e-Learning Platform Implementation - Learning Object an Learning Design Management Through Metadata Standards

Hugo Rego, Tiago Moreira and Francisco José García-Peñalvo
Department of Computer Sciences, University of Salamanca, Spain
hugo_rego05@yahoo.com
thm@mail.pt
fgarcia@usal.es

Abstract: AHKME (Adaptive Hypermedia Knowledge Management E-learning) system main aim is to provide a modular and extensible system with adaptive and knowledge management abilities for students and teachers. This system is based on the IMS specifications, developed by the IMS consortium since 2001, that allow the representation of information through metadata, granting semantics to all contents in the system, giving them meaning. 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, student or staff, promoting several types of collaborative and group learning. The system is also endowed with tools to retrieve, import and evaluate learning objects based on metadata, where students can use and learn through quality educational contents taking into account their characteristics. Also teachers have the possibility of using quality educational contents to structure their courses and activities. In our system, metadata management and metadata evaluation play an important role in order to get the best results in the teaching/learning process. Regarding the mechanics of the system, we have divided it in four different subsystems. These subsystems are in constant communication receiving feedback between them in order to adapt to students, teachers and different kinds of learning contexts. In order to develop our system we have started to analyse several current existing e-learning platforms and systems to identify strong points and weaknesses, so we could try to overcome these weeknesses with our system. We have also analysed several standards and specifications to find the one that best fitted our needs in order to help us reach our objectives. In this paper we will focus on the two subsystems that make possible the management and evaluation of learning objects through metadata described by the IMS specifications.

Keywords: e-Learning, educational standards, IMS specifications, learning object, knowledge management, metadata

1. Introduction

In learning environments, information has to be perceived and processed into knowledge. One of the problems that emerged from this transformation was how to represent knowledge, that's why standardization was indispensable. Nowadays several organizations are working in metadata standardization for educational systems, developing standards and specifications to structure pedagogical contents and to allow the characterization of a wide variety of learning environments (Wiley 2003). To develop AKHME, 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. Here we present an open source system that supports both knowledge representation and knowledge management based on metadata described by the IMS specifications. It provides tools where teachers can create didactic materials and evaluate, import and retrieve quality educational resources. Students can acquire knowledge through quality learning objects (LO), as well as through the most appropriate learning technique based on their characteristics, the available learning activities, the instructional design, their learning style and the LO characteristics.

The goals of AHKME and main contributions are:

- The LO management and quality evaluation;
- The usage of the IMS specifications to standardize all the platform's resources;
- The usage of standards like XML, an open source methodology both on programming languages and databases that facilitates the comunication between systems;

- The subsystems' interaction 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 start to present an analysis of e-learning current approaches and a comparative analysis of standards and specifications in order to find the best to develop our system. Then we will describe the system in order to give an overview and to context it. We will focus on the tools that provide the LOs' management and evaluation through metadata and finally we'll present some conclusions.

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 developing our system we have done an analysis of reference commercial and freeware/open-source e-learning platforms/systems, like Blackboard, WebCT, IntraLearn, Angel, Atutor, Moodle, Sakai and DotLRN (Angel 2005, Colace *et .al 2002*, Graf *et .al 2005*). Our goal in studying these platforms was to identify strong points and weaknesses, so we could try to correct them with our system. We have done an analysis of several tools/features where we have considered several aspects like shown on table 1 (x-non-supported feature; ✓-supported feature).

Table 1: Analysis of e-learning platforms/systems

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)	(1) (6)	(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	H	H	H	H	N	N	N	N
Documentation	(	(	(	(	(	(	(	(

SCORM - (1); IMS - (2); AICC - (3); LRN - (4); Section 508 - (5); Some IMS Specifications - (6); High - H; None - N

Analysing table 1 we found that the majority of the e-learning platforms/systems have good administrative and communication tools, the compliance with standards like SCORM, AICC and some IMS specifications. These platforms have high implementation level and good documentation. On the other hand we noticed that these platforms have some problems regarding LO management, quality evaluation, sharing and reusability. 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 the costs. In table 2 we resume the strong points and weaknesses that we have found.

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	Quality of resources
Implementation Level	Development of new components
Documentation	Diversity of pedagogies and applications
Possibility of hierarchical organization	Costs (Comercial Plataforms)

The weaknesses found are mainly related to problems regarding interoperability, reusability and quality of learning resources, learning domain independence and extensibility of the platforms, meeting some of our goals presented before. To solve these problems and from the comparison 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 quality evaluation.

