ABSTRACT

This paper aims to provide an experimental vision of the process of course creation using learning objects obtained in the <e-aula> project, a pilot e-learning system conceived as a research platform to study different aspects of adaptive learning. Based on these experiences we analyze how arising educational standards cope with personalization features at different levels of the course creation process, particularly focusing at LO creation and annotation processes. Standardization in e-learning is a relatively novel and complex domain, with many proposals and frequent new versions of the specifications. This makes it hard to obtain mature reference models for implementing standards in current e-learning systems. Our objective is to contribute to the practical application of the learning object approach for course creation by presenting how our system handles e-learning standards (i.e. IEEE LOM), what limitations we encountered in the fulfillment of our personalization objectives, and, finally, by proposing some possible solutions to these limitations.

KEYWORDS

e-learning standards, learning objects, personalized learning.

1. INTRODUCTION

In the recent years, the learning object (LO) concept has received considerable attention in e-learning. In the literature there are many different (and sometimes contradictory) definitions of LO but most of them share the idea that a LO is a digital learning resource that facilitates a single learning objective and which may be reused in different contexts (ideally without any change). Content development for e-learning is a very expensive and time-consuming task and the LO approach promises more efficiency in content management (i.e. courses are created by LO aggregation, preventing multiple development of the same content and facilitating content update) and more reutilization power of the educational contents (Polsani, 2003). Furthermore, the LO approach could provide an enhancement of the possibilities of personalization of the learning environments because, in the most futuristic vision, LOs would be assembled “on the fly” from repositories to create personalized instruction that satisfies learner’s specific needs and desires (Fletcher, 2000).

If this vision is to happen, instructional content must be developed as reusable, stand-alone objects, properly annotated with metadata so they can be located and retrieved. Moreover, objects and courses should be developed in a uniform manner according to standard guidelines.
To this end, there have been a number of global efforts to develop standards, specifications and reference models for learning objects, leading to increase the accessibility of the learning content that can be shared. In 2002 the IEEE 1484.12.1-2002 Standard for Learning Object Metadata (LOM) was released as the first accredited standard for learning technology.

However, there are numerous technical issues that must be dealt with before learning objects can be effectively reused and personalized to fulfill the LO approach objectives. Some of these issues are highlighted in this paper. This paper aims to provide a vision of the course creation process according to standard guidelines, to analyze how standards deal with personalization features, particularly focusing at the metadata annotation step of the process, and to what extent it is possible to offer a personalized learning experience using the LOM standard.

The structure of the paper is as follows: Section 2 discusses the course creation process according to the LO approach as it is conceived in <e-aula>, the standard initiatives involved at the different levels of the process are outlined in this section and some of the open issues concerning the standards at the different steps of the process are highlighted. Next, the limitations of the standards concerning adaptivity at LO level are considered and possible solutions (based on <e-aula> experiences) for this limitations are offered. Finally, some conclusions are future work are presented.

2. CREATING PERSONALIZED COURSES ACCORDING TO THE LO APPROACH

To create personalized learning courses is a very complex process where there are many aspects to take into account, but we think that the two key aspects are content management and user information.

A personalized learning experience can only be achieved if information about learner’s knowledge needs, knowledge level and preferred learning style is available at different levels of the course schema. Although <e-aula> is a global solution for e-learning, and we address the whole process from course design to its delivery to the learner, this paper is focused on the content aspects of an e-learning application, specifically at the LO creation and annotation phase. In this section we describe the course creation process and the difficulties encountered in the different tasks involved.

About the user information required for adaptation or personalization purposes, just mention that different techniques are used to track user info during his/her interaction with the system (e.g. LO visited, time used with each LO, assessment results). Besides, some initial info about learner knowledge level, preferred learning style and knowledge objectives is collected in order to initiate the session. All this information is used to set a user profile is stored in IMS LIP files.

Contents in <e-aula> are designed according to the LO approach. We have divided the course creation process in four different tasks. A number of open issues are outlined in the following schema, mainly concerning the standards and how they cope with our personalization objectives:

1. Overall instructional design.

2. Learning Object. Three steps are to be followed in this task:
   - Design LOs according to the overall instructional design.
   - Develop LOs. Once LOs are designed they have to be developed. Are there any tools to assist course creators in this step? Other relevant aspect for reusability purposes is the format of the LO content. For example, in most of the system the contents are represented in HTML format as it is recommended by IMS (IMS LD 2004).
   - Annotate LOs with standard metadata (LOM). Do standards cope with our personalization objectives, that is, adapt learning to student’s initial knowledge, knowledge objectives and preferred learning styles?

