

# Implementation of an E-Learning System – Learning Design and Learning Objects Management and Evaluation through Standardization of Resources

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**Abstract.** AHKME 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 representing information through metadata. 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 can use 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 the era we live in, information and its transformation into knowledge became crucial that's why standardization became important because it provides a semantic representation of knowledge through ontologies in which concepts are clearly and unambiguously identified, also providing a set of semantic relation types which allow representing meaning by linking concepts together [15][5].

In order to develop our system, Adaptive Hypermedia Knowledge Management E-learning system (AHKME), we had to choose from among several existing technological standards and specifications the ones that best fit our needs 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 [20]. AHKME uses both knowledge representation and management based on metadata described by specifications where teachers can create, evaluate, import and retrieve quality educational resources, and students acquire knowledge through quality learning objects (LO), as well as through the most appropriate learning technique based on their

characteristics and learning style, available learning activities, instructional design and LO characteristics.

The goals of AHKME and main contributions are: the LO management and quality evaluation; Use of the IMS specifications to standardize all the resources of the platform; the interaction of 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 will start to present an analysis of e-learning current approaches and a standards and specifications comparative analysis to find the best to develop our system. Then we describe the system and focus on applications that provide the LO management and evaluation. Finally we present the conclusions and future work.

## 2 Current Approaches

In order to start developing AHKME we have analysed several e-learning systems, though this analysis has to be an evaluative methodical process of several aspects, where we have to consider the system's main target, if it is an enterprise or educational environment and a training or educational implementation, the students' pre-knowledge and IT skills, the platform's support in terms of resources and infrastructures, and the criteria basis should be quality.

An e-learning platforms/systems analysis can be done empirically, which is a more technical analysis considering the platforms' features, tools and potentialities, in terms of availability and quality (✓-available, x-not available). So, we have analysed Blackboard, WebCT, IntraLearn, Angel, Atutor, Moodle, Sakai and DotLRN like shown on Table 1, in order to identify strong points and weaknesses, so we could try to use them in the development of our platform [4][7][10].

From Table 1 we found that almost all the platforms have good administrative and communication tools, compliance with standards, high implementation level and good documentation, though they have some problems regarding LO management, sharing, reusability and quality evaluation, resources adaptation 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 integrating with other systems and supporting different kinds of pedagogies and of course the costs.

These weaknesses are mainly traduced in problems regarding interoperability, reusability and quality of resources, learning domain independence, extensibility of the platforms, meeting some of our goals already presented. In order to solve these problems we have decided to develop an open source platform focused on these issues.

## 3 Standards and Specifications Comparative Analysis

One of the biggest difficulties of e-learning systems/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 teaching quality, that is why standards were developed for. As we know the use of standards have become very useful because automatically makes everything 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 know advantages [18].

**Table 1.** Analysis of e-learning systems

Tools/Features	Platforms							
	Comercial				Open Source			
	BB	WebCT	IntraLearn	Angel	ATutor	Moodle	Sakai	.LRN
<b>Technical Aspects</b>								
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	✓	✓	✓	✓
<b>Adaptation and Personalization</b>								
Interface custom. and personalization	✓	✓	✓	✓	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
<b>Administrative</b>								
Student manage. / monitor. tools	✓	✓	✓	✓	✓	✓	✓	✓
Database access mechanisms	x	x	✓	✓	✓	✓	✓	✓
Admin. workflows quality & functio.	✓	✓	✓	✓	✓	✓	✓	✓
Tracking users	✓	✓	✓	✓	✓	✓	x	x
<b>Resources Management</b>								
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
Evaluation of quality of resources	x	x	x	x	x	x	x	x
Learning objects sharing/reuse	x	x	x	x	✓	x	x	x
<b>Communication</b>								
Forum	✓	✓	✓	✓	✓	✓	✓	✓
Chat	✓	✓	✓	✓	✓	✓	✓	x
Whiteboard	✓	✓	x	✓	✓	x	x	x
Email	✓	✓	✓	✓	✓	✓	✓	✓
Audio and video streaming	x	x	x	✓	x	x	x	x
<b>Evaluation</b>								
Self assessments	✓	✓	✓	✓	✓	✓	✓	✓
Tests	✓	✓	✓	✓	✓	✓	✓	✓
Inquiries	✓	✓	✓	x	x	✓	x	x
<b>Costs</b>	H	H	H	H	N	N	N	N
<b>Documentation</b>	✓	✓	✓	✓	✓	✓	✓	✓

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

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 presented in Table 2.

