

AHKME, an E-learning Platform based on Knowledge Representation and Knowledge Management

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Abstract. AKHME's aim is to provide a system with adaptive characteristics and knowledge management abilities for students and teachers. This system is based on two fundamental aspects: knowledge representation and knowledge management, to satisfy the requirements of reusability, interoperability and multipurpose. To support knowledge representation, the system provides authoring tools for teachers to define learning methods with adaptive characteristics, as well as tools to create units of learning. To support knowledge management, the system is endowed with a knowledge management sub-system that provides collaborative and automatic evaluation of learning objects, and retrieval of learning objects, providing quality contents for teachers and students. The objective of AKHME is to be an open tool independent from the knowledge do-main, type of users, differentiating educational contents and the learning process. In order to reach this goal, guaranteeing interoperability and reusability of all educational elements, the system structures the semantic elements through the IMS specifications.

Keywords. Knowledge Management, Knowledge Representation, Adaptive, IMS Specifications.

1 Introduction

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.

In order to solve this problem there have been developed several specifications, which some have become standards, to structure pedagogical contents and to allow the characterization of a wide variety of learning environments [15].

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 existing specifications we have *Sharable Content Object Reference Model* (SCORM) [14], a project from *Advanced Distrib-*

uted Learning (ADL), and the specification *Educational Modelling Language* (EML) [10]. 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) [7] 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 (*Hyper-text Composer*), which is an authoring tool to create contents [3]. Finally we have the IMS specifications that are used as a guide for structuring contents, developed by the IMS consortium [5] 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.

Here we present AKHME (*Adaptive Hypermedia Knowledge Management E-learning Platform*), a platform that supports both knowledge representation and knowledge management. In this platform teachers have at their disposal tools to create didactic materials and to evaluate 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.

Through the use of IMS specifications it's possible to guarantee the reusability and interoperability of the educational elements. To guarantee this, IMS uses XML (*eX-tensible Markup Language*) to store the information in packages and schemas, using some mechanisms that Web Semantics allows, such as granting meaning to Web contents and providing a form of structured storage to guarantee easy access and integration of information.

In this paper we will initially present the description of the platform to give an overview and to context the system, and then we will analyse the importance of knowledge representation and knowledge management within this system. Finally we will present some conclusions and future work.

2 AHKME's Description

This platform is divided in several sub-systems: Learning Object Manager and Learning Design sub-system, Knowledge Management sub-system, Adaptive sub-system and Visualization and Presentation sub-system. These sub-systems were structured this way taking into account a certain sequence. At 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 sub-system makes the evaluation of the available infor-

mation. Then this information goes through an adaptive process based on the students' characteristics to be presented to the student, as we can see on Figure 1.

To implement the sub-systems 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 to implement several software agents.

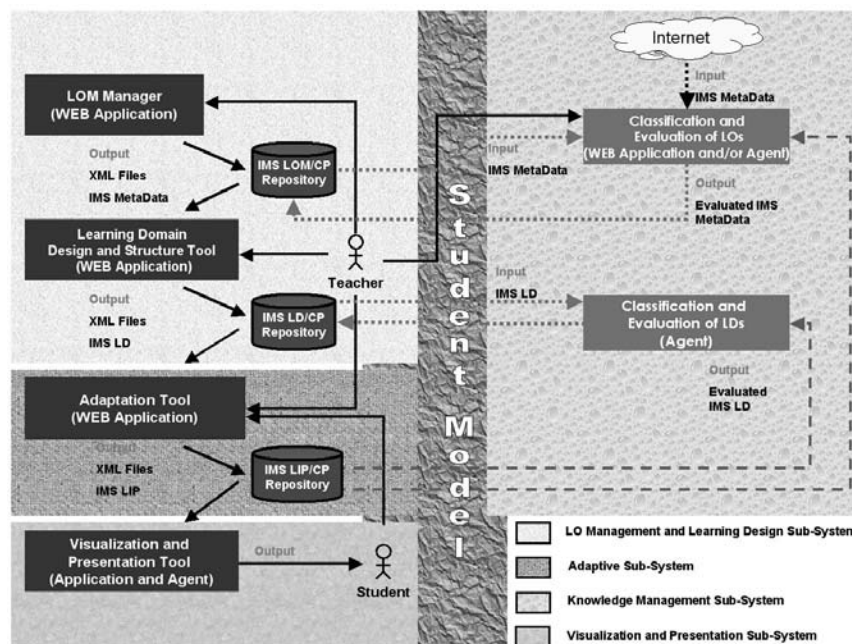


Fig. 1. AHKME's structure

These sub-systems 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.

