial sector or the standards organisations? Perhaps it is a mutually beneficial relationship, but one through which the customer is the overall winner.

Military Contexts

SCORM was originally developed for use within the military domain, as reusable resources are key to enabling the efficient training of a force with large numbers in procedural learning content, and where there is a continuous need for retraining as new technologies are introduced. There are numerous examples of SCORM deployments in the military, evidenced by the many papers presented at the annual military oriented *Interservice/Industry Training, Simulation and Education* conference, for example (see Ramachandran, Remolina, & Barksdale, 2006; Cherry, Westfall, & Baquero, 2005). It is interesting to note that, despite the apparent suitability of the military's subject content to SCORM and the origin of SCORM in this domain, its application has posed some challenges. For instance, while outlining the development of the first SCORM 2004 conformant course for the U.S. Army, Ramachandran et al. (2006) note that despite yielding many benefits, SCORM also proved to be restrictive due to the lack of a sequencing specification in SCORM 1.2 and the limit to the amount/size of information that could be transferred between the SCO and the LMS. They highlight that implementing SCORM involved a steep learning curve, despite close collaboration between the developers and ADL.

Tertiary Education Contexts

SCORM presents itself as a standard that is frequently applied to content, and it is interesting to note that a considerable amount of standards related work at tertiary level is centred on technical subject areas, such as computer programming. Qu and Nejdl (2001), for example, have designed and implemented a SCORM-conformant Java-based computer science course. This course is run collaboratively between a number of universities, implementing SCORM to provide a standardized means of aggregating and sharing course components. The existence of a run-time environment was a secondary factor for the authors. The authors do not report any major problems encountered while implementing the standard.

Although IMS LD, and its predecessor the EML, were designed with the requirements of tertiary education in mind (Koper, 2005), the relative immaturity of the IMS LD specification means that it is unsurprising that there are currently few implementations. A small number of educators and researchers have begun to experiment with this standard, however, for example McAndew and Weller (2005) discuss the application of IMS LD to distance learning courses in the UK's Open University, while Spang Bovey and Dunand (2006) applied the standard to a 28-week online course in information theory. While overall, the relevance of this standard to tertiary education contexts has been welcomed, a number of implementation issues have been reported. For example, Spang Bovey and Dunand (2006) found that LD was difficult for staff with limited technical skills to implement, while according to Berggren et al. (2005), IMS LD may be limited in its ability to handle unforeseen circumstances or pedagogical opportunities that occur once a design has been implemented.

Implementing SCORM at Tertiary Level–An Extended Case Study

The Teaching Undergraduate Programming Using Learning Objects (TUPULO) project, a European Union-MINERVA initiative, was established to create learning objects for undergraduate students studying Java programming. This initiative is a collaboration between various project partners in Europe. The LOs, which are delivered according to a blended learning strategy, are accessed by the student through the Moodle learning management system.

The project partners chose to make the developed content conformant to SCORM for a variety of reasons. Each partner institution was to make the LOs available to separate groups of tertiary education students. The content, therefore, needed to be portable. Furthermore, while each institution is currently using Moodle to deliver online material, it could not be predicted what LMS would be used in the future. Any content developed needed to be interoperable and durable, to allow for the natural evolution within the tertiary context. It was required that information regarding students' actions while using the material should be tracked, with the intention to use this data in the future to adapt to the students' individual learning experiences. Finally, due to the blended learning approach in question, the LOs were to be experienced by a single learner at his or/her own pace. All of these requirements, coupled with the suitability of the topic in question (Java programming) meant that the multicategorical SCORM was the most appropriate option. In addition, it was intended that the content would be shared with other tertiary education organizations via a SCORM conformant national digital learning repository in the future.

Macromedia Flash was chosen as the primary technology for implementation because it is sufficiently powerful to allow interactive content to be developed, while its portability is in keeping with SCORM's key aims. Following this, fundamental design decisions were made regarding granularity and functionality. For instance, subjects were divided into sub-topics, and one SCO was dedicated to each resultant lesson.

Once developed, each lesson needed to be made SCORM conformant:

- A SCO must, at a minimum, communicate at a basic level with the LMS. Additional information is an option however as SCORM's RTE data model elements can allow the management of information (e.g., scores) to be created as the student progresses through the lesson. ActionScript, that is, Flash's simple programming language, designed to tap into this data model functionality was first added to the Los (Figure 4). Following this, it was necessary to add the basic communication code to the SCO to allow the content and the LMS to share information. This is very easily done within Flash using the in-built option to publish Flash content for SCORM tracking (Figure 5).

- The TUPULO project partners needed to package their lesson material before it could be uploaded to an LMS. This was achieved using the Reload tool. Figure 6 illustrates a section of the manifest created during the packaging process. Metadata was added during the packaging process (Figure 7).

Figure 4. Sample of ActionScript added to facilitate SCORM tracking

Figure 5. Sample of basic SCORM communication code added by macromedia flash

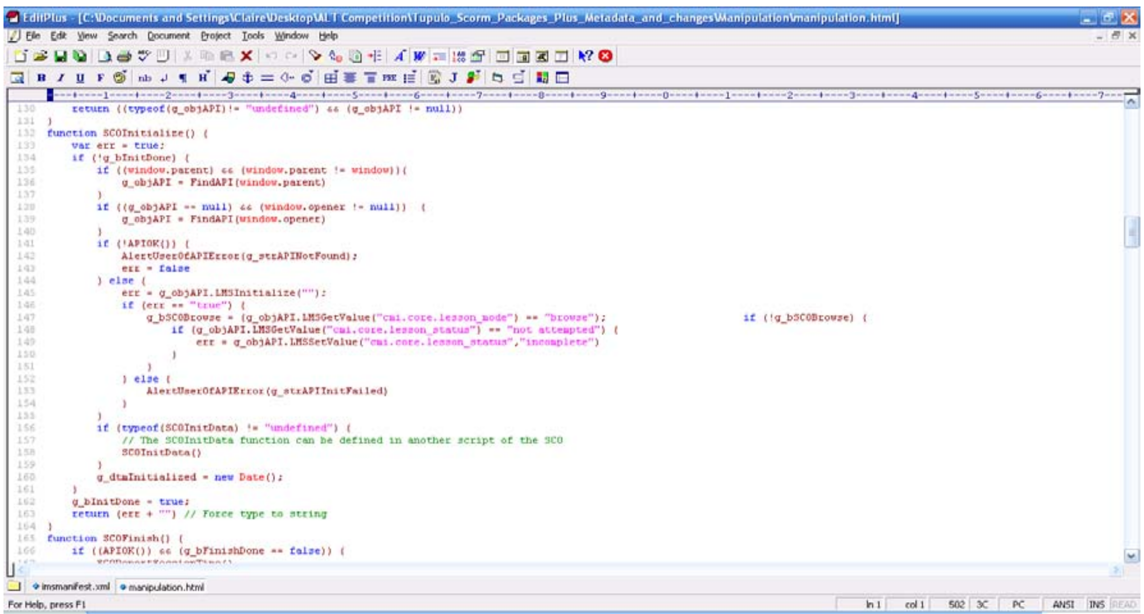


Figure 6. Section of manifest generated by reload

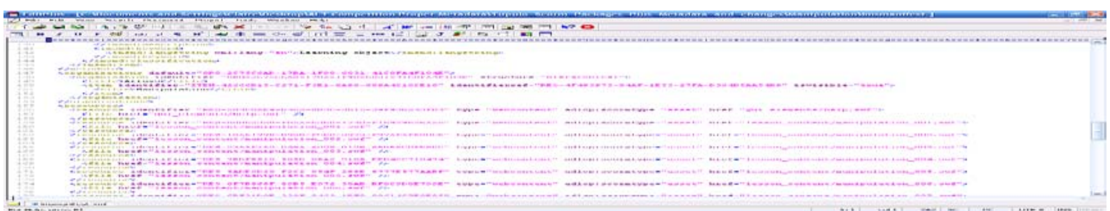


Figure 7. Sample of metadata added using reload

> This was of particular importance due to TUPULO's intended collaboration with digital repositories. The SCORM package was then uploaded to Moodle.

A number of lessons were learned by the project partners during the course of the project. It was found that applying SCORM was not a trivial task. The specification suite is of considerable size and, being unfamiliar with the individual standards, the partners had to study each individual document carefully. There were also compatibility issues with Moodle, both at the beginning and towards the end of the project. These issues first manifested themselves when deciding which SCORM release to use. Due to lack of support for SCORM 2004 within the LMS version being used, the TUPULO project implemented SCORM 1.2. This meant possible sequencing and navigation benefits available via SCORM 2004 could not be exploited. These versioning matters caused problems later, during testing, when a partner institution upgraded to a newer version of the LMS which was not fully compatible with SCORM 1.2. Furthermore, during testing, problems arose with the display of the SCORM lessons, such as the text size varying significantly when viewed in different browsers. It was also considered that the tracking information obtained was not presented to the instructor in an intuitive manner as, at times, it was in plain text format. These matters are not wholly due to the standard itself, but partly due to the way Moodle supports the standard.

Despite the problems encountered, many SCORM-related benefits became apparent to the TUPULO partners. Importantly, information was recorded that may not otherwise have been accessible, such as the number of times the student viewed each individual section of the lesson and the answers they submitted for small tasks they encountered. Once compatibility issues were resolved, the SCORM packages could be shared between partner institutions and uploaded to their respective LMSs. Overall, the project was deemed a success. As a result of the evaluation, small adjustments were made to enhance the SCORM related data made available to instructors, and preparations were made for the future move to SCORM 2004.

WHICH STANDARD?

With a range of e-learning standards and specifications available, it may be difficult for course instructors to determine which will suit their needs best. Each project is unique, and so a decision must be taken based on a variety of factors.

However, it is possible to recommend standards and specifications to consider, based on individual requirements as represented in Table 2.

FUTURE DIRECTIONS

There are clearly persuasive technical and economic arguments for the development and implementation of e-learning standards in a diverse

Table 2. Recommended standards based on individual requirements

Are questions to be represented formally?	YES	Consider implementing IMS QTI.
Is aggregation, particularly in a hierarchical manner, a requirement?	YES	Consider implementing a packaging standard, such as IMS Content Packaging.
Will student information, such as scores, need to be tracked?	YES	Consider implementing a communications standard, such as AICC CMI.
Is collaborative learning a requirement?	YES	Consider implementing IMS LD.
Will lessons be sequenced or adapt to student behaviour?	YES	Consider implementing IMS SS or IMS LD.
Will content be available for search and discovery?	YES	Consider using a metadata standard, such as IEEE LOM, DCMI or ARIADNE.
Is portable or aggregation content, in combination with data tracking and / or sequencing and metadata a requirement?	YES	Consider implementing SCORM.

range of education and training contexts. However, some have questioned the military and corporate origins of e-learning standards, while others consider that conformance with standards may constrain the range of pedagogical approaches available to educators, or restrict opportunities for pedagogical creativity (Marshall, 2004; Olivier & Liber, 2003). In addition, there are currently significant practical barriers to the application of standards, particularly for educators from non technical backgrounds. In this section we consider some of the limitations and criticisms of standards, and suggest directions in which standards may need to evolve if future widespread application is to be achieved.

Philosophical and Pedagogical Issues

Technical standards are inexorably ingrained with political, economic, social, and cultural biases (Feng, 2003; Hawkins, 1996; Postman, 1993), thus it is unsurprising that the drivers, assumptions, and values underpinning e-learning standards have been subject to debate. Slosser's (2002) representation of the ADL SCORM standard encapsulates some of the problematic issues in its limited conception of the teaching and learning process according to an information delivery model. In this model, information in the form of sharable content objects, are processed through a learning management system via course tracking, testing, intelligent tutoring and adaptive learning, for delivery to the learner. The underpinning assumptions highlight the particular the dominance and influence to date of a narrow range of stakeholders on the development and deployment of standards, and the significance of the pedagogical assumptions embedded in their design.

Marshall (2004) contends that current drivers for standards implementation are reified around political-economic priorities to commoditize education, and argues that many current standards have little or no relevance to the needs of K-12 and tertiary teachers and learners. He suggests that much of the standards literature promulgates the erroneous belief that compliance with standards is inherently desirable and "a requirement for e-learning to work" (Marshall, 2004, Benefits of standards section, para. 2). In addition, there is a concern that an over emphasis on compliance with standards could limit possibilities for innovation and pedagogic creativity (Marshall, 2004; Olivier & Liber, 2003).

Barriers to the reuse of learning objects and learning designs are well documented elsewhere, for example by Harris and Thom (2006) and Parish (2004). Harris and Thom (2006) categorise challenges to the retrieval and reuse of learning objects as: organisational (such as funding models that discourage sharing); cultural (such as concerns regarding intellectual property); and technical (such as file format and storage issues). While standards may help to overcome some of the technical barriers to reuse, they cannot on their own overcome organisational and cultural barriers.

There has also been considerable debate about whether e-learning standards are "pedagogically neutral" or whether they are instead implicitly ingrained with particular epistemological and ontological assumptions (Blandin, 2004; Friesen, 2004a; Marshall, 2004). For example, SCORM is described by its creators as "learning taxonomy neutral" (ADL, 2004a). However, SCORM is implicitly focused on the support of single-learner and content-driven pedagogic paradigms (Olivier & Liber, 2003). Similarly, while IMS SS claims to be "neutral with regard to models of pedagogy and the use of instructional strategies" (IMS, 2003b), the very intent of the specification to describe the hierarchical sequencing of content that is presented to a single learner means it cannot be neutral. Although single-learner and content-driven models may be desirable in certain contexts, they are at odds with contemporary approaches in tertiary and K-12 education, which emphasize context over content and stress the importance of collaboration and community (Wiley, 2003). The recently developed IMS LD specification claims to support a wider range of pedagogical approaches, and in particular to address some of the perceived limitations of the single-learner focus of other standards; however, the requirement for learning designs to be "pre-engineered" limits opportunities for "ecological" approaches to teaching which allow educators alter pedagogical designs "on the fly" (Berggren et al., 2005). Future standards will need to consider how to best address these issues if they are to support contemporary educational philosophies and avoid restricting possibilities for pedagogical innovation.

Many standards were originally developed in accordance with the needs of military and commercial training organizations, and are still heavily deployed and funded by these organizations. The appropriateness and transferability of ideologies and practices associated with military and corporate training to K-12 and tertiary education have been questioned by a number of authors, for example Friesen (2004b) and Marshall (2004). It has also been acknowledged by the standards organizations themselves; see Kraan and Wilson (2002, para. 4) for example. The problem of transferability of standards between contexts is demonstrated by the scant evidence of significant application of standards beyond military and commercial fields (Mason, 2003). A review of the literature on standards implementation indicates that deployment of standards is limited outside of these contexts, with few applications in tertiary education and even fewer examples in K-12 contexts. If standards are to be deployed more widely then it is crucial that educators outside of the currently dominant contexts become involved in dialogue about the future of standards.

Implementation Frameworks

Given the proliferation of standards it is unsurprising that many educators are confused about the "correct" standard to adopt (Heddergott, 2006). It is unlikely that all standards will be applicable, or necessary, in all contexts however (Kraan, 2003), while it is probable that some designers will need to combine two or more standards according to their requirements (Vázquez & Ostróvskaya, 2006). It might therefore seem reasonable to propose that standards should become more flexible and broader in scope so that they can be applied in a wider range of contexts. However we consider that this approach would be counterproductive. A certain trade-off, similar to that experienced when considering the optimum granularity of a learning object (Duncan, 2003), may exist. As a standard increases in flexibility it could well decrease in usefulness. A standard that can be applied to a range of contexts may in fact be of little real benefit to any context. At the very least, we expect a broad-ranging standard would need to be tailorable to the context in question. While this might increase the likelihood of the broad standard being of benefit in a particular context, it would inevitably lead to very technical, even unwieldy, collections of documents. It is therefore unlikely that the development of generic standards can meet the diverse needs of the various contexts, localities and educational approaches. Instead, a range of standards that can be assimilated according to the requirements of particular contexts is required. It is likely that some standards will be widely used in some contexts but may never be used others. As the number of standards increases, there is a need for practical frameworks to support educators in selecting a set of standards to support designers and educators in selecting and combining the standards most appropriate to their needs.

Technical Concerns

Standards implementation is notoriously complex and time consuming; see for example Bohl, Schellhase, Senler, and Winand (2002) for issues relating to implementation of SCORM and Berggren et al. (2005) for discussions relating to implementation of IMS LD. In order to enable adoption of standards across a range of contexts and subject areas, the usability of implementation tools needs be enhanced. In particular there is a need for tools that consider the workflow and terminology of educators rather than adopting the technical terminology of the specifications (Garcia, et al., 2004).

The limited support for e-learning standards in current VLEs and LMSs is also likely to inhibit possibilities for widespread application of standards. For example, the *CETIS Content Exchange Evaluation Report* (CETIS, 2002a) and the *Content Code Bash Final Report* (CETIS, 2002b) identify numerous problems and errors encountered in the exchange of IMS packages across a number of platforms. As has been discussed already, in the authors' experience, integrating SCORM with the Moodle VLE is challenging. Mohan (2004) reports that importing IMS content packages (CPs)—created both manually and with the Reload tool—generated errors when an attempt was made to import the CPs into a version of WebCT that also claimed to conform to the IMS CP specification. Currently no VLE or LMS provides support for the full IMS LD standard. Berggren et al. (2005) discuss problems encountered in integrating the specification with the Moodle VLE, including: difficulties encountered in reconciling the different language and terminologies deployed in the two systems; issues related to reconciling roles and permissions; and architectural and interface incompatibilities.

Future Technologies

The spread of mobile devices is on the increase as new technologies are developed and price structures allow devices to be more accessible to consumers, and we expect that more standards may be made applicable to mobile devices in the future. For example, Lin et al. (2001) have developed Pocket SCORM, which moves the PC-based SCORM version to the mobile learning context. The next generation of standards will also need to consider trends towards adaptability and personalization of learning objects and designs, as well as the impact of emerging technologies such as AJAX (Asynchronous Javascript and XML) and Web 2.0.