3. Standards and specifications comparative analysis

One of the major difficulties of e-learning platforms/systems is how to structure content and information using nowadays pedagogical models, in order to reach a wide range of educational systems and obtain a greater quality of teaching/learning. The answer was the development of educational standards and specifications, where some are more focused on the courses design and structure 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) (ADL 2006), a project from Advanced Distributed Learning (ADL), and the specification Educational Modelling Language (EML) (Koper 2001). However these have some problems.

SCORM becomes a standard integrator than a standard by itself, being dependent of the standards it integrates, besides it doesn't consider students' evaluation and characterization. EML is a specification that became obsolete when the IMS (Instructional Management Systems) Learning Design (LD) (Kooper *et .al* 2003) emerged, however it allows the building of the learning experience based on learning activities, being open to many 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 (Garcia *et .al* 2004). 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. IMS includes specifications to structure the learning process, the LOs 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 teaching/learning process. 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 it makes everything you do 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 compatibility and validation, increases search engine success, among many other known advantages. Having detected the main problems of current e-learning approaches, we have 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 features:

- Metadata - format to represent 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 representing 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 content communication;
- Learning Design – specifications for describing 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 resources in XML or RDF;
- Implementation handbooks – information available;
- Learner registration - format to register learner related information.

From this analysis we have 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 system 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 taking into account a line of reasoning, where first we have the process of LOs creation and management, which is followed by the course creation process through the learning design (LD). In parallel with these two processes the Knowledge Management subsystem makes an evaluation of the quality of the available LOs and courses. Then they pass through an adaptive process based on the students' characteristics so they can be presented to them, as we can see on figure 1.

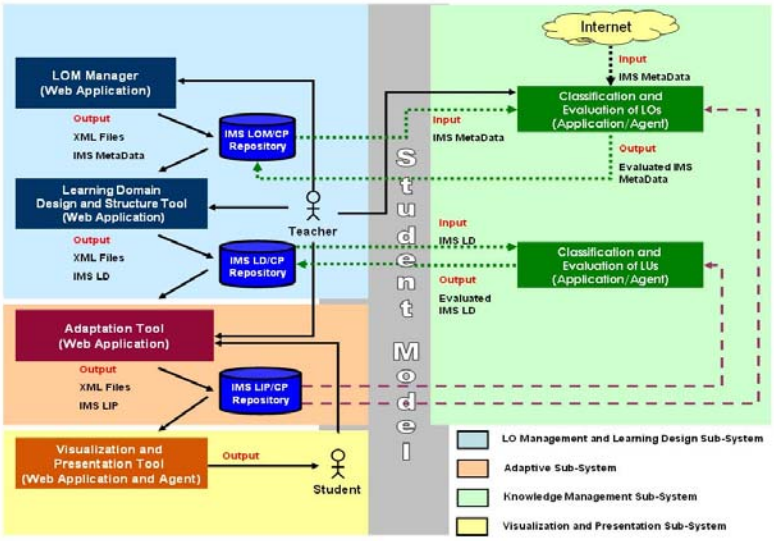

Figure 1: AHKME's structure

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.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). On our system XML becomes the basis of all since the IMS specifications use it as standard for structuring the information mainly due to its structure, interoperability and because it is a standard.

All the Learning Object management and Learning Design subsystem tools include a mechanism that packages information, at the level of LOs, courses as well as at the level of adapted courses. Like said before we will now focus on the parts of this system that provide the management and evaluation of LOs objects through their metadata.

4.1 LOM and learning design subsystem

The Learning Object Management and Learning Design subsystem is mostly used by teachers. With this subsystem we provide 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 subsystem 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 (Barker *et .al* 2006). On this subsystem the refered specification has a very important role since all the management/manipulation of the educational recsources is done through it.The architecture of this tool is described on figure 2.

This tool allows the user to edit LOs and associate descriptive metadata to them, information which is passed into a XML manifest that gathers all the XML files with metadata and all the resources used by the LO, facililtating its management and allowing its transportation in a structured/standardized format. It also gives the possibility to create general metadata that can be associated to any LO and allows the creation of packages with manifests and LOs that are stored in a MySQL database, enabling their management.

All the files and packages that are imported or created in the system pass through a schema validation process 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), being XML the basis of the communication between the different tools and storage systems.