3. Content aggregation and sequencing
   - Design content sequencing and aggregation according to the overall instructional design.
     - Develop content aggregations. There are three IMS specifications to implement LO aggregation: Content Packaging, Simple Sequencing and Learning Design. At the current project stage <e-aula> is testing the performance of the Content Packaging and Simple Sequencing specifications.

4. Content structure and behaviors.
Design content behaviors according to the overall instructional design.

- Develop content structures and rules.

Although <e-aula> is conceived as an e-learning infrastructure aiming at testing e-learning standards at all the levels in the course creation process, this paper is mainly focused in the LO aspects: the open issues encountered during the design, the development and the annotation phases, to what extent standards cope with our personalization objectives and the solution we have adopted to overcome these limitations.

3. DESIGNING AND ANNOTATING LEARNING OBJECTS ACCORDING TO STANDARDS

3.1 Designing and Developing LOs. Open Issues

As the design of LOs in courseware is not new, many commercial companies such as NetG and Cisco Systems have been using this design model with slight different point of views for several years (Barron, 2000). A review of the best practices of these companies, and the ideas presented in other publications (Downes, 2000; Longmire, 2000; Polsani, 2003; Sosteric, 2002; Hamel 2002) reveals a tentative set of principles and guidelines for designing instruction with LOs. A common set of principles collected from these works, together with our own conclusions derived from the results of <e-aula> project (Sancho, 2004), have led us to the following definition of learning object: a learning object is a self content reusable digital resource conceived as unit of instruction, that is, intended to fulfill a single learning objective.

The proposed definition together with our own exigencies in personalization and reutilization have led us to create learning objects for <e-aula> as an aggregation of digital resources consisting in: core material (typically <e-aula> files encoded in XML) containing mainly textual and graphical explanations with the scope of a learning topic, a set of examples, notes and a set of tests.

Other important issue not defined by standards, is granularity: what should be the extension of a learning object? This problem has traditionally be seen as a trade off between annotation effort and flexibility. The smaller the learning objects are, the more power of reuse and more flexibility in personalization they offer, but at the same time, the greater effort in annotation and processing has to be done.

In <e-aula> adaptation is organized at two levels. First, there is inter-LO or navigational adaptation, and second, we have intra-LO or content adaptation.

For the first level of adaptation, at the current project stage two different specifications are under evaluation: Content Packaging and Simple Sequencing. The results obtained in this evaluation are out of the scope of this paper.

For the second level of adaptation, two different techniques are currently being applied at two granularity levels:
- Metadata level. We are studying the performance of extending LOM schema with domain ontologies in order to achieve better adaptation results. This topic will be treated more extensively in section 3.2.
- Content level. We have added a supplementary granularity level. The object content itself is marked using XML which provides deeper and more detailed information that can be used for more extended adaptation mechanisms. The system is able to display the information contained in a learning object according to the student level of knowledge (<e-aula> has three possible levels: low, medium and high. XML contents also preserve content from external changes, even changes in standards’ specifications. Therefore, in <e-aula> all the basic course contents are also represented directly in XML and not in HTML as it is done in most e-learning systems. XML contents provide mechanisms of adaptation themselves instead of relying it on external structures (i.e. IMS specifications). When a specific content is accessed in the webserver a XSL transformation is applied to the content obtaining the HTML that is delivered to the web client (this approach is similar to the one used in other projects such as ARIADNE). The increase of complexity this additional granularity level implies, worth the excellent results we have obtained in adaptation as more complex processes can be defined using learner information at this level.
3.2 Annotating LOs: LOM standard. Open Issues

The discovery, management, and exchange of LOs can be considerably simplified by providing standardized information on each LO. This information is called metadata and facilitates the search, evaluation, acquisition and use of learning objects by learners, instructors or automated systems. To be effective, metadata needs to be standardized internationally.

The IEEE 1484.12.1-2002 Standard for Learning Object Metadata is the first accredited standard for learning technology. It is essentially a cataloging scheme for learning objects, storing data on each learning object, grouped into nine categories: General, LifeCycle, Meta-Metadata, Technical, Educational, Rights, Relation, Annotation, and Classification.

In our view, there are least two factors that may stand in the way of the LOM’s success, though. First, the full set of 86 elements in the specification is not suited to direct implementation since it entails a huge classification effort (Friesen 2002, Mohan 2003). Also, varying interpretations of the utility, scope and purpose of some elements may cause interoperability problems. Therefore it is beginning to appear so called application profiles aimed at easing the LOM usability in general or its applicability in specific domains. The Canadian Core Learning Resource Metadata Profile (CanCore) is a local adaptation of the LOM specification to make it more usable. CanCore contains only 36 “core” elements from LOM that are considered essential, but even these attempts at pruning the standard have result in large sets.

