LEARNING TO SHARE, IS SHARING TO LEARN

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The development of e-learning tools for construction education has been continuously growing. However, development of new tools and platforms is costly, time consuming and soon become out of date. This is mainly because of the fast changes in the information and communication technology and their incompatibility with the old systems. As a result, notion of learning objects, which are smaller chunks of learning content, has been developed in order to maximise the sharability and reusability of learning materials. The development of sharable learning objects however faces a number of barriers and challenges. This paper describes such barriers and challenges and also shows a conceptual framework which is developed for tackling the challenges. It then describes the enabling technologies such as metadata, ontology, semantic web and content packages and demonstrates how these technologies can be integrated to develop an environment for sharable learning objects. The paper finally describes the architecture of the learning objects repository which is developed using enabling technologies.

Keywords: content package, learning object, metadata, ontology, repository, semantic web

1. BACKGROUND

The development of e-learning tools for construction education, both in the context of academia and industry is continuously growing. This paradigm is evidenced by the advancement of new technologies, blended with interactive tools, and is underpinned by sound pedagogical methodologies. This is mainly provoked by the advanced technological developments, which produce interactive and visual tools that can promote experiential learning; hence, this mode of learning now exists in construction\(^\text{[1]}\). However, it is widely acknowledged that the cost of producing effective teaching and learning materials is often time consuming and cost-prohibitive. This is also compounded by incompatibility issues vis-à-vis systems/platforms, which continually make them out of date and obsolete\(^\text{[2]}\). These difficulties therefore often create barriers which encumber advancement and, moreover, require stakeholders to continually reinvent the wheel.

The rapid advancement of e-learning technologies generates new forms of media and communication, which can be used to improve the quality of educational materials\(^\text{[3]}\). Yet, new forms of such technology per se do not directly educate learners without the inclusion of high quality content. Therefore, what is lacking is content, specifically instructional content, termed Sharable Content Objects (SCO) (ADL-SCORM). This means the breaking down of e-learning content into small pieces. One of the key problems in developing educational software systems in general, and interactive instructional visualisation units in particular, is planning for change\(^\text{[4,5]}\). Educational software has been developed with potential for online learning. Some examples are complete packages, commercially prepared and disseminated. Many are individual programs, which often represent excellent applications of sophisticated computing capabilities and a good contribution to the library of educational software. However, they lack overall cohesion as an organised collection, because every software application is vertically engineered to comply within its specific domain. This makes their reusability and sharing capability more difficult to achieve, and can lead to maintenance and deployment difficulties, particularly as restrictive platform requirements accumulate over time.

The aim of creating sharable learning objects is to achieve the goal of maximum reusability, leveraging the high cost of production of quality materials without sacrificing the learning meaning. The concept of learning object emerges from the need to introduce and elaborate e-learning content with pedagogical aspects in a way that can be reused in different learning scenarios. The IEEE Learning Technology Standards Committee (LTSC) defines learning objects as “any entity, digital or non-digital, which can be used, re-used or referenced during technology
supported learning\(^{(a)}\). Figure 1 demonstrates how the learning objects can be reused within various disciplines. However, there are a number of barriers for sharing learning objects. The next section describes the barriers identified, using a pilot survey and details the challenges in sharing learning objects.

2. SHARING LEARNING OBJECTS: BARRIERS AND CHALLENGES

There are a number of social and cultural barriers that reduce sharability of learning objects. A pilot survey with 15 academic staff (at the School of the Built Environment, University of Salford) was conducted to identify the benefits and barriers to sharing learning objects, amongst our findings are shown in Table 1.

In order to overcome the main barriers concluded from the pilot survey (Table 1), it is extremely important that new learning environments for sharable learning objects, address such barriers, to serve the end users (educators, curricula developers and learners). As a result, a conceptual model was developed, identifying three main challenges for developing an effective learning environment for sharable learning objects, these are; intelligent, dynamic and sharable, as shown in Figure 2.

This conceptual model also shows the enablers for such challenges. To further elaborate on this, the semantic aspects of learning objects are developed using metadata, pedagogy and ontology. While, the delivery of learning objects is associated with the ontology, content package and Semantic Web. The structure of the learning objects mainly created using pedagogy, construction domains and content packaging standard.

The rest of this paper describes the enablers for developing sharable learning objects, covering metadata standards, ontology, semantic web technologies and content packages and demonstrates how these can be used to tackle the challenges mentioned in the conceptual model described earlier.