Metadata and Learning Object Repositories

With only 15 elements for describing resources, the Dublin Core metadata standard may be insufficient to describe resources adequately. In contrast, the IEEE LOM (IEEE, 2002), with 77 elements, may be too comprehensive. Duval and Hodgins (2003) note that many metadata elements are subjective, while completing a large number of metadata fields is likely to be a deterrent (Littlejohn, 2003; Neven, Duval, Ternier, Cardinaels, & Vandepitte, 2003). By way of example, in a study of 250 LOM records, Friesen (2004c) found that only 36% of the elements were used more than 50% of the time. In addition, many repositories do not support all of LOM's metadata fields, restricting opportunities for educators and computer agents to retrieve objects, while most systems only allow a single metadata instance to be associated with a learning object or design, potentially limiting the quality and quantity of information available to describe learning objects and designs (Brooks & McCalla, 2006).

Generic metadata schemes provide limited support across educational contexts and disciplines (Littlejohn, 2003). LOM allows the development of custom *application profiles* (custom or local vocabularies and implementation guidelines). For example CanCore is a streamlined subset of the LOM metadata elements developed with needs of Canadian educators in mind (Friesen, 2005) and Suthers (2001) describes how the LOM vocabularies were extended to meet the requirements of K-12 educators. Metadata schemes outside the recognized standards have also been proposed, for example Carey, Swallow, and Oldfield (2002) describe a metadata schema that would allow designers to describe "the critical elements in their design intent" (Carey et al., 2002, Introduction, para. 6). Brooks, McCalla, and Winters (2005) note that the growing proliferation of application profiles and alternative metadata schemes may limit possibilities for semantic interoperability however, and an important future consideration will be the implications for the reuse of learning objects and designs coded under alternative or adapted schemes (Agostinho, Bennett, Lockyear, & Harper, 2004).

New ways of generating metadata may also become important. Brooks and McCalla (2006) argue that data on usage, crucial in providing information on the relevance of learning objects to particular contexts, has been neglected to date. They propose an ecological approach that automatically collects metadata based on end-user experiences, while Mohan (2004) highlights the importance of automatic generation of objective metadata (such as size or language of a resource).

CONCLUSION

There is much debate amongst e-learning practitioners surrounding the use of standards for learning objects and designs, and their relative benefits, limitations, and relevance to a range of education and training contexts.

Standards may help to achieve economies of scale in e-learning by facilitating the reuse of learning objects and designs in different education and training domains, subject areas and geographical regions. Metadata standards used to describe content and activities can assist educators in locating learning objects and designs stored in digital repositories. Packaging standards describe how learning objects are organised and presented, and allow them to operate on different technical platforms. Instructional and communication standards may be used to track and share information about learners' preferences as well as their interactions with learning objects and designs, in order to tailor the delivery of content and activities to them.

Despite their proposed benefits, standards have been criticised from philosophical, pedagogical, and technical perspectives. To date, their application has mainly been restricted to the military and commercial domains, with less widespread application in the K-12 and tertiary education contexts where there is little evidence of their deployment outside technical subject areas. The appropriateness of standards originating in military and commercial contexts to the K-12 and tertiary sectors has been questioned, as has the narrow range of pedagogical approaches currently supported. Finally, there are significant technical barriers to the widespread application of standards because their implementation is complex and time consuming and there is currently limited support for e-learning standards in VLEs and LMSs. Future standards development will ideally involve input from a representative cross-section of stakeholders and consider how current limitations may be mitigated.

REFERENCES

ADL. (2001). Advanced distributed learning: Sharable content object reference model (SCORM). Version 1.2. Retrieved April 5, 2008, from http://www.adlnet.org

ADL. (2004a). Sharable content object reference model (SCORM). Content aggregation model (CAM). Version 2004. Retrieved April 5, 2008, from http://www.adlnet.org

ADL. (2004b). Sharable content object reference model (SCORM). Run-time environment (RTE). Version 2004. Retrieved April 5, 2008, from http://www.adlnet.org

ADL. (2004c). Sharable content object reference model (SCORM). Sequencing and navigation

(SN). Version 2004. Retrieved April 5, 2008, from http://www.adlnet.org

ADL. (2006). *Florida virtual school and academic ADL colab announce partnership to create next generation online learning* Retrieved April 5, 2008, from http://www.adlnet.gov/news/articles/359.cfm

Agostinho, S., Bennett, S., Lockyear, L., & Harper, B. (2004). Developing a learning object metadata application profile based on LOM suitable for the Australian higher education market. *Australasian Journal of Educational Technology, 20*(2), 191-208.

AICC. (2004). AICC CMI001 - AICC CMI guidelines for interoperability. Revision 4.0. Retrieved April 5, 2008, from http://www.adlnet.gov/news/articles/359.cfm

AICC. (2006). AICC CMI012 - AICC packaging specification. Version 1.0 (2006). Retrieved April 5, 2008, from http://www.adlnet.gov/news/articles/359.cfm

ARIADNE. (2004). The Ariadne Foundation. Retrieved April 5, 2008, from http://www.ariadne-eu.org

Ascione, L. (2006). California schools adopt digital history programme. *E-school News Online*. Retrieved April 5, 2008, from http://www.eschoolnews.com/news/showStory.cfm?ArticleID=6551

Berggren, A., Burgos, D., Fontana, J.M., Hinkelman, D., Vu, H., Hursh, A., et al. (2005). Practical and pedagogical issues for teacher adoption of IMS learning design standards in moodle LMS. *Journal of Interactive Media in Education, 02*. Retrieved April 5, 2008, from http://www-jime.open.ac.uk/2005/02/berggren-2005-02.pdf

Blandin, B. (2004, February 16-18). *Are e-learning standards neutral?* Paper presented at CALIE 04: International Conference on Computer Aided Learning in Engineering Education, Grenoble, France. Retrieved April 5, 2008, from http://www-clips.imag.fr/calie04/actes/Blandin_final.pdf

Bohl, O., Schellhase, J., Senler, R., & Winand, U. (2002, December 3-6). *The sharable content object reference model (SCORM) - a critical review*. Paper presented at the International Conference on Computers in Education, Auckland, New Zealand.

Brooks, C. McCalla G., & Winter M. (2005). *Flexible Learning Object Metadata 3rd International Workshop on Applications of Semantic Web Technologies for E-Learning (SW-EL 05) held in conjunction with the 12th International Conference on Artificial Intelligence in Education (AIED 2005)*, July 18–22. Amsterdam, The Netherlands.

Brooks, C., & McCalla, G. (2006). Towards flexible learning object metadata. *International Journal of Continuing Engineering Education and Life-Long Learning, 16*(1/2), 50-63.

Carey, T., Swallow, J., & Oldfield, W. (2002). Educational rationale metadata for learning objects. *Canadian Journal of Learning and Technology, 28*(3). Retrieved April 5, 2008, from http://www.cjlt.ca/content/vol28.3/carey_etal.html

CETIS. (2002a). CETIS content exchange evaluation report. Retrieved April 5, 2008, from http://www.cetis.ac.uk/groups/20010809144711/FR20020301142909

CETIS. (2002b). CETIS content code bash final report. Retrieved April 5, 2008, from http://www.imsglobal.org/developers/ims/imsforum/attachments/codebashsum.pdf

Cherry, A., Westfall, P., & Baquero, J. (2005, May 9-12). *Soar with eagles: Linking satellite networks and learning management systems to distribute and manage ADL*. Paper presented at Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2005, Orlando.

Dublin Core Metadata Initiative. (2006). Retrieved April 5, 2008, from http://dublincore.org/

Duncan, C. (2003). Granularisation. In A. Littlejohn (Ed.), *Reusing online resources* (pp. 12-19). Kogan Page.

Duval, E., & Hodgins, W. (2004, May 20-24). *A LOM research agenda*. Paper presented at WWW2003 - Twelfth International World Wide Web Conference, Budapest, Hungary.

Feng, P. (2003, October 22-24). *Studying standardization: A review of the literature*. Paper presented the 3rd IEEE Conference on Standardization and Innovation in Information Technology (SIIT 2003), Delft, The Netherlands.

Friesen, N. (2004a, August 30 – September 1). *Learning objects and standards: Pedagogical neutrality and engagement*. Paper presented the IEEE International Conference on Advanced Learning Technologies. Joensuu, Finland.

Friesen, N. (2004b). Three objections to learning objects. In R. McGreal (Ed.), *Online education using learning objects* (pp. 59-70). London: Routledge.

Friesen, N. (2004c). Final report on the international LOM Survey. Retrieved April 5, 2008, from http://jtc1sc36.org/doc/36N0871.pdf

Friesen, N. (2005). CanCore: In Canada and around the world. *International Review of Research in Open and Distance Learning*, *6*(1). Retrieved April 5, 2008, from http://www.irrodl.org/index.php/irrodl/article/view/210/293

Garcia, R., et al. (2004, September 29 – October 1). *Limitations of some e-learning standards for supporting learning.* Paper presented at International Conference of Interactive Computer-Aided Learning, ICL 2004, Villach, Austria.

Harris, M., & Thom, J. (2006, September 17-22). *Challenges facing the retrieval and reuse of learning objects.* Paper presented at the International Conference on Computers in Education. 10th European Conference on Digital Libraries, University of Alicante, Spain. Retrieved April 5, 2008, from http://ltcs.uned.es/wslo2006/7.pdf

Hawkins, R. (1996). Standards for communication technologies: Negotiating institutional biases in network design. In R. Mansell & R. Silverstone (Eds.), *Communication by design: The politics of information and communication technologies* (pp. 157-186). Oxford: Oxford University Press.

Heddergott, K. (2006). The standards jungle: Which standard for which purpose? In U. Ehlers & J. Pawlowski (Eds.), *Handbook on quality and standardisation in e-learning* (pp.185-191). Berlin, Heidelberg, Germany: Springer.

Heins, T., & Himes, F. (2002). Creating learning objects with macromedia flash MX. Macromedia white paper. Retrieved April 5, 2008, from http://download.macromedia.com/pub/solutions/downloads/elearning/flash_mxlo.pdf

Hodgins, W., & Conner, M. (2000). Everything you ever wanted to know about learning standards but were afraid to ask. *Learning in the New Economy e-Magazine (LiNE Zine).* Retrieved April 5, 2008, from http://www.linezine.com/2.1/features/wheyewtkls.htm

Horton, W., & Horton, K. (2003). *E-learning tools and technologies.* Indianapolis, ID: Wiley.

IEEE. (2002). IEEE 1484.12.1-2002 - draft standard for learning object metadata. Retrieved April 5, 2008, from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

IMS. (2003a). IMS learning design best practice and implementation guide. Version 1.0 final specification. Retrieved April 5, 2008, from http://www.imsglobal.org/learningdesign/index.html

IMS. (2003b). IMS simple sequencing best practice and implementation guide. Version 1.0 final specification . Retrieved April 5, 2008, from http://www.imsglobal.org/simplesequencing/

IMS. (2005). IMS content packaging overview, version 1.2. Retrieved April 5, 2008, from http://www.imsglobal.org/content/packaging/

IMS. (2006). IMS question and test interoperability overview, version 2.1 public draft (revision 2) specification. Retrieved April 5, 2008, from http://www.imsglobal.org/question/

ISO/IEC. (1996). Guide 2: Standardization and related activities - general vocabulary. Geneva: ISO/IEC.

Koper, R. (2005). An introduction to learning design. In R. Koper & C. Tattersall (Eds.), *Learning design: A handbook on modelling and delivering networked education and training* (pp. 3- 20). Berlin, Germany: Springer-Verlag.

Koper, R., & Tattersall, C. (Eds.). (2005). *Learning design: A handbook on modelling and delivering networked education and training.* Berlin, Germany: Springer-Verlag.

Kraan, W., & Wilson, S. (2002). Dan Rehak: SCORM is not for everyone. Center for Educational Technology and Information Systems. Retrieved April 5, 2008, from http://www.cetis.ac.uk/content/20021002000737

Lin, N.H., Shih, T.K., Hsu, H., Chang, H., Chang, H., Ko, W C., et al. (2004, March 23-24). *Pocket SCORM*. Paper presented at the 24th International Conference Distributed Computing Systems Workshops (ICDCS 2004 Workshops), Hachioji, Tokyo.

Littlejohn, A. (Ed.). (2003). *Reusing online resources: A sustainable approach to e-learning.* London: Kogan Page.

Mackenzie, G. (2004). SCORM primer: A (mostly) painless introduction to SCORM. Retrieved April 5, 2008, from http://www.mcgill.com/media/SCORM_2004_Primer_v1_McGill_Digital_Solutions_Gord_Mackenzie.pdf

Marshall, S. (2004, December 5-8). E-learning standards: Open enablers of learning or compliance strait jackets? In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference* (pp. 596-605). Perth, Australia. Retrieved April 5, 2008, from http://www.ascilite.org.au/conferences/perth04/procs/marshall.html

Mason, J. (2003, May 6-9). *Secret standards business?* Paper presented at EDUCAUSE in Australasia 2003, Adelaide Convention Centre, Australia. Retrieved April 5, 2008, from http://www.caudit.edu.au/educauseaustralasia/2003/EDUCAUSE/PDF/AUTHOR/ED030077.PDF

McAndew, P., & Weller, M. (2005). Applying learning design to supported open learning. In R. Koper & C. Tattersall (Eds.), *A Handbook on Modelling and Delivering Networked Education and Training* (pp. 281–290). Springer-Verlag.

Mohan, P. (2004). Building an online course based on the e-learning standards: Guidelines, issues, and challenges. *Canadian Journal of Learning and Technology*, *30*(3). Retrieved April 5, 2008, from http://www.cjlt.ca/content/vol30.3/mohan.html

Neven, F., Duval, E., Ternier, S., Cardinaels, K., & Vandepitte, P. (2003). An open and flexible indexation-and query tool for Ariadne. In *Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 107-114). Honolulu, HI.

Olivier, B., & Liber, O. (2003). Interoperability standards. In A. Littlejohn (Ed.), *Reusing online resources.* Kogan Page.

Parrish, P. (2004). The trouble with learning objects. *Educational Technology Research and Development, 52*(1), 49-67.

Postman, N. (1992). *Technopoly.* New York: Vintage Books.

Qu, C., & Nejdl, W. (2002, September 9-12). *Towards interoperability and reusability of learning resource: A SCORM-conformant courseware for computer science education*. Paper presented at the 2nd IEEE International Conference on Advanced Learning Technologies, Kazan, Russia.

Ramachandran, S., Remolina, E., & Barksdale, C. (2006, December 4-7). *Scenario-based multi-level learning for counterterrorism intelligence analysis*. Paper presented at Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2006, Orlando, FL.

Rehak, D., & Mason, R. (2003). Keeping the learning in learning objects. Reusing online resources. In A. Littlejohn (Ed.), *Reusing online resources* (pp. 22-30). Kogan Page.

SkillSoft. (2004). *SkillSoft is first e-learning content developer to achieve both SCORM and AICC certification*. Retrieved April 5, 2008, from http://www.skillsoft.com/about/press_room/press_releases/may_16_04_AICC_SCORM.asp

Slosser, S. (2002). ADL and the sharable content object reference model (SCORM). Retrieved April 5, 2008, from http://www.nectec.or.th/courseware/pdf-documents/adl-scorm.pdf

Spang Bovey, N., & Dunand, N. (2006, March 30-31). *Seamless production of interoperable e-learning units: Stakes and pitfalls*. In R. Koper & K. Stefanov (Eds.), Paper presented at the Workshop on Learning Networks for Lifelong Competence Development, Sofia, Bulgaria.

Suthers, D. (2001). Evaluating the learning object metadata for K-12 educational resources. In *Proceedings of The IEEE International Conference on Advanced Learning Technologies (ICALT 2001)* (pp. 371-374). Madison, WI.

Vazquez, A.R., & Ostrovskaya, Y.A. (2006, October 25-27). Analysis of open technological standards for learning objects. In *Proceedings of the Fourth Latin American Web Congress (La-Web'06)* - Volume 00. LA-WEB. Washington: IEEE Computer Society.

Wiley, D. (2003). *Learning objects: Difficulties and opportunities*. Retrieved April 5, 2008, from http://wiley.ed.usu.edu/docs/lo_do.pdf

KEY TERMS

ADL SCORM (Advanced Distributed Learning Sharable Content Object Reference Model): SCORM is a suite of specifications, combining IMS Content Packaging, AICC Computer Managed Instruction, Metadata, and, in the most recent version, IMS Simple Sequencing.

AICC CMI (Aviation Industry Computer-Based Training Committee computer managed instruction): The CMI specification details the communication between a lesson and the learning environment, the storage of the data communicated, and the movement of a course between multiple CMI learning environments.

ARIADNE (Association of Remote Instructional Authoring and Distribution Networks for Europe): Concerned with the development and use of metadata, a specification submitted by the association to the IEEE was harmonised with a similar specification submitted by the IMS to form the basis of the IEEE LOM standard

DCMI (Dublin Core Metadata Initiative): DCMI develops interoperable metadata standards primarily for an online environment.

IEEE LTSC LOM (Learning Technology Standards Committee Learning Object Metadata): This standard focuses specifically on the syntax and semantics of digital or non digital learning objects.

IMS CP (Content Packaging): This specification outlines the manner in which learning content can be combined and organised, and how this larger unit of instruction can be moved from one learning environment to another.

IMS LD (Learning Design): IMS LD aims to enable the sharing and support of a range of pedagogical approaches, including collaborative approaches to learning.

IMS QTI (Question and Test Interoperability): This specification seeks to define a generic means of defining tests, thus allowing the exchange of tests and results between learning environments.

IMS SS (Simple Sequencing): This specification outlines the route a learner can take through a particular unit of instruction, based on previous actions and behaviour within a unit.

Chapter XLII
Supporting Decision Making in Using Design Languages for Learning Designs and Learning Objects

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ABSTRACT

In developing modern instructional software, learning designs are used to formalize descriptions of roles, activities, constraints, and several other instructional design aspects and learning objects are used to implement those learning designs in instructional software. Central in both constructs is the use of design languages to support structuring a design task and conceiving solutions. Due to a lack of standardized design languages that are shared between designers, producers, and other stakeholders, the application of learning designs and learning objects is often unsatisfactory for three reasons: (a) different instructional and technical structures are often not meaningfully organized; (b) different levels of detail are mixed together; and (c) different expressions are used in a nonstandardized manner. A decision model is introduced—the 3D-model—that supports better selection and application of design languages. Two studies show that the 3D-model contributes to a better information transition between instructional designers and software producers.

