A Repository for Learning Objects: Supporting the Reuse and Repurposing of Redesigned Courses and Their Content

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This paper describes the design and development of a learning object repository for a new statewide higher education initiative. The Texas Higher Education Coordinating Board is funding the redesign of large undergraduate courses; the redesigned courses are intended to improve student learning, retention and outcomes. The learning object repository stores and provides access to content from these courses. Content has been decomposed into discrete learning object varying in levels of granularity. The paper provides details on the proof-of-concept implementation developed in Phase I of a two-phase project. Special attention is given to key aspects such as the levels of granularity, metadata, technology, and user testing. Issues that emerged in Phase I are informing all facets of the next iteration of the repository.

Introduction

The Texas Higher Education Coordinating Board (THECB) is a state agency that is responsible for planning for improvement of higher education in Texas. Under a mandate from the Texas Legislature, the THECB initiated the Texas Course Redesign Project (TCRP), which provides funding to redesign entry-level academic courses to improve student learning outcomes and lower costs. The goal of the TCRP is the development and widespread adoption of course designs and instructional resources that promote student success. The redesigned courses will be freely available to all Texas public institutions of higher education.

To assist the THECB in reaching its objectives, the Texas Center for Digital Knowledge (TxCDK) at the University of North Texas proposed the development of a learning object repository (LOR) to store, manage, and make accessible content from the redesigned courses. Specifically, TxCDK suggested that THECB could leverage TCRP investment in course redesign by making not only the entire courses available but also components of the course content for reuse and repurposing of discrete learning objects derived from the courses. THECB is funding a two-phase LOR design and development project intended to support course development. In Phase I, completed in December 2007, a TxCDK project team developed a proof-of-concept repository application that used content from one redesigned course to demonstrate the functionality and potential of a LOR for reuse and repurposing of learning objects. The redesigned course content was decomposed into discrete learning objects and yielded nearly 300 learning objects varying in levels of granularity. The proof-of-concept addressed a range of digital objects comprising the course content including text, images, audio, video, and flash animations. Phase II is a two-year effort that is addressing not only a next version of the LOR but also administration, workflow, and policies necessary for a production system. The following sections provide a brief background on LOR, and then a discussion of the THECB LOR in terms of requirements, technology, decomposition and organization of the objects, and key issues that emerged from the proof-of-concept application.

Background

Reusing and sharing resources for educational purposes is not a new concept. There is a long history of faculty sharing and reusing learning resource in the form of textbooks, published papers, syllabi, assessments, etc. Like traditional paper-based materials, digital learning materials can also be shared and reused (Campbell, 2003; Pras, 2001). To be useful, a learning object repository must provide flexibility in storing course content at whatever level of granularity is considered most appropriate. Also a repository must provide a storage environment for both learning objects and descriptions (i.e., metadata) of the objects to help users find, identify, select, and obtain relevant and useful learning objects. A number of factors need to be taken into account when developing a LOR including technological factors,

interoperability, educational, and cultural factors which are embodied in managed learning environments, tools, metadata, usability, granularity, pedagogy, subject specificity, intellectual property (Campbell, 2003).

Sharing and reusing digital learning resources has been a focus of research and exploration for the decade or longer. In some cases, such as the Gateway to Educational Materials (GEM) metadata records have made learning materials visible. More recently there has been the development of a number of LORs including the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) which contain thousands of learning objects. Also, based on specific teaching needs and education situations, local organizations are customizing their own learning object repositories. For example, the Orange Grove, a project of the Florida Distance Learning Consortium (FDLC), provides a single point of access for learning resources designed to be used by Florida's K20 teachers and educational institutions (FDLC, 2007).

A unique characteristic of the THECB LOR is that it is addressing entire courses, from which smaller learning objects can be derived. Also, the quality of the learning objects is emphasized since all content in the LOR is from the newly redesigned courses.

Functional Requirements for the LOR

Given the relatively short timeframe for Phase I (originally May – August 2007), the project team did not carry out a formal needs assessment to identify user requirements. Phase II includes those activities, however. For the proof-of-concept the project team's focus was on demonstrating likely functionality based on our understanding of the TCRP objectives. The project team documented that understanding by identifying a set of functional requirements based on a general understanding of what the LOR should support in the areas of administration, submission of learning objects, and end user access to the repository and its contents. The project team chose the DSpace digital repository platform for the proof-of-concept, and although the functional and technical requirements are generalizable, they were specified in the context of a DSpace-based LOR.