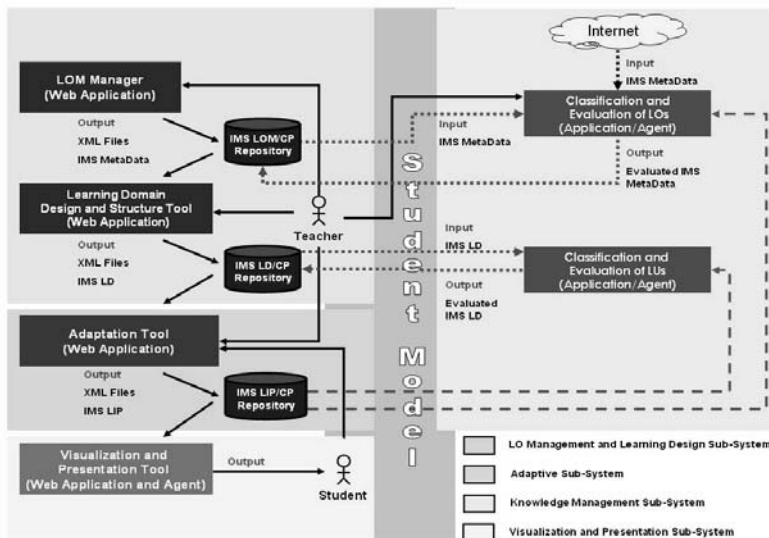
We have analyzed the IMS Specifications [12], AICC, SCORM [1] and Dublin Core [8], and from this analysis we've chosen the IMS specifications, since they allow most of the issues we've analyzed and that we consider important for our goals.

**Table 2.** 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		✓			

### 4 AHKME Description

AHKME, presented on Figure 1, 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.



**Fig. 1.** AHKME's structure

These subsystems were structured taking into account the following: First we have the LO creation and management process, followed by the course creation process through learning design (LD). In parallel the Knowledge Management subsystem evaluates LOs' and courses' quality that then pass through an adaptive process based on the students' characteristics to be presented to them.

These subsystems are web applications that were developed using Asynchronous JavaScript And XML (AJAX) to create interactive web applications [3], HTML and CSS for the Web pages' design, PHP (PHP: Hypertext Preprocessor) to run on server side to make the manipulation of XML files, Javascript to implement mechanisms in Web forms and .NET and C to implement several software agents. All of these subsystems use XML as standard for file storage and knowledge representation which allows content interchange between different applications and platforms, facilitating content publishing [6]. All LO management and LD subsystem tools include a mechanism that packages the generated information, at the level of LOs, courses as well as at the level of the adapted courses. We will now focus on the parts of this system that provide the LO management and evaluation through metadata.

#### 4.1 LOM and Learning Design Subsystem

The Learning Object Management and Learning Design subsystem is mostly used by teachers where they 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 Object Manager tool, presented on Figure 2, allows teachers to define/create metadata to describe LOs through IMS Learning Resource Metadata specification which is based on the IEEE Learning Object Metadata (IEEE LOM) [11] standard that allows the knowledge management and representation through LOs.

