Software Engineering Analysis Process applied on an e-Learning System

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Abstract. In order to implement an e-learning system we have to consider several factors, and to evaluate and compare different approaches and techniques during all the software engineering process. So, to implement an e-learning system we have first started to analyze several e-learning current approaches both systems and tools in order to identify strong points and weaknesses. Then we have made a comparative analysis of technological and educational standards and specifications to choose one to base our system upon in order to standardize all of the educational resources in our platform. Finally, we have also done an analysis of some key features of metadata tools confronting the learning object metadata tool we've developed on AHKME (Adaptive Hypermedia Knowledge Management E-learning System) with some similar learning object metadata tools. We aim to give a perspective of the methodologies used for analyzing e-learning systems, since there are several aspects to take into account.

Keywords: Educational Standards and Specifications, Software Engineering, Learning Information Systems, e-Learning.

1 Introduction

Here we present several analyses made for the development of AKHME, a system which goals and main contributions are: Learning object (LO) management and quality evaluation; Usage of the IMS specifications to standardize all the platform's resources; Interaction of all subsystems in order to adapt to students and teachers characteristics and to new contexts. We'll start to present an analysis of e-learning current approaches and a standards and specifications comparative analysis in order to define the system requirements as well as a comparative analysis between AHKME LO metadata tool and other metadata tools. Finally we'll present some conclusions.

2 Current Approaches

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

develop our system we have done an empirical analysis of reference commercial and freeware/open-source current approaches to e-learning platforms/systems.

In order to make an analysis of the state-of-art in e-learning platforms/systems, it can be done through an empirical analysis. This analysis is a kind of a technical analysis of the platforms considering features, tools and potentialities provided by kind of systems.

In this type of analysis we considered technical aspects like the ones presented on table 1.

Table 1. Technical aspects to empirically evaluate e-learning platforms/systems

Tools/Features	**Relevance**
Technical Aspects	Takes into account some technical aspects that should be considered regarding the platforms flexibility
Interoperability/integration	Interoperability of data and integration with other systems.
Standards and specifications compliance	The standards and specifications that the platform supports.
Extensibility	If it's possible to add new components to the platform.
Adaptation and Personalization	Takes care of issues regarding user personalization, adaptation and customization
Interface Customization And Personalization	Possibility to customize and personalize the interface regarding the users taste.
Choose Interface Language	How many languages the platform supports.
Students previous knowledge	Consider pre-knowledge of the student for adaptation.
Courses and Resources adaptability	Capacity to adapt courses and resources to environments and students.
Administrative	Takes care of issues regarding the management of the platform
Student Manage. / Monitor. tools	Manage how students are getting along in the courses and monitoring tools of all the behaviour of the system, system users and profiles.
Database Access mechanisms	Mechanisms to retrieve information from databases.
Produce reports	Produce statistical reports about the use of the platform.
Administrative workflows quality & functionalities	Mechanisms and functionalities to accelerate Administrative workflows in order to get better and faster responses.
Tracking users	Track user actions to check if they're in the right way.
Resources Management	Takes care of issues regarding the management of the resources like creation editing and authoring
Content Authoring and Editing	Allow the creation and edition of several types of contents.
LOs and other types of content Management	Support of several types of contents.
Templates to aid on content creation	Templates to aid users on content creation.
LO Search and Indexation	Search engines for a quicker retrieval of LOs.
File upload/download mechanisms	Mechanisms to import and export resources.

Evaluation of quality of resources	Evaluate the quality of resources so teachers can use quality resources and students can learn through quality resources.
Learning Objects Sharing/Reuse	Potentiate the sharing and reuse of materials decreasing the resources development time.
Communication	Takes care of the communications tools provided by the platform
Forum	Availability of forums so students and teachers can trade experiences and discuss themes.
Chat	Provides a synchronous tool for students and teachers to trade experiences and discuss themes.
Whiteboard	Whiteboard tools include an electronic version of a dry-erase board used by instructors and learners in a virtual classroom (also called a smartboard or electronic whiteboard) and other synchronous services such as application sharing, group browsing, and voice chat.
Email	Teachers and students can exchange emails facilitating communications
Audio and Video Streaming	Video services enable instructors to either stream video from within the system, or else enable video conferencing, either between instructors and students or between students.
Evaluation	Takes care of the assessment issues
Self Assessments	Allow students to make self-assessments to check how their evolution.
Tests	Allow teachers to create, administer, and score objective tests.
Inquiries	Allow teachers to make inquiries about certain relevant matters.
Documentation	Documentation provided

Taking into account the aspects described before we have done an analysis of several e-learning systems like presented on table 2, in order to identify strong points and weaknesses, so we could try to use them in the development of our platform [7][12].