Functional requirements address the behaviors of the repository application, and types of interactions the application should support. The requirements serve several purposes. First, they guided the development and configuration of the repository application. Second, they provided the baseline for use in the system-level assessment of the repository. The requirements were categorized to address:

- Administration
- Submission of learning objects
- End user access to learning objects.

Requirements Related to Administration

The following requirements address various administrative tasks and responsibilities for managing the LOR. Many of these tasks are carried out using the DSpace administrative interface, but some tasks require access to the server to edit configuration files, set indexing policies, and other responsibilities.

- Manage user accounts
- Set authorizations and permissions
- Implement organization structure for learning objects
- Customize submission workflow
- Implement metadata scheme
- Customize metadata input
- Administer and manage items in repository

Requirements Related to Submission of Learning Objects

The following requirements address the entire process of authorized users submitting learning objects into the repository. The submission process involves logging in to the LOR with an authorized username and password, creating metadata records for items submitted, uploading the files associated with a learning object into the repository, and workflow related considerations.

- Register for user account and edit profile
- Submitting items to one or more collection and create metadata

Requirements Related to End User Access to Learning Objects
The following requirements address end user interaction with the repository. There may be two or more sets of users who may be restricted in terms of viewing and downloading metadata, items, and content packages. All users should be able to search and browse the LOR and at the least see the metadata records associated with the learning objects, even if not all users will have access to the files associated with the learning objects.

- Search full-text and metadata elements
- Browse by various access points or categories
- View simple and complete metadata records
- Access learning objects as allowed by user account authorization

These requirements guided the configuration of the repository.

Technology for the LOR Application

For the proof-of-concept repository, the project team used DSpace (Version 1.4.2) an open source software repository platform developed by MIT Libraries and Hewlett-Packard Labs. DSpace was installed on a server under the administrative control of project staff, and configuration included a variety of tasks including: customizing the look and feel of the application; incorporating appropriate metadata elements required for the learning objects; setting up search and browse capabilities; modifying the submission process to enable easy submission of learning objects and creation of metadata records.

Project team chose Linux (Fedora) operating system and installed several instances of DSpace repositories for development and testing by several team members. A final production instance incorporated the results and decisions based on development and testing. The Handle server was installed on the production instance to provide efficient, extensible, and secure identifier and resolution services for the items in the repository. DSpace provides an administrative interface for many configuration options, including: a metadata registry for identifying elements available to the application; access controls; workflow controls, managing user groups, and other administrative tasks. Additional configuration required editing DSpace text and other files on the server itself.

Metadata Application Profile

Metadata is critical for any digital repository to support a variety of functions including management and end user interaction. DSpace provides Dublin Core (DC) metadata elements by default. For the THECB LOR, neither simple nor qualified DC elements are rich or precise enough for learning objects. The project team developed a metadata application profile (Heery and Patel, 2000) that addressed a variety of needs of the application, the objects, and the users.

The project team examined various potential metadata schema and/or profiles to see which would address the majority of needs. We investigated questions such as which metadata schema might serve as the basis for the THCEB LOR application profile; which elements should be designated mandatory, and other issues identified in guidance document (e.g., IFLA, 2003). The project team studied 24 learning object repositories listed by the Florida Distance Learning Consortium (2007) for its OnCoRe Blueprint project (funded by the Fund for the Improvement of Postsecondary Education, U.S. Department of Education). The repositories revealed the metadata supporting those applications are based primarily on two schemas: Dublin Core (DC), and IEEE 1484 Learning Object Metadata (IEEE LOM); Table 1 lists some of the repositories and the metadata schemas used.

The project team then compared and analyzed metadata elements in 13 learning object repositories to look at the use of elements and specifically the commonly used elements to guide the choice of elements

for the THECB LOR. For example, all of the examined repositories use the elements: Title, Subject, Description, Learning Object Type, Authors or Creator, Rights. More than half of them use the elements: Identifier (URL), Technical Requirement, Media Format, Typical Learning Time, and Interactivity.

