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Michael G. Hilgers

*University of Missouri - Rolla, hilgers@umr.edu*

Richard H. Hall

*University of Missouri - Rolla, rhall@umr.edu*

Matt Buechler

*University of Missouri - Rolla, buechler@umr.edu*

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# Design and Development Considerations of a Learning Object Repository

**Michael G. Hilgers**

Department of Information Science and  
Technology  
University of Missouri-Rolla  
[hilgers@umr.edu](mailto:hilgers@umr.edu)

**Richard H. Hall**

Department of Information Science and  
Technology  
University of Missouri-Rolla  
[rhall@umr.edu](mailto:rhall@umr.edu)

**Matt Buechler**

Center for Technology-Enhanced Learning  
University of Missouri-Rolla  
[Buechler@umr.edu](mailto:Buechler@umr.edu)

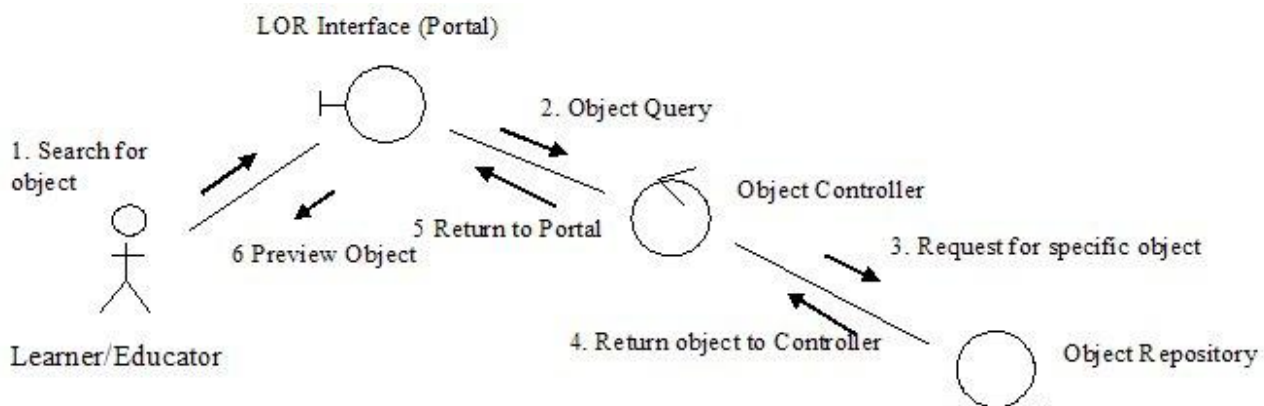
## ABSTRACT

A *learning objects repository* (LOR) is a web-based educational portal that houses, displays, and delivers sharable content objects for educational purposes. Design of such a repository encounters a number of considerations that relate the behavior of the information system to the content objects it manages. This paper examines these design issues in light of standards we have utilized. In particular, the instructional design of our learning objects is based on a concept called *progressive scaffolding*, which refers to the process of providing differing levels of media guidance. A brief description of related research is included. Furthermore, our objects are compliant with the Advanced Distributed Learning's Sharable Content Object Reference Model (SCORM) to ensure they behave in a uniform and predictable manner. This paper also reviews existing content portals and gives a summary of an evaluation project carried out with a prototype.

## Keywords

Learning Object Repositories, Sharable Content Object Reference Model, GIS.

## INTRODUCTION



**Figure 1. UML Collaboration Diagram of LOR interactions**

Information systems have the potential to impact education via interactive electronic content (e-content) delivered upon information networks (Swift and Watkins, 2004; Shiratuddin and Landoni, 2003). At the heart of e-learning networks is the *learning object*, which is any form of digital media coupled with a clear and measurable learning objective or designed to

support a learning process (Johnson, 2003). As the amount of e-content increases so does the need for an organized approach to information management. Obviously, a primary goal is to provide a searchable repository of learning objects accessible by a wide range of educators and students. But what other consideration should be addressed during the design and development of a repository?