All the tools of learning design 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.

3 Knowledge Representation in the Platform

In the 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 this knowledge. So a standardization of the knowledge representation was indispensable. In the year 2000 the Learning Objects Metadata Working Group's (a working group of the Learning Technology Standards Committee), in order to represent knowledge developed the IEEE (Institute of Electrical Electronics Engineers) LOM (Learning Object Metadata) standard, which referring to them, it "enables computer agents to automatically and dynamically compose personalized lessons for an individual learner"[4]. This standard proposed the knowledge representation as metadata (data about data) that has descriptive information about a resource (learning object) in a way that it can be easily retrieved and reused. Metadata has very well known advantages such as simplicity, compactness, robustness, verifiability and many others. For example, if you want to find a book in a library, the search would be faster if you have access to the cards that describes the contents and authors information than going around the library checking every book for author and content information. That's why a semantic representation, defined by a standard, is important to represent knowledge because it provides an *ontology* in which concepts are clearly and unambiguously identified, also providing a set of semantic relation types which allow representing meaning by linking concepts together [11].

Many theoretical persons have approached different ideas for the construction of Web sites, where the texts or formative contents should be divided into chunks or modules that refer only to one matter or theme, being completely independent between them. With this necessity of chunks of information the standard IEEE LOM also defines learning objects, that can be defined as "any digital or non digital entity that can be used, reused and referenced during technology supported learning" [9]. Being this way the information, through LOs, can easily be manipulated and accessed regarding users' necessities. So the development of this standard was very important to archive knowledge representation. Regarding course knowledge representation we must take into account that it's important to get the best learning objects to archive the learning objectives proposed.

Nowadays several organizations are working for the standardization of metadata for educational systems and beyond, from which we can detach W3C, the Dublin Core Metadata Initiative (DC), the Alliance of Remote Instructional Authoring and Distributed Networking for Europe (ARIADNE), the IEEE Learning Technology Standards Committee (LTSC), and the Instructional Management Systems project (IMS).

The standard presented before defined a conceptual model for metadata definition with a hierarchical structure, composed by several elements and sub-elements, but it had no specific format to allow the interaction with computers, to promote metadata interchange and to aid programmers in the implementation of the standard. To solve this problem IMS has developed, through the *IMS Learning Resource Meta-Data Best Practice and Implementation Guide (IMSLRM)* specification, which is based on the IEEE LOM standard, a way to represent metadata through XML (*eXtensible Markup Language*) [2]. The main goal of this IMS specification is to give general guidelines of how an application can use IEEE LOM elements, through the use of XML.

And people could ask, why XML? XML is a document with a hierarchical structure that includes elements that contain attributes and contents, what makes it perfect for hierarchical representation, meeting in perfection the requirements of the

for hierarchical representation, meeting in perfection the requirements of the IEEE LOM standard.

The XML standard defines a markup language that allows an easier way to read and exchange information, in which one of the main justifications that lead to its use is its flexibility, because it allows the reusability of the information presented in the files in order to present it in different formats and to different audiences without the necessity of reprogramming. Some of its main characteristics are: it is a structured language, it easily interacts with data bases and file systems, it is independent from any platform, it is an open standard, it is language independent, it is extensible, it supports a sharable structure through XML Schemas or DTDs (*Document Type Definition*) and allows interoperability and reusability.

So, considering all these characteristics and advantages of XML, it can be considered a meta-language, being highly recommended for knowledge representation.

In this platform we present, the two main critical success factors are the knowledge representation and knowledge management. The main objectives of the platform are to make it a multipurpose platform independent from the learning domain, the reusability of resources and courses and their interoperability.

In order to accomplish these objectives we had to choose the more adequate technological standards and specifications, and we've decided to use the IMS specifications. Our decision was made this way because these specifications allow a very embracing representation of knowledge comparing to other standards and specifications. The IMS can be used for structuring metadata, structuring courses and to package contents while the existing standards only allow one of the functionalities mentioned. For example, SCORM and AICC allow to structure courses but they don't allow the packaging of contents [13]. Besides this the specification to structure metadata (IMSLRM) is based on the IEEE LOM standard, the specifications are described in XML and allow the retrieval of user information and evaluation base on inquiries and the packaging of information is indexed in a manifest in order to make easier the location of information making possible the interoperability.

We will now describe and present how the different sub-systems contribute to knowledge representation.

3.1 Learning Object Management and Learning Design Sub-system

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 and their metadata.