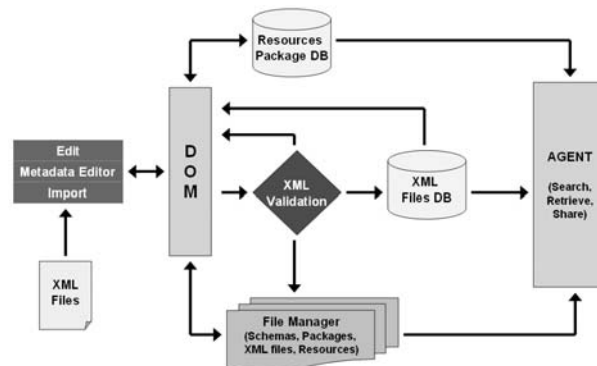


Fig. 2. LO Manager Architecture

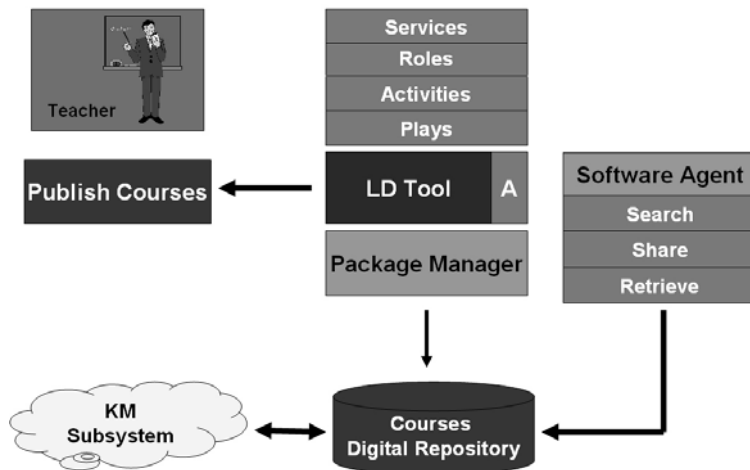
This tool structures all information in a XML manifest, that gathers all XML files with LO's metadata and resources facilitating the learning contents' management. It allows the creation of general metadata that can be associated to any LO and the creation of packages with their manifests and LOs and their storage in a MySQL database, enabling their management. All these files and packages pass through a validation process to check their conformance with the specifications, and the communication between tools and databases is based on the XML Document Object Model.

The LOs are not static in the repositories, but they are in constant evaluation by the KM subsystem. After the evaluation it may be needed to change the LOs' cataloguing or the way they are related with others to get better associations letting these changes to be reflected until the packages' creation, 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, find, use and reuse them.

#### 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 [13].



**Fig. 3.** Learning Design Tool architecture

This tool also provides the package creation with courses integrating them in a data repository, to reach a more efficient management and, also, communicates with the

KM subsystem to evaluate the courses created. After the evaluation this tool allows the courses' restructuring allowing the user to interact in the learning design process.

## 4.2 Knowledge Management Subsystem

We've decide to create a subsystem which main objective is to assure quality to the information in the platform through the LOs' and courses' evaluation, to get the best courses and the best resources to reach to the best learning/teaching process.

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

### 4.2.1 LO Evaluation

The quality of learning resources is becoming an aspect with great importance on e-learning environments, since when e-learning systems emerged there was a massive production of resources without taking into account their quality. 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 [19].

To archive an optimal evaluation of LOs, it's necessary to consider quality criteria from different kind of categories, for this reason the criteria with the respective weight presented on Table 3 were proposed [16].

**Table 3.** Evaluation criteria categories and matching with the IMSLRM educational category

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

The final evaluation is the sum of all category classifications multiplied by their weight and has following rating scale: 0=not present; 1=Very low; 2=Low; 3=Medium; 4=High; 5=Very High.

With these criteria, we're developing two different tools to evaluate LOs' quality. One tool allows teachers and experts to analyze, change and evaluate LOs through a Web application and after the individual evaluation, all the persons involved gather in an on-line forum to reach to the LO final evaluation [16].The other tool is an intelligent agent that automatically evaluates LOs which architecture is shown in Figure 4.

