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DEPARTMENT OF COMPUTER SCIENCES AND AUTOMATION

Adaptive Hypermedia Knowledge management elearning System (AHKME) – Management and adaptation of Learning Objects and Learning Design in a Web-based Information System towards the Third Generation of Web

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HACE CONSTAR

Que dicho trabajo tiene suficientes méritos teóricos contrastados adecuadamente mediante las validaciones oportunas, publicaciones relacionadas y aportaciones altamente novedosas. Por todo ello considera que procede su defensa pública.

En Salamanca, a 25 de octubre de 2011

Dr. Francisco José García Peñalvo
Director del Grupo de Investigación GRIAL
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ADAPTIVE HYPERMEDIA KNOWLEDGE MANAGEMENT ELEARNING SYSTEM (AHKME) – MANAGEMENT AND ADAPTATION OF LEARNING OBJECTS AND LEARNING DESIGN IN A WEB-BASED INFORMATION SYSTEM TOWARDS THE THIRD GENERATION OF WEB

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ABSTRACT

The World Wide Web commonly known as Web as evolve and nowadays passes through a transition to a third generation, Web 3.0. In parallel, different areas of application as also evolve. One of them was eLearning, with the development of several systems and tools. However, despite many years of research and the appearance of the concept of Semantic Web for quite a time, the Web and consequently eLearning systems and mainly the user's still seem not to be prepared for this transition. There are different reasons for this situation. First, the application of concept requires specialized technical knowledge of the users to design the systems and resources accordingly to the educational standards and semantic technologies. Consequently, their dissemination outside experimental contexts is limited. Moreover, since they lack application in eLearning systems of Semantic Web, and lack some basic knowledge regarding standardization of learning design, resources and also reusability and the stability of these concepts before go a step forward to semantic web. Thus, lacks for application systems that make the transition easier for the users.

In order to solve these problems, this thesis proposes the development of a web-based information system – AHKME (Adaptive Hypermedia Knowledge Management Elearning System) - that combines concepts of Web 2.0 and 3.0, regarding advanced collaboration, social networks, interoperability, standardization and adaptation, in a concept that we prefer to call Web/eLearning 2.5. The objective of this system is to prepare the users for the new paradigm and the application of concepts regarding reusability, giving flexibility to the users by offering tools to facilitate the learning design and even the creation of their own personalized schemas/structure for instructional design. AHKME is based on schemas of standards and specifications (e.g. IMS) for standardization of resources, data mining and workflow for adaptation, and user's interactivity with learning resources and collaboration through social networks and players.

Morevoer, an evaluation of this proposal was performed through laboratory tests to evaluate the results and behaviour of AHKME, simulating a real learning situation.

The main goal of this study is to open the way for new researchs and systems for preparing the users for this new generation of Web, and by this mean introduce the semantic technologies, cross-platforms systems and "intelligent web".

KEYWORDS: Web, eLearning, Learning Design, Standards, Adaptation, Collaboration.

ÍNDICE

FIGURES

TABLES

1. INTRODUCTION

This chapter exposes the approach of this thesis. It starts by identifying the current characteristics of the Web evolution and consequently the eLearning systems, and indicating areas capable of improvement in design and implementation. Taking this into account, it justifies this study and details the aims that it wants to reach. Later, it makes clear the method followed to elaborate this thesis and the frame of research. Finally, it presents the content of each one of the chapters.

1.1. PRESENTATION

The Internet is constantly evolving, and nowadays we live times of change on the Web, with Web 2.0, social networking and mass collaboration (Downes, 2005) and even showing already some signs of what Tim Berners-Lee and guru Nova Spivak, predicted such as the semantic web, intelligent web or in broader terms, Web 3.0 (W3CSW, 2009).