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, and 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 stor-

age in a MySQL database, what enables the management of these packages that will be used in the design of courses (The process of package creation is presented in the point 2.4)

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 LO's evaluation, it may be needed to change the LO cataloging 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 creation of the content package, taking into account the user's wishes, granting a higher level of flexibility. In Fig.2 we can see the part of this tool, which refers to the introduction of metadata of a LO.

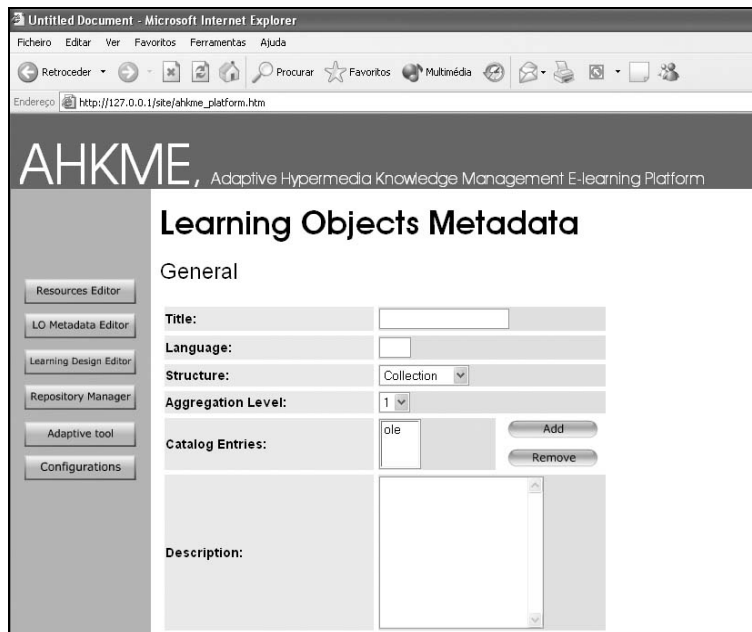


Fig. 2. AHKME platform – Learning Objects Manager tool

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.

The part of the sub-system referring to the Learning Design gives us a tool where the teacher can define learning design components, create and structure courses using level A of the IMS LD specification to define activities, sequence and users' roles, and to define metadata to describe the courses, making possible the knowledge representation of the courses.

In the process of course creation it's generated a manifest using XML that gathers all the XML files associated with the course created, as well as all the LOs, metadata and resource files needed for the course.

The platform, through this tool, allows the design of units of learning where the participants can assume different roles. These roles can be student or staff, what makes possible collaborative and group learning, which importance is recognized at the training and educational levels [7].

The use of the IMS LD allows the users to structure courses with metadata in XML files that can be reused in the construction of other courses making easier the portability of learning information to interact with *Learning Management Systems* (LMS).

This tool also provides the creation of packages with the courses integrating them in a data repository, to reach a more efficient management and, also, communicates with the knowledge management sub-system in order to evaluate the courses that were created. After the evaluation this tool allows the restructuring of the courses always allowing the user to interact with the learning design process.

3.2 Adaptive Sub-system

The objective of this adaptive sub-system is to determine the most adequate learning method according to students' characteristics, the learning design and the interaction with the student. It still establishes the best adaptive characteristics taking into account a specific learning method of the student, resources and assessments. This sub-system, for each student, stores his learning style, his characteristics, previous and actual knowledge.

The tool provided by this sub-system allows the user to fill inquiries, based on data and metadata about the student, defined by the IMS *Learning Information Package* (LIP) specification. This specification is based in a data model to represent knowledge that describes the characteristics (language, previous and actual knowledge about a certain matter, etc) of the students, necessary for general management and storage of historical data about learning, objectives and works developed [8]. Based on the results of the inquiries an agent automatically generates adaptive rules, through the use of fuzzy logic, to generate models of adaptation that will reflect on the presentation of the courses. This information is stored in XML files and this sub-system allows the creation of packages with this information, which is stored in a data repository to facilitate its management.

3.3 Visualization and Presentation Sub-system

This sub-system presents the educational contents to the students taking into account the adaptive meta-model generated for each student. It works as a knowledge representation tool.

Regarding this objective we've been developing a functionality to store the tracing information of the student when he interacts with the system, in order to give feedback to the other sub-systems.

This visualization tool is a Web application that automatically publishes course contents following some templates and the adaptive models that were generated.

