Design and Development of ReLOAMS: A Reusable Learning Objects Authoring and Management System

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Abstract
As e-learning environments become more popular, many studies have been proposed to provide adaptive environments offering learners and educators customized courses for more effective learning and course construction. Some solutions are aimed at helping learners, while others are aimed at helping educators and course designers/developers. However, a serious lack of conceptual clarity of definitions and uses of learning objects, could have resulted in design and usability problems in current e-learning systems. The paper proposes ReLOAMS, a Reusable Learning Objects Authoring and Management System, being implemented to address the problem of usability and reusability of learning objects in e-learning systems. The paper describes the design rationale, systems architecture, and development concluding with a discussion on the impact of the design of e-learning systems.

Educational technology is essentially the use of technology to help improve learning (Jolliffe et al. 2001). Ong and Wong (2004) defined supporting tools as gadgets that are technology-enabled and provided by the environment for teachers to track the profile and various competencies levels of the students. New approaches and innovative methods of teaching have been adopted to foster better learning, both classroom-based and electronically mediated. Learning with technology has brought about many new expressions. Many educational institutions are using educational tools in the form of e-learning in course delivery. With rapid advancement in the technology, e-learning becomes pervasive in the education industry.
Generally, e-learning uses two methods for learning, namely, the distance-learning method (Barron, 2002) as well as the distributed learning method (Bowman 1999) to allow one to take part in courses anywhere, anytime. Technologically driven, it provides a virtual learning experience and it is not meant to replace classroom teaching which provides face-to-face training using synchronous communication. E-learning can be both synchronous and asynchronous based and it provides a virtual classroom concept whereby different types of approaches can be incorporated to provide real-life learning.

Urdan and Weggen (2000) define e-learning as the delivery of content via all electronic media, including the Internet, intranets, extranets, satellite broadcast, audio/video tape, interactive TV, and CD-ROM. Werner (2001) defines it as “learning by using a Web browser to access instruction delivered on a network or on the Internet”. According to a glossary compiled by Kaplan-Leiserson (2002) of ASTD’s (American Society for Training and Development) Learning Circuits, ‘e-learning’ covers a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration.

Norton and Sprague (2001) argued that while technology provides limited possibilities for solving “conventional” problems, its offer of solving “emerging” educational problems is limitless. As e-learning environments become more and more popular, many attempts have also been proposed to provide adaptive environments offering learners and educators customized courses for more effective learning and course construction (Muzio, Heins and Mundell, 2001). Some solutions are aimed at helping learners, while others are aimed at helping educators and course designers/developers:

- **For Learners.** Recent educational research from a socio-cognitive perspective has validated learners’ collaborative engagement with new technologies and heightened understanding of influential factors shaping the effectiveness of peer interactions, learning contexts and computer interfaces for enhancing learning. For example, in a study by Kimber, Pillay and Richards (2005) on 17-year-old female students, the focus was on the analysis of the complexity of knowledge in student-designed, electronically created texts for what they might reveal about learning with technology, mediated by the creation of electronic concept maps and Web files to represent their developing understanding. For achieving the adaptive learning, a predefined concept map of a course is often used to provide adaptive learning guidance for learners. Tseng, Sue, Su, Weng and Tsai (2005) proposed a Two-Phase Concept Map Construction (TP-CMC) approach to automatically construct the concept map by learners’ historical testing records. Others like Escalada and Zollman (1998) investigated the effects of learning systems on students’ learning and attitudes.