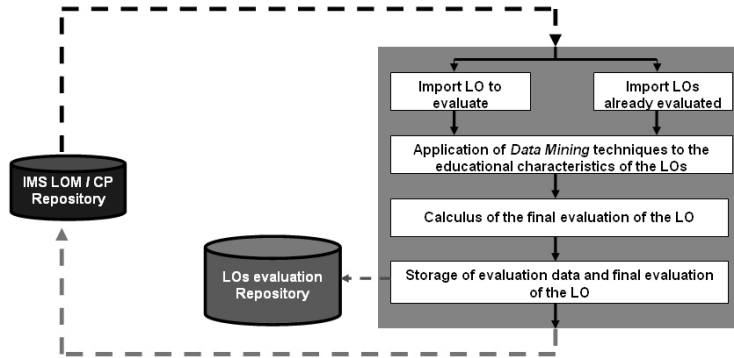


Fig. 4. Architecture of the agent

The agent starts to import the LO to evaluate and others already evaluated, then applies data mining techniques (decision trees) to the LO educational characteristics defined in the IMSLRM specification to calculus its final evaluation and agent stores it on a database and on the annotation element described in the specification.

For this evaluation we matched the IMSLRM educational category elements and the evaluation criteria categories like presented on Table 3. We have just considered the educational category because it has almost all LOs’ technical and educational aspects we found important.

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

## 5 Integration with Other Systems

The objective of integration with other systems is to give an opportunity for a LMS to benefit from this Learning Design Back-Office system, as well as to give a Front-End to AHKME as presented on Figure 5.

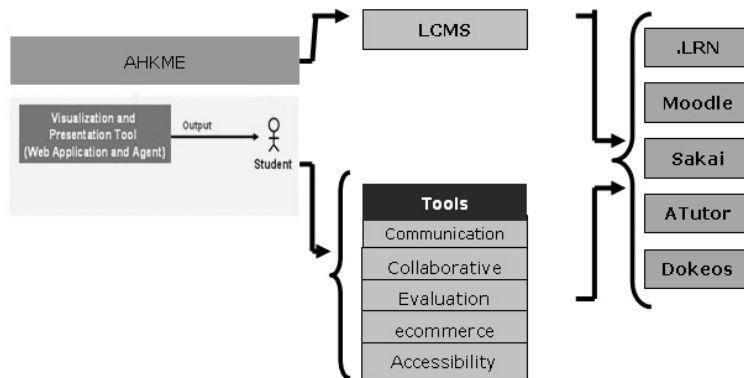


Fig. 5. Presentation Architecture



Our objective is to benefit from all the LMSs' strong points already mentioned on our analysis adding the tools we have developed by merging/integrating systems being possible depending on the LMSs' integration tools. For example if you have an open source system it can be directly integrated or if you have Blackboard it can be done through building blocks.

## 6 AHKME LOM Vs Similar Tools

We have also done an analysis of key features of some metadata tools along with AHKME's LO Manager (LOM Editor [14], ADL SCORM [2], Reggie [17] and EUN [9]). 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 analysed tools provide functionalities for meeting specific requirements like XML validation and metadata files creation, lacking important issues like: educational orientation, by not providing a list of available educational metadata; require that the person who edits metadata must know XML; functionalities regarding the user's needs to characterize several learning environments; resources' management.

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

Task	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				✓	

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.

## 7 Conclusions

In this article we have presented how AHKME uses metadata for learning resource management and evaluation through the IMS specifications, which use combine potentialities of metadata and XML, providing LOs' description through metadata allowing them to be catalogued, localized, indexed, reused and interoperable.

The main AHKME contributions are: the LO management and quality evaluation; the usage of the IMS specifications to standardize all the platforms' resources in order to reach learning components interoperability and compatibility; All subsystems interaction through feedback allowing the platform to adapt to the students and teachers characteristics and to new contexts; Being a multipurpose system it can be applied to several kinds of matters, students and learning strategies in both training and educational environments; As modular and open source system allows developers to add new modules and extend the system or integrate it with already develop e-learning systems and tools; through knowledge management the content has continuous evaluation, granting quality to all resources in the platform for teachers and students to use.

In terms of future work, we will include in the learning design tool, the level B of the IMS LD specification that allows the inclusion of properties and general conditions. In the adaptive subsystem we will add some functionality according to the IMS Question and Test Interoperability and Enterprise specification. In the knowledge management subsystem we will add the feature of course quality analysis, through the development of a standardization knowledge model and evaluation tools.

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