INTRODUCTION

Developing instructional software is becoming increasingly complex. Besides many recent *pedagogical innovations* such as holistic whole-task approaches as found in case-based learning or problem-based learning (van Merriënboer & Kirschner, 2007), developers have to pay attention to recent *technical innovations* as well. Amongst others, recent technical efforts are directed at modularization, reusability, and interoperability (Parrish, 2004). Finally, *organizational innovations* that emphasis the integration of working and learning by means of blended combinations of face-to-face learning, distance learning, and on-the-job learning (Cantoni & Botturi, 2005; Jochems, van Merriënboer, & Koper, 2004) complicate the situation even more. As a result, developing modern instructional software requires often iterative development processes and prototype-testing, involving multidisciplinary teams with many different members, including managers, producers, instructors, and subject matter experts (Bates, 1999; Botturi, Cantoni, Lepori, & Tardini, 2006).

In many cases, instructional designers are placed in charge of the instructional design and of managing the subsequent development process. They face the challenge of negotiating and communicating this design, with all its pedagogical, technical, and organizational implications, to all of the stakeholders, who often have a different

Table 1. Concerns of different stakeholders in the ISD process

Kind of stakeholders	*Types of Stakeholder Activities*	*Examples of Concerns*
Project Leader	Manage the whole ISD process	Optimal transfer of information and product during the ISD process
Subject Matter Experts	Validate the domain content	Impact on work floor
Instructors	Validate the didactical model	Impact of instructional design on their teaching (e.g., classroom based, coaching in practice)
Managers	Approve the instructional design	Impact of instructional design on their organization (e.g., financial, roles, infrastructure)
Producers	Translate instructional design into technical specifications (often conduct their own type of analysis and design)	Impact of instructional design on production process (e.g., selection of tools and media, programming, interfacing, usability)
Implementers	Use the instructional design as guidelines	Impact of instructional design on infrastructure, roles, school management, etc.
Learners	Participate in usability studies, interface design studies, and other formative evaluation activities.	Personal preferences and impact of instructional design on their learning processes
Evaluators	Use the objectives set in the instructional design as evaluation criteria	Impact of instructional design on assessment process

background and focus, and therefore different concerns (Botturi, 2006; see Table 1).

Consequently, there is an expectation placed upon the instructional designer to provide representations of designs that contain many different kinds of information. First, critical to communication in the *design phase* are optimal descriptions of the instructional design. For example, instructors want to be informed about pedagogical implications, by means of an explanatory text. Second, critical to communication in the *production phase* are optimal descriptions of learning materials. For example, producers want to be informed about technical and artistic implications, by means of precise, formalized diagrams and drawings.

According to recent literature, two constructs can be used in these two subsequent development phases, both emphasizing transparency, standardization, modularization, and reusability of designs and learning materials. First, in the design phase, "learning designs" can be used to *formalize*—often following a standard specification—descriptions of roles, activities, constraints, and several other aspects involved in an instructional design (Koper & Tattersall, 2005). Second, in the production phase, "learning objects" can be used to *implement* learning designs in instructional software (Gibbons, Nelson, & Richards, 2000; Wiley, 2000).

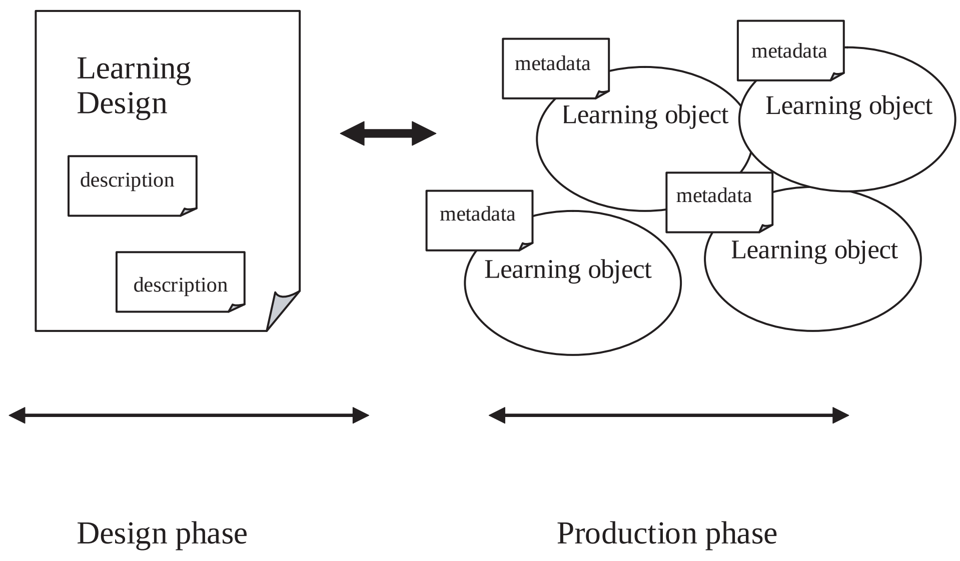
Central in both constructs is the idea of *design languages.* A design language is a set of concepts that support structuring a design task and conceiving solutions (Waters & Gibbons, 2004). They are mental tools, but can be expressed and communicated through notation systems, that is, sets of signs and icons that allow representation of a design solution to our senses. The combination design language and notation system is a central concept in the definition of a design team or community, because a shared language is the medium for the creation of shared culture (Gibbons, Botturi, Boot, & Nelson, 2008). From a practical point of view, shared design languages are fundamental for a design community to share their practices and to engage in reflective thinking (see, for example, Schön's "reflection on action"; Schön, 1983).

The terms (or "vocabulary" and "grammar") of design languages help the designer explore an instructional problem space and identify, refine, and document a solution. Design languages are related to the way designers think as they design, and they constitute the building blocks of an evolving design. They can be used to express learning designs, which are formalized and documented using design language terms. Learning designs can be training blueprints, scenarios, scripts, or technical descriptions. Design languages can also help to define instructional building blocks called learning objects. A learning object is "any entity, digital or nondigital, which can be used, re-used or referenced during technology supported learning" (see http://ltsc.ieee.org/wg12/). Learning objects range from small media components to complete instructional activities and lessons, labeled with metadata that can be based upon design language terms (Hamel & Ryan-Jones, 2002). Figure 1 shows both types of building blocks: learning designs with descriptions by design languages in the design phase, and learning objects with metadata by design languages in the production phase.

Given the importance of design languages in creating learning designs and learning objects, there is a fundamental problem that developers of instructional software lack standardized design languages that are shared between designers, producers, and other stakeholders. In domains other than instructional design (e.g., architecture, music, mechanics), design languages and their notation systems are used to capture and describe designs (e.g., concept drawings, blueprints, storyboards) at such a level of detail that producers can interpret it more or less unequivocally.

In this chapter, we will describe a decision model—the 3D-model—that supports selecting

Figure 1. Learning design and learning objects in the design and production phases



and applying design languages for formalizing learning designs and labeling learning objects. First, the concepts of learning designs and learning objects, related to design languages, are described, and the problematic lack of shared instructional design languages is discussed. Subsequently, the 3D-model is introduced, as well as two validations studies that show the contribution of the model to a better information transfer between instructional designers and software producers—an example of other stakeholders in the development process. The chapter will conclude with observations about how better use of design languages will (a) provide optimal communication of an integrative approach towards blended educational approaches, and (b) promote induction of concrete design and production instances into design patterns.

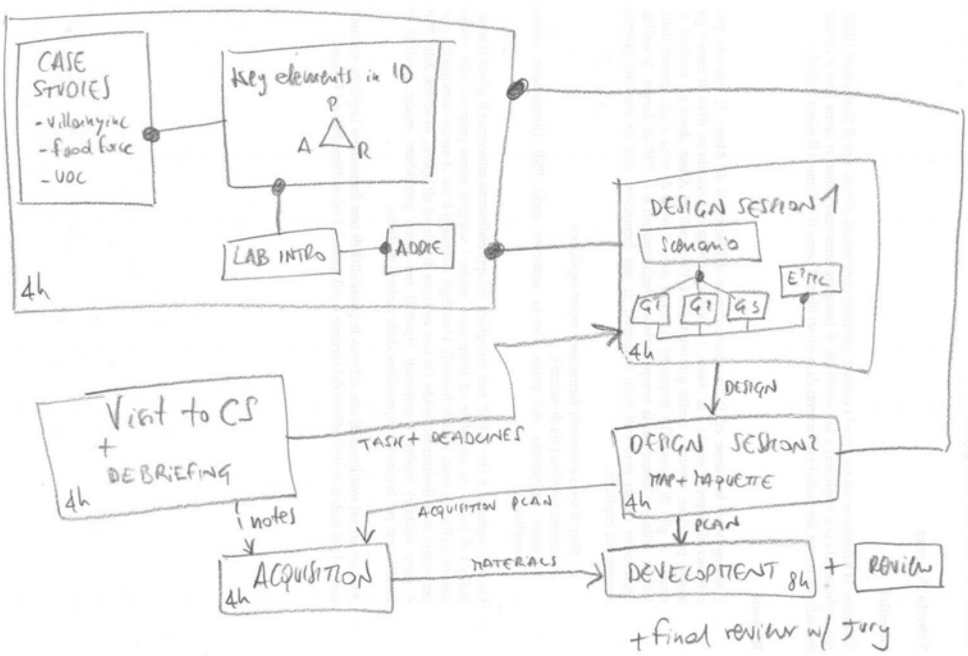
LEARNING DESIGNS AND DESIGN LANGUAGES

Instructional designers work in multidisciplinary teams on their own specialized tasks, such as the selection of an instructional strategy or of the appropriate media mix. They function also as communication catalysts among team members, and direct and support the complex communication flows between different stakeholders (Boot & Kremer, 2006; Botturi & Del Percio, in press). For this purpose, the use of an appropriate, expressive, and shared design language is crucial. Teams that do not have shared design languages at the beginning of their work must evolve them in order to complete their work, even if that is not done in a conscious, explicit way.

One of the uses of such design languages is to capture and describe abstract structures and properties into a design that can be reused. This is the idea of a *design pattern*, as expressed by Alexander (1979) in architecture: expressing the gist of a solution so that it can be reused many times. Defining a pattern, or a pattern system (Derntl & Botturi, 2006), is a way to capture the design knowledge of a community, to share it and to leverage it for future developments. Patterns have been used by the computer science community as programming patterns (Fowler, 2003; Gamma, Helm, Johnson, & Vlissides, 1995), and by Web designers as Web design patterns. The same idea can be applied to instructional designs, where patterns can describe activities (e.g., an assignment for a group), resource types (e.g., a Web quest), and so forth. For examples, see http://www.pedagogicalpatterns.org. If design patterns describe an instructional artifact, in terms of roles, activities, constraints, and other instructional design aspects, they are called *learning designs.*

The purpose of a learning design is to communicate the essential structures of the design itself. Communicating such a design is a complex. What are the language elements that can be used to describe a learning design? This question could be answered in many ways, depending on the designer's theoretical views on teaching and learning. Some current formal design languages take a pragmatic approach: they describe the *phenomenon* of teaching, striving to achieve pedagogical neutrality (Nodenot, 2006). The majority of these languages describe activities, roles, goals, and resources. These languages are motivated by the search for reusable "learning objects." An overview of the state of the art of such design languages can be found in Botturi and Stubbs (2008), and a framework for classifying these languages is proposed by Botturi, Derntl, Boot, and Figl (2006).

Figure 2. E2ML design



Depending on the features of language being used to express them, design patterns can be conceptual (abstract design solutions, e.g., the description of an activity), or usable for implementation (e.g., a piece of code for a software application, or a template for a Web page). For example, some design languages for instruction are exploration-oriented, making use of a free, flexible syntax for helping to conceptually shape design ideas. Examples are E^2ML (Botturi, 2006) and its notation, or the narrative approach proposed by Parrish (2006). Such languages support creativity, and provide a means to enhance communication with team members and stakeholders. Figure 2 shows an E^2ML working diagram, used to take notes on a course, and share the main design ideas with the instructor and co-designers.

Other languages take a more technically-oriented approach to instruction, and therefore to design patterns. Their goal is to provide a formally structured description of an instructional event or activity that is machine-readable, unambiguous, and useful for expressing complete designs that can be fed into a software application such as a learning management system (LMS). Examples are IMS Learning Design (IMS-LD; IMS, 2003), or coUML (Derntl, 2004). The use of such languages can be supported by software applications that translate the design into computer-readable code. Examples of such software applications are RELOAD (see http://www.reload.ac.uk) and LAMS (see http://www.lamsinternational.com/) that translate into standard XML coding. Figure 3 shows a sample of the IMS-LD XML code for an instructional unit.

The two examples given clearly represent the extremes of a continuum between informal and formal languages. Considering that the learning curve of some languages can be rather steep, it becomes very relevant to have a strategy for the selection a language and notation to be used for a specific project. This choice would depend on the knowledge and skills of the designer and the other stakeholders, and the size and importance of the development project. Before discussing such a model, we will discuss learning objects and their relation to design languages.

Figure 3. Sample of IMS-LD XML code

```
<imsld:play identifier="PLAY1" isvisible="true">
<imsld:title>A learning unit about Learning
Objects</imsld:title>
<imsld:act identifier="AC1">
<imsld:title>What are LO?</imsld:title>
<imsld:role-part identifier=" Learner1">
<imsld:title>Learner</imsld:title>
<imsld:role-ref ref="Learner"/>
<imsld:activity-structure-ref ref="AS-first-step"/>
</imsld:role-part>
<imsld:role-part identifier="RP-Facilitator-1">
<imsld:title>Facilitator</imsld:title>
<imsld:role-ref ref="Facilitator"/>
<imsld:support-activity-ref ref="SA-first-step"/>
</imsld:role-part>
<imsld:complete-act>
<imsld:when-role-part-completed
ref="Facilitator1"/>
</imsld:complete-act>
</imsld:act>
<imsld:complete-play>
<imsld:when-last-act-completed/>
</imsld:complete-play>
</imsld:play>
```

LEARNING OBJECTS AND DESIGN LANGUAGES

Instructional design languages and notations are used to express learning designs, mainly in terms of roles, activities, structures, properties, and several other aspects of an instructional design. The idea of modularity and reusability that has driven the development of learning designs is the same that led to the concept of learning objects. If the content representations of learning materials are divided into small, modular chunks—called learning objects—developers can, in principle, combine and recombine those objects to create new learning materials. A learning object is a set of such media components, instructional activities, or whole lessons, labeled with metadata and expressed in a standard format such as the ADL SCORM specifications (see www.adlnet.gov) or IMS Metadata standards (see http://www.imsglobal.org/metadata). Metadata is information that "labels" learning objects in order to enable an efficient search for them in databases. Examples of metadata are the title of a particular learning object, its producer, the possible application of that object, and so forth.

Imagine a teacher of photography looking for new resources to include in his course on digital photography for bachelor degree students. He may connect to an online repository and enter some keywords, probably related to the topic. He may then browse the presented results of the search (e.g., summaries of near-matching learning objects), select and download the most promising, and then view the actual content. He would probably first assess the quality of information in the learning object (e.g., is it correct, complete, authoritative?) and, if it is satisfactorily, he would then consider the instructional features: how was it originally integrated into course activities? Did students study the information on their own, or were they in class with the instructor presenting it? Were they assigned a specific task? How were they evaluated?

Many commercial developers believe that an open market for the exchange of learning objects would benefit both the suppliers ("created once, sold many") and buyers ("bought once, used many") (Boot, 2005). Noncommercial developers, too, who target learning objects available as "open source," also benefit from far-reaching standardization. However, it still has to be seen how much learning objects and standards will change the educational landscape of the future. Until now, the level of reuse of materials has remained very limited and it seems to be difficult to develop innovative educational forms through reuse in which meaningful, complex learning tasks are at the heart of the instruction. Even more, the use of learning objects in these innovative forms will, according to some researchers, generate fundamental problems.

One of these problems, as discussed by van Merriënboer and Boot (2005), refers to the fact that it is difficult and extremely labor intensive to specify metadata sets for large sets of learning objects. There is currently a vigorous ongoing discussion about the number of necessary metadata fields. If a developer of an object fills out too few fields, other developers searching for objects may be overwhelmed with a large amount of possibly relevant learning objects. However, using more fields greatly increases the workload associated with the specification of learning objects. And while doing so may help other developers to find *exactly* what they want, it also reduces the chance that they find anything at all, because the chance that an object has the exact desired features a, b, and c is smaller than the chance that it has only the features a and b. Furthermore, there is an ongoing discussion on the nature of metadata itself. Well-defined metadata fields make it difficult or even impossible for an individual developer to express intentions unambiguously, while loosely defined fields yield communication problems between developers and, eventually, between e-learning systems. Van Merriënboer and Boot (2005) propose, amongst others, automation as a solution to these problems. This includes the use of algorithms for the automatic analysis of multimedia content and the semantic indexing of this content in metadata fields. Such automation may not only be more cost-effective but also yield more objective metadata than indexing by hand.

Since the specification of metadata sets is mostly directly controlled by the information and structure of learning designs, it becomes clear that the selection and application of precise, information-rich design languages that entail practical metadata sets is very important. The next section presents a model to support this selection of design languages.

THE 3D-MODEL FOR SELECTING LEVELS OF INSTRUCTIONAL DESIGN LANGUAGES

Design languages are used for both specifying learning designs and defining metadata sets for learning objects, with the ultimate purpose to communicate instructional design information to different stakeholders in the development process. Boot (2005) showed that there are three basic variables that directly affect the quality of that communication. These three are the (1) functional structures used to describe the design, (2) level of detail required for the design, and (3) desired level of formalization of the design.

First, with regard to the *organization* of design information, descriptions of the instructional and technical structures in learning designs are often poorly defined. Designers for the most part do not have a good vocabulary for describing the different functionalities of their designs and the artifact properties that execute those functions. Changing such designs can be very difficult and confusing for designers. If producers must make changes, it can be very difficult for them to determine the effects of such changes. For instance, the training of an existing problem-solving task can change because a new device so strongly supports the original problem-solving task that it becomes a routine task. This implies considerable implications for instruction (e.g., more emphasis on repetition of similar practice items combined with just-in-time information), as well as technical issues (e.g., different information to be displayed, different interactions, different feedback mechanisms, and so on). One tool for simplifying the expression of different design functionalities has been described by Gibbons (2003) and Gibbons and Rogers (2007). It assumes that designs can be viewed as being *layered* according to the functions they perform. Changes to one function of a layered design can be made with minimum disruption of other layers. This view of the qualities of designs provides a basic vocabulary with which a designer can communicate with stakeholders about the qualities of a particular design.