The point here is to determine whether it is really useful or not the complete metadata set for every implementation. The answer is clearly not. The first step when annotating LOs for a learning environment should be an analysis of which of the 86 metadata elements in LOM are suitable for the system reutilization and personalization purposes. This does not interfere in interoperability as LOs marked up this way can be still used platform independently. Nevertheless, it could be an obstacle concerning reusability as searching methods are not defined for every field, but just for a few.

We think there is a need for communities of practice to identify and create their own metadata structures specific to their particular community, including specific vocabularies, in order to achieve better findability (Halm 2003).

In our current implementation we consider that the following elements and sub elements are required for our reutilization and personalization purposes:

- <general>
  - <identifier>
  - <title>
  - <language>
  - <description>
- <lifecycle>
  - <contribute>
- <educational>
  - <interactitytype>
  - <description>
- <classification>

As the LOM specification explicitly states, its scope does not include “how a learning technology system represents or uses a metadata instance for a learning object”. It turned out that these elements are enough to annotate and query our resources, and represent a compromise between more abstract and more detailed annotation sets.

The other factor that, in our view, may restrict LOM global applicability is that, under the current version of the standard, learning objects are treated as opaque entities (Rodriguez 2003). The description of the LOs is intended to advance the goals of interoperability, but does not address the need for accessibility to internal composition of the LOs which is essential for the goal of adaptation.

The intelligent discovery and assembly of learning objects require information not supported by the current set of elements of the LOM standard. A learning object has a context that is specific for its use. It is necessary for each learning object to specify exactly how that learning object is related to concepts in a particular domain within its context, i.e., an ontology of concepts in a particular domain.

An ontology is a specification of a conceptualization (Gruber 1993). It describes the concepts and relationship of some phenomenon in the world. By using well-defined ontologies on the Web, it is possible
for computers to meaningfully process data since there is a common understanding of terms used and the relationships between those terms.

We think a LO created using this annotation principle gets new dimensions of reusability and adaptivity. This way created LOs are more suitable for retrieving since their content can be inspected using ontology-based conceptualization. With this kind of knowledge, an agent can compare the course structure developed for a specific learner profile with the learning object, based on a common understanding of how they relate to each other.

Another issue is whether to opt for self defined ontology or to use one internationally accepted. Defining a private ontology for a specific field unfortunately works only in the close micro world of a single implementation. To be more general, we decided to use ontologies which are already part of internationally accepted classification systems, i.e., the ACM Computing Classification System [http://www.acm.org/class/1998]. There has been a number of recent efforts aimed at developing ontologies for learning objects (Urban 2003, Brase 2003) and to link elements in the LOM standard to specially developed ontologies.

LOM Metadata records can be effectively linked to ontologies. We are using Meta-Metadata element to declare dependencies of the metadata record with ontologies, and links to ontology terms in the Classification element as proposed in (Sicilia 2002) and (Palomar 2002). This permits to link data in learner profiles to ontology terms, which enhances system adaptation features.

4. CONCLUSIONS AND FUTURE WORK

<e-aula> is a pilot e-learning system conceived as a research platform to test and evaluate new learning technologies (learning standards, new learning design models (LO approach), markup and web technologies) in order to reach a personalized learning experience adapted to student’s needs.

The platform aims at testing standardization proposals at all the different levels in the course creation process, from course design to course implementation, but this paper is mainly focused at the limitations encountered when implementing the standards at learning object level. Based in our experiences, we have reached the following conclusions:

– There is a lack of metadata information applied to the domain the learning object is referred to. In this sense, we have identified a need for methods to create metadata structures to a specific domain of knowledge or to specific communities. These user created metadata are better suited for the community to locate and manage common resources.

– A learning object has a context that is specific to its use. An understanding of the many contexts in which an object is used, would result in increase of the reusability. To make this possible, it would be necessary to articulate the relationship between the metadata associated with the object and the surrounding objects, and report that relationship to the repository. To compose a course from a set of learning objects, an appropriate modeling of conceptual dependencies between fragments is needed. We are developing a concept taxonomy to describe the structure of the concepts and to specify the conceptual relations between fragments and concepts.

– The information about content itself offered by IMS metadata is not enough in terms of defining adaptation methods based on students’ knowledge level, knowledge objectives and learning method preferred. We consider that better results would be obtained reaching a deeper granularity level. We have obtained promising results marking up the LO content itself according to three knowledge levels (expert, intermediate, beginners).

Next step in <e-aula> are the fully implementation of the simple sequencing specification and the study of how to address the implementation of the IMS Learning Desing for personalization purposes.
REFERENCES