One of the areas which are expanding in information technology lies in the implementation of systems or platforms for distance learning. Currently, there are many eLearning systems, but the main difficulty lies in structuring the content and information in line with the existing learning models in order to achieve greater integration and comprehensiveness of the learning environment and by this providing better quality education. At the same time, yet there are not too many tools and eLearning systems for the Web/eLearning 3.0, enabling the practical point of view or preparing to implement the Semantic Web, mobility of resources, as well as the universality of learning design, allowing approach the teacher of the design process, in an intuitive and practical way.

In order to address these needs, will be of interest to study the use of specifications and standards for the structuring of learning resources, learning objects and instructional design (Rego, Moreira, & García, 2005), to allow the instructional designer and teacher having access to standardized resources and to evaluate the possibility of integration and reuse in eLearning systems, not only content but also the learning strategy. Similarly it is interesting to study the possible use of collaborative tools for the adaptation of resources, as well as collecting feedback from users to provide feedback to the system.

In addition, it would be interesting to study the importance of supporting technologies such as machine-learning and intelligent agents, for the practical application of the Semantic Web with the concept of Social Semantic Web (Breslin, Decker, & Passant, 2009), with the introduction of collaborative tools and systems with application in real situations as social and learning environments for the provision and sharing of resources and learning strategies, as well as enable the instructional designer access to tools that can provide autonomy to create/customize specifications/ontologies to give structure and meaning to resources. Also with the introduction of additional manual and automatic search with the recommendation of resources and instructional design based on the context, as well as recommending adaptations in learning resources.

Finally this work consider studying the concept of mobility and start to explore mobile technology applied to eLearning, further developed in future work, allowing access by teachers and students to learning resources, regardless of time and space (Bratt, 2006).

So, first will be explained the goals of the study, then formulate the hypothesis, second describe the state-of-the-art in the study areas and the week points, third expose the proposal, then present the results of the proposal evaluation and finally take some conclusions.

1.2. PROBLEMS AND JUSTIFICATION

For the structuring of educational materials were developed a large amount of technology standards - they were agreements on the education characteristics - which enable and shape the wider variety of learning environments (Wiley, 2003).

Among the many existing standards and specifications there are the Sharable Content Object Reference Model (SCORM), a project of the Advanced Distributed Learning (ADL) (SCORM, 2009), the specification Educational Modeling Language (EML), which led to the IMS Learning Design (LD) (IMSLD, 2003), however, the EML is not a standard is a specification that has become obsolete with the adoption of IMS LD (Koper, 2003), we also have a standard for structuring metadata such as Dublin Core (DC, 2010). Finally, we have the IMS specifications, which are a standard for structuring content, and were developed by the IMS Consortium (IMS, 2011).

In addition, nowadays there are many elearning systems and an analysis of some current approaches (WebCT/Blackboard[1], Angel[2], Intralearn[3], ATutor[4], Moodle[5], Sakai[6] and

[1] http://www.blackboard.com

[2] http://www.angellearning.com

[3] http://www.intralearn.com

[4] http://www.atutor.ca

dotLRN[7]) identified as strengths the functional and administrative capacity but as weaknesses, problems with interoperability, reuse, independence of learning domain, adaptation and extensibility (Rego et al., 2005).

In general, there are few experiences with web support tools that allow the teacher autonomy in instructional design and ontologies, as well as the use of technologies such as intelligent agents and data mining for the application to learning resources and instructional design and mechanisms of adaptive search and recommendation on the basis of educational technology specifications and ontologies.

Also there are few experiences of actual application of the combination of social networks and semantic web (social semantic web) in order to structure the resources in interoperable formats, and adaptive significance in a collaborative way and also automatically searchable by the context.

1.3. OBJECTIVES

This thesis declares that: the teacher should have access to instructional design tools without necessarily having to have prior knowledge of specialized technology or educational standards and specifications.

So this study proposal is **to obtain an interoperable, multi-purpose, open source and domain independent system, operating both in education environment and training, and is an evolutionary system, where in addition to automation - intelligent agents, adaptability - the main actors, the actual re-feeders of the system are students and teachers/trainers/tutors**.