The second variable is the level of *detail* of the design information. The level of detail in learning designs varies depending on the capabilities of the designer. More capable designers will typically add more detail (using specialized design languages and notation systems) to instructional issues. The level of detail can depend on the needs of stakeholders in the development process. To communicate between designers the application of the concept of "delayed cognitive feedback," a rather conceptual description will suffice as they will readily understand each other. But for other stakeholders, much more detailed descriptions of timing, content, and presentation of such delayed cognitive feedback are needed to be able to specify and implement it as intended by the designer. In some cases, for a design to be specified in exacting detail can take more time than it is worth. In other cases, it is not desirable to communicate the design in exact detail in order to take advantage of the creative abilities of producers (artists, video producers, programmers, etc.). Being able to define different levels of detail expected of a design provides a second way of describing the level of communication of the design with stakeholders.

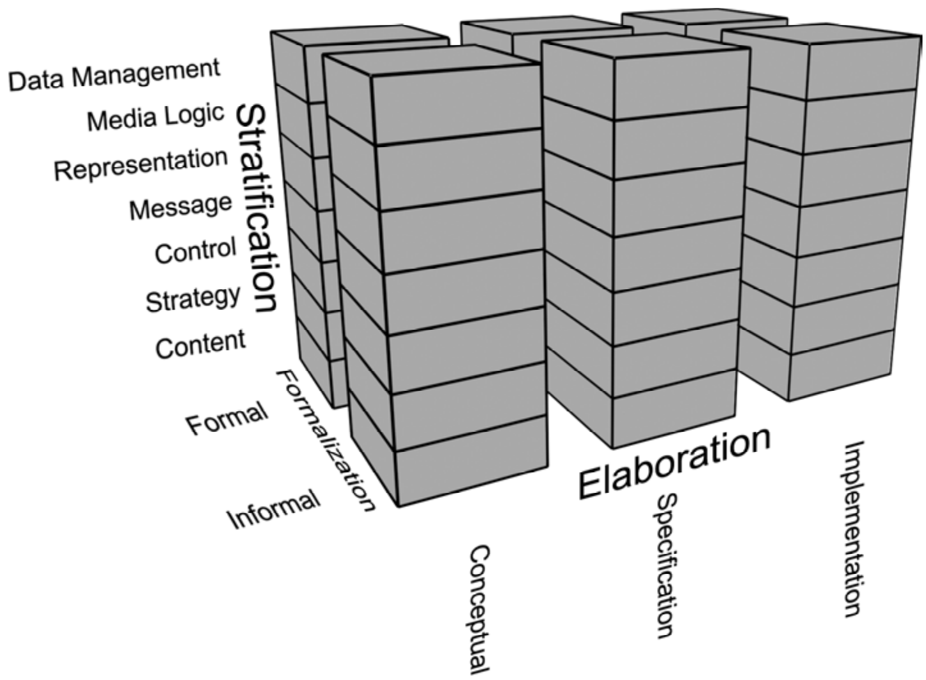
The third variable is the level of *formalization* of the design. This is closely related to the level of standardization of the terms used to describe the design. Designers often express an instructional design through notation systems such as textual expressions supplemented with tables, lists, flowcharts, and graphics—all in a nonstandardized manner. For other stakeholders, this leads to (a) semantic problems, as they may not fully understand the intentions of the designer, (b) interpretation problems, as they are left with too many degrees of freedom in creating the technical specifications, and (c) compatibility problems, as they cannot directly and (semi-) automatically translate a design description into technical specifications.

We assume that the three basic variables (a) organization, (b) level of detail, and (c) formalization of learning designs provide a starting point to improve the quality of the communication between designers and other stakeholders by better learning designs and better metadata sets for learning objects informed by these learning designs. Eventually, this will improve the quality of instructional software products.

THE 3D-MODEL

The 3D-model is created to support improving learning designs, and subsequently the specification of metadata sets for learning objects. The 3D-model is not a design language itself, but is to be used as a decision/discussion model or framework for selecting those design languages that enable designers and producers to build up a shared mental model of the design. The 3D-model consists of three dimensions, namely (a) *stratification*, (b) *elaboration*, and (c) *formalization*, based upon the variables discussed in the previous section. The three "D's" in the

Figure 4. The developing design documents (3D) model



name reflect the three dimensions and are also an acronym for Developing Design Documents. Independent designers—or teams with designers and other stakeholders—may use the 3D-model to (a) analyze their design situation (e.g., "what kind of designers and other stakeholders are involved?" "for what kind of training is the design made?" "which support tools are available?") for determining the most optimal configuration of the 3D-model, and subsequently (b) use this configuration to stratify, elaborate, and formalize their learning designs. Figure 4 presents the 3D-model in its full configuration, in which all dimensions are completely utilized.

First, in order to improve the organization of learning designs, designers may stratify their designs in terms of a layered design architecture. For example, according to Gibbons' model of Design Layers (Gibbons, 2003), each complete instructional design is organized on seven, interrelated layers: content, strategy, control, message, representation, media logic, and data management. Each layer is typified by the designer's selection of design languages pertaining to the solution of different instructional design subproblems. Together, the functional designs at the different layers, expressed in one or more design languages, make up the total design. The design of each layer may require different design activities, support tools, and specialists (see Table 2). For both designers and other stakeholders, stratification helps to identify the relations between the functionally different instructional and technical structures, while at the same time staying cognizant of the need for integration within the complete design. Designers should therefore decide to what extent they are able to complete the stratification dimension, given their specific design situation.

Second, in order to add sufficient detail to each layer, designers may elaborate their designs according to three different perspectives (Fowler, 2003). First, in a *conceptual* perspective, designers can describe the design superficially and descriptively, reflecting the general direction of the design. Second, in a *specification* perspective, designers can describe the design comprehensively and in a more detailed fashion, reflecting all design decisions. Third, in an *implementation* perspective, designers can describe the design more or less technically and functionally. For both designers and other stakeholders, elaboration helps to determine the required minimum level of detail, depending on the capabilities of the designer and the needs of the other stakeholders. Designers should therefore decide, for each design layer, to what extent they are able to progress along the elaboration dimension, given their design situation.

Third, in order to add sufficient standardization to the descriptions of each layer-perspective combination, designers may formalize their learning designs by making their informal or formal design languages explicit. Formalization helps to add rigor to a design and helps promote unequivocal understanding between both designers and other stakeholders, but it detracts from the positive ambiguity that is often a hallmark of creativity. Designers should strive for (combinations of) formal languages, but depending on the capabilities and needs of the designer and the other stakeholders, they can also select (combinations of) informal languages. Such a language can be specific for a particular layer, for instance, informal languages such as event-and-control flow diagrams for the control layer, and wire frames of layouts for the representation layer. Or, it can be specific for a particular perspective, for instance, an informal language such as plain text for the conceptual perspective; formal languages like the Unified Modeling Language (UML; Booch, Rumbaugh, & Jacobson, 1994) for the specification perspective, and the Extended Markup Language (see www.w3.org/XML) for the implementation perspective. Designers should therefore decide for each design layer and each perspective which level of formality is most suitable, given their design situation.

The 3D-model could be compared to the MISA

Table 2. Objectives and examples of the seven design layers (Adapted from Gibbons, 2003)

Layer	Objective	Examples of activities	Examples of outcomes
Content	Define the content and structure of the domain ("what should be learned")	Task analysis, Content analysis, Concept mapping, Model analysis	Task hierarchies, Mental model descriptions
Strategy	Define the instructional design ("how should be learned")	Identification of whole-task practice and part-task practice, Definition of and sequencing of learning tasks, Definition of social relationships during instruction, Definition and sequence of time-event structures, Definition of roles, goals, and initiative-sharing during instruction	Task classes, Case descriptions, Feedback mechanisms
Control	Define the command language given the learner for communication of actions and responses to the instructional source ("how can the user interact")	Identification of user actions, Definition of control space, Flow planning	Content controls, Strategy controls, Administrative controls
Message	Define the message design ("what should be sensed")	Definitions of message structure, Composition of elements and rules	Message standards design for content
Representation	Define the representation design ("how should it be shown)	Media selection, Selection of production tools and methods	Layout standards, Media channel assignment, Media synchronization methods
Media-Logic	Define the software architecture ("how should the program be structured")	Definition of logic structure, Algorithms Creation, Learning objects definition	Modularity plan, Packaging method, Software platform selection, Maintenance plan

continued on following page

Table 2. Objectives and examples of the seven design layers (Adapted from Gibbons, 2003) (continued)

Layer	Objective	Examples of activities	Examples of outcomes
Data Management	Define the data management ("how should information, captured during instruction, be organized, analyzed, stored, and reported")	Defining administration processes, Data base selection, Definition of data items, capture, filtering, storage, analysis, interpretation, compilation, and sharing	Security plan, Billing methods, Metadata assignment

model. This Instructional Engineering Method (Paquette, Léonard, & Lundgren-Cayrol, 2008) has a matrix structure composed by four axes and six phases. In a way, MISA takes a similar approach as the 3D model presented below, as it provides a framework of selecting and applying design approaches and languages at different stage in the design process. On the other hand, the 3D model is more limited in scope and at the same time more precise in describing the use context of design languages in ID.

The application of the 3D-model will result in a specific configuration for each different design situation. This is expected to result in a more efficient translation process and a higher satisfaction of stakeholders with these improved learning designs than with conventional learning designs.

EVALUATING THE 3D-MODEL

In order to evaluate the 3D-model, two empirical studies were conducted (Boot, Nelson, & De Faveri, submitted). These two studies focused on the communication of the instructional design information to one important kind of stakeholders, namely software producers. It was hypothesized that compared to conventional learning designs, the improved learning designs would lead to a better understanding by other stakeholders and require less time and perceived cognitive load to reach this understanding. For these studies, one group of stakeholders was selected, namely producers. Participants were respectively 16 and 13 software producers, randomly assigned to either a group with conventional design documents or a group with design documents based upon the 3D-model. Their task was to interpret the design document and translate it into technical specifications. The conventional and improved design documents covered an identical topic—learning to drive a car—and had an identical function: providing input for the technical specification process for an advanced car-driving educational simulation.

The conventional design documents emphasized the use of informal design languages, with only average stratification and elaboration. This configuration reflects the traditional approach towards design documents (see, for instance, Driscoll, 1998; Kruse & Keil, 2000; van Merriënboer, Clark, & de Croock, 2002). The improved design documents emphasized the use of combinations of informal and formal design languages, with an obvious stratification and more elaboration.

The ability to translate the design document into technical specifications (defined as the agreement between technical specifications and the intentions of the instructional design documents) was measured by the specification questionnaire. It consisted of 25 open questions, each question on one printed page with sufficient space to note down the answer. There was no time limit for answering the questionnaire, but the experimenter measured the time on task for each question unobtrusively. Each question addressed a particular aspect of translating the design document into technical specifications. For instance, the participants had to distill from the design document how many databases should be used in the instructional software; what the consequences would be from changing text-based messages into audio-based messages (the so-called "ripple effect"); how a particular program flow should be implemented; what it meant if just-in-time information would be applied in a particular learning task; where the producer would need a subject matter expert to provide additional domain information; which instructional design components should be implemented as reusable learning objects, and so forth. Also, the perceived cognitive load for each question in the specification questionnaire, defined as part of the costs of the translation process, was measured. A standard 9-point rating scale for cognitive load, developed by Paas (1992), is used.

The use of the 3D-model in both studies showed a significant increase in efficiency of creating technical specifications while requiring the same time and cognitive load. Table 3 shows that the improved design documents resulted in

Table 3. Means and standard deviations for measures of the communication process

	Study 1				Study 2			
	Conventional design documents group (n = 8)		Improved design documents group (n = 8)		Conventional design documents group (n = 6)		Improved design documents group (n = 7)	
	M	SD	M	SD	M	SD	M	SD
Quality of production (0 – 25)	12.25[a]	2.35	17.18[a]	1.94	8.33[c]	2.34	12.57[c]	1.62
Mean time per question (mins.)[b]	3.46[b]	0.89	2.75[b]	0.71	3.36	0.41	3.25	0.39
Mean perceived cognitive load per question	4.43	0.42	4.06	1.10	4.54	1.23	4.35	0.75

[a] $t = 4.58, p < .001$
[b] $t = 1.77, p < .05$
[c] $t = 3.85, p < .001$

higher scores for the agreement between technical specifications and the intentions of the instructional design documents than the conventional design documents. This indicates a higher level of understanding of the instructional design documents, which is required to translate the functional model into technical specifications. The results with regard to time were mixed. In Study 1, working with the improved design documents required less time, but in Study 2 there was no significant difference. In both studies, there were no significant differences in perceived cognitive load when comparing the same question on the conventional and the improved design documents.

CONCLUSION

Design languages are becoming increasingly important to the design and production of instruction. These languages provide important benefits to the design and production of instructional software, including the ability to generate and share design ideas and design patterns. However, the development and use of these languages in the design process is still not well understood. Dedicated instructional design languages are still under development and not yet standardized.

In this chapter we proposed a model to aid in the selection and implementation of design languages in an instructional design situation. The 3D-model (which derives its name its use of three dimensions and as an acronym for Developing Design Documents) details language and notation needs along the three dimensions of stratification, elaboration, and formalization. In addition, two validation studies were conducted to determine whether use of this model to increase the standardization of design documents improved communication between designers and sample developers. The use of the 3D-model showed a significant increase in efficiency of creating technical specifications while requiring the same time and cognitive load. This should promote better interpretation of learning designs and improved specification of metadata sets for learning objects.

MOT+ (Paquette et al., 2008) is another instructional design language with visual notation. It is different from the ones mentioned above in that it is based on an ontology for representing knowledge, instead of visualizing teaching and learning activities. MOT+ is part of a suite of conceptual design tools and it is coupled to MISA, an Instructional Engineering Method (Paquette et al., 2008). MISA has a matrix structure composed by four axes and six phases. In a way, MISA takes a similar approach as the 3D model presented below, as it provides a framework of selecting and applying design approaches and languages at different stage in the design process. On the other hand, the 3D model is more limited in scope and at the same time more precise in describing the use context of design languages in ID.

The need for interpretation of complex instructional designs will increase. In the field of instructional software, the focus has mostly been on technical, organizational, and economic issues, and on sustaining traditional pedagogical models but not introducing the more recent pedagogical models that rest on a holistic approach and aim at authentic learning tasks and blended approaches. In promoting instructional software to sustain such new pedagogical models, well-organized, detailed, and formalized design languages with explicit notation systems are required in order to communicate (the consequences) of instructional design according to these new pedagogical models.

Although the results of the use of the 3D-model are positive, without the availability of formal, standardized design languages, the situation remains suboptimal. In other words, if such languages were available, the need for strategies such as the 3D-model would be hardly needed. However, this situation will be hard to reach. Important objections of instructional designers against the use of such design languages are: (a) the required proficiency in technical aspects; (b) the extra time and effort they have to invest in learning and, in particular, applying these languages; and (c) the low yield compared to the required efforts (Boot, 2005). It can be expected that the first two objections will quickly become obsolete. With an increase of standardization of design languages for instructional software development, more support will become available to increase their efficient use. For example, support mechanisms such as automation and templates, embedded in design environments and tools, will lower both the required technical proficiency and the required time and efforts of usage. The third objection is more difficult to refute. As long as instructional designers work according to the traditional "push principle" associated with conventional Instructional Systems Design (ISD) models that separate design from production, they will leave it up to other stakeholders such as software producers to interpret their learning designs. It is not until new production models such as "lean production" (Woll, 2003) that emphasis a "pull principle"—in which design and production information are more integrated—are implemented, that the need for using standardized design languages becomes apparent. The chicken-or-the-egg paradox is that organizations will not implement new, lean production models on a broad scale until they are able to unequivocally transfer and communicate their designs, but the standardized design languages required for doing this will not be drafted and standardized until organizations implement lean production on a broad scale. As long as this situation remains unchanged, strategies such as the 3D-model remain relevant.

REFERENCES

Alexander, C. (1979). *The timeless way of building.* New York: Oxford University Press.

Bates, T.W. (1999). *Managing technological change: Strategies for college and university leaders.* San Francisco, CA: Jossey Bass.

Booch, G., Rumbaugh, J., & Jacobson, I. (1999). *The unified modeling language user guide.* Reading, MA: Addison-Wesley.

Boot, E.W. (2005). *Building-block solutions for developing instructional software*. Unpublished Ph.D. dissertation. Open Universiteit of the Netherlands, Heerlen.

Boot, E.W., Nelson, J., & De Faveri, D. (2008). *Lost in translation: Improving the transition between design and production of instructional software*. In L. Botturi & T. Stubbs (Eds.), Handbook of visual languages in instructional design: Theories and practices. Hershey, PA: Idea Group.

Botturi, L. (2006). E2ML: A visual language for the design of instruction. *Educational Technologies Research & Development, 54*(3), 265-293.

Botturi, L., Cantoni, L., Lepori, B., & Tardini, S. (2006). Fast prototyping as a communication catalyst for e-learning design. In M. Bullen & D. Janes (Eds.), *Making the transition to e-learning: Strategies and issues.* Hershey, PA: Idea Group, 266-283.

Botturi, L., & Del Percio, M. (in press). Communication patterns and effective design in eLearning teams. In A. Sangrá & U. Bernath (Eds.), *Research in distance education and online learning.* Oldenburg, Germany: Carl von Ossietzky University Press [ASF Series, Selected papers from the 4th EDEN workshop].

Botturi, L., Derntl, M., Boot, E., & Figl, K. (2006). A classification framework for educational modeling languages in instructional design. In *Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies* (ICALT'06), Kerkrade, the Netherlands (pp. 1216-1220).

Botturi, L., & Stubbs, T. (2008). *Handbook of visual languages for instructional design: Theories and practices*. Hershey, PA: Idea Group.

Cantoni, L., & Botturi, L. (2005). E-learning meeting modular education, the case of learning objects. *Revue Suisse de Sciences de l'éducation / Rivista svizzera di scienze dell'educazione / Schweizerische Zeitschrift für Bildungswissenschaften RSSE/SZBW, 27*(2), 231-251 [Thematic issue on Modularity].

Derntl, M. (2004). The person-centered e-learning pattern repository: Design for reuse and extensibility. In *Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications* (EDMEDIA 2004), Lugano, Switzerland.

Derntl, M., & Botturi, L. (2006). Essential use cases for pedagogical patterns [Special issue on pedagogical patterns]. *Computer Science Education, 16*(2) 137-156.

