LEARNING OBJECT MANAGEMENT AND EVALUATION

Working with IMS specifications and metadata on AHKME LOM tool

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Abstract: AHKME e-learning platform's main aim is to provide a system with adaptive and knowledge management abilities for students and teachers. This system is based on the IMS specifications representing information through metadata, granting semantics to all contents in the platform, giving them meaning. In this platform, metadata is used to satisfy requirements like reusability, interoperability and multipurpose. The system provides authoring tools to define learning methods with adaptive characteristics, and tools to create courses allowing users with different roles, promoting several types of collaborative and group learning. It is also endowed with tools to retrieve, import and evaluate learning objects based on metadata, where students can use quality educational contents fitting their characteristics, and teachers have the possibility of using quality educational contents to structure their courses. The metadata management and evaluation play an important role in order to get the best results in the teaching/learning process.

1 INTRODUCTION

In learning environments, information has to be perceived and processed into knowledge. One of the problems that have emerged from this transformation was how to represent knowledge. So standardization was indispensable.

Nowadays several organizations are working in the standardization of metadata for educational systems, in this way are developing standards and specifications for that purpose. So to develop AKHME platform we had to choose the most adequate technological standards and specifications in order to reach our objectives of multipurpose, independence of the learning domain, reusability and interoperability of resources and courses, since several standards and specifications have been developed to structure pedagogical contents and to allow the characterization of a wide variety of learning environments (Wiley, 2003).

Here we present AKHME (Adaptive Hypermedia Knowledge Management E-learning Platform), a platform that supports both knowledge representation and knowledge management based on metadata described by the specifications. In this platform teachers have at their disposal tools to create didactic materials and to evaluate, import and retrieve quality educational resources, and students can acquire knowledge through quality learning objects, as well as through the more appropriate learning technique based on their characteristics, the learning activities available, the instructional design, their learning style and the learning objects characteristics.

The goals of AHKME and main contributions are:

- The learning object management and evaluation of quality, where we tried to introduce some intelligence to these processes through intelligent agents;
- The usage of the IMS specifications to standardize all the resources of the platform;
- And the interaction of all subsystems through the feedback between them allowing the platform to adapt to the students and teachers characteristics and to new contexts.

In this paper we'll initially present an analysis of current approaches to e-learning and a comparative analysis of standards and specifications in order to find the best to develop our system and then we'll describe the platform in order to give an overview and to context the system, and we will focus on the tools that provide the management and evaluation of learning objects through their metadata. Finally we'll present some conclusions and future work.

2 CURRENT APPROACHES

Nowadays, there are several solutions to support e-learning, where most of them are content-centred neglecting some important educational issues.

Before we started to develop our platform we have done an analysis of reference commercial and freeware/open-source current approaches to e-learning platforms/systems, like Blackboard (Blackboard, 2005), WebCT (WebCT, 2005), IntraLearn (Intralearn, 2005), Angel (Angel, 2005), Atutor (Atutor, 2005), Moodle (Moodle, 2005), Sakai (Sakai, 2005) and DotLRN (DotLRN, 2005). Our goal in studying these platforms was to identify strong points and weaknesses, so we could try to correct them with our platform. We have done an analysis of several tools in these platforms where we have considered several aspects like shown on table 1.