Table 1: Barriers (Pessimists and Optimists)

<table>
<thead>
<tr>
<th>Pessimists</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>technical abilities</td>
</tr>
<tr>
<td>Culture</td>
<td>less willing to share</td>
</tr>
<tr>
<td>Technology</td>
<td>moving fast</td>
</tr>
<tr>
<td>Competition</td>
<td>what is mine, is mine</td>
</tr>
<tr>
<td>Attitude</td>
<td>why should I, and what is there in it for me</td>
</tr>
<tr>
<td>Lack of confidence</td>
<td>what is good for me, may not be good for others</td>
</tr>
<tr>
<td>Copyright</td>
<td>legal issues and approvals</td>
</tr>
<tr>
<td>No recognition for innovation</td>
<td>no one cares</td>
</tr>
<tr>
<td>Time constraints</td>
<td>quick fixes</td>
</tr>
<tr>
<td>Practicalities</td>
<td>what works for me, may not work for others</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optimists</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show me</td>
<td>Show me first, and I may consider it</td>
</tr>
</tbody>
</table>

Figure 1. The concept of Sharable Learning Objects
3. LEARNING TO SHARE: THE ENABLERS

Sharing learning objects among learners, educators and even institutions has been on the research agenda over recent years. However there are a number of approaches adapted to make learning objects sharable, while hardly any, address learning in construction. This section describes main enablers identified by the conceptual model in Figure 2, addressing their relevance to the construction domain, in order to develop and on-line environment for sharable learning objects.

3.1 Standards: Metadata

One of the key factors for making learning objects sharable and reusable is their standardised description, known as metadata. There are number of standardisation bodies in the process of creating precise metadata specification. UK LOM Core is an application profile of the IEEE Standard for Learning Object Metadata that has been optimised for use within the context of UK education[7]. In order to identify metadata for learning objects, the UK LOM metadata elements (which consist of 86 elements) were studied, that can be used to label each learning object, of which 44 are optional elements and the rest are mandatory. Not all these elements however, are found essential to identify learning objects via the search engine and to share among end users. Therefore, in order to identify the most relevant metadata elements that can be generically used, a pilot survey was conducted. Twenty participants took part in this survey, giving different rankings to the most relevant elements. The most relevant of these elements can be seen in Table 2 below. The table also shows the definition of each element as originally identified by IEEE LOM.

<table>
<thead>
<tr>
<th>Metadata elements</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title (M)</td>
<td>Name given to the learning object.</td>
</tr>
<tr>
<td>Language (M)</td>
<td>The primary human language or languages used within this learning object.</td>
</tr>
<tr>
<td>Description (M)</td>
<td>A textual description of the content of this learning object.</td>
</tr>
<tr>
<td>Object Type (M)</td>
<td>The type of Learning Object.</td>
</tr>
<tr>
<td>Keywords (O)</td>
<td>Keywords or phrases describing this learning object.</td>
</tr>
<tr>
<td>Version (O)</td>
<td>The edition of this learning object.</td>
</tr>
<tr>
<td>Contributor (M)</td>
<td>The entities i.e. people, organisation that have contributed to the state of this learning object during its life cycle.</td>
</tr>
<tr>
<td>Contributor Role (M)</td>
<td>The role of the contributor</td>
</tr>
<tr>
<td>Date (M)</td>
<td>The date of the contribution.</td>
</tr>
<tr>
<td>Format (M)</td>
<td>Technical data type(s) of the learning object.</td>
</tr>
<tr>
<td>Location (M)</td>
<td>A string that is used to access this learning object.</td>
</tr>
<tr>
<td>Level (O)</td>
<td>The educational level of this learning object.</td>
</tr>
</tbody>
</table>

The above metadata have been integrated within the learning objects environment in order to label appropriate and precise description onto the learning objects. Figure 3 shows the interface that is used for labelling learning objects. In order to build intelligence into the standardised learning objects, it is important to assign the relevant ontology to these objects, such that they can be described through common vocabulary of a particular domain.

3.2 Ontology

Ontologies are specifications of the conceptualization and corresponding vocabulary used to describe a domain[8]. In the other words, ontology is an explicit description of a domain and defines a common vocabulary as a shared understanding. It defines the basic concepts and their relationships in a domain as machine understandable definitions.