Driscoll, J. (1998). *Web-based training: Tactics and techniques for designing adult learning*. San Francisco, CA: Jossey-Bass/Pfeiffer.

Fowler, M. (2003). *UML distilled: A brief guide to the standard object modeling language*. Boston, MA: Addison-Wesley.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995). *Design patterns*. Reading, MA: Addison-Wesley.

Gibbons, A.S. (2003). What and how do designers design? A theory of design structure. *Tech Trends, 47*(5), 22-27.

Gibbons, A., Botturi, L., Boot, E., & Nelson, J. (2008). Design languages. In M. Driscoll, M. D. Merrill, J. van Merriënboer, & J.M. Spector (Eds.), *Handbook for research for educational communications and technology* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Gibbons, A.S., Nelson, J., & Richards, R. (2000). The nature and origin of instructional objects. In D.A. Wiley (Ed.), *The instructional use of learning objects* (pp. 25-58). Bloomington, IN: AECT.

Gibbons, A., & Rogers, P. (2007). The architecture of instructional theory. In C. Reigeluth & A. Carr-Chellman (Eds.), *Instructional-design theories and models, Vol III*. Mahwah, NJ: Lawrence Erlbaum Associates.

Hamel, C.J., & Ryan-Jones, D. (2002). Designing instruction with learning objects. *International Journal of Educational Technology, 3*(1).

IMS. (2003). *IMS learning design specification 1.0* [information model, XML binding and best practice and implementation guide]. Retrieved April 7, 2008, from http://www.imsglobal.org/learningdesign/

Jochems, W., van Merriënboer, J.J.G., & Koper, R. (Eds.). (2003). *Integrated e-learning: Implications for pedagogy, technology, and organization*. London, UK: RoutledgeFalmer.

Koper, R., & Tattersall, C. (Eds.). (2005). *Learning design: A handbook on modeling and delivering networked education and training*. Heidelberg, Germany: Springer-Verlag.

Kruse, K., & Keil, J. (2000). *Technology based learning: The art and science of design, development, and delivery*. San Francisco, CA: Jossey-Bass Pfeiffer.

Nodenot, T. (2006). Towards pedagogically neutral EML making use of de-contextualized learning objects: Myth or reality? In *Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies* (ICALT'06), Kerkrade, the Netherlands (pp. 1028-1030).

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*, 429-434.

Paquette, G., Léonard, M., & Lundgren-Cayrol, K. (2008). The MOT+ Visual language for knowledge-based instructional design. In L. Botturi & T. Stubbs (Eds.), *Handbook of visual languages in instructional design: Theories and practices*. Hershey, PA: Idea Group.

Parrish, P.E. (2004). The trouble with learning objects. *Educational Technology, Research and Development, 52*(1), 49-67.

Parrish, P. (2006). *Aesthetic principles for instructional design*. Paper presented at the annual conference of the Association for Educational Communications and Technology (AECT 2006), Dallas, TX.

Schön, D. (1983). *The reflective practitioner. How professionals think in action*. London: Temple Smith Cliffs; New Jersey: Educational Technology Publications.

Van Merriënboer, J.J.G., & Boot, E.W. (2005). A holistic pedagogical view of learning objects. In J.M. Spector, S. Ohrazda, P. van Schaaik, & D.A. Wiley (Eds.), *Innovations in instructional technology: Essays in honor of M. David Merrill* (pp. 43-64). Mahwah, NJ: Lawrence Erlbaum.

Van Merriënboer, J.J.G., Clark, R.E., & De Croock, M.B.M. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology, Research and Development, 50*(2), 39-64.

Van Merriënboer, J.J.G., & Kirschner, P.A. (2007). *Ten steps to complex learning*. Mahwah, NJ: Lawrence Erlbaum.

Waters, S., & Gibbons, A.S. (2004). Design languages, notation systems, and instructional technology: A case study. *Educational Technology Research and Development, 52*(2), 57-69.

Wiley, D.A. (Ed.). (2000). *Connecting learning objects to instructional design theory: A definition, a metaphor and a taxonomy*. Retrieved April 7, 2008, from http://reusability.org/read/chapters

Woll, C. (2003). *Identifying value in instructional production systems: Mapping the value stream*. Unpublished Ph.D. Dissertation, Utah State University, Logan.

KEY TERMS

3D-Model: A decision model that supports selecting and applying design languages for formalizing learning designs and labeling learning objects.

Design Languages: A set of concepts that support structuring a design task and conceiving solutions. They are mental tools, but can be expressed and communicated through notation systems, that is, sets of signs and icons that allow representation of a design solution to our senses. The combination design language and notation system is a central concept in the definition of a design team or community, because a shared language is the medium for the creation of shared culture.

Design Patterns: Expressing the gist of a solution so that it can be reused many times. Defining a pattern, or a pattern system, is a way to capture the design knowledge of a community, to share it and to leverage it for future developments.

Instructional Software: Software used to support learning processes, such as CBT, e-learning, simulations, gaming, mobile learning, advanced distributed learning, and so forth.

Learning Designs: Used to *formalize*—often following a standard specification—descriptions of roles, activities, constraints, and several other aspects involved in an instructional design.

Learning Objects: A set of such media components, instructional activities, or whole lessons, labeled with metadata and expressed in a standard format.

Metadata: Information that "labels" learning objects in order to enable an efficient search for them in databases.

Chapter XLIII
Principled Construction and Reuse of Learning Designs

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ABSTRACT

This chapter summarizes the work on instructional engineering and educational modeling accomplished since 1992 at the LICEF Research Center of Télé-université by the researchers of the CICE Research Chair. Recent results on learning design modeling and learning objects reusability processes are thoroughly presented using examples drawn from many projects conducted in the last 3 years. These are discussed to uncover the importance of a principled approach for the modeling of learning design and the reuse of learning objects in technology enhanced learning environments. Finally, delivery and dissemination issues are discussed and a summary of on-going and future directions for research is presented.

INTRODUCTION

At the end of the 1990s, technology enhanced distance learning developments were driven by dreams of producing high quality, low cost, online courses for massive delivery, based on the available e-learning platforms. Most of those platforms offer three types of loosely connected services: communication services such as discussion forums, chats and e-mail; basic information delivery services to present course resources such as documents and syllabi; and management services to help professors keep track of students' participation and products.

In the beginning of the 2000s, it was evident that low cost courses were more difficult to realize than expected unless they reproduced low quality classroom processes. There seemed to be a trade-off between quality and effort. Indeed, developing high quality distance learning courses or course modules remains a complex task. In the design, development, and delivery phases, a range of different actors and disciplines are involved, including instructional designers, media, ergonomic and graphical experts, experts in information and communication technologies, and cognitive scientists. Moreover building, maintaining, and supporting a rich, learner centered distance learning environment is a difficult and expensive task.

Does all this mean that it is impossible to produce high quality, economically viable e-learning? The good news is that advances in research are starting to be transferred into practice, implementing new ways to attain this dream. The key requirements for these advances can be grouped into four complementary dimensions: quality, viability, reusability and dissemination capability.

- Regarding quality issues, we need to center the efforts on pedagogy, sound methodologies, innovative course design processes, instrumentation, and support, while offering powerful and user-friendly technological tools that support the design, development and delivery of rich and flexible e-learning situations.

  This question is addressed in the first section, where the main pedagogical processes and principles are presented as well as our methodology for learning system engineering quality.
- Regarding viability issues, we need to generalize norms and standards to allow interoperability of the various learning environment components such as the pedagogical method or learning design objects, the learning materials or content objects, and the tools or processing objects. Consolidating repositories of best practices, templates, and course components will allow for faster, and possibly better, course development by re-composition or specialization.

  This question is developed in section 2, which is focused on educational modeling languages and the IMS-LD standard specification. The role of such standards to ensure the viability of delivery methods and tools will be presented.
- Regarding reusability issues, we need to provide quality assurance strategies including both technical and pedagogical high quality criteria. These criteria can be implemented during conception and applied as evaluation instruments after reuse to establish a feedback loop that will assure quality.

  In section 3, we will illustrate the concerns of reusability influencing both learning resources and learning scenarios (both are seen as types of learning objects), through the use of the MOT+LD graphic modeling software.
- Regarding dissemination issues, we need to transfer to actual practice the approaches from the preceding dimensions to the different actors through various strategies, such as training and best practice examples, supporting the emergence of communities of research and practice and their networking, defining clear open intellectual rights management, sharing, and recognition rules.

Section 4 will address the dimensions of community building, repository integration and interoperability as well as dissemination strategies. The Implementation and Deployment of Learning Designs (IDLD) project that has led to a Canadian portal of learning designs (see http://www.idld.org), will be used as a case study for this section.

In this chapter we will present some of the advances in this field, illustrating them with examples from our own experience and work. The chapter will address the above issues while going from the theoretical and methodological dimensions of instructional engineering principles and strategies through to the practical and technical dimensions of methods, processes, and information systems' support.

Although conceptually independent, those dimensions are tightly related. Standards such as the educational modeling language IMS-LD for learning designs, or the LOM for learning objects description, are guided by instructional design principles. They contribute to the goals of quality, favor reusability and facilitate dissemination activities.

The chapter concludes with the identification of some research trends, such as knowledge and competency representations, working and learning process alignment, quality assurance and learning design personalization as some of the essential emerging issues.

INSTRUCTIONAL ENGINEERING FOR QUALITY

A century ago, John Dewey hoped for the development of a science that could fill the gap between learning theories and educational practice. At the beginning of the 1960s, a new discipline, instructional design, was born under the influence of pioneering work from scholars like B.F. Skinner, Jerome Bruner, and David Ausubel. In the 1970s, several proposals (Reigeluth, 1983) were made for the construction of an instructional theory: explicit conditions of learning (Gagné, 1985), a cybernetic approach to instruction (Landa, 1976), a structural learning theory I and II (Scandura, 1973, 1976), Cognitive Apprenticeship (Collins & Stevens, 1989), the Component Display Theory (Merrill, 1983) and the Elaboration Theory of Learning (Reigeluth, 1983).

At the beginning of the new millenium, new technological advances have challenged these models and theories created before the Internet Era. Genetic evolution is a very long process and the human brain still functions in much the same way as it did 40 years ago; therefore, it is hazardous to say that these models and theories have become obsolete just because people have started to learn using new and rapidly evolving technology.

In fact, these theories and models still provide a solid foundation for instructional design. The problem lies mainly at the level of operational and methodological inefficiencies, as many researchers in the field have pointed out earlier. According to Gerry (1997) traditional instructional design practices are to slow and costly in most situations and suggests that the development of electronic performance support systems (EPSS) can close this gap. In concordance with this view, Gustafson (1993) remarks already in 1993 that, although, there has been moderate additions of instructional design tools and a visible change from a behaviorist to a cognitive psychology perspective, these changes are not fundamental. Moreover, he views instructional design methodology as incomplete and inadequate to satisfy needs for the near future, keeping in mind that Web technology was only in its cradle and an explosion of applications was to come.

These rather hard criticisms are still valid today when one considers the large set of interrelated decisions to make when building technology-based or online learning environment. These are decisions such as the following: What kind of delivery model shall we use or what mixture of these models? Will we support learners and trainers anywhere, anytime, at any pace; are there exceptions to this? What kind of learning scenarios do we need for this course? Should it be predefined, offer multiple learning paths, or be learner-constructed? Which actors will interact at delivery time, what are their roles, and what resources do they need? What kind of interactivity or collaboration should be included? Will we use multimedia or plurimedia materials? What materials can be reused and which ones need to be modified or newly created? How are we to manage distributed resources on the networks? What kind of eLearning standards will be used? How can we support interoperability and scalability of the eLearning system? How do we take into account the technological diversity between groups of users within the target population? How can we promote reusability, sustainability and affordability of the Web-based learning systems we are building?

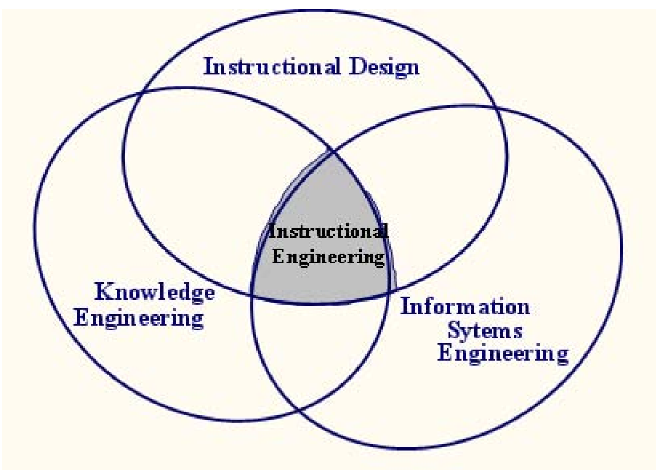
To address these important questions, a renewed instructional design methodology is needed more than ever. The next section defines and presents the basis of such a methodology, followed by a brief description of an example of such a method: the MISA method. We conclude this section by stating a set of principles for instructional engineering.

FOUNDATIONS FOR INSTRUCTIONAL ENGINEERING

We situate instructional engineering as a methodology to solve a particular class of problems: those aiming at the construction of learning systems that can increase human knowledge, skills, and competencies.

These problems share the main characteristics of design problems in other fields such as architecture, engineering or computer science. The input to the design process is a set of general specifications and goals, mostly ill-defined at the beginning, as well as a set of constraints to fulfill. The resulting product is an artefact, here a *learning system*, obtained by defining more and more precise specifications, until they become a set of materials and resources that are considered ready for delivery to the end users.

Figure 1. Systems design methodologies



Basically, instructional engineering lies in the general framework of systems science (LeMoigne, 1995; Simon, 1981). A system is defined as a set of dynamically interacting elements, organized towards a goal. In our case, an instructional engineering method groups a set of design products, tasks, and principles organized to support the construction of a learning system to be used at delivery time by learners and different kinds of facilitators. As illustrated in Figure 1, instructional engineering integrates features from previous instructional design methods as well as processes and principles from both information systems engineering and knowledge engineering.

From a technical point of view, an e-learning system is basically an information system hosting a complex array of software tools, digitized documents, and communication services. Similar to the evolution in software engineering, the current practice of artisan-like construction of Web based materials and the use of simplistic authoring tools are more and more insufficient to cope with instructional engineering. Software engineering principles and processes should inspire the general organization of the instructional engineering phases as well as the organization of subtasks and design documentation. The multi-agent view, now dominant in software engineering, is an important way to view an e-learning system as a set of agents, persons, resources, and computerized modules, interacting to support learning. This approach corresponds well to new pedagogical possibilities that Web2.0 technology offers.

The actual emphasis on knowledge management in organizations recognizes the importance of knowledge and higher order skills, as opposed to simple information acquisition. Knowledge engineering is now a well established methodology rooted in the development of artificial intelligence and expert systems. Knowledge elicitation, processing, and communication, and also knowledge modeling methods and tools should be at the center of instructional engineering. These will serve to build models of the subject matter, models of learning scenarios, models of learning materials, and models of delivery process. In the context of the Semantic Web, knowledge models can take the form of ontologies both to describe the domain to learn, as well as the corresponding activity processes to acquire knowledge and competencies.

Even though instructional engineering can support any instructional strategies or delivery model, it will be most helpful in the context of constructivist instructional strategies. In project-based learning, problem solving, or collaborative learning, learners are actively involved in knowledge and skills construction, guided by some form of *process-based learning scenario.* A learning scenario for a module should be described, whenever possible, as a generic process, corresponding to a metacognitive skill where domain knowledge is processed using and producing resources during activities in the scenario. In other words, if we want to develop knowledge in a subject matter as well as matching skills, such as classification, diagnosis, induction, or modeling, the scenario should consequently propose classification, diagnosis, induction and modeling processes, problems, or projects to the learner.

PRESENTATION OF THE MISA METHOD

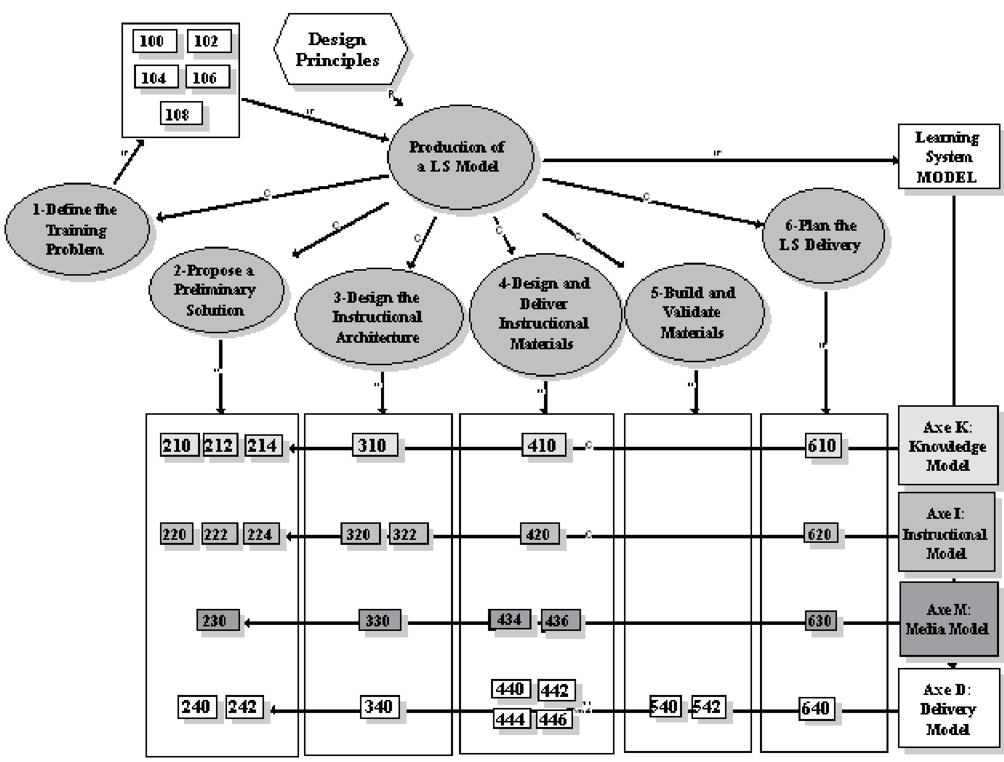
We now present a specific an instructional engineering method called MISA (Paquette, 2002a, 2004). Others are of course possible based on the same principles. This one is the result of 15 years of research in the field of instructional engineering, backed by practical experience acquired through the development of numerous educational environments.