Table 1: Analysis of e-learning platform

Tools/Features	**Platforms**							
	Comercial				**Open Source**			
	BB	**WebCT**	**IntraLearn**	**Angel**	**ATutor**	**Moodle**	**Sakai**	**.LRN**
Technical Aspects								
Interoperability/integration	✓	✓	✓	✓	✓	✓	✓	✓
Standards and specs compliance	(1), (2), (3)	(6), (1)	(1), (2), (3), (4), (5)	(1), (6)	(1), (2)	(1)	(6)	(6)
Extensibility	x	x	X	x	✓	✓	✓	✓
Adaptation and Personalization								
Interface Costum. and personaliz.	✓	✓	✓	✓	x	✓	✓	✓
Choose Interface Language	✓	✓	✓	✓	✓	✓	x	✓
Students previous knowledge	x	x	X	x	x	x	x	x
Courses and Resources adaptability	x	x	X	x	x	x	x	x
Administrative								
Student Manage. / Monitor. tools	✓	✓	✓	✓	✓	✓	✓	✓
Database Access mechanisms	x	x	✓	✓	✓	✓	✓	✓
Produce reports	✓	x	✓	✓	✓	✓	✓	✓
Admin. workflows quality & functio.	✓	✓	✓	✓	✓	✓	✓	✓
Tracking users	✓	✓	✓	✓	✓	✓	x	x
Resources Management								
Content Authoring and Editing	✓	✓	✓	✓	✓	✓	✓	✓
LOs and other types of content Mng.	x	✓	X	x	x	x	x	x
Templates to aid on content creation	x	✓	✓	✓	✓	✓	✓	✓
LO Search and Indexation	x	x	X	x	✓	x	x	x
File upload/download mechanisms	✓	✓	✓	✓	✓	✓	✓	✓
Evaluation of quality of resources	x	x	X	x	x	x	x	x
Learning Ôbjects Sharing/Reuse	x	x	X	x	✓	x	x	x
Communication								
Forum	✓	✓	✓	✓	✓	✓	✓	✓
Chat	✓	✓	✓	✓	✓	✓	✓	x
Whiteboard	✓	✓	X	✓	✓	x	x	x
Email	✓	✓	✓	✓	✓	✓	✓	✓
Audio and Video Streaming	x	x	X	✓	x	x	x	x
Evaluation								
Self Assessments	✓	✓	✓	✓	✓	✓	✓	✓
Tests	✓	✓	✓	✓	✓	✓	✓	✓
Inquiries	✓	✓	✓	x	x	✓	x	x
Costs	High	High	High	High	None	None	None	None
Documentation	✓	✓	✓	✓	✓	✓	✓	✓

SCORM - (1); IMS - (2); AICC - (3); LRN - (4); Section 508 - (5); Some IMS Specifications - (6)

Analysing table 1 we have found that the majority of the e-learning platforms have good administrative and communication tools, compliance with standards like SCORM, AICC and some of the IMS specifications. These platforms have high implementation level and good documentation. On the other hand we could notice that these platforms have some problems regarding LO management, sharing and reusability and in LO quality evaluation. They also have some problems related to the adaptation of resources to the students' characteristics among others. From the comparison of commercial and freeware/open-source platforms we found that the commercial ones have more difficulty in integrating with other systems and supporting different kinds of pedagogies and of course in terms of costs. So, in table 2 we resume some strong points and weaknesses that we have found.

These weaknesses are traduced in problems in terms of interoperability of resources, reusability of the resources, learning domain independence, quality of learning resources and extensibility of the platforms, what meets some of our goals already presented before.

So, in order to solve these problems and from the confrontation between commercial and open-source/freeware platforms, we have decided to develop an open source platform focused on issues like adaptation, LO and Metadata Management and evaluation.

Table 2: Strong points and weaknesses of e-learning current approaches

Strong Points	Weaknesses
Communication Tools	Resource management & portability
Administrative & Management Tools	Adaptability and personalization
Compliance with standards Implementation Level	Quality of resources Development of new components
Documentation	Diversity of pedagogies and applications
Possibility of hierarchical organization	Costs (Comercial Plataforms)

3 STANDARDS AND SPECIFICATIONS COMPARATIVE ANALYSIS

One of the biggest difficulties of e-learning systems and platforms is in structuring content and information using nowadays pedagogical models, so they can reach a wider range of educational systems and obtain a greater quality of teaching.

Among these standards and specifications there are some more focused on the design and structuring of courses and others that try to enclose, in a general way, all the process of teaching/learning. Among the specifications that first emerged we have Sharable Content Object Reference Model (SCORM) (Scorm, 2004), a project from Advanced Distributed Learning (ADL), and the specification Educational Modelling Language (EML) (Koper, 2003). However these have some problems.

