LEARNING OBJECT MEDIATION

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Abstract

The growing reliance on e-learning environments in business and academia is marked by an increasing interest in the design and development of learning objects and learning management systems (LMS). An LMS provides a framework for courseware creation from learning object, and offers a rich environment where interactions between learner, learning content and instructors can take place. There is a general consensus, however, that their usefulness and relevance depend to a large extent on an awareness of, and compliance with, e-learning architectural and packaging standards. In this paper a number of issues pertinent to effective mediation are addressed. Specific requirements for mediation are identified as part of a wider research programme on learning content mediation. An IMS compliant learning management system and corresponding learning content were developed and presented as an initial stage in the realisation of effective mediation.

Keywords: e-learning, learning object, learning management system, IMS standards.

1 INTRODUCTION

The shift towards a knowledge society, a constantly evolving business environment and an accelerated technological development are pushing to the forefront the need for continuous and effective learning models and technologies. These factors have ushered in a new era where study and work are two complementary facets of life-long learning programmes. In many sectors, this is translated by the need for a tight coupling between university curricula and business requirements. E-learning is seen as a key factor in gaining and maintaining competitive advantage, reducing skill gaps and acquiring core competences.

Two major factors are presiding over the deployment of e-learning frameworks: effectiveness and availability. There is increasing evidence that computer mediated instruction can reduce training costs and enhance the effectiveness of instructional learning. Furthermore, with the advent of the web as a 'universal delivery system', instructional content can be accessed anywhere, anytime. The flexibility afforded by this instructional model can assist in supporting diversified learning paths. A wider adoption of e-learning is, however, predicated on the availability of learning management systems and on the emergence of an e-learning economy where learning objects can be located and accessed (Fletcher *et al* 2000). Learning objects are seen as reusable entities that can be aggregated into courseware according to a specific pedagogy. There is also a growing awareness that conformance to e-learning standards is a requirement for the use of these objects. Beyond transactional

considerations, standards can promote interoperability and reuse and thus ease the task of creating courseware.

One of the main issues that e-learning frameworks need to address concerns the provision of effective instruction. This requirement can be fulfilled through the design and development of a more focussed and enhanced e-learning framework and through carefully crafted learning content (Boyle 2003). This work is part of a wider research programme aimed at providing an environment for the management of learning content and for enhancing instruction and customisation with agent technology (Anane *et al* 2003). The programme spans a number of tasks: learning needs identification, curriculum/courseware design and curriculum/courseware delivery. As the context of this work is largely defined by learner and learning content interaction, the initial stage of the project was driven by the need for an appropriate infrastructure. To this end, learning management system and learning object requirements are identified with respect to conformance to standards and to instructional design and delivery. A learning management system is presented as the focal point of instruction with adequate support for the deployment of learning content.

The remainder of the paper is organised as follows. Section 2 describes the main features of a learning management system. Section 3 introduces learning objects and highlights some of their characteristics. Section 4 discusses e-learning standards and underlines their impact on learning content mediation. Section 5 presents IMS compliant learning management system and learning content. Section 6 identifies issues for further research, and Section 7 concludes the paper.

2 LEARNING MANAGEMENT SYSTEMS

A learning management system can be defined as a learner-centric environment where various interactions take place. The need for these interactions is created by the underlying pedagogical setting which defines three main perspectives: learner/content, learner/instructor and learner/learner. Learning management systems, whether proprietary such as WebCT (WebCT) or open source such as Moodle (Dougiamas *et al* 2003) are aimed at offering a range of tools for: curriculum design (content sharing, course templates, customisation, instructional design), course delivery (course management, testing), administration (course authorisation and registration), productivity (progress review, orientation, search), student involvement (group work, community building) and communication (discussion, mail, whiteboard).

Although most of the LMS's on the market aim at creating a virtual classroom, few are closely associated with a specific pedagogical approach. In contrast, Moodle was designed deliberately with a pedagogical bias, namely social constructivism (Dougiamas *et al* 2003). Support for pedagogical interaction between learners is one of the main features of this system.

3 LEARNING CONTENT

Although a virtual classroom entails the simultaneous existence of various components, the learner/content mode of interaction is still the central part of instructional design, especially in a training environment. It is the primacy of the learner/content interaction that is driving the research into content development in general, and learning objects in particular. These objects are available and accessed through a specific context, and mediated by a learning management system (LMS). This process covers two main stages. First, the LMS interacts with its own repository or remote repositories in order to make learning objects accessible, as part of a designed curriculum and courseware. Second, once the objects are available, the learner is able to interact with them as part of courseware delivery.