- **For Educators and Course Designers/Developers.** Numerous studies (e.g. Mills, 1999; etc.) have been carried out to understand the use and perception of e-learning systems from the perspective of teachers’ concerns and their influence on the way in which integrated learning systems could be implemented. Mills’ (1999) study showed that teachers’ concerns can influence the way in which an ILS can be implemented. Anderson (2003) provided a qualitative examination on the faculty members’ perception about the Blackboard learning platform. The study involved content analysis which comprises several categories that include mainly benefits of increased communication/collaboration/community through online
instruction. Bonifacia, Demetrescua, Finocchib and Lauraa (2004) described Leonardo Web, a collection of tools for building animated presentations that could be useful for teaching, disseminating, and e-learning. Conole, Dyke, Oliver and Seale (2004) proposed how models could be used to represent theoretical approaches and support practitioners’ engagement with these. Their assertion was that a better articulation and mapping of different pedagogical processes, tools and techniques would provide a pedagogic approach that was more reflexive and consistent with practitioners’ theoretical perspective on learning and teaching. Wang and Hsu (2005) emphasized the design of electronic teaching materials (ematerials) to support teaching and describe a system to separate e-materials for use as teaching templates and LOs and to label the materials with use of semantic metadata for searching. One of the most crucial prerequisites for successful implementation of e-learning is the need for careful consideration of the underlying pedagogy, or how learning takes place online. Govindasamy (2002) identified the pedagogical principles underlying the teaching and learning activities that constitute effective e-Learning.

To some, e-learning can take the “form of courses as well as modules and smaller learning objects (LOs)”. E-learning may incorporate synchronous or asynchronous access and may be distributed geographically with varied limits of time. Himes and Wagner (2002) propose strategies for leveraging their content assets when developing and deploying e-learning. Developers can create content objects that can be used over and over again for a variety of applications. This is achieved through the use of modular pieces of content known as LOs.

However, there is no universally accepted definition of what constitutes a learning object or of what size such an object should be to maximise its reusability capability (Muzio, Heins and Mundell, 2001).

ASTD Learning Circuits (2002) defines a learning object as “a reusable, media-independent chunk of information used as a modular building block for e-learning content”. The Learning Object Metadata Working Group of the IEEE (2002,Section 1.1) Learning Technology Standards Committee (LTSC) defines reusable LOs as “any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning”. Wiley (2000) defines LOs as any digital resource that can be reused to support learning. Wentling et al. (2000, p.5) define “e-learning as the acquisition and use of knowledge distributed and facilitated primarily by electronic means”. This form of learning currently depends on networks and computers but will likely evolve into systems consisting of a variety of channels (for example, wireless, satellite), and technologies (for example, cellular phones and PDAs) as they are developed and adopted.

Hence, more recent concerns in integrated learning systems have been on managing the millions of LOs created, addressing disorganization, the lack of use and reuse of these LOs in e-learning systems (Polsani, 2003). The availability of reusable LOs are necessary for an e-learning system to improve its efficiency and productivity by reducing the time and costs involved in developing LOs (Wiley, 2003).
Our Project: Reusable Learning Objects Authoring and Management System

In contrast with other systems (for example, Mispelkamp and Sarti, 1995; Valderrama, Ocana and Sheremetov, 2005; etc.), we propose ReLOAMS, a Reusable Learning Objects and Authoring and Management System (Theng et. al, 2006), to address the serious lack of conceptual clarity of definitions, and uses of LOs, resulting in design and usability problems in current e-learning systems (Polsani, 2003). We see ReLOAMS as a practical LOs management system to help teachers and administrators manage the complexity of construction and deconstruction of LOs.

In this section, we describe the design rationale leading to conceptual design, system architecture and implementation issues relating to ReLOAMS.

Underlying Design Rationale

We highlight related work that has helped to inspire the conceptual design of ReLOAMS in the areas of definitions, models of sharing, digital rights management, usefulness and usability, and authoring of LOs:

- **Defining LOs.** Deriving from the “object-oriented programming” discipline, LO basically describes an object or small part of content that is designed for a specific purpose such as to aid in the learning process. It can be organized using what is called metadata (meaning “data about data”) (Watson, 2001). LOs are also described as usable digital or non-digital entities that are used with technology-supported learning as computer-based training systems, interactive learning environments, intelligent computer-aided instruction system, distance learning system, and collaborative learning environments (Wiley, 2003). The key to defining LOs is to have “components” (or “objects”) that can be reused in a various combination of ways (Wiley, 2003). In other words, instructional components or objects created by instructional designers can be assembled for different learning situations. Often a web-based learning activity may involve, for example, a web page, an animation, and a form of assessment (Mills, 2005). Together with the elements that comprise the entire learning activity can make it extractable, or stand-alone, greatly enhancing the possibilities of appropriate learning environments where it could be used.