SCORM becomes more a standard integrator than a standard by itself, what makes it dependent of the other standards it integrates, besides it doesn't consider the evaluation and characterization of students. EML is a specification that became obsolete when the IMS (Instructional Management Systems) Learning Design (LD) (IMS, 2004) emerged, however it allows the building of the learning experience based on learning activities, being open to any other learning theories, including aspects such as sequence of activities, users' roles and students' characterization and evaluation. An example of an EML application is HyCo (Hypertext Composer), which is an authoring tool to create contents (García *et al*, 2005). Finally we have the IMS specifications that are used as a guide for structuring contents, developed by the IMS consortium (IMS, 2004), that began its activity with the definition of specifications for instructional structure, to become the standard it is today. It includes specifications to structure the learning process, the learning objects and their metadata, to design units of learning and courses, to evaluate and characterize the users, among others. The main objective of these specifications is to be as general as possible, so they can be applied to any process of teaching/learning.

As we know the use of standards have become very useful not just for the sake of saying that you use a standard but because the use of a standard or standards automaticaly makes everything you make cross systems providing this way common knowledge. The use of a standard helps to achieve more stable systems, reduces the development and maintenance time, allows backward compatilibity and validation, increases search engine success, among many other know advantages.

Having detected the main problems of current e-learning approaches, we've started to analyse several aspects of several standards and specifications to choose the one(s) that would best fit our needs, like described on table 3.

Table 3: Standards and specifications comparative analysis

Features		IMS	AICC	SCORM	Dublin Core
Metadata		✓		✓	✓
Learner Profile		✓			
Content Packaging		✓	✓	✓	
Q&T Interoperability		✓			
DR Interoperability		✓			✓
Content structure		✓	✓	✓	
Content Communication			✓	✓	
Learning Design		✓			
Simple Sequencing		✓		✓	
Accessibility		✓			
Bindings	XML	✓		✓	✓
	RDF	✓			✓
Implementation handbooks		✓		✓	✓
Learner registration		✓			

We have analyzed the IMS Specifications, AICC (AICC, 2005), SCORM and Dublin Core (Dublin Core, 2005), regarding the following:

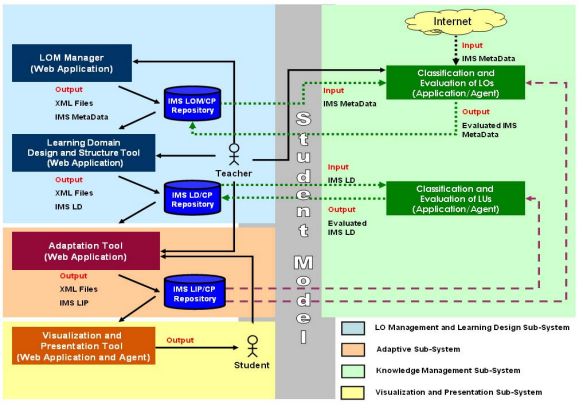
- Metadata - format to represent the metadata to describe the learning resources;
- Learner Profile – format to record and manage learning-related history, goals, and accomplishments;
- Content Packaging – format to package courses and resources so they can easily be transported to other systems;
- Question & Test Interoperability - structure for the representation of questions and test data and their corresponding results reports;
- Data Repositories Interoperability – description how to interact between data repositories;
- Content Structure – format to structure contents;
- Content communications – format to promote the content communication;
- Learning Design – specifications for describing the elements and structure of any unit of learning;
- Simple Sequencing – format to represent information needed to sequence learning activities in a variety of ways;
- Accessibility – takes into account the issue of accessibility;
- Bindings to XML and RDF – specifications to describe the resources in XML or RDF;
- Implementation handbooks – information available;
- Learner registration - format to register learner related information.

From this analysis we've chosen the IMS specifications, since they allow most of the aspects we've analyzed and that we considered important to reach our goals.

4 AHKME DESCRIPTION

AHKME is an e-learning platform that is divided in four different subsystems: Learning Object Manager and Learning Design subsystem, Knowledge Management subsystem, Adaptive subsystem and Visualization and Presentation subsystem. These subsystems were structured this way taking into account a certain line of reasoning, where first we have the process of creation and management of learning objects (LO), which is followed by the process of course creation through the learning design (LD). In parallel with these two processes the Knowledge Management subsystem makes an evaluation of the quality of the available learning objects and courses. Then they pass through an adaptive process based on the students' characteristics to be presented to them, as we can see on figure 1.

To implement the subsystems mentioned before we have been developing Web applications using HTML (Hypertext Markup Language) and CSS (Cascade Style Sheets) for the Web pages' design, PHP (PHP: Hypertext Preprocessor) to run on server side to make the manipulation of XML files, Javascript to run on client side to implement mechanisms in Web forms, pop-up windows and



.NET and C to implement several software agents.