The OWL (Web Ontology Language) is a language for defining and instantiating Web ontologies. The OWL language provides three increasingly expressive sublanguages designed for use by specific communities of implementers and users. OWL Lite supports those users primarily needing a classification hierarchy and simple constraint features. OWL DL (Description Logic) supports those users who want the maximum expressiveness without losing computational completeness and decidability of reasoning systems. OWL Full includes all OWL language constructs with restrictions such as type separation. OWL Full is meant for users who want maximum expressiveness and the syntactic freedom of RDF with no computational guarantees. OWL Full allows an ontology to augment the meaning of the pre-defined RDF or OWL vocabulary.
Ontology defines complex structures based on the concepts and their relations. It is particularly useful in defining course structures, their relationships and level in learning environments. Figure 4 demonstrates a sample course structure from school level to learning object level. This figure shows how one module can be taught in number of different programmes and similarly one topic can belong to number of modules. A learning object can also belong to number of topics.

The complexity of the above structure can be modelled using ontology. Ontology enables development of learning objects that can be mixed and matched in different learning contexts and for different topics. The above structure is integrated within the learning environment using ontology as Figure 5. It enables the learning objects to be shared under a number of topics which can belong to number of modules. As a result, ontology based learning objects increase sharability and reusability and hence reduce the needs for reinventing the wheel.

Next section describes the Semantic Web technology that can be used to tackle a challenge in order to deliver learning objects dynamically.

3.3 Semantic Web

Semantic Web is an extension of the current web in which information is given a well-defined meaning, enabling computers and people to work in cooperation\(^9\). The current web can only be accessed by humans and provides information in a syntactic manner. However in Semantic Web concept, information is given well-defined meaning that can be accessed by both humans and machines. Semantic Web has been developing a layered architecture with the technologies and standards. These form the basic buildings blocks for the Semantic Web to support the development of meaningful web. Figure 6 shows the architectural layer developed to demonstrate for the Semantic Web concept.
Figure 4. Course/Module Structure and Learning Objects

Figure 5. Programme Structure
The standards and technologies mentioned above helped to develop the overall Semantic Web architecture. Unicode is the standard for computer character representation while URI is the standards for identifying and locating information on the web. URIs can be used to identify definitions for concepts. XML separates data from presentation and forms a common way of structuring data on the web. It also associated with some other related standards such as Namespaces and Schemas. The Resource Description Framework (RDF) is the first layer that forms the Semantic Web. RDF represents metadata using URIs to identify and locate resources and information on the Web. It provides a graph model for describing and defining relationships between resources. RDF Schema is a modelling language for defining and describing classes of resources in the RDF model. Logic and Proof layer provide reasoning support for the ontologies and to make new inferences while SPARQL is a query language for getting information from such RDF graphs.

Semantic Web technologies together with the ontologies provide rich medium for facilitating learning via the semantic annotated learning objects and shared repositories. The following section describes next enabler, Content Packages that can be used to package learning objects together to deliver to other learning management systems.

### 3.4 Content Packages: SCORM

Content packaging standards and specifications allow courses to be transported from one Learning Management System (LMS) to another. Content packages consist of learning objects and the information about how these learning objects can be put together to form learning modules. They also specify the protocols for content delivery to learners.

There are a number of initiatives dealing with content packaging specification including IMS Content Packaging specification, IMS Simple Sequencing specification, Aviation Industry CBT committee guidelines for computer managed instruction and Advanced Distributed Learning Initiative Sharable Content Object Reference Model (SCORM). SCORM has defined its own Content Packaging Information Model that extends the IMS Content Packaging Information Model with several SCORM specific elements. SCORM has a unique feature by providing a RTE (Run-Time Environment) that offers a standardised way for Sharable Content Object (SCO) based learning objects to communicate with LMS through the use of common API (Application Program Interface). Figure 7 shows the contents of a SCORM content package which has two sections, one is manifest file which has metadata and other related information about the learning objects and other is physical learning objects.
A SCORM Content Package may represent a course, lesson, module, or may simply be a collection of related content objects. The manifest, an essential part of all SCORM Content Packages, is defined as an Extensible Markup Language (XML)-based file named “imsmanifest.xml”. This file, similar in many ways to a “packing slip”, describes the contents of the package and may include an optional description of the content structure.