Another approach to the definition of LO, for all practical purposes, is described as an object or set of resources that can be used for facilitating intended learning outcomes. These LOs can be extracted and reused in other learning environments and are often called as "Reusable Learning Objects," (RLO's) or "Educational Objects," (Mills, 2005). The term RLO has been associated with electronic learning resources that can be shared in multiple learning environments as recommended by Information Technology Standards Committee (ITSC). (ITSC PlugFest, 2004).

- **Sharing of LOs.** For LOs to be widely used and applied in educational institutions, it has to be readily available and sharable amongst academic staff. One well-established standard called the Sharable Content Object Reference Model (SCORM) (Liang, Cheng & Herng, 2005), helps to establish technical foundations of Web-based learning, providing guidelines
for LOs or contents and systems to meet the following high-level requirements in areas such as: accessibility; adaptability; durability; interoperability; reusability; and “searchability”. However, some researchers think that resolving the instructional/pedagogical issues is where real challenges lie. Reigeluth and Nelson’s findings show how teachers break the resource down into its constituent parts first, and then puts them together again in a different arrangement (Boskic, 2003). Thus, to avoid the deconstruction/reconstruction process, a LO should be that elemental constituent component that cannot be broken down any further and is ready for instructional use in different combinations. As for the size of LOs, Boskic (2003) suggests moving from the course level to the concept level of granularity, but at the same time be conscious that “the optimal level of granularity must be determined for each project based on its individual goals”.

- **Dealing with Digital Rights.** However, breaking down resources inevitably leads to the issue of ownership. Though some are strong supporters of open-source type of approach, but not all agree with the concept of free sharing. Those who champion the legal rights of the authors may actually prevent the reusability of some LOs. The pros and cons were debated at the Commonwealth of Learning (COL, 2005).

- **Addressing Usability and Usefulness.** The reusability of LOs offers an efficient way to facilitate instruction of commonly taught concepts, procedures, applications, and skills. We can repurpose some LOs for different types of users. By developing learning content in these objects or “chunks”, teaching staff can accomplish both current teaching needs as well as potential future teaching needs (Yacovelli, 2004). Longmire (2000) notes several advantages to designing teaching material as LOs such as ensuring flexibility of use; ease of updates, searches and content management; customization; interoperability; and facilitation of competency-based learning.

Understanding how students interact with ideas will help teaching staff identify how to select and evaluate a learning object. Web-based instruction demands the learners’ active relationship not only towards the written word, but also towards a content that is interactive which demands more than a passive reading role (Boskic, 2003). Understanding of learners’ cognitive process and the importance of interactions in the learning setting, coupled with their ability to evaluate a learning object and reuse it in a new customized digital environment leads to better and effective instructional design. Good instructional design includes the right selection of instructional materials, activities, and methods of assessment. Therefore these create a comfortable and more acceptable content by a learner (Hillman, Willis & Gunawardena, 1994).

- **Authoring of LOs.** There are many tools (including both software and hardware) available for developing their learning resources. Presently, Software such as Microsoft Office and Macromedia Studio are some common application tools that bundled with other specific programs help to create complete LOs such as documents, images, audio clips, videos, animations, virtual reality worlds, or multimedia exercises.