Figure 1: AHKME's structure

These subsystems use XML as standard for file storage. This standard has been widely used because

it allows the interchange of contents between different applications and platforms, facilitating the publishing of contents (Bray *et.al*, 2004).

All the tools of the Learning object management and Learning Design subsystem include a mechanism that packages the generated information, at the level of learning objects, courses as well as at the level of the adapted courses.

Like said before we will now focus on the parts of this system that provide the management and evaluation of learning objects through their metadata.

4.1 LOM and Learning Design Subsystem

The Learning Object Management and Learning Design Sub-system is mostly used by teachers. With this sub-system we provided several features where teachers can develop, search, retrieve, import and analyze resources and also create courses.

We will now describe the tools and features of this sub-system and how they are related with the IMS specifications.

4.1.1 LO Manager

The Learning Objects Manager is a tool that allows teachers to define and create metadata to describe LOs. It uses the IMS Learning Resource Metadata specification, which is based on the IEEE LOM standard that allows the management and representation of knowledge through LOs. The architecture of this tool is described on figure 2.

This tool allows the user to edit LOs and associate descriptive metadata to them.

Then all information is passed into a XML manifest, that gathers all the XML files with their metadata and all the resources used by a LO. By this, it makes it easier to manage all the learning contents, structuring all the information in XML files, that can easily transport this structured information, an also gives the possibility to the user to create general metadata that can be associated with any LO. Besides that, it still allows the creation of packages with their manifests with the LOs and their storage in a MySQL database, what enables the management of these packages that will be used in the design of. All the files and packages that are imported or created in the platform pass through a validation process with the schemas to check if they're in conformance with the IMS specifications, and all the communication between tools and databases is done based on the XML Document Object Model (DOM).

The information packaging enables the creation of packages of LOs and courses with their metadata, so they can easily be transported and reused in other systems, going towards reusability and interoperability, using the IMS CP specification (IMS, 2004).

The LOs are not static in the repositories, but they're in constant evaluation made by the knowledge management sub-system that has tools that communicate with this LO Manager. After the LOs' evaluation, it may be needed to change the LO cataloguing or the way that a LO is related with other LOs, to get better LOs' associations, in order to obtain courses in a easier way taking into account the content models that were more efficient. So, this tool allows these changes that are reflected until the

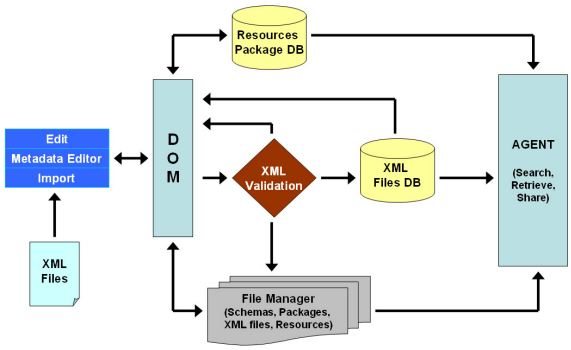


Figure 2: LO Manager architecture

creation of the content package, taking into account the user's wishes, granting a higher level of flexibility.

The main advantage of using the IMS specification for LOs is that through the association of descriptive tags, we can better index them, find them, use and reuse them.

4.1.1.1 LO Search Engine

The search of learning objects is a very important task in order to reach reusability. The descriptive metadata associated to the LOs becomes now more important than ever, since the search is based on it. The learning object's search engine, provided by this platform, is based on an intelligent agent that receives as inputs the metadata elements from IMS LRM for the search and retrieval of the LO.

When the teacher accesses the LO search engine, he can choose from two different types of search – simple or advanced. If the teacher chooses a simple search the agent automatically presents the metadata elements mostly used in searches for him to fill.

Otherwise if the teacher chooses an advanced search, the search engine allows the selection of whatever elements he wants to search for.

Finally, the search engine, as result of the elements selected, presents the LOs according to the teacher's search query with the respective quality evaluation, attained by the LOs evaluation. From this search results the teacher can choose the LOs with more quality to integrate the courses he is creating.