By this mean the following hypothesis is formulated:

[5] http://moodle.org

[6] http://www.sakaiproject.org

[7] http://openacs.org/projects/dotlrn

"The implementation of an eLearning system can improve the interoperability, reusability, adaptation of learning resources to the user characteristics and can contribute to the application of the Web 3.0."

The Figure 1 represents the study model with the presentation of the hypothesis, its assumptions and characteristics.

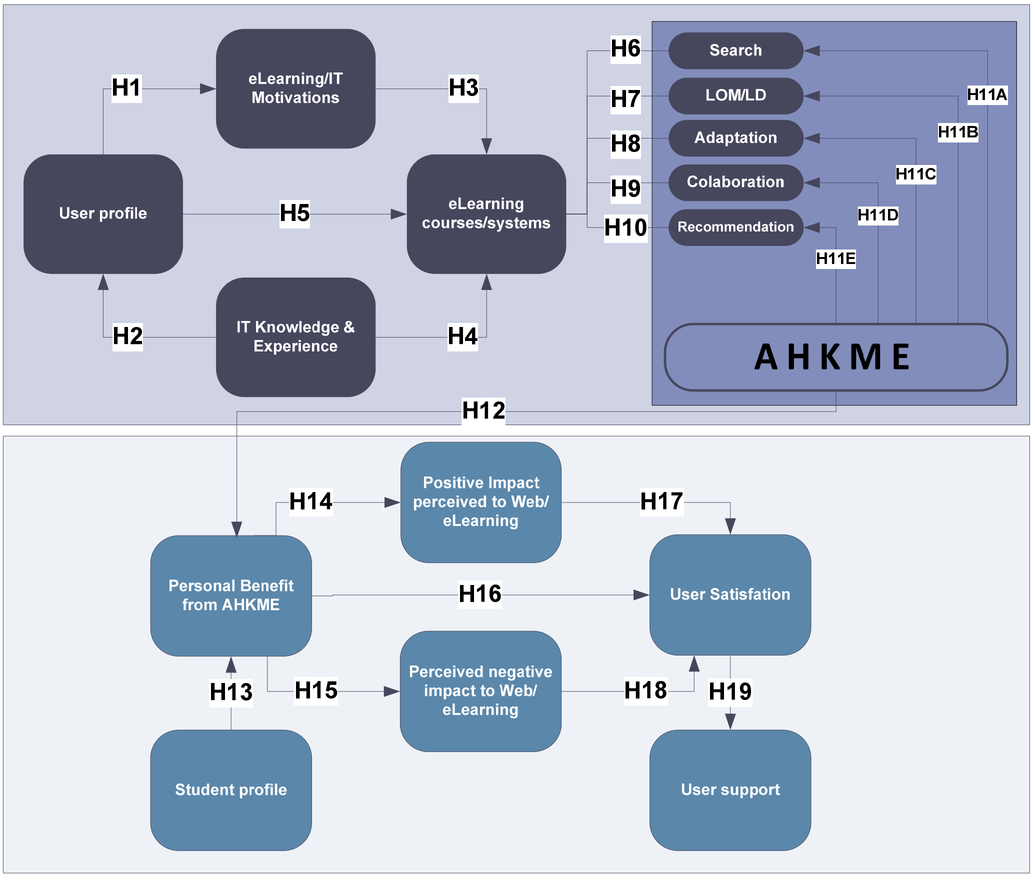


Figure 1. Study model and Assumptions

So, more specifically the following assumptions are made:

H1: The User profile has specific motivations regarding the use of IT and eLearning systems.

H2: The User has specific IT knowledge and experience.

H3: The User motivations influentiates the user experience with eLearning systems.

H4: The user IT knowledge and experience facilitates the interaction with eLearning courses/systems.

H5: The user profile influentiates eLearning courses/systems.

H6: If a search tool of learning resources from metadata is developed, it improves the reuse of learning resources.

H7: If an eLearning system that allows the standardization of the resources is created, it contributes to the interoperability and reuse of them.