Repository Name	Basis of Metadata for Application
Gateway to Educational Materials (GEM)	GEM (based on DC)
Education Network Australia (Edna)	AGLS (Australian Government Locator Service) Metadata Element Set
European Knowledge Pool System (ARIADNE)	LOM
Campus Alberta Repository of Educational Objects (CAREO)	CanCore (an application of LOM)
The Digital Library for Earth System Education (DLESE)	AND (an application of NSDL-DC)
Jorum (a JISC-funded collaborative venture in UK Higher and Further Education	UK LOM (an application of LOM)
National Science Digital Library (NSDL)	NSDL-DC (based on DC and LOM)
Florida Distance Learning Consortium (OrangeGrove)	SCORE (based on LOM and GEM)
The Learning Federation (TLF)	DC and LOM
Food and Agriculture Organization Learning Resources (FAOLR)	DC, LOM, and AGS (Agricultural Metadata Element Set)

Table 1. Comparison of Learning Object Repositories

The project team concluded that a combination of DC and LOM elements (with one element from GEM) would address requirements for the prototype, and the resulting application profile documents the team's decision. Table 2 lists the display form and element names defined in the THECB LOR application profile (note some of these elements are DSpace-specific).

Intended Educational Audience (dc.audience.educationLevel)
Author's Affiliation (dc.contributor.affiliation)
Authors (dc.contributor.author)
Other Contributors (dc.contributor.other)
Date Published (dc.date.dateAccepted)
Date Accessioned (dc.date.dateAccessioned)
Date Available (dc.date.dateAvailable)
Date Issued (dc.date.dateIssued)
Summary (dc.description.abstract)
Learning Object's Content (dc.description.tableOfConents)
Learning Object Description (dc.description.uri)
Media Format (dc.format)
Size (dc.format.extent)
Format (dc.format.mimetype)
URI (dc.identifier.uri)
Instructional Method (dc.instructionalMethod)
Language (dc.language)
Creation and Ownership Information (dc.provenance)
Publisher (dc.publisher)
Course Structure (dc.relation.isPartOf)
IMS Content Package (dc.relation.uri)
Rights (dc.rights)
Access and Use Rights (dc.rights.accessRights)
Access and Use License (dc.rights.license)
Rights Holder (dc.rights.rightsHolder)
Subjects (dc.subject)
Title (dc.title)
Other Title (dc.title.alternative)
Learning Object Type (dc.type)
Individual Cataloger (gem.cataloging.individualCataloger)
Domain Cataloger (gem.cataloging.individualCatalogerDomain)
Discipline and Subdiscipline (lom.classification.taxonPath.taxon)
Difficulty Level (lom.educational.difficulty)
Interactivity Level (lom.educational.interactivityLevel)
Interactivity Type (lom.educational.interactivityType)
Typical Learning Time (lom.educational.typcialLearningTime)
Technical Requirement (lom.technical.requirement)

Table 2. Metadata Elements in THECB LOR Application Profile

Decomposition of Course Content

Learning object repositories have a variety of materials that can be reused for instruction. In the case of the THECB LOR, the focus is on providing the complete course as one learning object as well as discrete learning objects derived from the complete course. A major component in Phase I was making decisions about the levels of granularity for the derived learning objects. While the literature indicates that more granular learning objects have an increased potential for reuse (Hummel, Manderveld, Tattersall, & Koper, 2004; Wiley, Waters, Dawson, & Lambert, 2004), there is little empirical data about what is an appropriate level of granularity for learning objects. This issue is discussed in a later section.

For purposes of the proof-of-concept, the goal was to demonstrate the various levels of granularity that can be considered. The U.S. History I course has a relatively traditional structure, and the project team used that structure to provide the levels of granularity. These levels of granularity became the organizing structure of the repository (see below). The following are the five levels of granularity used, from the least to the most granular level:

- Complete course as a learning object
- Unit: Each unit consists of two or more Lessons
- Lesson: Each lesson belongs to a unit, and each lesson has two or more topics
- Topic: Each topic belongs to a lesson
- Free-standing Learning Object

Each of these learning objects consists of one or more files. The project team worked with the course creator to bundle the appropriate files together for each of these levels of granularity to submit into the repository and describe with a metadata record. The level of Free-standing Learning Object provided a mechanism to describe and make available specific learning objects (e.g., self-tests, glossary review, interactive maps, etc.) that while created for this specific course may be reusable or repurposed in other contexts besides U.S. History. Once the course content (i.e., individual files) was organized into the levels of granularity, the project team began submitting these and creating metadata records for each learning object. The repository was then organized (using the DSpace construct of community, collection, subcollections, etc.) into the following for presentation to the end user (see also Figure 1):