The LO search is based on an intelligent agent that makes the search based on keywords but we aim to base the search on ontologies to relate concepts among them.

4.1.1.2 Metadata Automation Process

The insertion of metadata can be a complex and time-wasting process, because it has several categories and in them several elements and items.

So, in our platform we provide an automation of this process, to facilitate the insertion of metadata, and to describe the LO's through the most adequate metadata elements. This way we can optimize the LO's search, retrieval and reusability and facilitate the user's task reducing the time of development of learning objects.

4.2 Knowledge Management Sub-System

The main objective of this system is to assure quality to the information inside the platform through the evaluation of LOs and courses, in order to get the best courses and the best resources to reach to the best learning/teaching process.

To evaluate LOs we're developing two different tools. One the tools allows teachers and experts to analyze, change and evaluate LOs through a Web application based on evaluation model that will be described next. The other tool is an intelligent agent that automatically evaluates LOs basing its final evaluation on previous evaluations of other learning objects.

We will now describe how the learning object evaluation is processed and the knowledge model to import external learning objects.

4.2.1 LO Evaluation

The quality of the learning resources is becoming an aspect with great importance on e-learning environments, since when e-learning systems first emerged there was a massive production of resources without taking into account their quality. Resources were developed without measure, where features like reusability were discarded. Nowadays the scenery is changing and there are already several criteria and aspects to consider in order to evaluate the quality of a learning resource.

Vargo, *et.al* states that a systematic evaluation of learning objects must become a valued practice if the promise of ubiquitous, high quality Web-based education is to become a reality (Vargo *et.al,* 2003).

Here we present a feature of our platform to evaluate the quality of LOs based on metadata.

To archive an optimal evaluation of LOs, it's necessary to consider quality criteria from different kind of categories, for this reason the following criteria with the respective weight for the evaluation of learning objects were proposed: Psychopedagogical category (30%), contains pedagogical criteria that can evaluate, for example, if the LO has the capacity to motivate the student for learning; Didactic-curricular category (30%), this criteria can evaluate if the LO helps to archive the unit of learning objectives, etc; Technical-aesthetic category (20%) tries to evaluate the legibility of the LO, the colors used, etc.; Functional Category (20%), tries to evaluate its accessibility among other aspects to guarantee that the LO doesn't obstruct the learning process. The final evaluation value is the sum of all the classifications attributed to each category multiplied by their weight. The classification of the categories has the following rating scale: 0 = not present; 1 = Very low; 2 = Low; 3 = Medium; 4= High; 5=Very High (Morales *et al,* 2004).

With these quality evaluation criteria defined, we're developing two different tools to evaluate the quality of LOs. One of the tools allows teachers and experts to analyze, change and evaluate LOs through a Web application based on the evaluation model mentioned before. This is a collaborative tool in which experts and teachers analyse the LOs and give an individual evaluation to the LO.

After this individual evaluation, all the persons involved in the evaluation of the LO gather in a sort of on-line forum to reach to the final evaluation of the LO (Morales *et.al,* 2004).

The other tool is an intelligent agent that automatically evaluates LOs basing its final evaluation on previous evaluations of other learning objects. A schematic representation of the agent is presented on figure 3.

In order to evaluate the LO, the agent starts to import the LO to evaluate and other LOs already evaluated. Then he applies data mining techniques (decision trees) to the educational characteristics of

the LO defined in the IMS LRM specification in order to calculus the final evaluation of the LO.

In order to use the learning objects evaluation defined before we have made a correspondence between the educational characteristics defined on the IEEE LOM standard and the aspects described in the evaluation model (IEEE LOM, 2002).

For now we have just considered the educational category because it has almost all the information about the technical and educational aspects of LOs we have considered important to evaluate LOs.

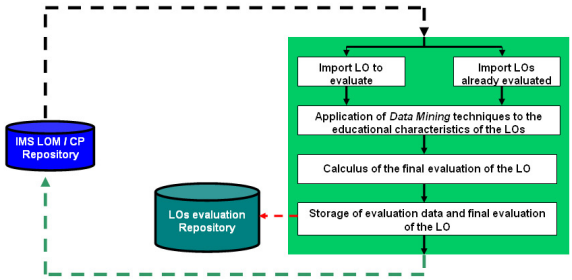


Figure 3: Agent schematic representation

In order to use the learning objects evaluation defined before we have made a correspondence between the educational category elements and the aspects described in the evaluation model that is as follows:

After the calculus of the final evaluation of the object, the agent stores this information in an auxiliary database made for this purpose and also inserts it in the annotation element described by the IMS LRM specification.