A LOR's design decomposes into three components: portal (interface), object manager (controller), and objects (entities). The Unified Modeling Language (UML <http://www.uml.org/>) is appropriate to highlight the operational activity. Figure 1 is a UML *collaboration diagram* which shows how the elements of the system interact to provide a service. Architecturally, most information systems, such as an LOR, possess an interface (the circle with the sideways T) through which external actors (the stick figure) communicate with the system. For a repository, the interface is a portal through which people can search, preview, check out, and purchase licensed materials. A prototype portal for LOR Initiative (LORI) on our campus is seen in Figure 2. The object controller (shown in UML as the circle with the arrowhead) is normally a learning management system (LMS) such as Blackboard®. Since the object controller is hidden to the user, most of the educational requirements concerning a learning object repository address the portal and the content (entities, shown as a circle sitting on a line) it delivers. These topics will be considered separately though they are coupled. The design requirements of portals are presented in conjunction with a qualitative examination of various existing educational portals to introduce some major design features. After examining the related design issues for the learning objects, a prototypical implementation will be examined with an analysis of the results.

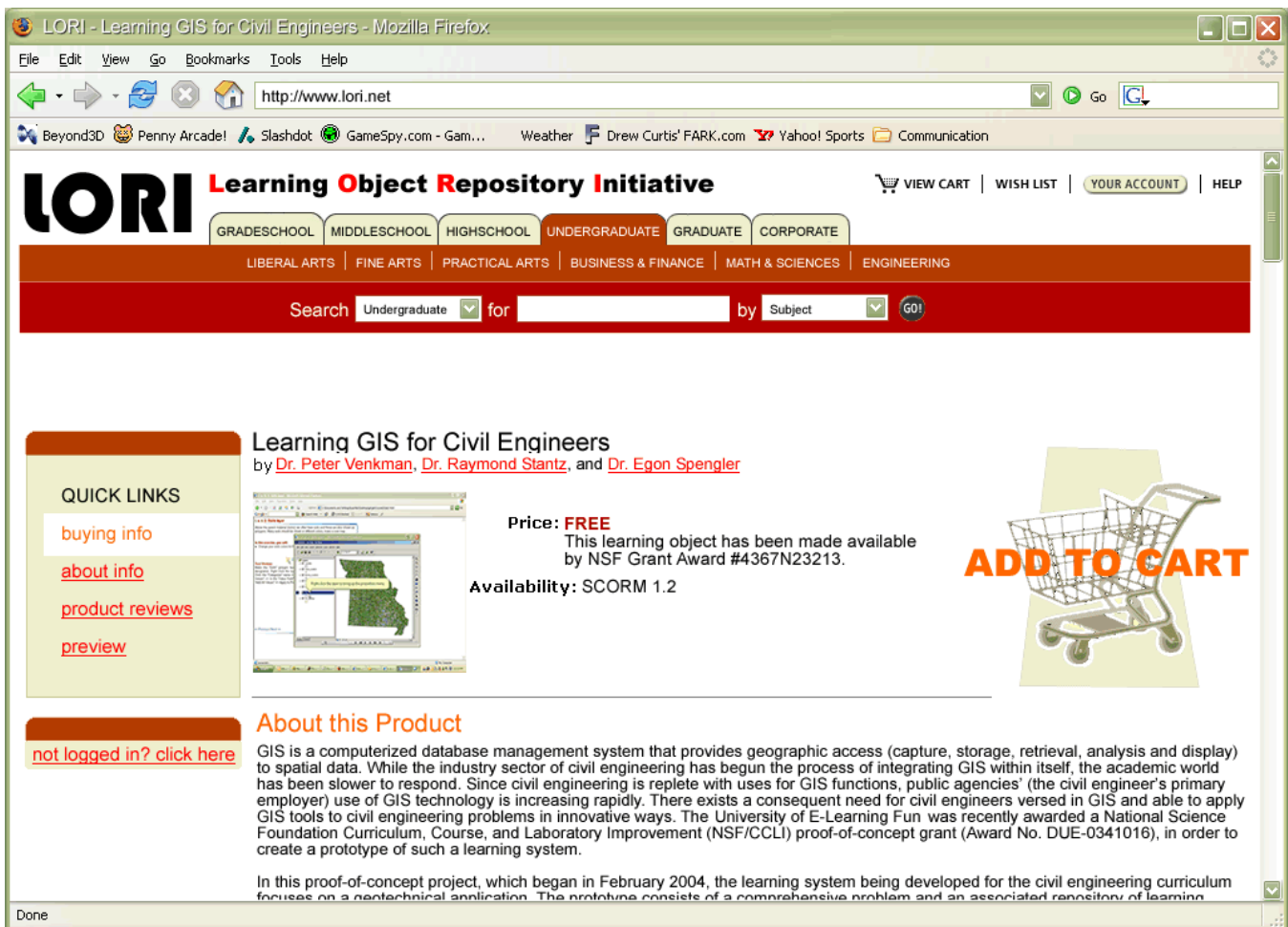


Figure 2. A Prototype of a the LORI Portal

## EXISTING E-CONTENT REPOSITORIES

In this section, several existing repositories are surveyed. The results are purely qualitative and are offered from the perspective of clarifying design issues. We examined seven portals: AShareNET, Learning Commons, Iconex, Maricopa Learning Exchange, MERLOT and SMETE Digital Library. One striking feature of the survey is that 4 of the 7 portals offer a means to sell the intellectual property (IP). This addresses a key hindrance to the formation of a repository, namely motivation to provide content. University educational information networks have been slow to adopt and utilize formal methods of standardizing e-content (Cheese, 2003). One hindrance is that professors are reluctant to view themselves as “content-providers.” One strategy being suggested to address this concern is the opportunity to use the portal to provide economic reward for the content author (Howard, Schenk, and Discenza, 2004). In fact, AShareNET claims to manage 21,869 objects, no doubt due to their attention to IP issues. Protection of IP is critical. Maricopa specifically warns, “You do not want to meet our Legal Department.” Hence the portal must be able to sell licensed material as well as secure the distribution of copyrighted content.