- Complete Course
- Course Units
- Course Lessons and Related Assessments
- Course Topics
- Free-Standing Learning Objects

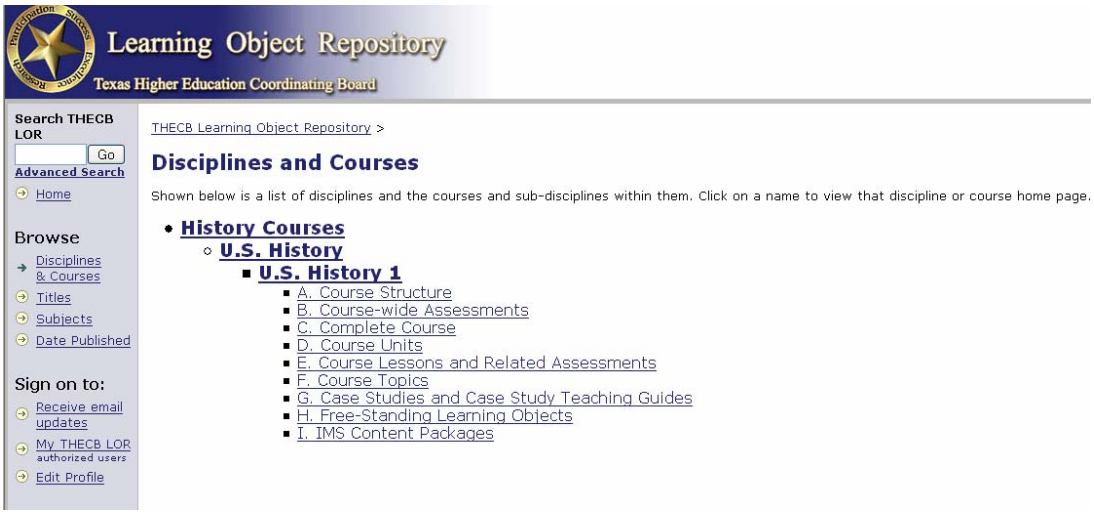

Figure 1. Organization of the Learning Objects in Repository

In addition, there were other course materials that were important to provide but that didn't fit into the levels of granularity described above, and these include:

- Course Structure: Contains a syllabus and course map that outlines the components of this particular course
- Course-wide Assessments: assessments in the form of mid-term and final examinations, developed specifically for this U.S. History I course
- Case Studies and Case Study Teaching Guides: contains multiple items that comprise interactive learning materials that may be associated with a particular unit, lesson, or topic, but comprise a separate, course-contextualized learning object

The final collection presented to the user is IMS Content Packages. Another objective for the proof-of-concept was to demonstrate how learning objects can be easily ingested into learning management

systems (LMS). The IMS Content Package is a specification for wrapping up all files associated with a learning object, along with metadata to produce a zip file which can be directly ingested into a LMS such as Angel, Blackboard, and Sakai. A user can discover an appropriate learning object in the repository, and the metadata for that object contains a URI to an associated IMS Content Package, which can then be downloaded.

Submission of Learning Objects and Metadata Creation

The proof-of-concept implementation used the basic submission workflow provided in DSpace. The project team configured the DSpace metadata registry to accommodate the elements needed, and customized the submission pages to assist in metadata creation. Graduate students from history and library and information sciences carried out the metadata creation and submission. The project team used a workflow option in DSpace so that the history students (subject matter experts) completed metadata elements related to subject representation, summary of learning objects, type of learning object, difficulty and time expected to complete the learning object. Additionally, the project team set certain default values (e.g., the creator name, license, etc.) to speed manual metadata creation.

A critical concern was controlling the subject terms assigned to the learning objects. While DSpace provides a function for using controlled vocabularies to limit the set of terms metadata creators can use, the proof-of-concept needed a way to dynamically develop (i.e., add to and enhance) a controlled vocabulary as well as using it during the process of metadata creation. The project team developed a controlled vocabulary application that resides outside of DSpace but links to the DSpace metadata entry interface (Figure 2).

