MOVING FROM THEORY TO PRACTICE IN THE DESIGN OF WEB-BASED LEARNING USING A LEARNING OBJECT APPROACH

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Abstract

This paper describes the design of a web-based learning module. The aim in the design was to operationalize the concepts of granularity, reusability, scalability, and interoperability as they relate to learning objects. The prototypical module was designed for contexts where identifying and solving ill-structured problems is relevant. The module consists of an aggregation of learning objects including video segments, a bibliography and discussion forum activities. The module specifies an instructional sequence through reliance on a problem-solving model. Two rounds of module testing using WebCT™ were conducted. The module represents one perspective on operationalizing concepts related to learning objects.

Keywords: instructional design; learning objects; computer-mediated communication; architectures for educational technology systems.

Introduction

While the imperative to provide e-learning opportunities may well loom large, the process of designing online content remains cost- and time- intensive. For example, in relation to course development at the post-secondary level, Boettcher (1999) estimates that about 18 hours of faculty time are needed to create one hour of web instruction. Schrum (1998) claims that online course creation takes two to three times as long as creating a face-to-face course. Bates' (2000) estimation of costs for the creation of an entire course is of 30 days for the content expert's time with additional time required for interface design. The development of digital repositories of granular, reusable, scalable and interoperable learning objects aims to address some of the challenges

associated with e-learning such as cost, infrastructure and quality (South & Monson, 2000). These objects will have the capacity to function on many operating systems or in many disciplines with any number of learners in any learning contexts with a minimal degree of increased requirement for temporal, human or financial resources.

Learning objects are any digital resource that can be reused to support learning or "instructional components that can be reused a number of times in different learning contexts" (Wiley, 2000a, p.3). Chitwood, May, Bunnow and Langan (2000) refer to learning objects as "self-contained, reusable, high-quality learning chunks that can be combined and recombined in courses, learning activities and experiences, and assessments that meet a learner's immediate needs" (p.1). Objects can be "small bits of text … animations, and smaller web-delivered applications, like a Java calculator" as well as larger resources such as "entire web pages that combine text, images and other media or applications to deliver complete experiences, such as a complete instructional event" (Wiley, 2000a, p.7).

Numerous attributes of learning objects have been discussed in the literature including "durability, interoperability, accessibility, reusability, discoverability, extensibility, affordability, and manageability" (South & Monson, 2000). Williams (2000) identified from the literature what he refers to as "criteria for learning objects" (p.19) such as reusability, repurposability, granularity, and the "ability to adjust to the needs of the context in which they are being used" (Ibid.). Wiley (2000a) refers to objects as having the potential for reusability, generativity, adaptability and scalability.

Wiley (1999) argues that reusability and granularity represent "the two most important properties of learning objects" (p.2). The concept of granularity is evoked frequently in the literature to emphasize a conception of objects as fine units or 'grains' than can be combined or aggregated in varying ways. The concept reminds us that while an object can serve a purpose on its own, it also has the capacity to be aggregated with other objects. South and Monson (2000) argue that reusability is largely a function of the degree of granularity of the objects. The more granular an object is, the more it becomes reusable. Reusability is at the core of the objet concept since, as Wiley (2000a) argues, all the "ivities such as generativity and adaptivity, are “facilitated by the property of reuse" (p.12). Scalability and interoperability are also key attributes of objects. An object that is scalable and interoperable

allows for an increase in the capacity to function in many disciplines with any number of learners in any learning contexts on many operating systems with a minimal degree of increased requirement for resources.

In theory, the concept of learning objects as well as the attributes of granularity, reusability, scalability, and interoperability appear well defined. However, from the perspective of practice and the design of learning objects, it is less clear how the concept and these attributes actually translate into courses or modules that can be used for instructional purposes. As Wiley (2000b) argues, there appears to be "little conversation around the instructional design implications of learning objects" (p.9). Yet, information about how the objects should be instructionally sequenced is extremely important for their effective use (Hodgins, 2000) and instructional strategies "must play a role in the application of learning objects if they are to succeed in facilitating learning" (Wiley, 2000b, p.9).