With these two tools the learning objects are constantly being availed of their quality, playing an important role in the reusability of the learning objects for different contexts.

5 AHKME LOM VS SIMILAR TOOLS

We have also done an analysis of some key features of metadata tools confronting the learning object metadata tool of AHKME with some other similar learning object metadata tools. To make this analysis we have defined a set of tasks like the ones described on table 4 and tested if the different tools supported them.

The Advanced Distributed Learning (ADL) Sharable Content Object Reference Model (SCORM) Metadata Generator (ADL SCORM, 2005) is an application for creating XML metadata files based on SCORM specification and provides data validation. The resource description tool of EUN, created by Lund University in Sweden, is an HTML page where the user can fill a number of fields that represent the EUN (EUN, 2005) proposed specification of educational metadata. Reggie metadata editor (Reggie, 2005) supports a number of metadata educational specifications where the user has to complete the required fields and to select the metadata format required from a list of technologies available (Resource Description Format, HTML). The LOM Editor (Lom Editor, 2005) is an application for creation and modification of XML metadata files based on a previous version of LOM v1.4. The Alfanet (Alfanet, 2005) has an authoring tool that is based on the standards of the IMS Global Learning Consortium. So, AHKME LOM provides some additional features regarding the packaging of LO metadata and their evaluation. Although, AHKME is the only tool that allows these features, Alfanet also packages information but only at the level of courses.

Table 4. Comparative analysis between AHKME LOM tool and similar tools

Task	Alfanet	LOM Editor	ADL SCORM	Reggie	AHKME LOM	EUN
Creation of new metadata files	✓	✓	✓	✓	✓	✓
Modification of data in metadata files	✓	✓			✓	
Support any educational metadata standard, specification			✓	✓		
Modification of structure of metadata files					✓	
Validation in terms of data values	✓		✓		✓	✓
Validation of structure of metadata	✓				✓	
Support of the XML	✓	✓	✓		✓	
Packaging of LOs metadata					✓	
Evaluation of LOs metadata					✓	
LO Search and Indexation					✓	
Allow metadata document management					✓	

The analysed tools can provide functionalities for meeting specific requirements like XML

validation and support, and creation of metadata files, lacking some important points like:

- Lack of educational orientation, by not providing a list of available educational metadata;
- Require that the person who edits metadata must know XML;
- Lack on functionalities regarding the user's needs to characterize several learning environments;
- They do not provide management of the resources.

So, AHKME LOM distinguishes itself from the others by introducing an abstraction level to the user from the technical aspects in terms of the XML language and is more focused on the user needs, by facilitating the metadata annotation of the LO through a metadata automation process and the search and retrieval of the LO, for the user to reuse the LO in another scenarios. Because of AHKME's LO quality evaluation, the user may choose the best LOs that best fit his educational scenario

6 CONCLUSIONS

In this article we've presented how the platform AHKME uses the IMS specifications and metadata for learning resource management and evaluation.

The IMS specifications, which use the combination of potentialities of metadata and XML, are excellent to represent knowledge.

Through knowledge management the platform allows a continuous evaluation of contents, granting quality to all the existing resources in the platform for teachers and students to use.

The presented platform uses knowledge representation and knowledge management as two processes that work simultaneously to grant success to the process of teaching/learning.

The main contributions of AHKME are the learning object management and evaluation of quality, where we tried to introduce some intelligence to these processes through intelligent agents; the usage of the IMS specifications to standardize all the resources of the platform in order to reach interoperability and compatibility of its learning components, and the interaction of all subsystems through the feedback between them allowing the platform to adapt to the students and teachers characteristics and to new contexts. So, it's very important to have the resources well catalogued, available, and with quality so we can create quality courses. Meanwhile, we should take into account that quality courses don't just depend on quality resources, but mainly in the design of activities to reach determined learning objectives.

Being a multi-purpose platform it can be applied to several kinds of matters, students, and learning strategies, in both training and educational environments.

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