The elaboration of MISA started in 1992 and a first version of the method was produced in 1994, embedded in a first computerized support system for instructional designers called AGD (Paquette, Crevier, & Aubin, 1994). The method was later validated with instructional designers and content experts in nine different organizations. It was rebuilt according to results and observations gathered during these validations. In parallel, we have extracted and rebuilt a tool for knowledge modeling (MOT) to support central aspects of the method (Paquette, 1996, 2002b). After another round of validation, our attention focused on resource typologies. We defined seventeen typologies on concepts such as knowledge models, skills, learning scenarios, learning materials, delivery models and so on. In 1998, this effort had led to MISA 3.0 in which these typologies are used to present numerous alternatives to the designer on which to build viable design decisions for high quality and reusability. Also, the method was restructured in six phases and four axes under which the main design tasks have been distributed.

The actual MISA 4.0 version has been built in coordination with a Web-based support system called ADISA. It is organized around 35 main tasks shown in Figure 2. Its macrodesign process is decomposed into six phases or processes performed by the designer to progress from general to specific, defining the project, elaborating a preliminary solution, designing the architecture of the environment, reusing/adapting/designing instructional materials, producing and validating of the materials, and planning the delivery.

After the preliminary definition and adaptation of the process where only relevant tasks are selected, four axes are deployed in parallel during phases 2 to 6. The first axis helps define

Figure 2. The structure of the MISA 4.0 instructional engineering method[2]



the *knowledge model* (K) that groups knowledge and competencies to be learned. The second one, *the instructional* model (I), helps define learning events and their actors, scenarios, activities, and resources. The third axis define the *media* model (M) describing the conceptual design of the learning materials to be built or adapted. The last axis, the *delivery* model (D), describes actors and their interaction processes at delivery time. These two last axes are not always necessary. For example, if only existing material or learning objects are reused, the media model is not needed unless important adaptations need to occur. Also, if the delivery is mostly classroom based, the delivery model is simple enough and does not need any further elaboration.

Table 1 presents the 35 design tasks classified according to the four axes. Similar to software engineering methods, each axis starts with the statement of orientation or vision principles. Each of these sets of principles in the documentation element DE 210, 220, 230, and 240 are guidelines that the designers state for themselves. This is valuable particularly if, as is now most often the case, the design is built by a team. These statements help team members communicate, promote goal directed behaviour, and help in maintaining consistency throughout the design process.

Knowledge modeling using the MOT or MOT+ software is the backbone of the method in each of the four axes. To build a structured view of the general content, a graphic knowledge model is built (212). Then the content of learning units (310) and learning resources (410) is described as submodels of the global knowledge model. In the instructional axis, graphic modeling helps represent the structure of the learning events at the course or program level (222), and also for

Table 1. Main instructional engineering task in the MISA 4.0 method

<table>
<tr><th colspan="2">Problem Definition</th></tr>
<tr><td colspan="2">100 Organization’s Training System
102 Training Objectives
104 Target Populations
106 Actual Situation
108 Reference Documents</td></tr>
<tr><th>Knowledge Model</th><th>Instructional Model</th></tr>
<tr><td>210 Knowledge Model Orientation Principles
212 Knowledge Model
214 Target Competencies
310 Learning Unit Knowledge Models
410 Learning Resource Knowledge Models
610 Knowledge/Competency Management</td><td>220 Instructional Principles
222 Learning Event Network
224 Learning Unit Properties
320 Learning Unit Scenarios
322 Learning Activity Properties
420 Learning Instrument Properties
620 Actors and Group Management</td></tr>
<tr><th>Media Model</th><th>Delivery Model</th></tr>
<tr><td>230 Media Principles
330 Development Infrastructure
430 Learning Materials List
432 Learning Material Models
434 Media Elements
436 Source Documents
630 Learning System/Resource Management</td><td>240 Delivery Principles
242 Cost-Benefit Analysis
340 Delivery Planning
440 Delivery Models
442 Actors and User’s Materials
444 Tools and Telecommunication
446 Services and Delivery Locations
540 Assessment Planning
542 Revision Decisions Log
640 Maintenance/Quality Management</td></tr>
</table>

the scenarios describing the activities in each learning unit (320). In the learning material axis, we model for example a Web site or hypermedia software (432), showing the media components, their interrelations through hyperlinks, the media constraints and templates and the source documents to be displayed. Finally, in the delivery axis, we model (440) the actors, their roles, their interactions, their input resources, and their productions at delivery time. The multi-agent approach is applied mainly through the design of the learning scenarios and, even more directly, while building the delivery models.

Most of the other tasks in MISA describe properties of the objects contained in the graphic models. For example, we describe target competencies (214) related to objects in the knowledge model, learning activities (322) or learning instruments (420) as properties of the objects in learning scenarios, source documents (436) as objects in learning materials models, and finally tools, communication links (444) and services (446) as objects in the delivery models.

PRINCIPLES FOR INSTRUCTIONAL ENGINEERING

Figure 2 indicates that design principles must guide the design process. This is the most important aspect of an instructional engineering method like MISA. Table 2 summarizes 20 design principles that are only briefly explained here. For more details consult Paquette (2002a). Our goal is to give the reader an overview of what we mean by a principled approach to instructional engineering.

Self-management principles deal with how the learner analyzes previous knowledge, needed knowledge, or desired knowledge, consequently building a view of his/her own knowledge and generic skills. Self-management is a way to encourage metacognition. The structure of the knowledge models and the learning scenarios are critical to enable learners to self-manage their activities and thus trigger metacognitive processes that are essential to learning. For example, the first principle states that small knowledge units, isolated knowledge units, or a list of unstructured subjects do not provide a good basis for learner self-management. A learning unit should group a sufficient number of interrelated knowledge units: not a single small concept, but a concept with its main components and the procedures where it is used; not a single small procedure but also its inputs, products, and control principles; not a single principle, but a set of related principles linked to the procedures they regulate or the concepts they define. Principle 2 recognizes that knowledge, which is specific to a domain and metaknowledge (knowledge about knowledge) are being constructed at the same time (Pitrat, 1991; Romisowski, 1981). A learning unit without an associated target generic skill or competency is like a set of data without any process acting on it. Other principles in this group state that designers need to provide choices for self-management to occur.

The *information processing principles* focus on the interactions of a learner, with resources providing fuel for thought. These resources are online content experts, mediated information sources, or learning objects. From an instructional engineering viewpoint, this type of interaction corresponds to information acquisition triggering information processing activities where a generic skill is mobilized. Through these activities, the learner can construct personal knowledge and also communicate new information the learner has produced to other learners or decide to ask for assistance. For this, learning scenarios must define clear information goals**.** The large diversity of information sources can decrease the motivation of a learner in the quest for useful information. To counter this “lost in space” effect, it is essential that the learner has a clear view of the information which is needed. To better understand the goal, it can be given in the learning activity

Table 2. A set of instructional engineering principles

Learner Self-Management.	Information Processing
1 – Well-structured large enough knowledge models 2 – Knowledge related to generic skills and to competencies 3 – Learning scenarios built upon a generic skill's process model 4 – Open and multiple choice learning scenarios at design time 5 – Instructional model adaptable by learners and/or trainers at delivery time 6 – Explicit activities and support tools for self-management and meta-cognition.	7 – Rich and diversified information resources and learning objects 8 – Dynamic resources for bi-directional communication 9 – Information search guided by process-based scenarios 10– Tools for information search, annotation and restructuring 11– Information production tools adapted to generic tasks.
Collaboration	**Personalized Assistance**
12 – Balanced collaborative and individual activities sustaining each other 13 – Collaborative tasks adapted to the generic process in a learning scenario 14 – Balanced synchronous and asynchronous interactions between learners. 15 – Management tools for group coordination by learners and trainers	16 – Human or computer agent assistance based on the generic process in a learning scenario 17 – Variety of facilitator and facilitating agents 18 – Careful assistance, mainly at the learner's request. 19 – Heuristic and methodological guidances
Coherence	
20 – Coherence between target competencies and the knowledge, instructional, media and delivery models.	

assignment by stating target competencies and success indicators. The most crucial part of the learner's interaction with information occurs in processing the information to build a product of a learning activity, that is, in acquiring knowledge. The choice of tools associated with a learning unit depends very much on the generic process on which the activity is based. For example, a planning process will necessitate a spreadsheet or a project management tool, while a taxonomy construction will make good use of a graphic or tree editor.

The *collaboration principles* are concerned with the interaction between and among learners. From a multi-agent perspective, these interactions are defined essentially by the assignment of tasks in a learning activity, the distribution of responsibility between learners and their coordination. The main principle here is the complementarities and equilibrium between collaborative and individual activities, between asynchronous and synchronous collaboration, and between generic tasks adapted to the competencies and the specific knowledge to be built.

Finally, the *assistance principles* focus on the interactions between learners and facilitators. Facilitators are resources providing help and assistance to the learning process that can be made available to the learner in different forms: as a checklist to consult from time to time, as an intelligent advisor tracing the learner and providing advice, or as a guide to the trainers' interventions towards the learner. Principle 16 states that assistance resources should be based on the principles regulating the generic process on which a learning scenario is constructed. For example, if the scenario proposes a diagnostic project, the trainer assistance should at first assist the learner in the analysis of the component structure of the system under scrutiny, and only then propose methods or pertinent questions. In Principle 19, we suggest using "heuristic and methodological assistance" most of the time, where typically, the human trainer or the intelligent advisor system will suggest building tables or graphs, decomposing the problem and more generally giving advice based on his or her knowledge of the generic process purported by the learning scenario. This strategy permits the learners to progressively construct their own knowledge model or schemata by avoiding the use of too specific and precise algorithmic guidance, which might, in turn, prevent every mistake, but also give too much of the solution.

STANDARDIZATION FOR OPERATIONAL SUPPORT AND VIABILITY

This section focuses on educational modeling languages and the IMS-LD standard specification, providing a transition from design engineering methodology, such as MISA to operational support to address viability concerns.

The term "Educational Modeling Language (EML)" was first introduced in 1998 by researchers at the Open University of the Netherlands (OUNL), as a response to instructional design and pedagogical concerns towards standardization and interoperability needs. The work on educational modeling languages (Koper, 2005) has led to the adoption by IMS of the Learning Design Specification (IMS-LD, 2003), thus integrating instructional design preoccupations into the international standards movement. IMS-LD describes a formal way to represent an instructional model as an instantiation of a standardized XML schema that specifies learning scenarios, which structure the roles that learners and facilitators can play as they are performing activities for which they use services and learning objects in environments. The conceptual model also proposes outcomes of an activity; however, the XML does not include this concept.

The IMS-LD specification leaves open the choice of instructional methods and modeling tools that can support designers in the process of building learning designs, as well as the learning materials and environments that will instantiate these models. Figure 3 presents a schematic view of the relationship between the IMS-LD specification and instructional engineering methods and tools, including the MISA method presented in the previous section. Such methods build learning system models. When expressed as a standard IMS-LD XML file, these models can be read by any compliant delivery system, such as learning portals, learning management systems (LMS), or learning content management systems (LCMS), such as the LICEF Explor@ system (Paquette, Marino, De la Teja, Léonard, & Lundgren-Cayrol, 2005).

In fact, the IMS-LD specification corresponds quite well to one of the four models the MISA method, namely the instructional model. We have shown that even though the sets of concepts do not correspond exactly, the MISA method qualifies as an educational modeling language (Paquette, De la Teja, Léonard, Lundgren-Cayrol, & Marino, 2005). This has two important implications. First, the instructional engineering processes and principles become available to guide the construction of IMS-LD specifications. Second, it is thus possible to use the MISA graphic and form-based tools to produce IMS-LD standard models, providing operational support to implement the specification (De la Teja, Lundgren-Cayrol, & Paquette, 2005).

To achieve that, we have adapted the MOT+ graphic editor, the main MISA tool, to the IMS-LD semantics. The new MOT+LD graphical editor

Figure 3. Interrelations among IE Methods, IMS-LD designs, and delivery systems

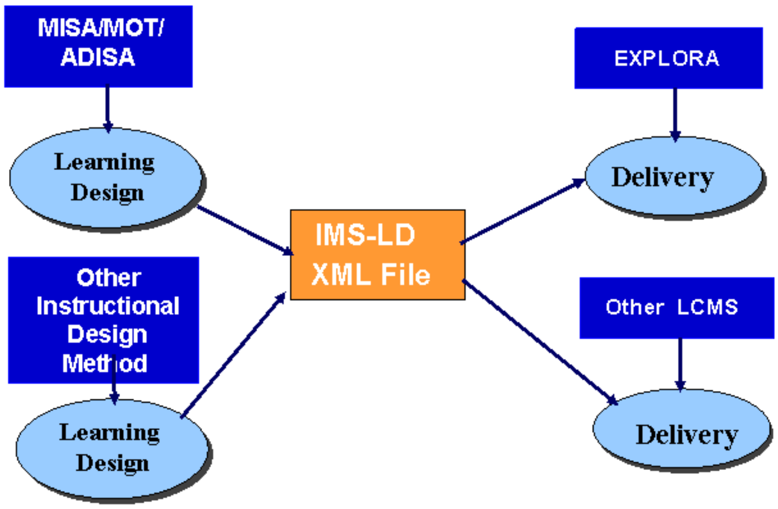
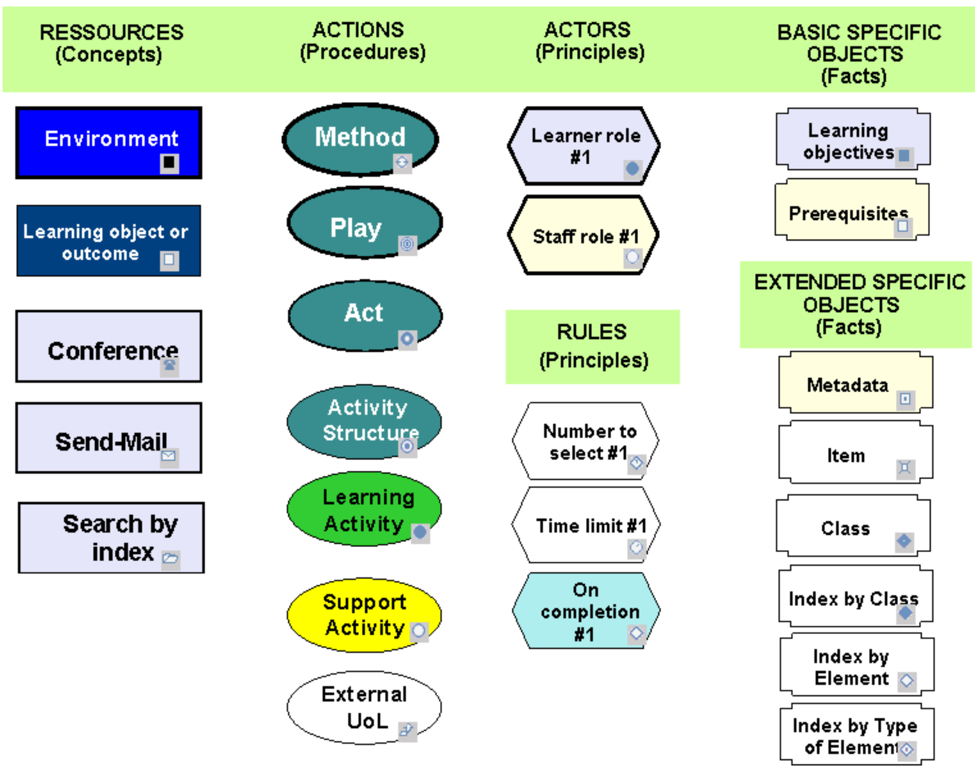


Figure 4. MOT+LD basic vocabulary

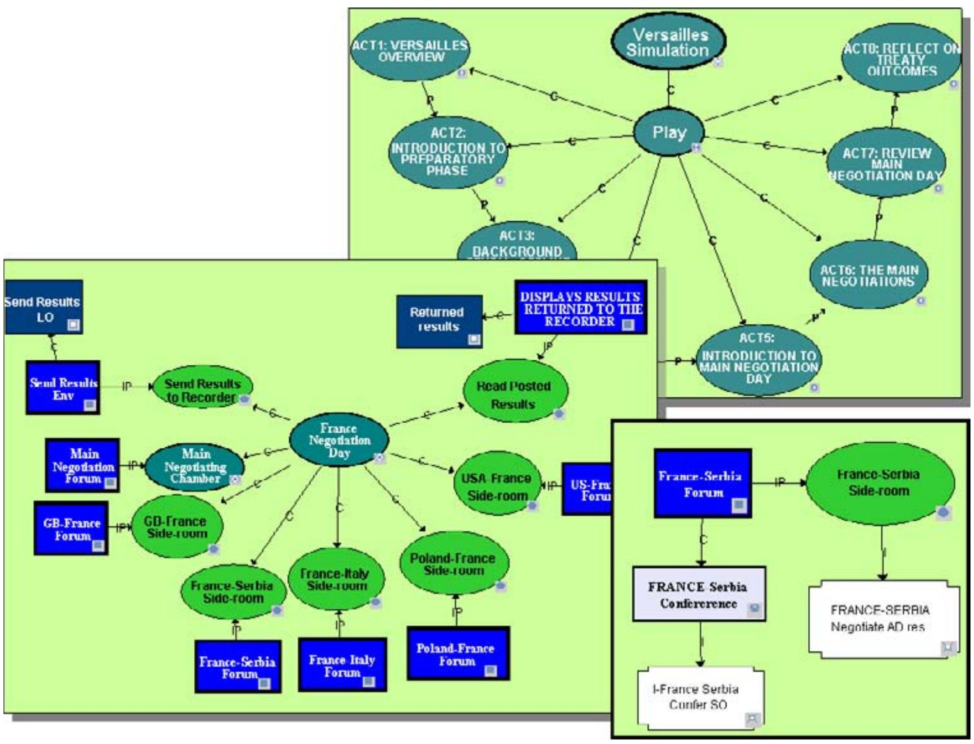


(Paquette, Léonard, Lundgren-Cayrol, Mihaila, & Gareau, 2006) enables designers to fully describe the structure and concepts in the IMS-LD Level A specification, producing an instance of a standard LD XML schema. In Griffiths, Blat, Garcia, Votgen, and Kwong (2005), this approach is considered "significant, not only because it provides an example of a powerful and expressive high-level LD editor, but also because the structure of LD are mapped onto a graphical language which appears to be very remote from the specification." Our aim is to offer instructional designers a more natural way to model learning scenarios and their related concepts than XML code or UML software engineering graphic models.