Table 2. Analysis of e-learning systems

Tools/Features	**Platforms**							
	Commercial				**Open Source**			
	BB	**WCT**	**IL**	**A**	**AT**	**M**	**SK**	**.LRN**
Technical Aspects								
Interoperability/integration	✓	✓	✓	✓	✓	✓	✓	✓
Standards and specifications 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 customization 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

Administrative								
Student management/Monitoring tools	✓	✓	✓	✓	✓	✓	✓	✓
Database access mechanisms	x	x	✓	✓	✓	✓	✓	✓
Produce reports	✓	x	✓	✓	✓	✓	✓	✓
Tracking users	✓	✓	✓	✓	✓	✓	x	x
Resources Management								
Content authoring and editing	✓	✓	✓	✓	✓	✓	✓	✓
LOs and other types of content management	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
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; BB - Blackboard; WCT - WebCT; IL - IntraLearn; A - Angel; AT – Atutor; M - Moodle; SK – Sakai

Analyzing table 2 we found that the majority of the systems have good administrative and communication tools, compliance with standards, high implementation level and good documentation. On the other hand we noticed that they have problems regarding LO management, sharing and reusability. LO quality evaluation, resources adaptation to 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 in terms of costs. On table 3 we resume some strong points and weaknesses that we have found.

Table 3. 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)

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 prob-

lems and from the comparison between commercial and open-source/freeware platforms, we have decided to develop an open source platform focused on these issues.

3 Standards and Specifications Comparative Analysis

Several standards and specifications have been developed in order to structure content and information on e-learning systems is order to promote interoperability between systems and to obtain a greater quality of teaching.

Among these technological educational standards and specifications there are some more focused on the course design and structuring and others that try to enclose all the process of teaching/learning. We have standards like Sharable Content Object Reference Model (SCORM) [1], a project from Advanced Distributed Learning (ADL), that becomes more a standard integrator than a standard by itself, what makes it dependent of the other standards it integrates, but it doesn't consider the evaluation and characterization of students. We also have the IMS specifications that are used as a guide for structuring contents, developed by the IMS consortium that began its activity with the definition of specifications for instructional structure, to become the standard it is today. It bases its metadata specification on the IEEE LOM [8] standard and 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, storing them in XML files [4]. The main objective of these specifications is to be as general as possible, so they can be applied to any process of teaching/learning [9][13].

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 automatically 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 compatibility and validation, increases search engine success, among many other advantages.

So it is why is important to analyse several aspects of standards and specifications in order to check the ones that best models the teaching/learning process , so we can choose a platform that is compliant with those standards and specifications.

Having detected the main problems of current e-learning approaches, we've analysed several aspects of several standards and specifications to choose the one(s) that best fit our needs in terms of resources standardization, like described on table 4.

Table 4. 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 [2], AICC [3], SCORM [1] and Dublin Core [5], regarding the following [14]:

- 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 could verify that the IMS specifications, since they cover most of the aspects we've analyzed.

4 AHKME LOM vs similar tools

We have also done an analysis of some key features of metadata tools confronting the AHKME LOM tool with some other similar LO metadata tools. To make this analysis we tested the support of a set of tasks described on table 5.

Table 5. Comparative Analysis

Task	LOM Editor	ADL SCORM	Reggie	AHKME LOM	EUN
Creation of new metadata files	✓	✓	✓	✓	✓
Modification of data in metadata files	✓			✓	
Support education metadata standards &		✓	✓		

specifications					
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 Advanced Distributed Learning (ADL) Sharable Content Object Reference Model (SCORM) Metadata Generator [2] 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 [6] proposed specification of educational metadata. Reggie metadata editor [11] 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 [10] is an application for creation and modification of XML metadata files based on a previous version of LOM v1.4. Thus, 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.

5 Conclusions

As we have seen the paradigm of analysing an e-learning system involves a whole process that deals with many factors and in order to get a real value of the analysis, we have to contemplate a specific context or situation to analyse. Other factor that also influence an e-learning analysis are the standards compliance in order to choose the platforms that are compliant with the standards or specifications that best model the actual teaching/learning process.

So, analysing and choosing an e-learning system requires planning and knowing very well the variables and factors of the choice.

In this article we have seen that in order to implement an e-learning system we have to consider several factors, and to evaluate and compare different approaches and techniques during all the software engineering process. So, first we have to define the study goals with a strong system requirements definition by identifying current approaches strong points and weaknesses, considering different context aspects like standards for learning resources standardization. Finally, we have to follow the work progress development with checkpoint analysis. Both empirical and testing approaches revealed to be strong indicators for the software engineering process in AHKME development.

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