H8: The implementation of a tool that generates forms enabling users to create or adapt their metadata specification and/or ontology prepares the system and contributes to the implementation of the Semantic Web.

H9 and H10: A collaborative workflow tool to adapt the learning resources and metadata, and an automated recommendation tool of adaptation factors, can improve the customization and adaptation of resources.

H11: The design and algorithms of tools affects the overall performance of AHKME.

H12: AHKME contributes to personal benefits.

H13: User Profile can influentiate the personal benefits.

H14: The benefits from AHKME can have a positive impact perception to Web/eLearning.

H15: The benefits from AHKME can have a negative impact perception to Web/eLearning.

H16: The personal benefits contribute to the user satisfaction.

H17: Positive impact perceived contributes to user satisfaction.

H18: Negative impact perceived contributes to user satisfaction.

H19: The user satisfaction contributes to user support.

The study proposal has the following specific objectives:

1. Identify a specification that is more comprehensive in terms of structuring course content.

2. Evaluate a range of learning systems with the intention of determining the potential and needs to be provided to users by a multi-purpose and interoperable system.
3. Develop a basic structure of the web platform to access the different design and management tools of resources and learning methods.
4. Implement a tool to create and manage learning objects (LO) and its metadata.
5. Create a data repository for storage and management information packages of instructional design and learning resources.
6. Develop a tool to create and design methods and learning units.
7. Create an adaptation engine and a set of adaptive agents.
8. Implement a workflow system to allow the generation of collaborative workflow for the adaptation of learning resources and metadata.
9. Implement tool that automatically generates forms which create and store the specification or ontology.
10. Assess range of Learning Management Systems (LMS) and/or Open source social networks to integrate with LD Back-Office System.
11. Implement middle-tier between LD Back-Office and LMS/social network (presentation tool for learning resources).
12. Develop feedback system for LD Back-Office based on data feedback from users.

Thus, it seeks to show that:

- The creation of an eLearning system that allows the standardization of the resources, can contribute to the interoperability and reuse of them.
- A search tool of learning resources from metadata improves the reuse of learning resources.
- The implementation of a tool that generates forms enabling users to create or adapt their metadata specification and/or ontology prepares the system and contributes to the implementation of the Semantic Web.

- A collaborative workflow tool to adapt the learning resources and metadata, and an automated recommendation tool of adaptation factors, can improve the customization and adaptation of resources.

Objetives Indicators

For evaluating the objectives of the study some indicators have been defined that are presented in Table 1.

Table 1. Indicators of the objectives

Metrics for the objectives	
Objective No 1	
Objective	Identify a specification that is more comprehensive in terms of structuring course content.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 2	
Objective	Evaluate a range of learning systems with the intention of determining the potential and needs to be provided to users by a multi-purpose and interoperable system.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 3	
Objective	Develop a basic structure of the web platform to access the different design and management tools of resources and learning methods.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 4	
Objective	Implement a tool to create and manage learning objects (LO) and its metadata.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 5	
Objective	Create a data repository for storage and management information packages of instructional design and learning resources.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 6	
Objective	Develop a tool to create and design methods and learning units.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 7	
Objective	Create an engine of adaptation and a set of adaptive agents.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%

Objective No 8	
Objective	Implement a workflow system to allow the generation collaborative workflow for the adaptation of learning resources and metadata.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 9	
Objective	Implement tool that automatically generates forms which create and store the specification or ontology.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 10	
Objective	Assess range of Learning Management Systems (LMS) and/or Open source social networks to integrate with LD Back-Office System.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 11	
Objective	Implement middle-tier between LD Back-Office and LMS/social network (presentation tool for learning resources).
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%
Objective No 12	
Objective	Develop feedback system for LD Back-Office based on data feedback from users.
Measurement indicator	(Values of metrics/No metrics)*100
Goal	Fullfilled: Average value of the objective metric >= 50%
	Exceeded: Average value of the objective metric >= 83%

These objectives are measured according to specific metrics described later in the chapter of the testing process.