Another startling feature is the heterogeneity of the learning materials presented. AShareNET offers “learning materials” while Maricopa “learning packages”, and Iconex has “learning objects”. What one receives with these materials, packages, or objects varies greatly both across and within repositories. Several fundamental problems have been identified by developers in the implementation of standard-compliant courseware (Tanner, Tarr and Cavanagh, 2003). First and foremost is a lack of a common vocabulary for the metadata associated with learning (IEEE, 2002). That is, there is no standard means by which a course should be decomposed into smaller units such as section, chapter, unit, lesson, and so forth. This is sometimes referred to as course *granularity*. Granularity ties to the reusability of an object. A fine grain object, like a definition, is highly reusable. A coarse grain object, such as a semester of thermodynamics, is less usable by other educators. Similar to this is a need for learning objects to have a common *texture*, which addresses the format, appearance and layout of an object. Intuitively one would expect decomposed components to maintain a similar look and feel across decomposition lines to provide a consistent and stable learning experience. What levels of granularity and texture are required to optimize learning is an open question and one that we are pursuing in this course of investigation. Some preliminary results will be given below. Of course, it should be noted that such restriction will reduce the volume of objects present in the repository, which could be viewed as detrimental.

## LEARNING OBJECT REQUIREMENTS

The definition of learning object is very broad. Anything thing from a text file to an interactive animation or video is permitted, provided a web-browser can display it. The challenge to associating learning outcomes to material typically found on the web is in coupling assessment capability to it. This requires that the materials interact with some form of Learning Management System (LMS) so that a student’s progress can be tracked. There are hundreds of commercial LMS available. Furthermore, there are over 84.5 million users of LMS with about 2/3’s of the market being middle-size corporations and 14% being government (Chapman, 2004). The ideal learning object would work with all LMS. This is not realizable to date. So learning object design focuses on building a *reference model* maximizing four major design characteristics: *interoperable*, *accessible*, *durable*, and *reusable*. This means that the fundamental educational units satisfying the reference model are able to interact with a variety of systems, be open to a wide community of users, have a relatively long, productive life-time, and be able to be used in environments other than that for which it was created. If the learning objects possess these attributes, they are said to be *sharable* and the associated information system delivering the content is *efficient* (Chisholm, 2003). This results in a situation where educators have available to them a wide variety of resources and are free from creating what others have already done, and students can learn wherever there is a computer. These efficiencies can lead to substantial cost savings in both time and travel expenses, as has been demonstrated in training-oriented environments (Blickensderfer, Johnston and Paris, 2003). Fortunately, the attributes of such reference models have been extensively examined by several groups including: Institute of Electrical and Electronics Engineers (IEEE), Aviation Industry Computer-Based Training (CBT) Committee (AICC), IMS Global Learning Consortium, Inc. (IMS), Alliance for Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) in Europe, and Advanced Distributed Learning (ADL) Co-Laboratory (Co-Lab).