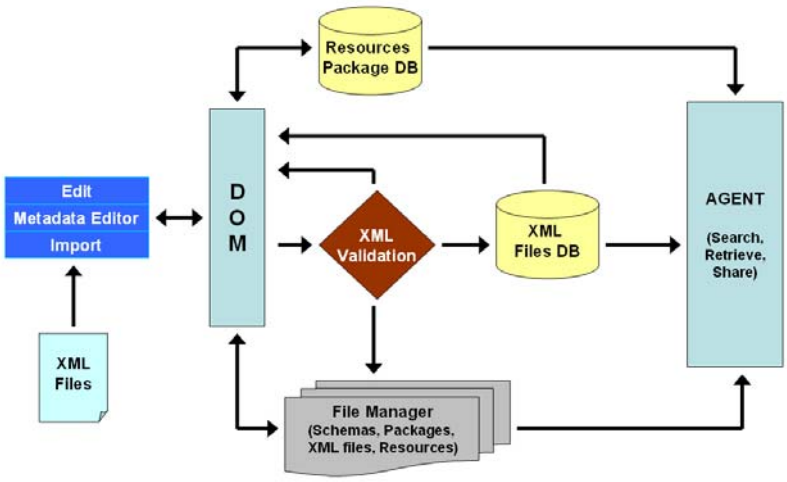

Figure 2: LO Manager architecture

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 (Smythe *et.all* 2004).

The LOs are not static in the repositories, but they're in constant evaluation made by the Knowledge Management subsystem 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 to be reflected until the 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 we can describe learning contents through descriptive tags, facilitating their indexation, location, usage and reusability and also it's a standardized format we provide for the contents in our system allowing us to export them in a standardized form. This tool also includes a LO search engine that is very important 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 is an intelligent agent that receives as input the metadata elements from IMS LRM specification. The search is done on a database matching the elements described on the XML files. This tool is also important to give us an indicator related to the usage of the contents, by allowing us, for example, to collect statistics of which resources are mostly used, and possibly use it as a quality factor.

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 selected elements, 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.

4.1.2 LD editor

The subsystem's part referring to the Learning Design (Figure 3) provides a tool where teachers can create and structure courses using level A of the IMS LD specifications defining courses' activities, sequence, users' roles, student or staff, and metadata. It generates a XML manifest gathering all the courses' XML files, LOs, metadata and resource files. With the usage of XML files information can be reused in the construction of other courses facilitating the learning information portability (Koper *et. al* 2003).

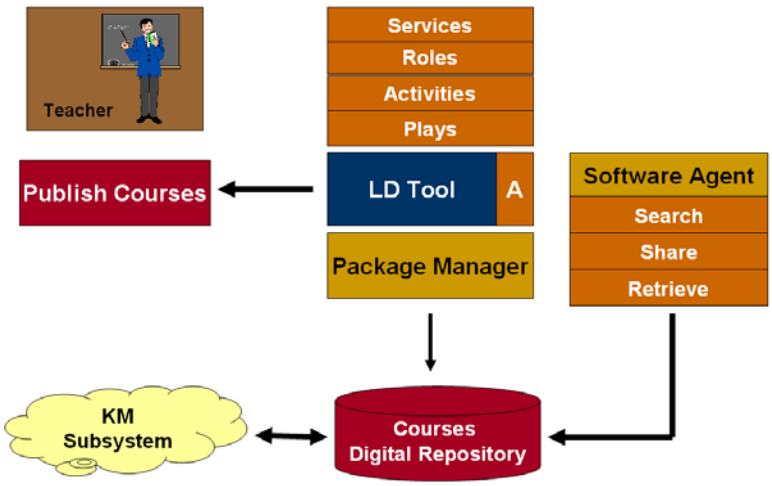

Figure 3: Learning Design Tool architecture

This tool also provides the creation of packages with courses integrating them in a data repository, to reach a more efficient management and, also, communicates with the KM subsystem to evaluate those courses. After the evaluation this tool allows the courses to be restructured letting the user interact with the learning design process.

4.2 Knowledge management subsystem

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

We will now describe how the learning object evaluation is processed.

4.2.1 LO evalution

The quality of the learning resources is becoming an aspect with great importance on e-learning environments, since 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 learning resources.

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).

In order to archive an optimal evaluation of LOs, it's necessary to consider quality criteria from different kind of categories, for this reason we proposed weighted criteria and made a correspondence between them and the educational characteristics defined on the IMS LRM specification that is based on the IEEE LOM (IEEE 2002) standard, like show on table 4.

Table 4: Evaluation criteria categories and matching with the IMSLRM educational category

Eval. criteria categories	Weight	IMSLRM Ed. elements	Description
Psychopedagogical	30%	intended end user role; typical age range; difficulty	Evaluates, for example, if the LO has the capacity to motivate the student for learning;
Didactic-curricular	30%	learning-resource type; context; typical learning time; description	Evaluates if the LO helps to archive the unit of learning objectives, etc;
Technical-aesthetic	20%	semantic density; language	Evaluates the legibility of the LO, the colors used, etc;
Functional	20%	interactivity type; interactivity level	Evaluates LOs accessibility among other aspects to guarantee that it doesn't obstruct the learning process;

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.