However, for more effective deployment of reusable LOs, there need to be tools to publish metadata records of various resources, also considered as LOs. A metadata record consists of
a set of elements, describing a multimedia resource. Examples of these elements are date of creation or publication, type, author, format, or title of a resource (Kassanake and Steinacker, 2000). For example, IEEE's specification of Learning Object's Metadata (LOM) defines the following nine categories for metadata: Each of these categories groups appropriate metadata fields of a specific aspect (Standard for Learning Object Metadata, 2002): (i) General (metadata, such as the title, language, structure, or description of a LO); (ii) Life Cycle (status, version, and role of a LO); (iii) Meta MetaData (metadata describing the metadata used for a LO); (iv) Technical (all technical information about a LO, such as the format, the length, browser requirements, etc.); (v) Educational (information about the educational objective of a LO, such as interactivity, difficulty, end-user type, etc.); (vi) Rights (commercial use and ownership of a LO); (vii) Relation (references to other LOs); (viii) Annotation (additional information about a LO); and (ix) Classification (different purposes of a LO, together with its location within a taxonomy of keywords).

System Architecture

The design issues discussed have been implemented in ReLOAMS. Figure 1 shows the ReLOAMS architecture with two major modules to support construction and deconstruction of LOs:

- **Constructor Module.** This module is concerned with the creation of LOs and consists of three components: (i) LO Search and Retrieval supports personalized and collaborative searching and browsing; (ii) Editor provides an environment to create and edit new LOs; and (iii) Control Authentication incorporates authentication of users and LOs before allowing them to be stored in the respective databases. XML-driven construction module generates various documents as outputs of the ReLOAMS system. Template driven will still be used in the prototyping design as we need to control layout of the output documents. Figure 2 shows the ReLOAMS constructor module architecture.

The LO components are maintained either in a Static LO Component Repository (for example, text, images, etc.) or a Dynamic LO Component Repository (for example, video clips, animation, etc.). To store complete LOs used in different scenarios for teaching, an Aggregated LO Repository is created. An Addressing System is designed to separate LO content from location as a matter of good software engineering practice for better maintenance.

- **De-Constructor Module.** This module supports the de-construction or de-composition of LOs into smaller units of LO components with a learning objective, and consists of three components: (a) LO Component Extractor allows meaningful LO components be extracted for reuse; (b) Metadata Tagger provides a systematic, role-based workflow to complete the metadata details of the LO components; and (c) LO Content Management provides a course content management environment with a proper taxonomy structure to organize the LO components or atomic level LOs.

The current prototype allows the documents to be extracted based on a template-driven mechanism. Some templates used in the prototype design consist of a slide template, a book
chapter template, a journal template, and a conference paper template. The atomic level LOs will be extracted from the documents using its respective file extractor based on its document type (for example, PDF, HTML, Word, and PPT).

The editor shows the data from extracted document in the HTML form (tree view) based on its page, its sections, and its paragraph. Final form of the extracted document will be an XML document based on specified schemas that the ReLOAMS has predefined before. Metadata need to be created to explain the extracted documents. Figure 3 explains the full process of the de-construction of aggregated learning objects into atomic learning components.

To provide use and reuse mechanism, the LOs need to be tagged with the appropriate metadata standard. ReLOAMS has implemented the Dublin Core standard, IEEE Learning Technology standard and Content Exchange Metadata standard.

Figure 1: ReLOAMS Systems Architecture
**Figure 2:** ReLOAMS Constructor Module architecture

**Figure 3:** ReLOAMS De-Constructor Module Architecture
Initial Development

ReLOAMS has been designed to be integrated with the Nanyang Technological University’s existing learning management system (http://edventure.ntu.edu.sg/) called edveNTUre, powered by Blackboard. In fact, ReLOAMS modules can be integrated with any existing Learning Management Systems. Adapter design pattern is used to wrap the ReLOAMS legacy system to expose its object as a service, and for the University’s by edveNTUre, hence the wrapper needs to be constructed too.

The ReLOAMS-edveNTUre Business Process Executing Language handles the business process between those systems. Figure 4 shows the ReLOAMS and edveNTUre service-oriented architecture. A three-tier architecture employing various open source components is being used to develop ReLOAMS:

- **Presentation Layer**: By changing from request-based into event-driven architecture, the interaction between ReLOAMS and user can be more dynamic.

- **Business Logic Layer**: To avoid the expensive overhead cost of network traffic, and application server, a lightweight container need to be used to implement the business logic layer. Loosely coupling architecture will make the system architecture layers independent each other and easy to maintain.