According to the IEEE Learning Technology Standards Committee (LTCS), a learning object is defined as "an entity, digital or non-digital, that can be used, reused or referenced during technology-supported learning" (IEEE 2002). Under this definition, learning objects can include multimedia content, learning objectives, software tools and even persons. This definition is generally considered as too inclusive and lacking discrimination. Wiley for instance proposed a more focused definition of a learning object as "any digital resource that can be reused to support learning" (Wiley 2000). The discrete nature of the learning objects raises a number of issues that should be addressed (Hamel *et al* 2002):

- Pedagogical completeness: they should have instructional content and are different from information objects such as a graph, for instance.
- Independence: they should be built upon a single learning objective and should be self-contained.
- Granularity: the learning object should be small enough to support flexible learning design.
- Composition/assembly: learning objects should be reusable and able to be assembled into a sequence in order to create courseware and provide instructional context.
- Metadata: learning objects should be tagged with appropriate metadata so that they can be located in repositories, re-purposed and reused.

4 E-LEARNING STANDARDS

Adherence to e-learning standards is intended primarily to ensure the consistent development of courseware and learning objects. Some of the advantages that accrue from the adoption of standards include (IMS 2003):

- Interoperability: operation of instructional content across different platforms.
- Reusability: incorporation and re-purposing of instructional content into multiple learning experiences.
- Accessibility: access to instructional content from anywhere, anytime.
- Durability: continuous use of instructional content despite changes in underlying technology.
- Affordability: reduction in costs and enhancement of learning effectiveness.

Standards for learning resources can be implemented at two levels. The first level refers to the context and use of the learning resource and requires a description of the resource in terms of standard metadata such as author or ability level. Conformance to standards at this level is designed to ensure interoperability. In the second level, the reuse of content is the motivation behind the adherence to standards. The aim is to facilitate the search for and the acquisition of appropriate learning objects. This requirement postulates the existence of a classification system and related terminology.

Among the e-learning standards that have emerged the IEEE LTSC standard has received a lot of attention for its description of instructional content. It includes the following metadata levels: general (information such as title, keywords, language etc.), lifecycle (history and current state), meta-metadata (description of the metadata itself), technical (technical characteristics such as format), education (educational and pedagogic features such as level), rights (conditions of use), relation (link to other learning objects), annotation (comments on use) and classification (position in existing classification system). Among these the most relevant for the search for, discovery and selection of learning content are the education and relation information categories. This standard is only a subset of the specifications adopted and promoted by IMS. The IMS description has a broader scope in its requirement for interoperability, and covers five different areas:

- Enterprise, for sharing data and information about learners and courses.
- Content Packaging, for creating and sharing reusable content objects.
- Metadata, for describing learning resources for search and discovery.
- Question and Test Interoperability (QTI), for constructing and exchanging tests and assessment information.
- Learner, for organising learner information to satisfy different needs.

5 AN E-LEARNING FRAMEWORK

The initial stage of the research programme involved the design and implementation of a learning management system with a narrow focus and specific functions. The aim of the research project is not to create a virtual classroom but to investigate ways of enhancing content delivery. As the main objective is to enhance learner/content interaction, conformance to IMS standards, learning content mediation and class management were the key functional requirements for the LMS. Tightly coupled with this requirement is the development of relevant learning content. The system supports transparently a number of functions:

- navigation through system functions and learning content
- creation of learning content that can be reused, aggregated and dis-aggregated.
- course management
- provision of formative and summative tests/assignments
- monitoring of learner performance.

The system was designed in a modular fashion and written in Java so as to facilitate the integration of additional agent-supported functionality.

5.1 A learning management system

The mediation process of the LMS defines various tasks and perspectives. Teachers, for example, are able to manage courses by creating classes and assigning content and by monitoring the interaction of learners with learning content. Most of the work, however, was concerned with the provision of tools for courseware creation, delivery and assessment.