It was in consideration of these issues that a research and development project was undertaken to design a learning experience that would illustrate how the attributes of granularity, reusability, interoperability and scalability might be operationalized. The experience would also illustrate a way in which objects could be instructionally sequenced. The remainder of this paper describes this project, the theoretical framework on which the design was based, the design results, and the results of two rounds of testing and one iteration of redesign. The following section illustrates the framework related to the four attributes that informed the design of the learning experience.

Design framework

This section presents the theoretical framework that informed the design. It outlins the concepts or attributes of learning objects as follows: granularity, reusability, scalability and interoperability. The purpose of the section is to consider how the attributes have been characterized in the literature on learning objects. The paper subsequently illustrates how these attributes were operationalized in the design of a web-based learning experience.

Granularity

Granularity in the context of learning objects is often used to refer to the size of an object (see Wiley, Gibbons & Recker, 2000; IEEE, 1998). The term can also refer to the level of aggregation of an object with the smallest level being

that of a picture and the largest being a "set of courses that lead to a certificate" (IEEE, 2002). Wiley et al. (2000) relate the concept to the need to "'pre-deconstruct' instructional media in order to increase the efficiency of instructional design" (p.2). Deconstructing occurs by creating units of fine granularity that could subsequently be combined with other units of similar although not necessarily identical levels of granularity. According to the authors, in the "course hierarchy", a full course would be the largest grain size contrasted with an image that would constitute the smallest grain size.

Quinn (2000) argues in favor of promoting a finer level of granularity than that of a course in order to ensure a "greater potential for reuse of objects". Porter (2001) describes the notion of modules or modularity as key to providing flexibility for learners in the use of objects. We can use South and Monson's (2000) description to characterize a learning module as "granular enough to be useful in a variety of contexts, but aggregated enough to provide a robust exploration of multiple facets of a single concept" (p.1). Designing learning around a module concept as opposed to a course concept allows us to move from the "traditional course-building approach" to that of "building blocks concept" (Ibid.). Merkel, Seeberg and Steinmetz (2002) argue that "modularization of courses and course building elements as objects are essential for reusability" (p.1).

Reusability

Cisco Systems,Inc. (2000) adopts use of the term Reusable Information Object or RIO, which they describe as a "granular, resuable chunk of information that is media independent … [and] can be developed once, and delivered in multiple delivery mediums" (p.2) such as via the web, on CD-ROM or in instructor-led training materials. It can be "combined to form a larger structure called a Reusable Learning Object (RLO)" (p.2.) or a lesson. Socrates Learning Systems (2002) defines three types of reuse: to share, meaning "to use again, with little or no special treatment", to multipurpose, meaning "to use again, especially after special treatment or processing permitting reuse across mediums" and to repurpose meaning "to use again, especially after special treatment or processing permitting reuse across mediums and audiences" (p.1).

This last reference to the concept of reusability highlights some of the distinctions that might be made in relation to the reuse of an object. As Wiley

(1999) indicates, "…one of the major interests in learning objects is their ability to be used more than once" (p.2). However, there is a distinction to be drawn between the reusability and repurposability of learning objects. Reusability can be described as "the ability to take a learning object as is and reuse it wholesale" whereas repurposability refers to "the ability to extract portions of a learning object and adapt them to new learning contexts" (Ibid.). A further explanation of the importance of and distinctions between these concepts is provided by the Broadband Enabled Lifelong Learning Project (2003):

> Typically, an educational object is created for the use of the creator and is not always extensible beyond the context for which it was produced. For example, a CD-ROM on geophysics may be designed for use in a specific course, but only parts of it will be useful elsewhere (…) Content repurposing allows learning objects to become customizable and thereby promotes their reuse. Designing and developing educational material in a manner that allows the customization, editing and adaptability to learner needs is key to providing cost effective, sustainable, and high quality educational materials. (BELLE, 2003.,p.1)

Interoperability

In many cases, in order for a learning object to be usable by different types of audiences in different contexts, it should function across a wide variety of hardware, operating systems and web browsers. Porter, Curry, Muirhead and Galan (2002) refer to interoperability in relation to objects being usable across provinces and internationally. Porter (2001) describes interoperability as follows:

> Interoperability is a requirement for systems that manage granular learning objects. It is the retrieval and transfer of the media assets from within the systems to new delivery environments and to learners and customers that adds value to them. Learners and other education clients are in a better position to use an education provider's products when they observe platform-independent standards and can be confident that the learning materials that they acquire will work with their own systems. Content can be delivered for different client groups through open source delivery environments such as Linux, or be transformed electronically to proprietary systems such as WebCT or PLATO. (p.50)

In the case of a learning module designed to be interoperable, as Porter indicates, it will operate on different learning management systems such as WebCT™ , Blackboard Learning System™ , TopClass™. All objects within the module should as well be interoperable. For example, if the module contains video segments, they will ideally be viewable with a variety of plugins such as RealOne Player™, Windows Media Player™ or Quicktime Player™.

Scalability

Gibbons, Nelson and Richards (2000) describe scalability as the "…production of quantity at specified levels of quality within specified time and resource constraints. It also requires an increase in productivity without a proportional increase in production cost" (p.49). In computer terms, scalability is described as "…[t]he capacity to serve additional users or transactions without fundamentally altering the application's architecture or program design"(InfoWorld Media Group, Inc., 2001). Scalability refers to the ability of a system to maintain, if not improve, its average performance as the number of clients grows (Espisito,2001). Scalability can also be described as "the property of reducing or increasing the scope of methods, processes, and management according to the problem size" (Laitinen, Fayad &Ward, 2000, p.107).

A scalable module is described for the purposes of this paper as one that could be easily adapted for use with different sizes of groups. In the case of a learning experience designed for practitioners, we can imagine it able to be used with a group of 10 users or a group of 30. The more scalable the product, the wider the range of users with whom it might be used.

The design

The goal of the project was to operationalize concepts related to learning objects through the design of a web-based learning experience for practitioners. In this sense, the attributes become features that the designer will aim to highlight in the design. The features aimed for in the design were:

- Granularity facilitating aggregation with other modules or inclusion in other learning experiences such as a course.
- Reusability with a different group of learners and/or with learners in varying disciplines.
- Scalability allowing use with large or small groups of learners
- Interoperability in a wide variety of technical contexts i.e. with different operating systems, browsers, plugins, connection speeds.

The objective was to create a granular learning module that constitutes a self-contained learning object but that can also be integrated with other objects. To ensure that the final product was interoperable required a selection of tools commonly found in learning management systems. Reuse required designing an experience that is sufficiently contextualized to be relevant and meaningful and yet sufficiently broad that it can be adapted for use in other contexts. Scalability required designing activities to accommodate a range of size of users or groups.

A modular- as opposed to a course- approach was adopted for the design of the learning experience. The module can be defined in temporal terms representing the equivalent of approximately 12 hours of classroom instruction. The module was named *Solving Problems in Collaborative Environments* (SPICE) and is designed for a context of use where ill-structured problem-solving is the focus of learning. This type of focus might be relevant with teachers, nurses, social workers or, as well, in a context of organizational learning where individuals are being trained to solve workplace or management problems.

The module consists of an instructional sequence of activities structured around a problem-solving model to guide users through the learning experience. The module represents an aggregation of seven objects in HTML format, one object in JPG format that can be embedded in one of the HTML pages and a set of thirty video segments. The description of the problem itself constitutes an object in HTML format. The problem-solving model constitutes another object and prescribes the instructional sequence through a series of phases. The model consists of three phases of Consult, Gather and Act. Each of these phases is represented by one object in HTML format. In between each of these phases is a Reflection. The latter phase is represented in an HTML page that links to an online asynchronous discussion forum. The ACT phase relies on a link to a shared workspace that supports learners' upload of documents. The 30 video objects are accessed from the Consult Phase, HTML page. These are available in RealPlayer™ format requiring a real media player and in .avi format on a CD-ROM. The module is summarized as follows:

Table 1: SPICE learning module

Number of objects	Type	Title of object	Format
1	Diagram	SPICE: Problem Solving Model - Diagram	JPG-Image
1	Description of model	SPICE: Problem Solving Model – Description	HTML-Web Page
1	Consult Phase	SPICE: Problem Solving Model - Consult Phase	HTML-Web Page
1	Gather Phase	SPICE: Problem Solving Model - Gather Phase	HTML-Web Page
1	Act Phase	SPICE: Problem Solving Model - Act Phase	HTML-Web Page
1	Reflect Phase	SPICE: Problem Solving Model - Reflect Phase	HTML-Web Page
1	Bibliography	SPICE: Problem Solving Model- Gather Phase - Bibliography	HTML-Web Page
1	Problem Description	SPICE: Problem Solving Model – Problem Description	HTML-Web Page
30	Video segments	SPICE: Consult Phase - Video segments	Video in streamed & CD-ROM formats

The last three items are separated from the others in the table because, unlike the other objects in the module, these objects require customization to match the problem chosen for the module. The bibliography, problem description, and video segments must be recreated each time a different problem is chosen. For example, in one context, the module could be used with a group of French teachers in training. In this case, the problem set in advance in the module might be the problem of using the target language during instruction. The description of the problem would identify and introduce this problem as the focal point for the learning experience. The bibliography of readings would then be designed to match this problem by presenting links to research on this topic. Finally, the video segments might feature French

teachers in practice talking about how the problem manifests itself in their context. In another case, assuming the module were to be used with a group of nurses undergoing a professional development experience, the problem chosen might be ethical issues related to the confidentiality between patient and nurse. Again, the description, bibliography and video segments would be customized to match the problem.

The 12-hour module is designed to be completed independently by the learner. In this regard, an instructor or moderator is not required to guide learners through the modules phases and activities. The module does not present or prescribe any evaluation or assessment techniques. Th intent of the design is to accommodate multiple contexts for learning. This perspective recognizes that learners in a professional development context may provide self-assessment of learning. Use of the module in the context of university course could be accomplished by submission of the learners' output in the module to the course instructor.

Testing of the design

Testing of the first iteration of the design required choice of a context of use and subsequent customization of three of the module's objects: the problem description, bibliography and the set of video segments. The context of use was that of French teachers in training. The problem chosen was the one described in the previous section of this paper and which involved using French as the language of instruction in the French as a second or foreign-language classroom. A group of eleven teachers in training agreed to participate in the testing of the module. These teachers were enrolled in a French as a second-language methods' course in an undergraduate university degree program. Prior arrangements were made between the course instructor and the researcher so that the module could be incorporated into the course as a unit that could be used by those who volunteered for the testing. Participants completed the learning experience on their own and submitted to the instructor all work and contributions completed during the experience. The instructor then evaluated this work as part of the students' evaluation for the course. Those in the course who did not opt to volunteer to participate completed a different evaluation exercise designed by the instructor and which counted for an equivalent percentage of the total course evaluation.

WebCT™ learning management system was used for the testing as the university where the teachers were enrolled held a license to this system. The testing process included online monitoring of participation in the experience by the researcher and her assistant, ongoing response to problems or questions that arose during the experience and follow-up, semi-structured interviews with the participants. The purpose was to determine the usability and feasibility of the design and to reveal any potential problems or flaws.

The testing of the module revealed that, overall, participants described the learning experience in positive terms. However, viewing the videos presented significant technical problems and frustrations. Comments concerning the use of the video segments related to technical problems with use of the video plugin required for their viewing. The video was streamed from a server on which there was only a license RealPlayer™. Participants could not opt to use other players. Comments related to the video included: "I wasted a lot of time trying to figure it out, especially with RealPlayer", "It wasn't accessible enough. I don't understand why RealTime (sic) had to be used. I thought any video program would do such as Windows Video", "I tried to download it at the lab but I was not allowed. I have a dial-up account at home so it took about ½ hour to finally download it there".