A several year effort to combine these standards has resulted in the Sharable Content Object Reference Model (SCORM) 2004 (ADL, 2004). Learning objects that conform to the SCORM reference model are called *sharable content objects* and should be interoperable, accessible, durable, and reusable (Englebrecht, 2003). The fundamental idea of SCORM compliance is to use XML to attach metadata tags to content objects. The objects are bound together in a package described with an XML manifest. Using the manifest, information networks can access and distribute learning objects to a variety of educational environments using Learning Management Systems. The learning objects interface with the LMS via JavaScript using a standard API defined by the reference model. The API enables a variety of standardized activity from sequenced navigation

to interactive testing. Hence, SCORM does not impose standards on object content; rather it ensures meaningful interactions with information networks. According to <http://www.adlnet.com> there are 5 LMS's that have completed all requirements to prove they are SCORM 2004. The Army has seen remarkable success with its Distributed Learning System (Chisholm, 2003) with cost savings resulting in millions of dollars. As mentioned, universities have been slow to adopt SCORM (Cheese, 2003), but the need for other avenues of economic development should be a motivating factor. Hence, we are requiring SCORM as our only object standard.

While the concepts of object granularity and texture address several issues in content development, we now introduce another idea which focuses how the object aid in learning. *Progressive scaffolding* is a term we use to refer to a systematic method of providing users with an optimal level of assistance. Within such a system, different levels or tiers of facilitation are provided to match the optimal levels of assistance required. The level could be set by the learner, an instructor, or automatically, based on learner response. We conducted two previous studies which indicated that the approach provides a flexible and viable learning environment. Learners tend to select the most minimal level of assistance first, in order to minimize their interaction with the learning scaffold and maximize their interaction with the fundamental problem to be solved (Hall, Digennaro, Ward, Havens and Ricca, 2003, Hall, Stark, Hilgers and Chang, 2004). This behavior is indicative of the basic principal that the learning system is simply a tool to help facilitate problem solving.

It's important to note that scaffolding, as defined within our framework, refers to guidance that supports the core content, which remains constant across differing levels of scaffolding. Therefore, the degree of scaffolding is not equivalent to difficulty of the content; rather it refers to the degree of supportive context provided. More specifically, in our research the scaffolding dimension has been represented by the media in which the content is embedded: plain text, text with graphics, or video. Thus the scaffolding differs in the degree of abstraction, fidelity, and richness.

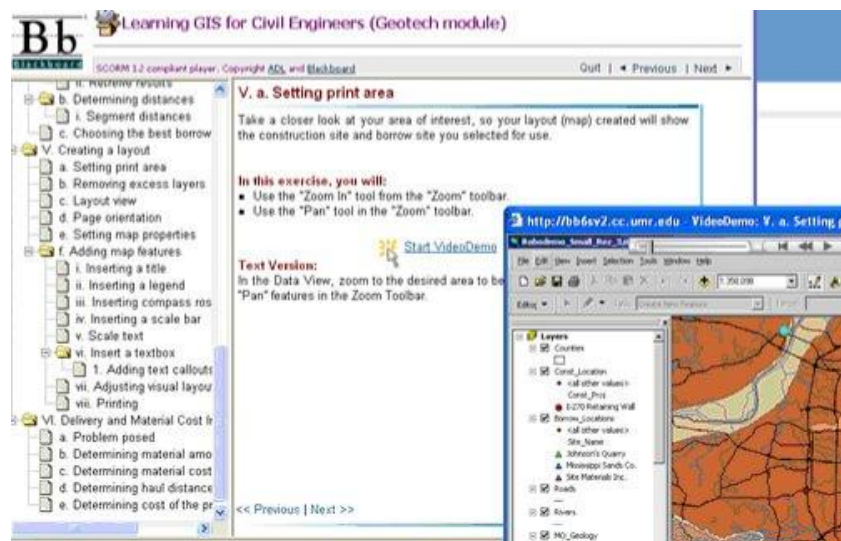


Figure 3. Screen Shot of a GIS Learning Object from the Repository

### PROTOTYPE SYSTEM EVALUATION: TEACHING GIS TO CIVIL ENGINEERS

A prototype learning system was developed, which was representative of a module that would be included as a part of LORI. That is, it was SCORM-compliant, followed a granularity and texture pattern we set, and utilized progressive scaffolding. This system which was developed as a part of an NSF Course, Curriculum, and Laboratory (CCLI) grant (Award No. DUE-0341016), for training Civil Engineers to use Geographic Information Systems (GIS) within the context of an applied problem. The system was presented via an experimental version of the Blackboard® Learning Management System, which is SCORM 1.2 compliant. The content is a series of steps for using GIS software (ArcGIS/Arcview) to solve a specific soil borrow site problem. The steps are a set of learning objects. Each step/learning object is referred to as an exercise. The exercise begins with a screen that lists the steps in an exercise, a text version of the activities necessary to carry out the exercise, and a video version, which shows these steps being carried out. The videos were annotated with comments. The only exercise that deviated from this was an interactive soil analysis tool, where students ordered a specific laboratory soil

analysis and the results came back to them via email. There were a total of fifty exercises. The web interface consisted of two frames; the left was a navigation frame with the objects represented as collapsible folders and the content was displayed in a second, main, frame (see Figure 3).