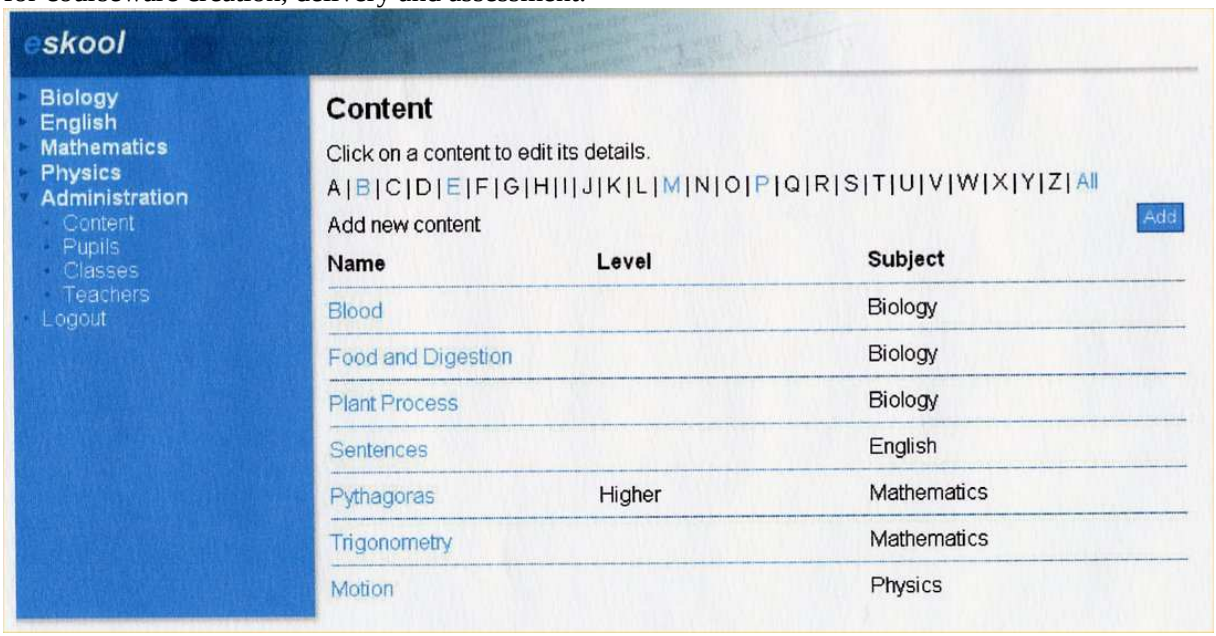

Figure 1. Learning content management

In addition to managerial functions, the foremost task of the LMS is to facilitate navigation through learning content that conforms to the IMS specifications. An example of a user interface for High School learning content management is shown in Figure 1.

5.2 Content Package conformance

It is generally agreed that a pedagogically sound approach to courseware design and implementation should include at least a combination of information content, example and assessment (Cisco). This provision is catered for in the LMS, by conformance to Content Packaging and Question and Test Interoperability (QTI) specifications. The courseware developer is therefore able to create instructional content that incorporates information and assessment, which satisfy interoperability and reusability criteria.

With Content Packaging specification, conformance is ensured by means of the manifest file. Each content package contains two parts, a manifest file written in XML and the physical resources that make up the content itself. The components of the manifest file include:

- Top level manifest: description of the package in general
- Metadata: description of the content; used for accessing learning objects in repositories
- Organisation: structures that organise the content
- Resources: actual resources that make up the content, including references to external packages.
- Sub-manifest: used for aggregation/dis-aggregation of learning objects.

The assessment part of the courseware component conforms to a QTI subset, QTIlite, also written in XML. QTIlite deals mainly with multiple-choice questions. The QTI file is one of the resources of the content package. Content deployment under the LMS involves the parsing of the manifest file and the generation of objects that can be uploaded.

5.3 Instructional content

Instructional content for different topics was created in conformance with the IMS specification. Learning objects offer an illustration of the feasibility of pedagogical commitment in instructional design. The learning content was carefully designed in order to take advantage of the added value afforded by the computational power of interaction. Figure 2 shows one example of a suite of learning objects for simulating various encryption algorithms.