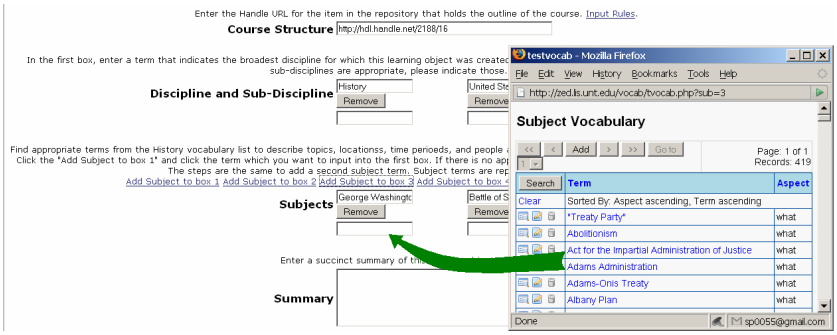

Figure 2. Metadata Entry Page and Controlled Vocabulary Interaction

The vocabulary was developed using open source database management system MySQL and PHP scripting language as well as Java Script. The vocabulary was tested while submitting hundreds of items to the repository by the group of six people working concurrently from different locations. The controlled vocabulary tool provides the following functions:

- Provide an online version of a controlled vocabulary that metadata creators can link to and have open when they are determining what terms to put into the Subject field;
- Let metadata creator click on a term in the online controlled vocabulary and have it automatically pasted in to the Subject field;
- Allow the metadata creator to add new terms to the controlled vocabulary through a simple to use submission form;
- Make newly submitted terms immediately available for all users working on items submissions.

End User Interaction with Repository

This section briefly describes the look and feel of the repository along with features implemented for the proof-of-concept. Because Phase I focused on demonstrating functionality, customization to the user interface (UI) was not a priority. Although some changes were made to the out-of-the-box DSpace interface, they were to show that customization is possible. Phase II will focus much attention on UI issues, and the project team will use Manakin, an XML-based tool available in the current DSpace

distribution, to improve presentation of information, user interaction, etc. Users can initiate searches, browse, sign-in, and other functions.

The project team configured the proof-of-concept to address the functional requirements discussed above, which resulted in the following (see Figure 1):

Browse Capabilities
The THECB LOR provides four main browsing options:

- Browse by Discipline and Course: a hierarchical list of disciplines, sub-disciplines, and courses;
- Browse by Title: a list of titles of learning objects contained in the LOR;
- Browse by Subject: a list of subject terms assigned to the learning objects; and
- Browse by Date Published: a list of learning objects in reverse chronological order.

Search Capabilities
The THECB LOR supports Boolean searching by Title, Subject, Learning Object Type, Media Format, Intended Educational Audience, Instructional Method, and Author Affiliation within a selected disciplines, courses, or the whole LOR. It also allows for full-text searches of textual learning objects. Each search returns a list of objects ordered alphabetically by title.

Viewing and Downloading
The THECB LOR enables the user to open and view learning objects by clicking on the "View/Open" link in the grey box at the bottom of each record (see Figure 3). The user can download the IMS Content Package associated with a learning object for import into a LMS.

Testing and Evaluating the Repository

The project team conducted two assessments of the proof-of-concept: system-level functionality assessment and user scenario testing. System-level functionality assessment used a checklist based on the functional requirements identified at the outset of the project, and focused on three categories: administration of THECB LOR, submission of learning objects, and end user access to learning objects. These three sections encompassed 13 functionalities with 70 specific, testable sub-functions. The assessment determined that 63 of 70 or 90% of the sub-functions are working as specified in the THECB LOR proof of concept proposal. Phase II development is being informed by the results of this assessment.

Figure 3: Viewing and Downloading Learning Objects from Metadata Record Entry

For the end user testing, the project team created use scenarios, each designed to present a real life situation to exercise functionality in the repository. Four subject matter experts, with no previous experience with the LOR and who served as representatives of the intended user group for the LOR, completed actions that focused on browse tasks, search tasks, and a combination of tasks, including downloading objects. The specific purpose of the testing was to determine if new users who were familiar with repository content could locate particular information and download this information so they could use it for scenario-defined teaching purposes. Users could ask questions and make comments during the process. At the end of the experience, project team members interviewed the user in order to clarify any questions or issues about what the observer recorded and to get any additional comments from the user. Overall, these users were able to use the LOR successfully, but the testing identified issues that are being addressed in Phase II. For example, terminology used in the LOR confused some subject matter experts such as the distinction between the term "topic" and the term "lesson" that represent levels of granularity. Phase II includes much more in-depth user testing, usability, and other assessments to ensure the LOR responds to user needs. This Phase I assessment served more as a reality check about the LOR and the direction the development is taking rather than a full-blown usability and user assessment.