Figure 4 shows the correspondence between MOT+ graphic symbols and IMS-LD concepts. Resources are represented by five kinds of concepts (rectangles), the LD method components (actions) are represented by seven kinds of procedures (ovals), whereas actors and rules are represented by five kinds of principles (hexagons). Individual objects are represented by clipped rectangles (called "facts" in MOT+) representing learning objectives and prerequisites, metadata, items, and four other types of objects needed to describe conference, send-mail, and index-search services.

The same basic links as in the general MOT language (Lundgren-Cayrol & Léonard, 2006) can be used; however, a number of new constraints on links between subtypes were added in order to comply with relationships specified in the IMS LD Information and Binding model in order to produce a valid XML manifest file. A post-validation mechanism was built into the XML translator informing the designer whether an IMS-LD rule has been violated and where

Figure 5. A MOT+LD unit-of-learning (The Versailles example)



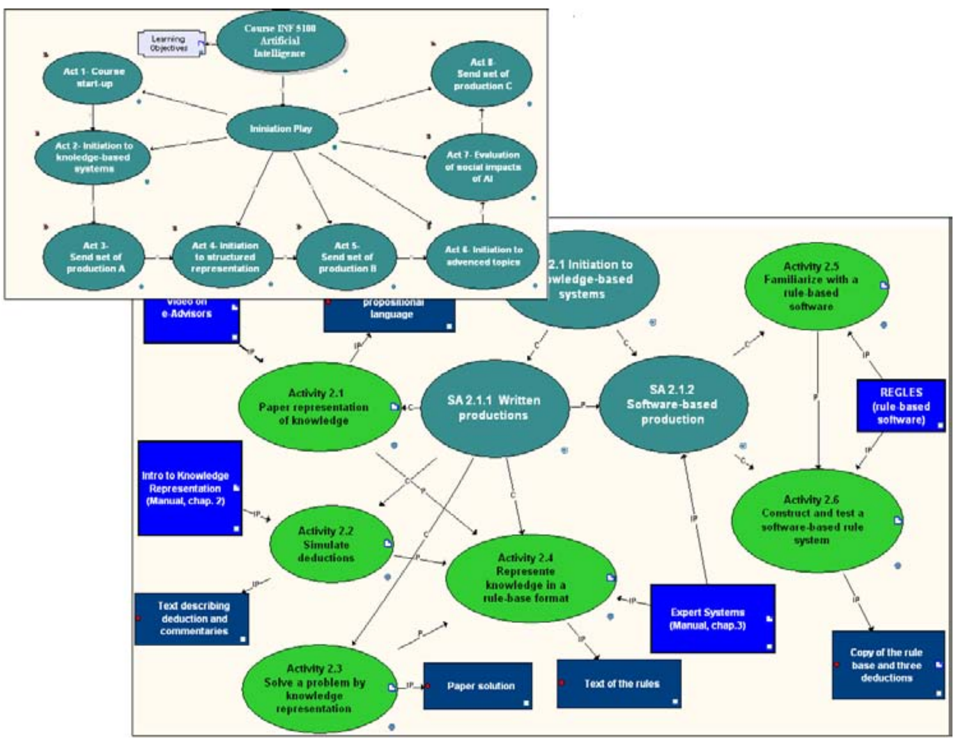
to find it in the model. The number of possible violations was reduced by limiting the choice of possible links between subtypes according to the IMS-LD constraints alerting the designer to these while conceiving the model.

Figure 5 shows an example of a MOT+LD model for the Versailles unit of learning proposed by the IMS-LD team.[3] In this unit of learning, students are organised in six groups corresponding to the six countries negotiating the Treaty of Versailles at the end of World War I. A single "Play" is composed of (C links) eight "Acts" ordered sequentially (P links). Act 6 is composed of several activity structures describing the negotiation day for each country. The left-hand graph in Figure 5 shows one of these negotiation models. Finally, each of the learning activities within this activity structure is structured the same way, as illustrated by the smaller model in the bottom right hand corner. This model presents the France-Serbia side-room discussion in an environment composed of a conference service and a discussion activity as well as their items pointing to corresponding concrete resources.

REUSABILITY-CENTERED DESIGNS

This section addresses the question of reusability of both learning objects and learning scenarios. We discuss this issue by analyzing a use case where an existing Télé-université course, designed using the MISA method, was initially transposed into a graphic MOT+LD model. Later in the process, this standardized model was made generic, then decomposed into smaller generic units of learning (UoL) or scenario templates, also named nuggets (Bailey, Zalfan, Davis, Fill, & Conole, 2006). All

Figure 6. Part of the MOT+LD model for the course on artificial intelligence



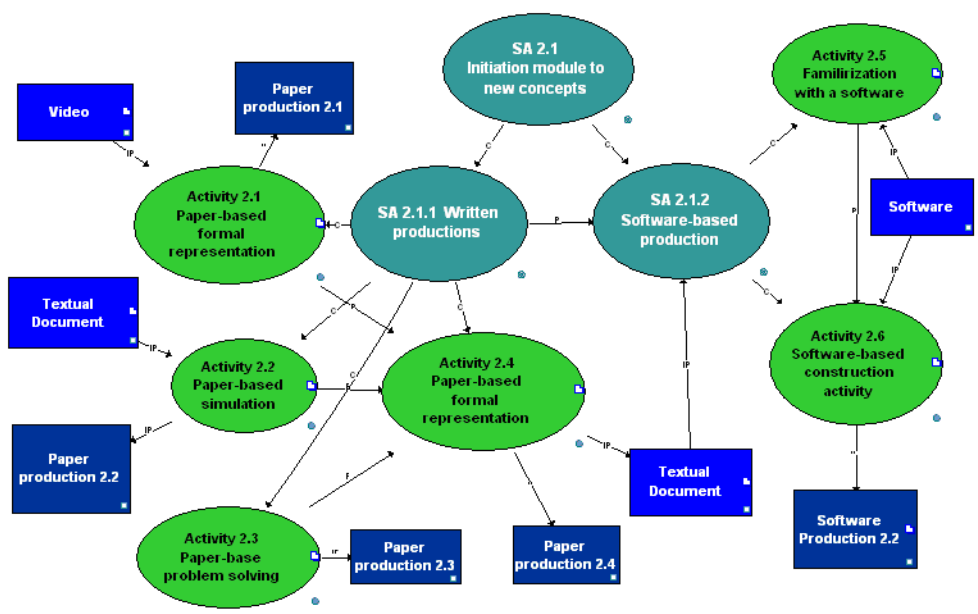
these UoL were stored as learning objects in the Canadian LD repository (Paquette, Marino, De la Teja, Lundgren-Cayrol, Léonard, & Contamines, 2005).[4] At this point the learning object repository can be searched for UoL templates to be combined into larger templates that are put back as learning objects in the repository. Finally, a new search can be done in the repository, this time for content or tool objects, to instantiate the scenario possibly in different subject matters. Let us review this use case in more detail.

1. Building a MOT+LD standard model for a course. Since the course was initially developed applying the MISA method, an MOT model was available. This model was imported directly in the MOT+ editor and adapted using the MOT+LD graphic objects and links presented above. If it had been a brand new course, the models would have been created directly in the MOT+LD editor, guided by the MISA method.

Figure 6 shows, on the right upper hand, the structure of the course, equivalent to the IMS LD's concepts Method, Play, and Acts. This course is divided into eight acts. The left-hand image represents an activity-structure within Act 2. In this activity structure, we show four learning activities leading to written productions and two other activities leading to software-based productions. In each activity, resources (rectangles) serve as inputs to help learners create the productions.

2. Obtaining a scenario template, as well as content and tool learning objects. In this phase of the process, the learning design model is made generic. This is done by just removing all the specific items in the graphic shown in Figure 6 that provide the resource URLs for activity assignments, texts, videos, and software tools in the scenario. The content and tool learning objects are stored in the learning object repository. These resources are replaced in the scenario graph

Figure 7. A MOT+LD generic scenario template

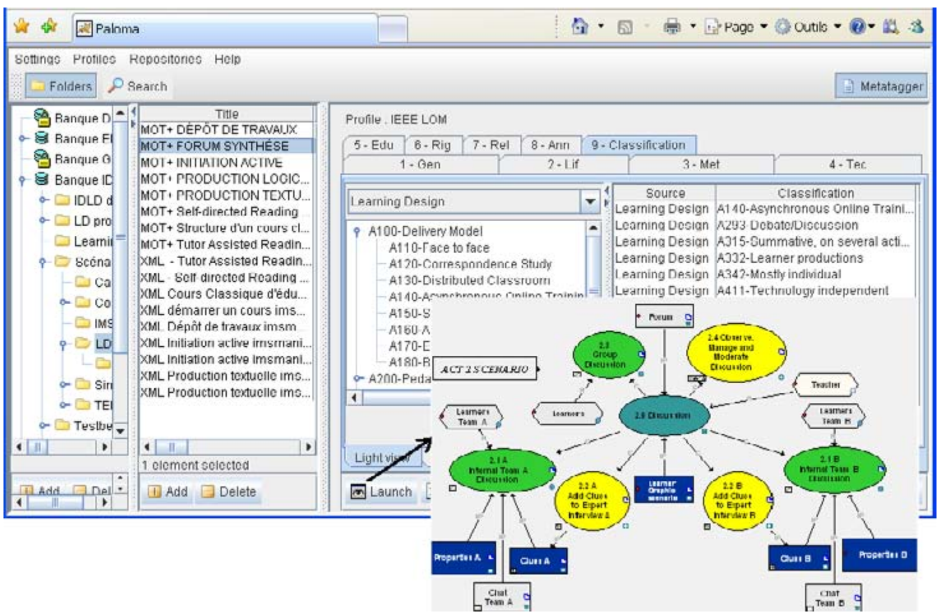


of Figure 7 by resource place-holders using generic terms, but free of specific Artificial Intelligence (AI) content. We then store this scenario template into the PALOMA repository, both as a XML Level A manifest file and as a MOT+LD graphical scenario.

Figure 8 shows a list of such templates referenced in the PALOMA learning resource manager. The left pane shows a list of repositories. The center pane presents the titles of a set of learning designs resulting from a search in the repository according to some metadata. The right pane presents the metadata of the selected object, here the Forum Synthesis scenario template is shown. By clicking on the button with an "eye," the MOT+LD model of this learning design can be displayed. It can then be selected to be used in the following steps where it will be aggregated with other LD templates and resources.

4. Recomposing new MOT+LD course templates. By recomposing the five basic templates obtained at the preceding step, it is possible to build a new unit of learning corresponding exactly to the course template produced in Step 2, which confirms the reusability of such templates. It is also possible to modify the structure to provide alternative plays, for example a course template with only five acts, or another with eight acts but with more difficult activities for more advanced students.
5. Instantiating a course template into different knowledge domains and contexts. Once a course template is obtained by grouping smaller grain templates, a search in the PALOMA repository will provide links to content objects (text, videos, etc.), tool objects (software), assignment texts, or learning objectives that can be associated

Figure 8. A set of learning design objects referenced in a PALOMA metadata repository



as items to the graphic LD objects in the model. For example, the initial artificial intelligence course structure, or another one built in Step 4 for another context, can be instantiated back into the AI knowledge domain using new AI resources. It can also be instantiated in completely different domains like politics or physics by selecting content, tools, assignments or learning objectives objects in these knowledge domains.

The interesting thing about this use case is that it shows how simple manipulations on graphic models can rapidly populate learning object repositories with learning design patterns (the generic scenario templates) as well as with content, tool, activity, and learning objective resources. Then using federated search in a network of repositories using a tool like PALOMA, it becomes possible to reuse, structure, and integrate all kinds of resources into new meaningful modules and courses that can be played directly on any IMS-LD compliant delivery system. This is a strong argument for the viability of the general approach presented here.

DELIVERY, IMPLEMENTATION, AND DISSEMINATION ISSUES

In this section the delivery, implementation, and dissemination issues that have emerged during the Implementation and Deployment of Learning Design project, IDLD,[5] are discussed. In this project we elaborated a general methodology for transposing, creating and adapting learning scenarios into fully compatible IMS-LD units of learning.

In the first phase, our research group's tools, documents, and expertise were used by three other teams besides Télé-université, at Concordia University, at Simon Fraser Universities, and also one at the Canada School of Public Service to build standardized learning designs. The two main standards needed here are the IMS Learning Design Specification and a metadata schema, in our case the IEEE LOM. This helped build, in the PALOMA Resource Manager, a repository of around 50 learning designs. The IDLD portal (www.idld.org) gives access to this repository as well as to the documents, methodological aids, software tools, and reference sites referenced during the project.

In a second phase, a test bed was carried out with new instructional designers distributed all over Canada to test the use of the IDLD repository and portal. This test bed yielded ample information not only on implementation and deployment issues, but also on the types of reuse that are potentially viable.

The implementation and deployment process that was elaborated during the experimentation is both collaborative and iterative. Face-to face events as well as e-mail and other communication services were used to support the participants. Moreover, several examples were available in the repository.

Throughout this process, the teams were involved in the following activities:

1. Familiarization: Explanation of the main IMS LD concepts and paradigms and the demonstration of MOT+LD editor.
2. Planning: Clarification of the context at hand and construction of a plan on how to best implement and deploy IMS Learning Design Specification.
3. Preparation: Analysis of existing courses with the following features:
    a. Constructivist or cognitivist learning paradigms.
    b. Collaborative learning strategies in a blended or online learning setting.
    c. Multi-actor design, making use of content/field experts, teachers, moderators, and so forth.
    d. Generic and/or easily adapted learning environment.

e. Ensure instructional quality by applying a known ID method, that is, MISA.

4. Implementation: Model building supported by mentoring activities and community exchanges through the following steps:
   - *Face- to-face workshop:* Participant training, where the objective was to explain the constraints required by the IMS LD specification and to demonstrate the MOT+ LD editor tool.
   - *Exemplification*: Presentation of IMS LD narratives, units of learning models and xml files.
   - *Drafting*: Elaboration of a first draft of a course.
   - *Face-to face workshop:* Validation of the initial model and a demonstration

Table 3. Issues, problem areas and effective principles for sustainability

Issue	Problem area	Principles
IMS LD Implementation and deployment	Pedagogical quality • Complexity of LD • Foreign to actual practices • Conceptual confusions – mixing pedagogy with delivery strategies	• Provide guidelines for the use of the IMS-LD concepts and the modeling editor. • Clearly explain the issues of reusability, such as – Technical interoperability and metadata tagging – Storing the learning object – Structured narrative of UoL • Involve the technological department in the project • Add a glossary of terms explicit enough to avoid confusion • Identify the new competencies required in this approach
Delivery process and tools	Technical Viability • Editors and authoring systems • Publishing tools Referencing • Learning a new technology	• Plan a minimum of a two day training session to develop autonomous LO designers • Make tools more transparent and intelligent • Provide a variety of examples including explanations on the process of adaptation
Reuse and Dissemination Issues	• Interoperability • Intellectual property and copyright • Usage data	• Be sure all installation requirements and other technical issues are documented in the metadata of the UoL • Provide evaluation criteria and adaptation principles to facilitate reuse • Introduce the Creative Commons[1] to protect illegal/unwanted use and secure authors • Provide usage data by annotation and recommendation.

of advanced features of the MOT+ LD editor.
- *Modeling Support*: Discussion of alternatives to the proposed solutions and continuous coaching in the modeling process.

5. Validation:
   - Exportation of the MOT+LD model as an xml manifest file, testing it in an IMS-LD compliant player, such as RELOAD Player.
   - Summarizing and documentation of impressions.
6. Referencing:
   - Publishing the Units of Learning and indexing them using a recognized metadata scheme.

Table 3 shows problem areas resulting from this experience as well as some principles that emerged in order to solve them.

In conclusion, the case studies and the testbed allowed identifying several important principles in order to ensure quality, viability, dissemination, and reuse.

RESEARCH TRENDS AND CONCLUSIONS

The work presented in this chapter shows that research in the field of technology enhanced learning has progressed rapidly in the direction of the goals we have mentioned in the introduction. On one hand, software engineering concerns such as formal specification, Reusability and interoperability have made their way in this community and are here to stay.

On the other hand, the problem of designing and delivering technology enhanced learning is now widely recognized as being a complex task in which different dimensions or concepts have to be modelled separately and harmoniously integrated. Either explicitly as in our four axes MISA method or more implicitly as in the IMS Global Learning Consortium specifications partition, researchers and practitioners are considering distinct but interrelated concepts such as: learning scenarios, knowledge and competency models, learner models, media, resources, or learning objects models, evaluation models, assistance models, and so on. This delimitation of concerns has allowed for a better understanding of these dimensions and a more precise specification of technological requirements both during design and, at delivery, allowing new technologies to be effectively tested and integrated into rich learning environments.

Where can we go from here? There is a lot of work still to be done. We will give examples of this by presenting some of the research directions carried out in at the CICE[6] Research Chair. The first very active orientation addresses the competency and knowledge models. Our team is actively working on the specification, modelling, and instrumentation of such models, as well as on the integration of these models to include competency modelling (Paquette, 2006; Ruelland, Brisebois, & Paquette, 2005) and ontology construction. The goal here is to enable semantic annotation and search (Rogozan & Paquette, 2005), as well as ontology-driven architectures (Magnan & Paquette, 2006). We are also exploring the concept of competency equations (Paquette & Rosca, 2004) to create the best configurations possible for learning activities, learning objects, and teaching support agents, in order to help a learner acquire a set of knowledge units and to develop adequate competencies.

A second direction is the work being done around the learner model, both from a cognitive and from a social perspective, a learner model should be evolving; it should integrate the perception of the different actors of the learning process and it should include the different learning domains and competencies of the learner (Moulet, Marino, & Hotte, 2006).

A third research direction concerns the learning scenarios. Starting from the work presented here on scenario modeling, decomposition, recomposition, and indexation, our work will follow-up the issues of learning scenario patterns, alignment of learning processes with working processes for in-work learning (Marino, Casallas, Villalobos, Correal, & Contamines, 2006), and design and delivery of process-oriented vs. community-oriented learning situations. From a software engineering point of view, our research concerns the design and development of ontology-driven learning platforms (Magnan & Paquette, 2006).