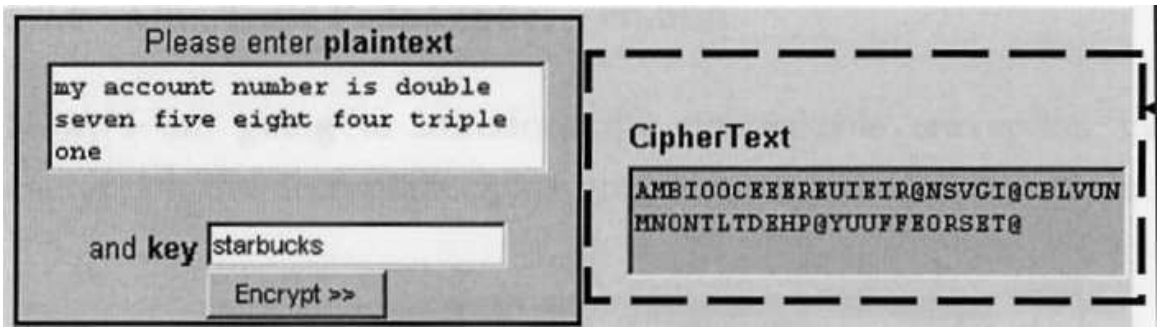

Figure 2. Encryption learning content object

The assessment component of the instructional content serves a dual function. First, it provides feedback to learners who can check the results without being able to alter them. Second, it enables the instructor to monitor the performance of learners and reset tests when required. Content Packaging and QTI specification interpretation are combined seamlessly to provide interaction with learning content.

6 DISCUSSION AND FURTHER WORK

This project was motivated by the need to create a framework that will facilitate effective mediation between learner and content. IMS conformance to Content Packaging was seen as a fundamental

requirement for appropriate content provision and instructional design. The facilities offered by the LMS presented in this paper, although restricted, are fundamental to content provision and conform to the aims of the project. They represent, however, an initial stage in the creation of an e-learning environment. Its current status points to further investigation, and development and a number of areas for further research have been identified: conformance to SCORM e-learning standards and pedagogical awareness, improved access to instructional content and learning objects and customised courseware creation.

6.1 Enhanced e-learning standards

The delivery and presentation of learning material is outside the scope of the IMS specification. The lack of a specification on how learning content is presented implies that the LMS has a lot scope for interpretation in the navigation and sequencing of objects. The prominent role played by the LMS in this respect is matched by a reduction in the independence and autonomy of the learning objects. Future work will aim at reinforcing internal object navigation by full conformance to SCORM (Sharable Content Object Reference Model). SCORM has adopted the IMS specifications and set four main goals for any compliant learning obeject: reusability, interoperability, accessibility and durability (RAID) (ADL 2003). SCORM compliance offers a solution to the coupling between object and LMS by requiring learning objects to be responsible for their own navigation. This is achieved by embedding navigational instructions in objects and by providing a run-time environment (RTE) for their interpretation. This requirement promotes flexible learning by enabling course developers to create instructional courseware from existing learning content by specifying sequencing constraints (Quinn *et al* 2000).

6.2 Pedagogical and technological alignment

In addition to concerns over self-contained units of instruction, recent research into e-learning has seen an attempt ‘to position pedagogy at the heart of the system design’ (Earle 2002). Earle argues very strongly that pedagogically neutral instruction is a myth and that there is shift towards more emphasis on models of pedagogy, which take into account explicitly the instructor, the learning content and epistemologies, in particular. On a more pragmatic basis, this highlights the difference between providing information and providing instruction (Merrill 1997). Instruction learning objects should incorporate information content, structure and organisation, feedback and guidance. In the instructional programme of the Cisco Academy, for instance, learning objects include content, practice and assessment. While learning objects are stand-alone objects, courseware design and therefore instructional context is, however, provided by a logical assembly and sequencing of learning objects. Some researchers are even applying the reuse approach to learning design. They have promoted the use of learning design templates, which encapsulate a learning scenario with clear roles for instructor, learner and activities in collaborative learning, for instance (Tattersall *et al* 2003). The implication of this approach is that the learning design should drive the instructional design. It has the advantage that courseware creation and customisation, for a specific learner at least, could, in theory, be performed independently by the learning management system.

6.3 Learning object discovery and access

The current implementation assumes that the learning objects are already stored locally, and that they can be easily accessed and interacted with by the learner or the instructor. Given the focus of the current system, the LMS does not make use of the metadata of content packages. In the long-term this limitation can constrain the construction of appropriate courseware. Repositories of learning objects are becoming an increasingly important source of learning and instructional content. A transactional model for learning objects is gaining currency and the conditions are being created for a learning object economy (Koutlis *et al* 2000). On the technical side, this model can take advantage of the infrastructure provided by Web Services. *This marks a shift from reuse in aggregation to reuse in*

composition. Their pervasive nature owes much to their reliance on XML, the utilization of lightweight protocols for transport (SOAP) and object discovery (UDDI), and the promotion of languages for service description (WSDL) and service composition (BPEL4WS (Khalaf *et al* 2003).