1.4. METHODOLOGY

This work is developed on the research lines of eLearning, web engineering and software architecture of the GRIAL research group from the Faculty of Science, University of Salamanca.

The project is divided into five phases:

1. **Research literature (state of art):**

    a. **Comparative analysis of current platforms and tools** - Evaluate a set of systems of teaching and learning in order to determine the capabilities/requirements that a multi-purpose, interoperable system should provide to the user.

   b. **Specifications and standards -** A comparative analysis of different specifications and educational standards, which choose the specifications of IMS Consortium.

   c. **Metadata, learning objects, ontologíes and learning design.**

2. **Definition of the proposal:**

   a. **Definition of the structure of the system and sub-systems - Learning Object management and learning design Subsystem, Knowledge Management Subsystem, Adaptation Subsystem and Presentation subsystem.**

   b. **Implementation of AHKME user profiles.**

3. **Development of the proposal:**

   a. **Development of prototype for the subsystems and tools.**

   b. **Learning object and metadata management tool -** Metadata management for LO according to the IMS Learning Resource Metadata (LRM) specification, still able to import or customization and validation using schemas.

   c. **Implementation of a tool for the generation and external import of specification, ontology and schema.**

   d. **Database repository -** A database for storing and management of information package and metadata in XML and schemas, generated by the tools.

   e. **Learning design and learning units structuring tool -** To insert the metadata of the learning units at the IMS LD specification, plus with the possibility for customization or import and validation by the schemas.

   f. **Adaptation engine –** Software agents to implement the adaptation engine based on rules adapted to model the characteristics of the student/teacher or environment.

g. **Collaborative workflow tool –** System that enables the management and creation of workflows to model the teaching and learning process, particularly for the annotation and adaptation of learning objects, learning design and metadata.

h. **Presentation tool:**

    i. Comparative and compatibility analysis to choose an LMS/Open Source Social Networking to integrate with AHKME, giving LD Back-Office a Front-end.

    ii. Middle-tier between LD Back-Office and LMS/social network (presentation tool of learning resources and visualization).

    iii. System of automatic publication of content and resources – player for learning resources and units.

i. **Feedback system of tracking and usage storage:**

    i. Collection and storage of data and characteristics of the student and teacher (IMS, 2011).

    ii. Survey Engine to collect feedback from students and teachers.

4. Validation of the proposal:

a. AHKME test architecture deployment.

b. Installation and setup the test environment server hosting, with the system and with most tools.

c. Testing system architecture.

d. Usability testing and case study for different educational settings (education/training) to implement and evaluate the proposed model (Nielsen, 1993).