- **Persistent Layer**: High performance object/relational persistence and query service will support the ReLOAMS to achieve the reliable query processing and lousy-coupled architecture of the ReLOAMS.

Figure 5 shows the ReLOAMS prototype homepage. ReLOAMS allows faculty to upload the existing created LOs provided they tag it using the metadata tagger module. The uploaded files will be stored into the aggregated learning object repository (see Figure 6). XML-based documents will be used to store the extracted text based documents, and all LOs will be tagged based on XML document. The search module will do full text search onto the XML based document in the addressing system.
Figure 4. ReLOAMS and edveNTUre Service-Oriented Architecture

Figure 5. ReLOAMS prototype homepage
Figure 6. Uploading Module

Related Work

The focus in ReLOAMS is addressing the reusability and usability of LOs via the Constructor and De-Constructor modules. The premise is that LOs should be “broken down” into learning components. In contrast, other projects concentrate on the creation of LOs as part of the coursework development cycle. For example, Mispelkamp and Sarti (1995) develop a modular, multimedia authoring environment that comprises tools to support authors along the various steps of the courseware development cycle. Their system, Design and Interactive Specification of Courseware (DISCourse), addresses both the design and production of courseware, together with other authoring issues such as creation of simulation-based learning environments, the reuse of learning materials and aspects related to the learner's interface.

Hanisch and Straber (2003) review how reusable software components and a scripting architecture allow for creating interactive learning objects that are adaptable in all aspects and interoperable with other LOs. The project also looks at how developers, educators, and learners can be enabled in this courseware’s “community” to share efforts and collaborate in getting highly interactive Web-based courseware off the ground. Authors may define and modify scripts using online wizards. The authors present a prototype script database that is rated, annotated, and extended by community members. The focus is also not on de-composing learning materials into atomic learning components for greater sharing and reusability. Valderrama, Ocana, and Sheremetov (2005), with their Intelligent Reusable Learning Components Object Oriented (IRLCOO), try to solve the problem of rich content multimedia by producing the special type of reusable learning objects (RLOs), but the interface and functionality of the learning materials are standardized. Closer in ReLOAMS’ objectives is the system developed by Wang and Hsu (2006), from the Teaching-Material Design Center, which allows educators and designers/developers find existing teaching templates and LOs, providing a convenient environment for constructing customized e-materials for different requirements. Their system follows the standard of Sharable Content Object Reference Model to separate e-materials for use as teaching templates and LOs, and labeling the materials using semantic metadata for better searching.
In ReLOAMS, we aim to provide an authoring as well as a management environment. Also, reusability of LOs in ReLOAMS is implemented via the metadata system using controlled vocabulary by expert users and social tagging by the average users. Shareable Content Object Reference Model metadata standard is used as an alternative metadata in ReLOAMS to support its reusability.

**Conclusion and On-Going Work**

The underlying design of ReLOAMS is drawn from different perspectives that are pertinent to the success and failure of e-learning systems addressing use and reuse of LOs. We believe our multi-disciplinary approach is novel, timely and important. Institutions are spending millions of dollars implementing e-learning systems. They are at a stage of development where more and more of them are on-line, and educators/developers are concerned with the usability and reusability of the LOs created by e-learning systems, and effectiveness of these LOs in enhancing teaching and learning. E-learning systems of universities, polytechnics and schools have large user populations, in tens and hundreds of thousands of users. Improvements in e-learning design can have a major organizational, national and international impact. Initial, informal feedback on ReLOAMS has been positive. On-going work involves evaluating it with different categories of stakeholders such as teachers, students and administrators, and validating the taxonomy frameworks and structures for specific domain areas.

**Acknowledgments**

We would like to thank the following graduate students exploring different aspects of LOs, and hence giving us useful insights on the design and development of ReLOAMS.: Lek Li Kheng; Arumugam Swaminathan; Kamaludeen Mohamed Rafi and Mohamed Fauzan Bin Haji-Siraj; Jeff Siaw and Chee Sok Cheng.

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