### Usability Evaluation

The system initially underwent a series of usability tests that were carried out in an iterative fashion with development of different versions of the prototype system. A total of three usability tests were carried out with five participants in each test. In each test, the participants were students with similar experience to those who would use the interface being tested. As they carried out a series of relevant tasks, they were videotaped, and these were synchronized with dynamic screen video of their activity. These were combined into a picture-in-picture video, which is typical of this type of iterative usability testing (Barnum, 2002; Dumas & Redish, 1999). The videos were then reviewed in detail with a particular effort to identify ways to improve the interface. We were also interested in developing insight into ways in which students used the software to inform development, while also providing more fundamental information on ways in which students interact with learning objects designed in this fashion.

A number of improvements were made to the system based on these tests and the final prototype was substantially improved in comparison to the first based on task performance. We also found that students used the scaffolds in a relatively systematic fashion, beginning with the lower/simplest levels and utilizing more elaborate scaffolds as the need arose. A more detailed description of the evaluation and results is available elsewhere (Sullivan, Hall, Luna, Hilgers, Buechler, and Lawrence, in press).

### Applied Evaluation

#### Method

The completed pilot system was evaluated within the context of a Civil Engineering Course (CE 215: Fundamentals of Geotechnical Engineering). One laboratory section for the course used the learning object repository while the other section acted as a control group utilizing traditional methodologies. Outcome measures between the two groups were compared. Both sections had the same learning objectives, which were: 1) Define what are the engineering objectives and material requirements for a construction earthwork operation; and 2) Select an appropriate soil borrow site for a particular construction site. In addition, the experimental group had a third objective: 3) Use a Geographic Information System (GIS) for the selection of a borrow site. Those in the experimental group used computers installed with GIS software (ArcGIS/Arcview) and the learning objects open in a web browser. Those in the control group used a learning cards/board game, developed for this lab, where the students role-played through the procedure of how to examine and analyze geotechnical data to support the borrow site decision. The lab deliverables for both sections included a statement with regard to the site selected, list of lab tests and results, total cost, and justification. For the experimental group, they were also required to turn in a map developed in the GIS documenting the construction and borrow sites with the appropriate data. Those in the control group were required to submit a description of the anticipated geology or soils for the borrow site and indicate major roadways to get to/from the construction site. In both groups, students were divided into two person teams. Each team was given different data for the construction site, and each team was responsible for one set of deliverables. This activity was completed during one afternoon session.

#### Results

The next class period (two days after the session) students were given a quiz over the material covered in the lab. Those in the experimental groups scored 17% higher ( $M = 81.82\%$ ,  $SD=10.38\%$ ) than the control ( $M=69.70$ ,  $SD=7.08\%$ ). A between-subjects t-test indicated that this difference was statistically significant  $t(34) = 3.63$ ,  $p < .01$ . More details on the applied experiment and results are available elsewhere (Hall, Luna, Hilgers, Sullivan, Lawrence, and Buechler, in press)

### DISCUSSION AND CONCLUSIONS

In summary, it is suggested that a strong LOR should:

- Provide a means for protecting and selling intellectual property
- Clearly defined object granularity and texture standards
- Provide SCORM-compliant objects
- Utilize progressive scaffolding used for content delivery

The evaluation of the prototype system was encouraging. The iterative usability studies, integrated into the development process, helped to ensure that the usability of the system was optimized, while providing insight into ways in which students used the learning objects. The effectiveness of the module in impacting learning was further supported by the evaluation carried out within the context of a class, where students who used the system scored substantially (17%) and significantly higher than peers in a control section on a quiz that covered the content covered in the labs. However, it's important to note that these evaluations were limited in that they were carried out with only one set of objects delivered via the LORI system, which does not represent an analysis of the complete system. However, these results do provide initial support for the pedagogical effectiveness of the basic design criteria, which is an important step in the iterative design and implementation of the system.

## ACKNOWLEDGMENTS

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