5. Thesis writing and conclusions.

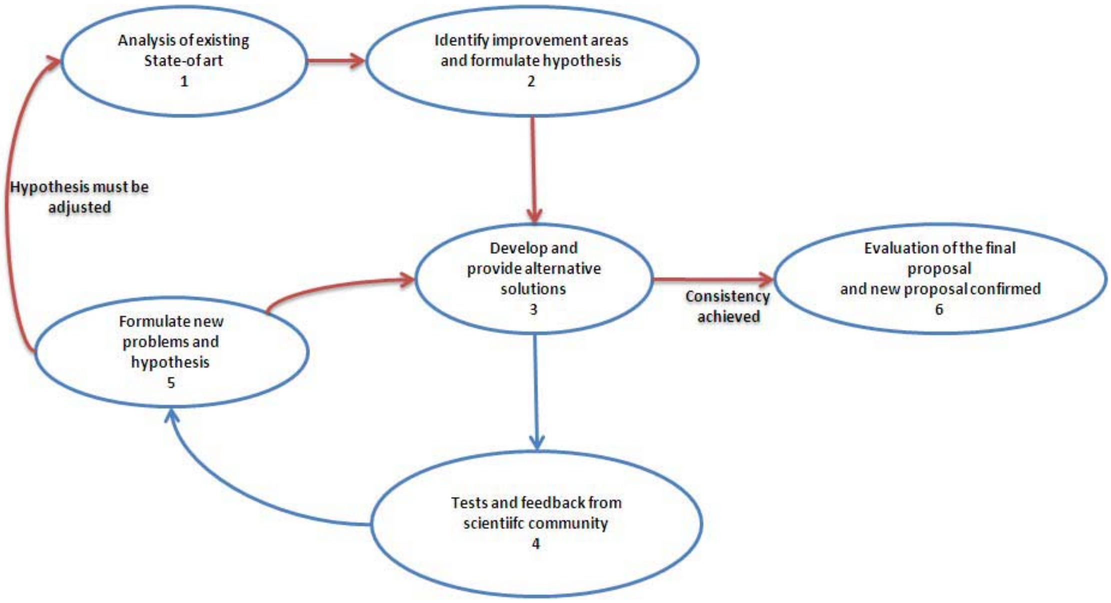


Figure 2. Study Methodology

The Figure 2 outlines the steps in that are divide the working method used to develop this thesis.

In the first, it gets to know the state of art, explores the work in the field of the study, as well as the objective and characteristics of technologies for the educational metadata. In the second stage, areas for improvement and relevant problems are identified, for formulate hypothesis, in order to devote the third stage to develop and provide alternative solutions. Subsequently, tasks are directly to set the course of the investigation and its proposals to the scientific community that works in these issues through articles exposed in conferences and workshops for obtaining feedback. Fifth stage reflects on the feedback received for, after evaluating the latest additions to the state of art, refine the investigation, and against of again.

Once the proposal is sufficiently consisting, in the sixth and final stage is tested and evaluated through the implementation of a practical case in a context for learning.

Technological aspects

One of the decisions of the research work was to choose programming languages, libraries and support (databases, etc.), based on freeware and Web 2.0/3.0 technology, Asynchronous JavaScript And XML (AJAX) to create interactive Web applications

(AJAX, 2007), Javascript for forms, Hypertext Markup Language (HTML) and Cascade Style Sheets (CSS) for Web design, PHP (PHP: Hypertext Preprocessor) for web programming (Sæther et al., 2003). Additionally, we also used .NET to make the manipulation of XML files and schemas and to implement software agents. The databases are in MySQL/MSSQL Express.

1.5. CONTEXT OF THE THESIS

The research work of this thesis is part of a general context, but also a specically context that involves other research as explained below.

1.5.1. IN THE RESEARCH GROUP

This work of doctoral thesis is one of the lines of investigation of the research group in interaction and eLearning (GRIAL) at the University of Salamanca. GRIAL is a multidisciplinary group composed of researchers from the Software Engineering, the Educational Sciences and Humanities. Within its research topics are the Educational Informatics, Web Engineering, the Semantic Web, the Human-Computer Interaction, the architecture of Software and eLearning.

These lines of investigation have been carried out through different projects. The Figure 3 shows a diagram that represents it.

The work of this thesis, which is indicated in Figure 3 through a box of double blue line, includes AHKME web system, with its main concepts - LOM and LD management, adaptation (through collaboration and recommendation) and finally presentation. The knowledge management domain has been developed by Tiago Moreira (Rego, Moreira, & García Peñalvo, 2010) (Rego, Moreira, Morales, & García, 2010), as a learning object evaluation tool.

In the rest of the projects carried out in the field of eLearning in the GRIAL research group is the work of Erla's thesis (2008), which propose to evaluate the quality of the LO from a pedagogical and technical perspective. To this end, it presents criteria for evaluate them from different points of view through an instrument that, by collecting quantitative and qualitative information on the quality of the LO, allow teachers to select resources related to teaching objectives and reused for other educational situations (Morales, García, & Barrón, 2011).

As research evaluation mechanisms for AEHS (Adaptive Educational Hypermedia Systems), has been developed a tool to define and package adaptive assessment tests (Barbosa, 2010), by standards for the marking of educational metadata such as IMS QTI and IMS CP (2011).