6.4 Courseware creation and customisation

If the promise of flexible learning is to be realised, then it becomes imperative to move away from undifferentiated courseware offered anywhere, anytime to anyone, to a more customised instructional content that takes into account the abilities of learners and their preferences, including cultural characteristics. This new context, required for an enhanced mediation, confers greater prominence to pedagogical decisions and instructional design. This entails access to a large number of repositories on which refined searches can be performed for locating learning objects that can be aggregated and re-purposed. JIT training for example can be accommodated by on-the-fly courseware creation. From the learner perspective, however, focused mediation and personalisation of instructional content requires the generation and maintenance of user profiles, an area where agent technology can make a significant contribution (Wooldridge *et al* 1995). Semantic Web technologies, ontologies, in conjunction with agent technology, can provide a way of expanding the scope of e-learning (Gruber 1993).

7 CONCLUSION

The emergence and adoption of e-learning standards is now seen as a testimony to the growing importance of instructional content in the acquisition of competences. Conformance to standards is, however, a prerequisite to the creation and promotion of interoperable and reusable learning objects. This endeavour needs to be supported effectively by the development of learning management systems that can provide enhanced learning content mediation.

In this paper a number of issues concerning the development of courseware and its delivery were raised. It was argued that one of the fundamental functions of an LMS was to provide enhanced instruction through effective mediation. Within a restricted scope this has led to the development of an IMS compliant learning management system, and the design of appropriate learning objects. Although this is an essential prerequisite for content mediation, the creation of an environment for effective mediation depends, however, on the availability of advanced features, such as learner profiling, performance monitoring, adaptive behaviour and enhanced content provision.

References

ADL, 2003. *http://www.adlnet.org/*

Anane R., Chao K-M, Hendley R.J. and Younas M. 2003. 'An Agent-mediated Approach to eLearning'. *Proceedings of the International Conference on Internet and Multimedia Systems and Applications,* (IMSA 2003), Honolulu: 104-108.

Boyle T. 2003. 'Design Principles for authoring dynamic, reusable learning objects'. *Australian Journal of Educational Technology*, 19(1): 45-58.

Cisco Academy. *http://cisco.netacad.net/public/academy/catalog/index.html.*

Dougiamas M. and Taylor P.C. 2003. 'Moodle: Using Learning Communities to Create an Open Source Course Management System', *EDMEDIA 2003.* Available at *http://dougiamas.com/writing/edmedia2003*.

Earle A.D. 2002. 'Designing for pedagogical Flexibility – Experience from the CANDLE project'. *Journal of Interactive Media in Education*, 2002 (4). *www-jime.open.ac.uk/2002/4*

Fensel D. and Bussler C. 2002. 'The Web Service Modeling Framework WSMF'. *Electronic Commerce Research and Applications 1(2002)*: 113-137.)

Fletcher J. and Dodds P. 2000. 'All about ADL'. *ASTD learning Circuits*.

IMS, 2003, *http://www.imsglobal.org/content/packaging/*

Gruber T. 1993. A Translation Approach to Portable Ontology specifications, *Knowledge Acquisition 5*: 199-220.

Hamel C.J. and Ryan-Jones D. 2002. Designing Instruction with learning objects. *International Journal of Educational Technology, Vol 3(1).* *http://www.outreach.uiuc/ijet/v3nl/hamel/index.html*

IEEE (2002). IEEE Learning Standards Committee (LTSC), Learning Object Metadata Working Group. *http://ltcs.ieee.org/wg12/*

Khalaf R., Mukhi N. and Weerawarana S., Service-oriented Composition in BPEL4WS, *http://www2003.org/cdrom/papers/alternate/P768/choreo_html/p768-khalaf.htm,* 2003

Koutlis M., Roschelle J. and Reppening A. 2000. 'Developing educational software components', *IEEE Computer*, 32: 50-58

Merrill M.1997. 'Instructional Strategies that teach', CBT Solutions, Nov/Dec, 1-11, *http://www.coe.usu.edu/it/id2/constancy.html*

Quinn C. and Hobbs S. 2000. 'Learning object and instructional components'. *Educational Technology and Society, 3(2). http://www.ottersurf.com/CQResume.html*

Tattersall C. and Koper R. 2003.'EML and IMS Design: form LO to LA'. *LTSN Generic Centre, SSeLF* Session 1.

WebCT. *http://www.webct.com/*

Wiley D.A. 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. http://reusability.org/read/chapters/wiley.doc*

Wooldridge M. and Jennings N. 1995. 'Intelligent Agents: Theory and practice'. *The knowledge Engineering Review, 10(2)*: 115-152.