Key Issues from Proof-of-Concept Implementation

The goal for Phase I was to demonstrate a proof-of-concept learning object repository's capability to leverage redesigned course content for reuse and repurposing, and had a number of objectives including:

- Identify and implement an appropriate metadata scheme to describe and manage the learning objects in the repository.
- Enable search and browse capabilities in the repository to support end user tasks of finding, identifying, selecting, and accessing the learning objects.
- Decompose a THECB redesigned course in at least three levels of granularity and store the decomposed course content in the learning object repository
- Provide course content in packages that conform to the IMS content packing standard for import into learning management systems that support the IMS standard.

In carrying out Phase I work, the project team identified issues that are informing development underway in Phase II. The following are several key issues to represent the range of things that need consideration and further research:

- **Levels of granularity:** Although there is discussion in the literature about the concept of granularity (Duncan, 2003; Sicilia, & García, 2003; Wiley, 2000; Wiley, 2002), there is little or no empirical evidence of the efficacy of particular levels or criteria on which to base a choice of level. This may be the most important decision to consider when designing a LOR. The proof-of-concept implementation provides several levels and it is possible that a LOR should provide multiple levels. However, from the user testing, it is clear there is a paramount need to determine appropriate terminology and definitions to apply to the levels for end user understanding.
- **Reuse and repurposing:** The user testing also indicated that the concepts of reuse and repurposing **in** the context of levels of granularity are not well understood. Reuse and repurpose have been defined in the learning object literature (Boyle, 2003; Duval & Hodgins, 2003; Hawryszkiewycz, 2002; Sicilia & García, 2003; Verbert, Duval, Meire, Jovanovic, & Gasevic, 2006; Wiley, 2000). These well accepted definitions were used for the current proof of concept study. These definitions of reuse and repurpose do not appear to be mutually exclusive. For example, any time a learning object is reused it must fit within an instructional context. The learning object will fit within a sequence of instructional materials. Therefore the reuse of a learning object will require additional effort by users to integrate the learning object into an instructional sequence. The definition of repurposing includes using learning objects in ways that were not originally intended. Depending on the level of granularity an object could be reused for a different purpose than intended without having to make modifications. As the level of granularity increases the likelihood of the learning object being used as intended by the originator increases. However, smaller learning objects are less likely to be used as intended and they could be reused in this capacity with little effort (Harvey, 2005; Wiley, 2000). In conclusion,

learning objects are integrated into instruction by way of reuse and repurposing, but these definitions do not hold together for all uses.

- **Adequacy of metadata for end users:** The THECB LOR application profile defines a set of metadata elements that serve several functions; a primary function is to communicate to users what the learning object is regarding subject, type, difficulty, etc. The current metadata scheme, however is deficient in supporting an understanding how and if the object by itself can be reused or repurposed. Instructional designers analyze learning needs and then formulate learning objectives to address those needs. Consequently, learning objectives will likely be a good starting point to initially determine if a learning object may fit the user's purpose. The current metadata does not identify learning objectives the learning object addresses. Reuse and repurposing may be dependent upon learning objectives; the challenge will be having the course designer (not the metadata record creator) to supply learning objectives of individual learning objects (especially at the finer levels of granularity).
- **Representing dependencies of learning objects:** If individuals learning objects contain dependencies to other learning objects their reusability is compromised. The user may not be able to use an object at the level of granularity they are seeking because of these dependencies. The metadata may need to better represent dependencies that currently provided in the THECB LOR application profile.
- **Preparing course content for efficient repository submission:** Phase I used a course being redesigned at UNT, and the creator of the course was a co-principal investigator on the project. This allowed for easy communication and cooperative work to get the course content files organized. However, the physical structure of files associated for the delivery of the course did not reflect the bundling of files for submission into the repository. Filename conflicts, relative and absolute URLs in HTML files, and other issues emerged when the rebundling for submission. Balancing the repository requirements for bundling files associated with a learning object with the course designer's needs and structure presents challenges that Phase II will explore. Stated simply, course developers are likely not designing their courses in terms of learning objects; disaggregation and decomposition of course content is needed for reuse as discrete components of instruction.

These issues warrant special attention by developers of LORs. The proof-of-concept implementation surfaced not just those listed above, and the project team anticipates more issues emerging in Phase II in which there will be much more focus on user needs, usability, and user testing.