The final quality 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).
This subsystem evaluates the LOs quality based on the metadata described by the IMS Specifications. This way the standards/specifications play an important role on this subsystem since the quality is attained by analysing its elements. Following these criteria, we are developing two different tools to evaluate the LOs quality. One of the tools, which is a Web collaborative tool, allows teachers and experts to analyze, change and evaluate LOs and their descriptive metadata giving them an individual evaluation. Then they gather in an on-line forum to reach to the LO final evaluation (Morales *et.al* 2004). The other tool is an intelligent agent that automatically evaluates the LOs quality, basing its final evaluation on previous evaluated LOs. A schematic representation of the agent is presented on figure 4.

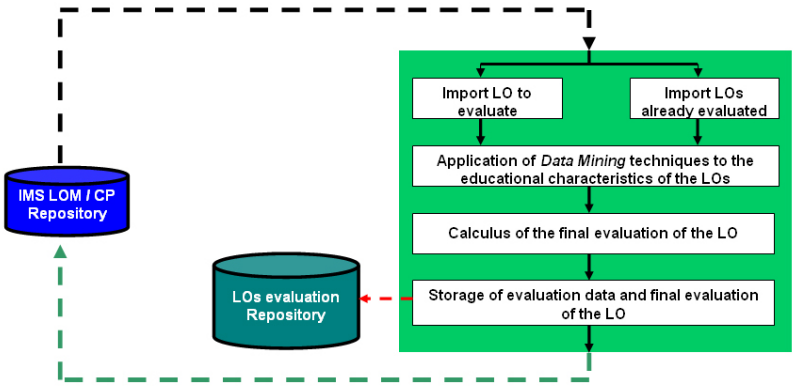

Figure 4: Agent schematic representation

To evaluate the LO, the agent starts to import the LO to evaluate and others already evaluated. Then he applies data mining techniques (decision trees) to the educational characteristics of the LO described by IMS LRM specification in order to calculus the final evaluation of the LO.Then it 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 based on the IMS specifications, playing an important role in the reusability of the learning objects for different contexts.

5. Application scenarios

AHKME tool's usefulness application scenario could be both educational and training contexts for instance in classes' laboratories. It's important to make a comparative analysis of AHKME tool's application vs similar tools, both qualitative, like the level of feature support, and quantitative, like

the level of user satisfaction in a application testing process. For instance comparing the AHKME LOM Tool with similar tools, in AHKME users catalogue the LO with metadata, with and without the help of the automation metadata process, where he/she packages LO metadata through the AHKME LOM feature and searches for a specific LO (with best quality classification for a specific context application, expressed in the metadata) with and without the use of the LOM search engine, also using the quality tools to evaluate the LO. Regarding the qualitative level, we've analyzed some key features of metadata tools confronting the learning object metadata tool of AHKME with some other similar learning object metadata tools (LOM Editor [16], ADL SCORM [2], Reggie [19] and EUN [11]). To make this analysis we have defined a set of tasks mapping it to the study goals, like described on table 5, and tested if the different tools supported them.

Table 5: Comparative analysis between AHKME LOM tool and similar tools

Task	Goal	LOM Editor	ADL SCORM	Reggie	AHKME LOM	EUN
Creation of new metadata files	LD Independence	✓	✓	✓	✓	✓
Modification of data in metadata files	LD Independence	✓			✓	
Support any metadata standard & specif.	LD Independence		✓	✓		
Modification of structure of metadata files	LD Independence				✓	
Validation in terms of data values	Interoperability		✓		✓	✓
Validation of structure of metadata	Interoperability				✓	
Support of the XML	Interoperability	✓	✓		✓	
Packaging of LOs metadata	Interoperability				✓	
Evaluation of LOs metadata	Resour. Quality				✓	
LO Search and Indexation	Reusab./ Res. Quality				✓	
Allow metadata document management	Reusability				✓	

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.

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. It 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. Due to AHKME's LO quality evaluation, the user may choose the best LOs that best fit his educational scenario.

6. Conclusion

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, allowing content indexation, location, usage, reusability and content interchange between different applications and platforms, facilitating their publishing and transportation in a structured format.

Knowledge management through the IMS specifications allows a continuous quality evaluation of contents, since it is based on them, granting quality to all the existing resources in the platform for teachers and students to use. The main contributions of AHKME are the learning object management and quality evaluation, 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, compatibility and quality of its learning components; 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.

It's very important to have standardized resources, well catalogued, available, and with quality so we can create quality courses and atain the best teaching/learning process. 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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