Following AEHS area has been developed an authoring tool for creation of Adaptive Instructional Design (DIA for its acronym in Spanish, *Diseños Instructivos Adaptativos*), Hyco-LD (Hypermedia Composer-Learning Design) (Berlanga, García, & Carabias, 2006), the creation of Learning Objects (LO) (Berlanga & García, 2006), the conceptual definition of DIA, and the presentation of the DIA to the student (Berlanga, Bitter-Rijpkema, Brouns, Sloep, & Fetter, 2011).

METHADIS (for its acronym in Spanish, "Metodología para el diseño de Sistemas Hipermedia Adaptativos para el aprendizaje, basada en Estilos de Aprendizaje y Estilos Cognitivos") (Prieto & García, 2006) is a line of research seeks to develop and validate a methodology for designing AEHS in which are considered learning and cognitive styles of students to present them appropriate information. From a technical perspective, defines and characterizes the student, the domain and adaptation models; from the pedagogical perspective, seeks how selecting teaching strategies to be used, depending on the learning objective and the characteristics of both of each learning style, as each cognitive style.

Finally, more current research lines include mobile learning, service oriented architectures in eLearning domain (Guerrero, Conde, Forment, & García:, 2009), interoperability issues among eLearning systems (Forment, Guerrero, Conde, García, & Severance:, 2010), personal learning environments, semantic knowledge visualizations (Aguilar, Therón, & García, 2009) and learning management system information visual analytics (Aguilar, Conde, Therón, & García, 2010).

In technical terms the implementation of the system – AHKME - was executed by the computer science elements, and the rising of relative data to the treated processes, was done in cooperation with pedagogic/education people involved in GRIAL.

The coordination of this project was done by the thesis Supervisor who is also the GRIAL head, and the implementation was executed by the computer science specialists, with the following distribution:

- LOM and LD, Adaptation, and Presentation Subsystems - Hugo Rego
- Knowledge Management Subsystem - Tiago Moreira
- Analysis of Requirements and system, Database and Software Engines - Hugo Rego and Tiago Moreira