Participants' comments revealed a problem with interoperability in the design. However, it was not possible to provide access to the streamed video in a variety of formats to accommodate different technical contexts because the university in which the testing was being conducted held a license to only one streamable format. Participants also experienced technical difficulties in the use of the shared workspace linked to the Act phase which required them to load up a document representing a concrete solution to the problem featured in the module. The shared spaced dictated that the document had to be in HTML format and had to be titled in a specific way in order to be viewable by other learners in the module. In spite of explicit instructions, participants sometimes inadvertently saved their file in .HTM (as opposed to .HTML) format or, in other cases, in wpd.htm format etc. The result was that their document was not viewable.

Following this first round of testing, the module was redesigned. In this second design, the video was made available to users in two formats: streamable and on CD-ROM. Additional instructions and support were provided for the Act phase to make it easier for users to upload documents to

the shared space. The second round of testing was with a group of 30 users. Scaling use of the module in this way did not require any change to the module itself. However, the discussion forum used in conjunction with the module was structured in advance (unlike with the group of ten in the first round of testing) so that the learners were placed into discussion groups of ten learners each. This strategy was adopted to ensure that the discussion was manageable for the learners in terms of the amount or number of postings that they would be required to read. Each learner was required by the module to make nine postings in a 12 hour period spread over four weeks. With ten learners per group, the total number of postings was a minimum of 90 whereas it would have been a minimum of 270 had the 30 participants not been grouped. All other features of the module remained the same.

Results of the testing revealed that that participants encountered few or no problems with accessing the video. The grouping of students in the discussion forum generated positive reactions from participants. One participant commented as follows: " I liked the discussion forum, itself. It was just small enough that I could read what everyone else said. If it were any larger, though, it would have been too big." Another individual remarked as follows:

> I think the size was really good – not too big and not too small. We got a lot of feedback, but it wasn't too much. I found it was good that at least one person would respond to what you said. If it were any bigger, I think there would have been too much repetition and people would have started saying the same things.

The use of the shared space on the other hand generated some negative comments in spite of changes in the design such as the additional support and instructions. One participant remarked as follows: "The only thing I would say about organization would be the attaching of the activities. I had so much trouble figuring out that simple procedure. I should have asked for help earlier, I realize." Another individual noted regarding the shared space: "That was tricky. I kept adding ".doc" to the file name, along with the ".html". Such a simple thing, but I couldn't get it."

Discussion of the design

The discussion of the design is structured around the four attributes of granularity, reusability, scalability and interoperability. The features of the design as well as the results of the testing and redesign are discussed in

order to gain insight into how the attributes of learning objects were operationalized in the learning experience.

Granularity

The module represents an object that is sufficiently small that it could be used in the context of a course or aggregated with other modules to form a course on its own. The testing of the module in the context of a course verifies its capacity to be successfully aggregated with other learning elements. The module represents the equivalent of approximately 12 hours of classroom instruction with the assumption that a post-secondary course at a given institution might, for crediting purposes, represent 36 hours of classroom time spread over a 12-week period. According to this assumption, potentially, an individual could select a module as a learning object and combine it with two others to form the equivalent of one course. However, the module could have been designed on the basis of a different amount of time such as 18 hours with the aggregation of two modules constituting the equivalent of a course. Given a bank or repository of a large number and variety of modules, a user might choose to combine varying modules in order to form the equivalent of a course or the smallest crediting unit of the institution or organization. The module could also be used independently as a professional development learning experience.

Reusability

The module was used in this case with a group of French teachers in training. The problem presented in the module was designed to be usable with teachers in practice as well. Use of the module in a different context for different purpose such as with nurses or social workers requires customization only of certain aspects of the module. The instructional sequence and the way in which the objects are aggregated remain the same. An instructional designer responsible for the preparation of course or course modules in a variety of disciplines such as education, nursing, social work and business could reuse the module for a different purpose by customizing the discipline specific aspects such as the problem, the bibliography and the video. To save effort and costs, audio segments could be substituted for the video segments.