SCORM CP provides an API in order to hide LMSs’ implementation details from SCOs and thus notably promote the reusability and interoperability of learning objects. Figure 8 shows an interface where the SCORM is integrated within the online learning environment. Learning objects can be imported within the environment and then can be packaged using SCORM. The packaged content, the zip file can then be exported to other learning management systems like Blackboard.

Content packaging creates a container for shipping learning objects from one environment to another. The parts of online environment discussed in this section of the paper, such as metadata form, ontology based course structure and content packaging were combined together to create an online environment of learning objects. The following section of this paper describes the online environment in detail.

4. SHARING TO LEARN: THE LEARNING OBJECTS REPOSITORY

Learning content is the heart of education and also expensive to produce. The notion of learning objects which are smaller chunks of learning content inevitably enhances sharability and reusability of learning content and thus creates a need for storing and maintaining learning objects in an accessible form. Learning objects may be stored in a repository that will be served as a portal for educators and learners. A learning object repository is a collection of learning objects enabling educators to share, manage and use educational resources. Learning objects and their associated metadata are located in distributed Learning Object Repositories.

There are many initiatives developed and continue to develop learning objects repositories based on various metadata standards. GEM, founded in 1996, established and developed the architecture, software, and training materials necessary to build and maintain a repository called “The Gateway to Educational Materials”. It enhanced the ability to search by state and national curriculum standards, expanding elements and vocabularies in postsecondary levels of education based on GEM metadata standard. MERLOT is a leading edge, user-centered, searchable collection of peer reviewed, higher education, online learning materials created by registered members, and a set of faculty development support services. However, the emerging technologies opened new opportunities in developing repositories with cutting edge technologies that can facilitate smart search and dynamic discovery of learning objects based on their associated metadata and learning contexts.

The enablers for sharing learning objects such as metadata, ontology, content packages and Semantic Web technologies are used to develop an online repository of learning objects. Figure 9 shows the architecture of the learning objects repository.
Learning objects repository is built using open source software and tools. The core of the system is the Semantic Web toolkit called Jena. Jena is a Java framework for building Semantic Web applications. It provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine. The repository has two separate systems that work together to function as a repository. The learning objects system is built using Semantic Web technologies and ontologies. The interface is built using Velocity template engine and the searching mechanism is provided using Lucene search engine. The content packages part is built using content packaging standard called SCORM. Figure 10 shows one of the interfaces in the learning objects repository.

The interface shown in Figure 10 can be used to search for learning objects based on their pedagogical and structural aspects such as objects types and learning styles. Figure 11 shows how the learning objects are labelled using semantic metadata. Each metadata element such as Title is provided as a URI and linked to its definition file, thus make it understandable to automated processes and machines.

Learning objects types and learners’ learning styles have been integrated within the repository to aid the discovery of suitable and appropriate learning objects. Repository has also searching tools that can be used to search particular learning objects based on their types and learning styles. Next section describes future work associated with the learning objects repository.

5. FUTURE WORK

Learning objects repository is currently being evaluated in terms of accessibility and usability. It will then be validated with the end-users such as educators, learners and curriculum developers to see whether it meets the requirements. Ontology will be improved with more classes and relations. The functional and non-functional requirements will be assessed using pre-defined requirements. The performance of functional requirements such as searching, ontology navigation, metadata creation, content packages manipulation will be measured accordingly.

6. SUMMARY

This paper identified the cultural barriers to the sharing educational content, demonstrating the potential benefits to online repositories, in order manage the learning process through building learning blocks that are transparent and transferable between different learning environments. The paper identified enablers for developing sharable learning objects such as metadata, ontology, content packages and Semantic Web technologies and also developed a conceptual framework with enabling technologies. It demonstrated how the enabling technologies facilitate the development of sharable learning objects using a prototype online environment. Finally, it showed the system architecture of the learning objects repository and also the interface of the repository. The system can be improved in the following aspects.
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Figure 9. Architecture of Learning Objects Repository

Figure 10. Use of Ontology in the Repository
Improving ontology with more classes and relations
- Developing a number of ontologies for different purposes such as metadata, structure and pedagogy
- Introducing Semantic Web Services for dynamic discovery of learning objects from other repositories

The learning objects repository is developed using emerging Semantic Web technologies. As Semantic Web technologies are still in the early stage of development, in the near future, there will be more ontology based semantic learning objects that can be discovered and accessed from the repository we have developed.

REFERENCES
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