A fourth direction is focused on learning objects and resources. It involves partners from the GLOBE community on quality assurance strategies in learning object repository practice (Lundgren-Cayrol, Paquette & Lapointe, 2006). The goal is to identify and compare the elements of a quality assurance process that are applied by the major learning object repositories and propose an integrated process and instrumentation to ensure the quality of learning objects, before, during, and after their inclusion in a repository.

These research directions all converge to the advancement of TELOS (Paquette, Rosca, Mihaila, & Masmoudi, 2006), a service-oriented and ontology-driven assembly system to help build e-learning platforms and applications. These tools are also validated and explored in a number of tests beds and practical work in community building and support, such as the deployment and validation processes started in the IDLD project.

Our main points of a principled approach to construction and reuse of learning designs are:

- Use a recognized instructional engineering method to guide the design allowing taking all aspects of a learning design into account. Our MISA Method is a good example, where four models guide the designer:
    - Knowledge and Competency Model to constrain content and describe competencies to be developed;
    - Instructional Modeling to construct the instructional structure and describe learner and staff activities and resources;
    - Material and Media Model to identify type and delivery of a resource; and
    - Delivery Model to describe runtime behaviour, administrative resources and services.
- Employ editing tools to ensure high technical quality and interoperability.
- Semantically reference and store validated high quality Units of Learning both generic and specific to increase reusability.
- Increase the possibility of reuse by linking a textual description to each Unit of Learning.

REFERENCES

Bailey, C., Zalfan, M.T, Davis, H.C., Fill, K., & Conole, G. (2006). Panning for gold: Designing pedagogically inspired learning nuggets. *Educational Technology & Society*, *9*(1), 113-122.

Collins, A., Brown, J.S., & Newman, S.E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics! In L.B. Resnick (Ed.), Knowing, learning, and instruction: Essay in honor of Robert Glaser. Hillsdale, NJ: Erlbaum. Also in J.S. Brown, A. Collins, & P. Duguid (Eds.), Situated cognition and the culture of learning. *Educational Researcher, 18*(l), 32-42.

De la Teja, I., Lundgren-Cayrol, K., & Paquette, G. (2005). Transposing MISA learning scenarios into IMS units of learning. In C. Tattersall & R. Koper (Eds.), *Journal of Interactive Media in Education (Advances in Learning Design [Special issue]*. Retrieved April 7, 2008, from http://www-jime.open.ac.uk/2005/13/

Gagne, R. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart, & Winston.

Gerry, G. (1997). Granting three wishes through performance-centred design. *NATO Communications of the ACM, 40*(7), 54-55.

Griffiths, D., Blat, J., Garcia, R., Votgen, H., & Kwong, K.L. (2005). Learning design tools. In R. Koper & C. Tattersall (Eds.), *Learning design - a handbook on modelling and delivering networked education and training* (pp. 109-136). Germany: Springer Verlag.

Gustafson, K.L. (1993). Instructional design fundamentals: Clouds on the horizon [Special issue on instructional design fundamentals]. *Educational Technology: XXXIII*(2), 27-32.

IMS-LD. (2003). *IMS learning design*. Information model, best practice and implementation guide, binding document, schemas. Retrieved April 7, 2008, from http://www.imsglobal.org/learningdesign/index.cfm

Koper, R. (2005). An introduction to learning design. In R. Koper & C. Tattersall (Eds.*), Learning design - a handbook on modelling and delivering networked education and training* (pp. 3-20). Germany: Springer Verlag.

Landa, L.N. (1976). *Instructional regulation and control: Cybernetics, algorithmization and heuristics in education*. Englewood Cliffs, NJ: Educational Technology Publications.

Lemoigne, J.L. (1995) *Les épistémologies constructivistes.* France: PUF.

Lundgren-Cayrol, K., & Léonard, M. (2006). IDLD modelling technique. Retrieved April 7, 2008, from http://helios.licef.teluq.uquebec.ca/residld/2/MOT+LD_Modeling_Technique_1.0.doc

Lundgren-Cayrol, K., Paquette, G., & Lapointe, S. (2006, August 8-11). Quality assurance strategies for high quality learning objects. In *Proceedings of the 6th Annual MERLOT International Conference,* Ottawa, Canada.

Magnan, F., & Paquette, G. (2006, June). TELOS: An ontology driven e-learning OS. In *SOA/AIS-06 Workshop,* Dublin, Ireland.

Marino, O., Casallas, R., Villalobos, J., Correal, D., & Contamines, J. (2006). Bridging the gap between e-learning modeling and delivery through the transformation of learnflows into workflows. In S. Pierre (Ed.), *E-learning networked environments and architectures: A knowledge processing perspective.* Germany: Springer-Verlag.

Merrill, M.D. (1983). Component display theory. In C. Reigeluth (Ed.), *Instructional design theories and models.* Hillsdale, NJ: Erlbaum Associates.

Moulet, L., Marino, O., Hotte, R. (2006, November 8-10). Holistic, evolving and multi-viewpoints learner model. In *i2LOR-06 Conference*, Montreal, Canada.

Paquette, G. (1996). La modélisation par objets typés: Une méthode de représentation pour les systèmes d'apprentissage et d'aide a la tâche. *Sciences et techniques éducatives, 3*(1).

Paquette, G. (2002a). *L'ingénierie du télé-apprentissage, pour construire l'apprentissage en réseaux*. Canada: Presses de l'Université du Québec.

Paquette, G. (2002b). *Modélisation des connaissances et des compétences, pour concevoir et apprendre*. Canada: Presses de l'Université du Québec.

Paquette, G. (2004). *Instructional engineering for network-based learning.* USA: Pfeiffer/Wiley Publishing Co.

Paquette, G. (2006, November 8-10). Building graphical knowledge representation languages - from informal to interoperable executable models. In *Proceedings from I2LOR-06 Conference,* Montreal, Canada.

Paquette, G., Aubin, C., & Crevier, F. (1999, August). MISA, a knowledge-based method for the engineering of learning systems. *Journal of Courseware Engineering, 2*.

Paquette, G., Crevier, F., & Aubin, C. (1994). ID knowledge in a course design workbench. *Educationnal Technology, 34*(9), 50-57.

Paquette, G., De la Teja, I., Léonard, M., Lundgren-Cayrol, K., & Marino, O. (2005). How to use an instructional engineering method and a modelling tool. In R. Koper & C. Tattersall (Eds.), *Learning design - a handbook on modelling and delivering networked education and training* (pp. 161-184). Germany: Springer Verlag.

Paquette, G., Léonard, M., Lundgren-Cayrol, K., Mihaila, S., & Gareau, D. (2006). Learning design based on graphical knowledge-modeling [Special issue on learning design]. *Journal of Educational Technology and Society ET&S, 9(1)*, 97-112.

Paquette,G., Marino, O., De la Teja, I., Léonard, M., & Lundgren-Cayrol, K., (2005). Delivery of learning design: the Explor@ system's case. In R. Koper & C. Tattersall (Eds.), *Learning design – a handbook on modelling and delivering networked education and training,* Germany: Springer Verlag.

Paquette, G., Marino, O., De la Teja, I., Lundgren-Cayrol, K., Léonard, M., & Contamines, J. (2005). Implementation and deployment of the IMS learning design specification. *Canadian Journal of Learning Technologies (CJLT*). Retrieved April 7, 2008, from http://www.cjlt.ca/

Paquette, G., & Rosca, I. (2004, August 23-26). An ontology-based referencing of actors, operations and resources in e-learning systems. In *SW-EL/2004 Workshop Applications of Semantic Web Technologies for Educational Adaptive Hypermedia,* Eindhoven the Netherlands.

Paquette, G., Rosca, I., Mihaila, S., & Masmoudi, A. (2006). TELOS, a service-oriented framework to support learning and knowledge management. In S. Pierre (Ed.), *E-learning networked environments and architectures: A knowledge processing perspective*. Germany: Springer-Verlag.

Pitrat, J. (1991). *Métaconnaissance, avenir de l'Intelligence Artificielle.* Paris, France: Hermès.

Reigeluth, C. (Ed.). (1983). *Instructional theories in action: Lessons illustrating selected theories and models.* Hillsdale, NJ: Lawrence Earlbaum.

Rogozan, D., & Paquette, G. (2005, September 19-22). Managing changes to ontology versions to maintain referencing integrity on the Semantic Web. In *Proceedings from The 2005 IEEE/WIC/ACM International Conference on Web Intelligence*, Compiègne University of Technology, France.

Romiszowski, A.J. (1981). *Designing instructional systems.* New York: Kogan Page London/Nichols Publising.

Ruelland, D., Brisebois, A., & Paquette, G. (2005, October). Supporting self-assessment in a competency approach to learning. In *Proceedings from eLearn-05 Conference,* Vancouver, Canada.

Scandura, J.M. (1973). *Structural learning I: Theory and research*. London: Gordon & Breach.

Scandura, J.M. (1976). *Structural learning II: Issues and approaches*. London: Gordon & Breach.

Simon, H.A. (1981). *The sciences of the artificial.* Cambridge, MA: The MIT Press.

KEY TERMS

Competency: Present or target capacity of a group or an individual to perform a cognitive, affective, social or psychomotor skill with regard to certain area of knowledge and in a specific context. The context consists in defining whether the skill can be attributed to the knowledge in a guided or autonomous way, in simple or complex, familiar or new situations, in a global or partial, persistent or sporadic manner.

IMS Learning Design: A learning design is a description of a method enabling learners to attain certain learning objectives by performing certain learning activities in a certain order in the context of a certain learning environment. A learning design is based on the pedagogical principles of the designer and on specific domain and contexts variables (e.g., designs for mathematics teaching can differ from designs for language teaching; designs for distance education can differ from designs which integrate face-to-face settings).

Instructional Engineering: Instructional engineering is defined as a method for the analysis, design, development and delivery planning of computer-based learning systems, integrating concepts, processes and principles of instructional design, software engineering and cognitive modeling.

Knowledge Model: Set of knowledge of various types, facts, concepts, procedures, principles, skills, structured by the type of links representing the relationship among them.

Ontology: In the context of AI, we can describe the ontology of a program by defining a set of representational terms. In such an ontology, definitions associate the names of entities in the universe of discourse (e.g., classes, relations, functions, or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these terms. In this text we use it to describe logical relationships in an instructional system.

Plurimedia: A plurimedia material is a set of large grained digitized files delivered on different supports: print, CD-ROMs, DVDs, Web servers, and so forth. The emphasis on fine grained, closely structured multimedia, will decrease as designers prefer to interoperate existing videos, textbooks, courseware materials waiting to be digitized. Instructional engineering shifts the attention from multimedia micro-design to macro-design of learning scenarios integrating plurimedia materials reusing many available corporate documents and tools

Reusability: Reusability refers to the degree of flexibility of a learning object or design in the following aspects: pedagogically, culturally, technically and ergonomically. It indicates how it can be adapted to fit different target audiences and learning situations.

Sustainability: Sustainability refers to the idea that the Learning Object should have long-term viability for all concerned and meet provider objectives for scale, quality, production cost, margins and return on investment (Walker, 2005; Walker, Ed. A Reality Check for Open Education. Utah: 2005 Open Education Conference. Retrieved August 27, 2007 http://cosl.usu.edu/media/presentations/opened2005/OpenEd2005-WalkerEd.ppt

ENDNOTES

1. http://creativecommons.org/
2. Adapted from Paquette (2004, p. 107)
3. For more information please consult: IMS LD Best Practices, section 4.2. p.50-75, http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html
4. For more information see http://www.idld.org/
5. See http://www.idld.org
6. CICE is the Canada Research Chair on Instructional Cognitive Engineering to which all the authors are participating.

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Geraldine has over 30 years experience in education including 10 years as an academic developer where she has successfully conducted teaching and research on appropriate use of educational technologies for improving learning. In her role as vice president, Australasian Society for Computers in Learning in Tertiary Education (ascilite), Geraldine is coleading the research component for the development of the Carrick Exchange, a national higher education initiative to develop services and a repository for teaching and learning in Australia.

Michel Léonard holds a master's degree in andragogy and works as a research professional at the LICEF Research Centre, Télé-université as well as at the chair in instructional and cognitive engineering, CICE. Since 1994, he has participated in the design, development, and validation of methods of instructional engineering, knowledge, and competency modeling techniques, modeling tools, learning design tools, preparation, and delivery of training for development and knowledge/competency transfer projects.

Allison Littlejohn is professor of learning technology and director of the Caledonian Academy at Glasgow Caledonian University (www.academy.gcal.ac.uk). Allison leads a range of research and professional development initiatives on learning innovation. In 2003, she published the first international textbook on sustainable e-learning: *Reusing Online Resources*. Along with Chris Pegler (UK Open University), Allison recently launched a new book series for Routledge (www.connecting-with-elearning.com) and co-authored *Preparing for Blended Learning*. Allison is a fellow and former associate scholar of the UK Higher Education Academy, where she co-chaired the UK Forum on Supporting Sustainable eLearning. In 2005 she was awarded the first ASCILITE scholarship.

Oleg Liber is professor of e-learning and director of the Institute for Educational Cybernetics at the University of Bolton. He is also Director of the national JISC Centre for Educational Technology and Interoperability Standards, advising and supporting the UK higher and post-16 education sectors on developments in educational technology, and representing the UK on relevant international standards bodies. He has led a number of major development projects, including the Colloquia learning environment and RELOAD, the authoring and runtime system for developing interoperable educational software. His research interests are in the application of concepts from cybernetics to help understand educational institutions and systems.

Lisa Lobry de Bruyn is a senior lecturer, and has been involved in teaching many areas of natural resources at tertiary level in University of New England, Australia, since 1993. She holds a Bachelor of Science (Honours 1st Class) and a PhD from the University of Western Australia and a Certificate in Higher Education from University of New England. Her innovative teaching methods have been recognised and showcased in four Australian University Teaching Committee grants. She is author of over 75 journal and conference papers encompassing a wide range of interests including soil agro-ecology, soil condition monitoring, ethnopedology, natural resource management, and teaching and learning practice. As a university lecturer, she is committed to engaging with students in the process of learning and for them to realise their full potential as graduates and to approach life's challenges with confidence and wonderment.

Kate Lowe is a lecturer in educational design and educational development in the Teaching and Learning Centre at Murdoch University (Western Australia). Kate works as an educational designer within the Teaching and Learning Centre. Her primary role is to provide support for flexible learning initiatives. Kate has worked in learning materials development in a range of media. She has substantial experience in educational design of interactive learning materials and in the management of development projects.

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Karin Lundgren-Cayrol holds a PhD in educational technology and specializes in online collaborative learning, educational modeling techniques, learning object repository development, interoperability standard implementation, and media. For the past 12 years, at LICEF, she has been involved in educational, corporate, and governmental applications. She has participated in various Canadian and European initiatives to implement international interoperability standards, such as Canada's E-Learning Quality Guidelines, CanCore, Normétic, UNFOLD, and IDLD. She is presently leading the Q4R (LO Quality for Reuse) project in collaboration with members of the GLOBE International Consortium.

Olga Mariño holds a PhD in artificial intelligence. She was cofounder and codirector of the laboratory of research and development in information technologies for education, LIDIE at University of Los Andes, Colombia, for more than a decade. She is a principal investigator of LORNET. Her recent research concerns workflow and learnflow alignment, e-learning, learning objects, and knowledge management. Her online course on knowledge management won the Price of the Minister of Education of Quebec (2005), Olga is member of the Excellence Circle of the University of Quebec.

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Elizabeth Masterman has over 10 years' experience researching and evaluating learning technologies at all educational levels, having previously worked for 15 years in the commercial IT sector. She is currently researcher and evaluation specialist with the Learning Technologies Group, Oxford University Computing Services. Since 2004, she has worked on a number of externally-funded projects investigating the tools and processes involved in designing for learning, and also has a longstanding interest in the integration of cognitive and sociocultural approaches in the design and evaluation of e-learning.

Robert McCormick has worked on courses on curriculum, assessment and learning, and on ICT in the classroom. He has directed research projects in technology education: studies of problem solving, the use of mathematics in Design and Technology, and of electronics in the curriculum. He has studied the use of ICT research evidence to inform policy, evaluated of the use of digital material in European classrooms (CELEBRATE) and peer-to-peer review of the use of ICT in schools. He recently codirected a research project learning how to learn—in classrooms, schools, and networks—and directed an evaluation of the UK National College for School Leadership online environment.

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Dominique has over 20 years experience in education and has successfully managed and conducted teaching and learning research and development in relation to projects for the higher education sector. Dominique has managed the stage 1 and 2 Australasian Society for Computers in Learning in Tertiary Education (ascilite) research subprojects for the development of the Carrick Exchange. She has undertaken research: to identify and evaluate key success factors and issues in the use of digital repositories for enhancing teaching and learning; and into user engagement, resource identification, and contribution and peer review and commentary to inform development of the Carrick Exchange.

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Margaret Turner is a writer and visual designer, lecturing in electronic media design at University of the Sunshine Coast, Australia. Her research concerns the effects electronic and networked media is and will have on communication and its meanings. Turner believes that haphazard change characterizes the way meaning is being made in such places as YouTube, Myspace, and other community blogs. Turner advocates that academics, who have vested interest in meaningful communication, begin to consciously observe and change the way they construct their meanings to suit the networked environment and thus begin the evolutionary process of developing new ways of managing meaning to suit the unique characteristics of the medium. In this, Turner believes we both learn from the students who occupy the space so well and model for them new methods of academic writing for networked media. Turner's most recent published article is "Transitional Movement: Value-Adding Animation Design," *International Journal of Learning* (Vol. 14, Issue 2, 2007).

Sandra Wills is director of the Centre for Educational Development & Interactive Resources at the University of Wollongong and holds a chair in educational development. In the past 30 years she has authored more than 200 publications and educational products as well as attracted over $10 million in grants. She is a fellow of Australian Computer Society (1991), a fellow of Australian Council for Computers in Education (2002) and received a Silver Core Award from International Federation for Information Processing (1995).

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Kirsty Young is a lecturer in the Faculty of Education at the University of Technology, Sydney. She teaches in a range of research perspectives and methods subjects at the undergraduate and postgraduate levels. Her research interests include informal learning facilitated by technology and the nature of online language and communication. As a member of the Faculty's Designs for Learning Research Cluster, she is currently involved in the development of projects examining the effects of Web 2.0 technologies on learning and her role on the UTS Human Research Ethics Committee has developed a strong interest in the ethical implications of online research

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