3.4 Information Packaging

The tools presented on the Learning Object Management and Learning Design sub-system and in the Adaptive sub-system, follow the IMS *Content Packaging* (CP) specification, which allows the creation of packages (*content interchange package*) with the information related with the learning process, manifests, XML files and their schemas. By this, the packaging of information represents knowledge in a compact form, through structured manifests, to facilitate its indexation, reusability and interoperability. It structures knowledge in a form where the resources are completely integrated, referenced and related what enables a better course organization and structure.

With this specification authors can build learning contents on-line, administrators can manage and distribute content and the students can interact and learn with these contents, providing an efficient way of aggregation, distribution, management and availability of this contents.

This specification distinguishes between 3 different types of user profiles: teacher (author) that creates the packets for distribution, the administrator that interacts with the LMS, by storing and managing data, and student that interacts and learns with the systems [6].

So, the Learning Object management tool allows the creation of packages with the LO and their metadata, the Learning Design tool allows the creation of packages with all the information of a course and the Adaptive tool allows the creation of packages of information related with the student.

4 Knowledge Management in the Platform

Nowadays, we live in an information society where there is a huge amount of information, but we must know what information is more important to us, we must know how to manage information to get knowledge. That's where knowledge management comes in. Knowledge management is one of the biggest sources of power in our society, because it enables people with the power to manage information in order to extract knowledge to get accurate information for decision making, being one of the main priorities for the survival of organizations.

Knowledge management and e-learning are two concepts that are strictly related, as e-learning needs an adequate management of educational resources to promote quality learning, to allow students to develop in an active and efficient way.

The knowledge management features on an educational environment are presented by Bates that points the requirements of e-learning independently from the location where you're at: [1] Access to information from multiple resources and formats; select, store, restructure and create information; communicate directly with instructors, colleagues and other students; incorporate materials that have already been worked

within a study work documents and share and manipulate information, documents, projects, etc.

Regarding this features we've decide to create a sub-system that would integrate materials from other sources into our platform and would evaluate the quality of these incoming materials as well as the materials generated by the Learning Object Manager and Learning Design sub-system. We will now present the basis and the functioning of this sub-system.

4.1 Standardization through Knowledge Model for Learning Objects

If we import resources from other sources it's most likely that they'll have been designed taking into account a different instructional design, and therefore comes the necessity to standardize this resources. It has been proposed a knowledge model for this purpose, presented on Fig.3 [12].

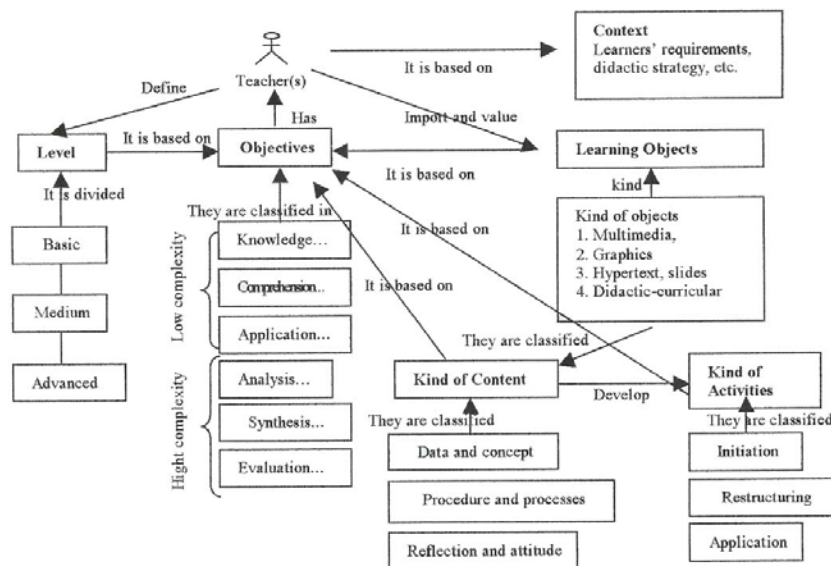


Fig. 3. Knowledge Model

Figure 3 represents the components of the proposed knowledge model and the relations among them. The teachers to structure a unit of learning considering LOs, may have to take into account the learning context because issues like learners requirements, learners situations, time for teaching and learning, the environment, are elements which direct the learning and teaching processes and aim to promote an efficient educational process. To define the objectives of the learning and teaching processes it has been used Bloom's classification verbs into cognitive domain because they've been widely used in education because it divides the objectives into high and

low levels. As we can see on Fig.3 the objectives maybe considered to: the level of difficulty, the process to import and select LO's and in the classification of the kind of contents and activities. To describe the difficult level of the learning process it has been proposed three kinds of complexity levels, basic, medium and advanced, that are not restricted to fixed objectives. The content of the LOs will be classified into three kinds of content: data and concept; procedure and processes and reflection and attitude. This way it's possible to define the context in which a LO will be used [12]. Finally when all the LOs are standardized, an evaluation model has been proposed to analyze the quality of the learning objects, which will be presented next.