Conclusion

This two-phase research and development project has special characteristics and requirements not necessarily shared by other learning object repositories. Instead of the repository simply collecting a variety of learning objects for others to use, the THECB LOR is focused on managing, storing, and providing access to entire courses and learning objects derived from those courses. Phase I surfaced technical, organization, workflow and other questions, some of which have been described in this paper. Issues such as reusability, repurposing, levels of granularity, and others, however, will likely be faced by many LOR developers and users. These issues will not be resolved by technologists (or even information scientists); rather instructional designers, subject matter experts, librarians, technologists, usability experts, metadata specialists, and others will need to collaborate in successful designing and deploying efficient and effective LORs.

The project team is not only defining some of these key questions but will continue to do some of the research necessary to answering and resolving these questions. Phase II provides us the opportunity to do this through, for example, enhancing the technical infrastructure (e.g., using DSpace Manakin for user interface development); revising the metadata elements to better communicate aspects of dependencies, learning objects, etc., and other aspects of the LOR. In addition Phase II also is exploring and conducting research on:

- Identification of user requirements and subsequent usability testing against those requirements
- Policy issues related to intellectual property when learning object are modified by those reusing/repurposing
- Administration of an production system
- Distributed submission of items into the repository

- Machine-processes to assist metadata generation

Phase II will add 4-6 redesigned courses from disciplines of mathematics, foreign language, and English. Issues defined above will be further clarified working with other course developers. Upon completion of Phase II, THECB will have a near-production level system populated with substantial high-value course content.

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References

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology, 19*(1), 46-58.

Campbell, L. (2003). Engaging with the learning object economy. In A. Littlejohn (Ed.), *Reusing Online Resources*. London: Kogan Pages.

Duncan, C. (2003). Granularization. In A. Littlejohn (Ed.). Reusing Online Resources: A Sustainable Approach to E-Learning. London: Kogan Page.

Duval, E., & Hodgins, W. A. (2003). A LOM research agenda. *The Twelfth International World Wide Web Conference, Alternate Paper Tracks*. Retrieved July 2, 2007, from http://www.www2003.org/cdrom/papers/alternate/P659/p659-duval.html.html.

FDLC. (2007). TheOrangeGrove Florida's K20 Digital Repository. Retrieved January 24, 2008, from: http://www.theorangegrove.org/index.asp.

FDLC. (2007). Alphabetical list of online repositories. Retrieved January 24, 2008, from http://www.oncorebluepprint.org/Repositories.htm.

Harvey, B. (2005). Learning objects and instructional design. *International Review of Research in Open and Distance Learning, 6*(2).

Hawryszkiewycz, I. (2002). Designing learning activities from learning objects. Paper presented at the *ASCILITE 2002 Auckland*.

Heery, Rachel & Patel, Manjula. (2000). Application profiles: Mixing and matching metadata schemas. *Ariadne*, 25. Retrieved January 24, 2008, from http://www.ariadne.ac.uk/issue25/app-profiles/.

Hummel, H., Manderveld, J., Tattersall, C., & Koper, R. (2004). Educational modeling language and learning design: New opportunities for instructional reusability and personalized learning. *International Journal of Learning Technology, 1*(1), 111-126.

IFLA. (2003). Guidance on the structure, content, and application of metadata records for digital resources and collection (draft). Retrieved January 24, 2008, from http://www.ifla.org/VII/s13/guide/metaguide03.pdf.

Pras, A (2001). Sharing telematics courses - The CANDLE project. Retrieved January 24, 2008, from http://www.simpleweb.org/nm/research/results/publications/pras/2001-09-04-eunice.pdf.

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), Retrieved June3, 2006 from: http://www.irrodl.org/index.php/irrodl/article/view/2155/2236.

Verbert, K., Duval, E., Meire, M., Jovanovic, J., & Gasevic, D. (2006) Ontology-based learning content repurposing: the ALOCoM framework. *International Journal on E-Learning, 5* (1), 67-74. Retrieved November 20, 2007 from: http://www.editlib.org/index.cfm?fuseaction=Reader.ViewAbstract&paper_id=21750

Wiley, D. (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.

Wiley, D. A. (2002). The instructional use of learning objects. *Agency for Instructional Technology and the Association for Educational Communications and Technology*. Retrieved July 7, 2007, from http:www.reusability.org/read/.

Wiley, D. A., Waters, S., Dawson, L., & Lambert, B. (2004). Overcoming the limitations of learning objects. *Journal of Educational Multimedia and Hypermedia, 13*(4), 507-512.