Scalability

Testing was conducted with two groups - one being three times larger than the other. The module itself did not require any changes to accommodate a

larger group although it was necessary to impose a structure on the discussion forum in order to accommodate a larger group. If the user of the module e.g. the instructor of a course wanted to add more groups, there would be no effect on the module's design nor would there result any difference in the experience of the learners. Grouping learners in the forum means that a private discussion takes place only between those who have been assigned as members to that group. If the shared workspace of the learning environment e.g. WebCT did not support grouping (WebCT does support it), learners could be directed instead to present their products of the ACT phase as an attachment to a message which they could post in their group in the discussion forum. As long as the learning environment in which the module is being used features a discussion forum and shared workspace that allows grouping and private members, the module could be scaled to any number of users.

Interoperability

As the first testing of the module showed, interoperability of the video segments was low since these could only be used with one type of software i.e. RealPlayer™. The second round of testing showed, on the other hand, that provision of the video in CDROM format met the needs of all thirty users. In this case then, interoperability was met by relying on the concept of redundancy or by providing a choice to users. In the second round of testing, some learners made use of the streamed video while the majority preferred the CDROM format. However, both formats were available to users thus facilitating operability in varying technical contexts with different computers. Where the level of interoperability might be considered lower is in the module's reliance on a discussion forum. The learning environment in which the module is used requires a discussion forum. However, given that the more commonly used learning environments in education today do include a discussion forum, this requirement is unlikely to be an issue. Furthermore, discussion forums such as those found at Google and Yahoo could support a private discussion.

The module's requirement for use of a learning environment supporting a shared space still requires redesign. The difficulty with use of the shared space is specifically a problem with the module per se. However, the module does rely on this shared workspace or a mechanism to upload documents. A subsequent redesign of the module could place reliance for the uploading of files on the discussion forum instead of on a shared workspace.

Conclusion

Moving from theory to practice demands operationalization of concepts that normally reside in an abstract realm. Transposing the abstract into the concrete has the benefit not only of practical use but also of clarifying and further defining concepts and principles. The growing body of literature related to learning objects continues to grapple with defining and clarifying its premises and concepts. However, these concepts remain little more than reifications unless they can be defined through instances or examples derived from actual application and usage in real contexts. Such was the goal of the project described in this paper: to operationalize concepts such as granularity, reusability, scalability, and interoperability. The project provides only one contribution to presenting instances or examples of the operationalization of the concepts and principles. It is possible that these terms could take on somewhat of a different meaning when used to design a learning experience different from the one described in this paper. The more examples we can provide of instances of the use of the concepts and attributes, the closer we will come to understanding what they can actually mean in practical terms for teaching and learning. Ultimately, it is the practical context of use that counts.

The design of the module represents a preliminary attempt at moving from theory to practice in the use of learning object approach. Further testing of the attributes of learning objects in a variety of contexts would contribute to our understanding of notions of interoperability, reusability, granularity and scalability. Research into learning objects is contributing to our capacity to keep pace with demands for e-learning in particular. Nonetheless, the challenges and imperatives remain to put into practice the results of our thinking and theorizing in order to make good on the promise of truly advancing the practice of teaching and learning.

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References

Bates, A. (2000). *Managing Technological Change*. San Francisco: Jossey-Bass Publishers. Retrieved January 08, 2003, from: http://mlg-gam.ic.gc.ca/sites/acol-ccael/en/report.html

Boettcher, J. (1999). How Much Does It Cost to Develop a Distance Learning Course? It all Depends.... *Corporation for Research and Educational Networking (CREN).* Retrieved November 08,2002, from: http://www.cren.net/~jboettch/dlmay.htm

Broadband Enabled Lifelong Learning Project. (2003). Content repurposing. Retrieved December 22, 2003, from: http://belle.netera.ca/info_repurp.htm

Chitwood, K., May, C., Bunnow, D., & Langan, T. (2000). Battle stories from the field: Wisconsin online resource center learning objects project. In D. A. Wiley (Ed.), *The Instructional Use of Learning Objects: Online Version*. Retrieved November 23,2003, from: http://reusability.org/read/chapters/chitwood.doc

Cisco Systems, Inc. (2000*). Reusable Learning Object Strategy: Definition, creation process and guidelines for building*. Version 3.1. Retrieved June 06,2003, from: http://www.cisco.com/warp/public/10/wwtraining/elearning/implement/rlo_strategy_v3-1.pdf