4.2 Learning Objects Evaluation

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 was 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 in 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 [12].

With the LOs from external sources standardized and this quality evaluation defined we will now present the knowledge management sub-system.

4.3 Knowledge Management Sub-system

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

To classify LOs we're developing two different tools. One the tools allows teachers and experts to import, analyze, change, classify and evaluate LOs through a Web application based on the knowledge model and evaluation model mentioned before. This tool is an evaluation collaborative system in which experts and teachers analyse the LOs and give an individual classification and evaluation to the LO. After this individual classification and evaluation, all the persons that classified and evaluated the LO gather around in a sort of forum to reach to the final evaluation of the LO. It has also been projected a search engine to search for LOs, being the results presented in order of evaluation [12]. This tool is being developed in JAVA.

The other tool is an intelligent agent that classifies and evaluates LOs automatically that base its final evaluation on previous classifications and evaluations. A schematic representation of the agent is presented on Fig. 4.

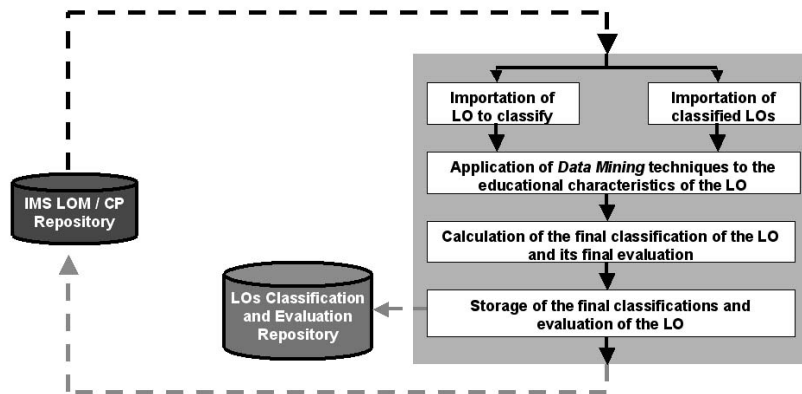


Fig. 4. Schematic representation of the agent

In order to do the evaluation, the agent starts to import the LO to classify and other LOs already classified and applies to the educational characteristics, defined in the IMSLRM specification, data mining techniques.

The educational characteristics of LOs, described in the IEEE LOM are as follows: interactivity type, learning resource type, interactivity level, semantic density, intended user role, context, typical age range, difficulty, typical learning time, description and language. In order to use the learning objects evaluation defined before we have made a correspondence between these educational characteristics and the categories described in the evaluation model. After the calculation of the final evaluation of the object, it stores this information in an auxiliary database made for this purpose and also inserts it in the annotation element described by the IMSLRM specification. This agent is being developed using .NET and manipulates the XML files that are in the platform.

To evaluate LDs we are developing a similar process as done for LOs, we're studying a knowledge model to standardize LDs to allow the importation of courses, and an evaluation method to classify and evaluate the LDs.

We also want to include the feedback from the adaptive sub-system to consider on the process of evaluation the students and teachers interests that may emerge from the platform's use.

5 Knowledge Management in the Platform

In this article we've presented how the platform AHKME contributes to knowledge representation and knowledge management, since it is based on those two principles.

The IMS specifications, which use the combination of potentialities of metadata and XML, is an excellent way of representing knowledge, dividing information in

several meaningful chunks (learning objects) allowing their description through metadata and their storage in XML files, therefore permitting their cataloguing, localization, indexation, reusability and interoperability, that is permitted through the creation of packages of information. These specifications grant to the platform the capacity to design learning units that simultaneously allow users with different roles, promoting both collaborative and group learning of several types.

Through the knowledge management tools described, 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 advantages of AHKME platform are its adaptive functionalities based on students' characteristics, and its knowledge representation and knowledge management capacities, as well as the interoperability and compatibility of its learning components that come from the use of the IMS specifications.

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.

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 sub-system we will add some functionalities according to the IMS *Question and Test Interoperability and Enterprise* specification. And in the knowledge management sub-system we will add the feature of analysis of quality of the learning design, through the development of a standardization knowledge model to import external courses and evaluation tools made for this purpose, and is also projected the development of a search engine for resources.

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