Espisito, D. (2001). Scalability, Sweet Scalability. Retrieved January 2,2003 from: http://www.msdn.microsoft.com/library/en-us/dndive/html/data03082001.asp

Gibbons, A., Nelson, J. & Richards, R. (2000). The nature and origin of instructional objects. In D. A. Wiley (Ed.), *The Instructional Use of Learning Objects: Online Version*. Retrieved November 06,2003, from: http://reusability.org/read/chapters/gibbons.doc

Hodgins, W. (2000). *Into the Future: A Vision Paper.* Commission on Technology and Adult Learning. Retrieved November 06,2003, from http://www.learnativity.com/into_the_future2000.html

Institute of Electrical and Electronics Engineers. (1990). *IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries.* New York, NY.

Institute of Electrical and Electronics Engineers. (1998). IEEE Learning Technology Standards Committee (LTSC) Learning Object Metadata Dictionary v2.1. Retrieved October 25, 2003 from: http://ltsc.ieee.org/doc/wg12/LOMdict2_1.html

Institute of Electrical and Electronics Engineers. (2002). IEEE learning Draft Metadata version. Retrieved October 25, 2003 from: http://jtc1sc36.org/doc/36N0255.pdf.

InfoWorld Media Group, Inc., (2001). Designing High-Performance Scalable Web Applications: What is Scalability? Retrieved January 2,2003 from: http://www.infoworld.com/suppsad/loudcloud3/t_lc1.html

Laitinen,M., Fayad, M., Ward, R. (2000). The Problem with Scalability. *Communications of the ACM.* Vol. 43, No. 9.

Merkel, O., Seeberg, C. & Steinmetz, R. (2002). Choosing an Online Learning Platform focusing on Reusability of Learning Objects and its Implications for Comparison Schemata Design. In *Proceedings of ED-MEDIA 2002*. Association for the Advancement of Computing in Education (AACE).

Porter, D., Curry, J., Muirhead, B., Galan, N. (2002). *A report on learning object repositories: Review and recommendations for a Pan-Canadian Approach to repository Implementation in Canada*. Canarie and Industry Canada and the TeleLearning NCE.

Porter, D. (2001).Object lessons from the web: Implications for Instructional development. In G. Farrell (ed.). *The Commonwealth of Learning: The Changing Faces of Virtual Education*.(pp. 47-63).The commonwealth of learning: Vancouver,BC.

Quinn, C. (2000). Learning Objects and Instruction Components. International Forum of Educational Technology & Society: Formal Discussion Initiation. Retrieved October 20, 2003, from: http://ifets.ieee.org/discussions/discuss_feb2000.html

Schrum, L. (1998). Online education: A study of emerging pedagogy. In B. Cahoo (Ed.), *Adult learning and the Internet* (pp. 53-61). New directions for adult and continuing education, No. 78. San Francisco: Josey-Bass.

Socrates Learning Systems. (2002). Content Repurposing with Layered Learning Objects: Breaking down LEGO. Retrieved December 10, 2003, from: http://www.socrateslearning.com/media/LLO.pdf

South, J. & Monson, D. (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 November 08,2003: http://reusability.org/read/chapters/south.doc

Wiley, D. (1999). *So what do I do with a learning object*?. Retrieved October 20, 2003 from: http://wiley.ed.usu.edu/docs/instruct-arch.pdf

Wiley, D. (2000a). 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*. Retrieved November 08,2003, from: http://reusability.org/read/chapters/wiley.doc

Wiley, D. (2000b). *Learning object design and sequencing theory*. Unpublished doctoral dissertation, Brigham Young University. Retrieved November 08,2003, from: http://davidwiley.com/papers/dissertation/dissertation.pdf

Wiley, D., Gibbons, A. & Recker, M. (2000). *A reformulation of learning object granularity*. Retrieved November 23, 2003 from: http://reusability.org/granularity.pdf.

Williams, D.(2000). Evaluation of learning objects and instruction using learning objects. In D. Wiley (Ed.), *The Instructional Use of Learning Objects: Online Version*. Retrieved December 15, 2003, from: http://reusability.org/read/chapters/williams.doc

Vitae

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