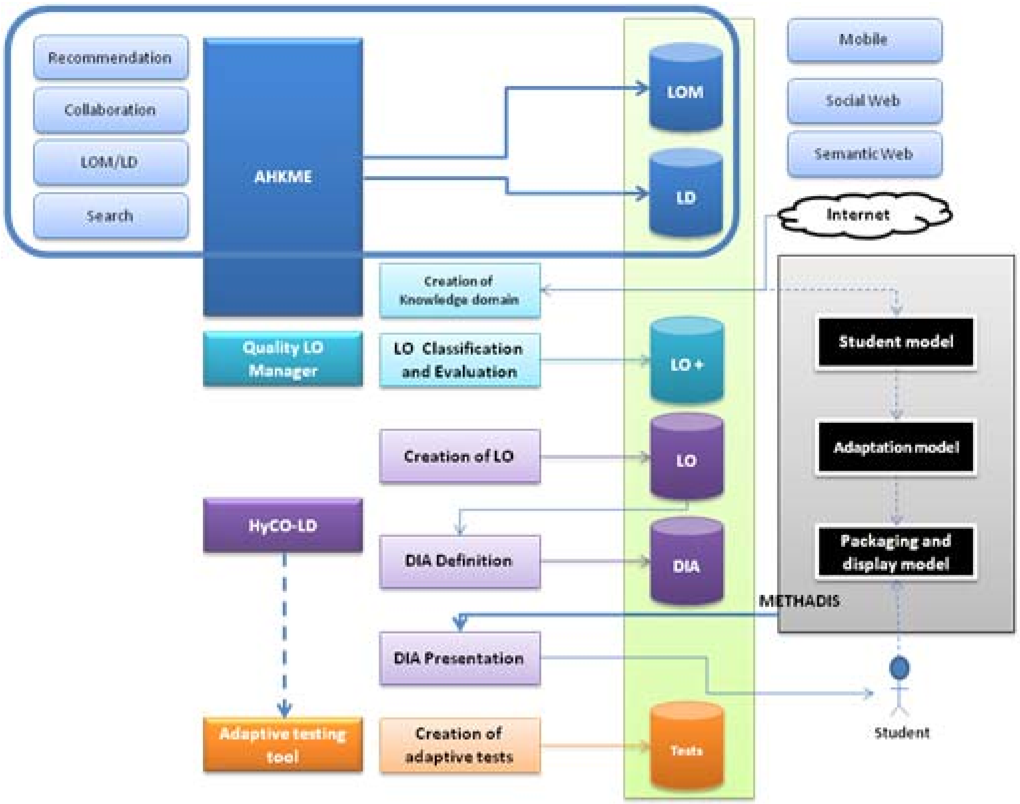


Figure 3. GRIAL Research lines and projects

1.5.2. In a general context

This thesis approaches two lines of research. The first is the development of web-based information eLearning system, by structuring the instructional design and the learning resources. The second one is introducing and combining technologies regarding collaboration, workflow, data mining and databases for preparing it for the Web 3.0 concept.

This thesis contributes to the state-of-the-art in both areas - education and web engineering - because it helps developing and expanding the educational standards and specifications for the application to instructional design, and at the same time the combination of different technologies does enrichment to the web-based systems and facilitates the introduction in the elearning research field.

Adicionally, a third research line of this thesis, is the contribution to Adaptive Hypermedia Systems (AHS), by introducing a collaborative tool and data mining techniques for recommendation of adaptation processes.

Finally, this reflects the need to provide teachers and designers of tools and formalisms to facilitate their work.

1.6. PRESENTATION OF THE FOLLOWING CHAPTERS

This thesis is divided into five chapters. The current exposes the objective and justification of the thesis, explains the method of work done and detailing the scientific framework in which fits.

The second chapter explains the evolution in web and in parallel the eLearning systems, and introduces the eLearning systems most representative developed so far to profile the state of the art. Then stresses its main constraints, among which is the lack of a notation of marking common. From this circumstance, also presents marking technologies and detailed IMS, their components and characteristics. After presents other specifications and compares them. Also, in this chapter is presented AHS, focusing in the AEHS, some current tools and their characteristics. Finally, summarizes the main weaknesses and point out the areas of improvement in eLearning systems, tools, standards, but also in AEHS.

Once raised the state of the art of the eLearning systems and marking technologies for educational metadata, the third chapter presents the proposal for this thesis: recording AHKME with IMS Specifications to introduce the concept of instructional design in this type of systems, and ensure its interoperability and reusability. It starts presenting the concept and main contributions, then it elaborates on the reasons for which in this investigation was selected IMS as outline marking to standardize the learning resources. After, it explains the system and its main subsystems and tools, introducing engineering aspects and specifying technical aspects of the system. Finally, it presents the application/integration scenarios of the system.

Then, the fourth chapter describes the practical case that lets you test and evaluate the proposal. First it introduces some main concepts in the testing process techniques, then explain in more detail the testing process applied in the context to AHKME evaluation. Finally, it presents the results and makes an analysis to the objectives achievement.

The fifth and final chapter provides conclusions, lines of future research, and presents the set of publications that allowed us to monitor performance and progress in the development of this thesis.

In conclusion, the thesis includes appendices and bibliography referenced. The Appendix A detailed different eLearning systems that have been developed. The Appendix B describes in general the data architecture of AHKME. The Appendix C contains, respectively, the evaluation test of the study.

The Appendixes D and E show the terms and acronyms used in this work.

At the end presents a summary of the research in Spanish language.

2. WEB AND ELEARNING SYSTEMS

This chapter presents the theoretical framework of web and eLearning systems and technologies.

This sets the stage for in the following sections, to identify some of the problems of the eLearning systems and justify some evolutions that are being purposed.

Consequently, this chapter presents the fundamentals of Web, eLearning systems, adaptive hypermedia, goes on to explain the characteristics of some adaptive hypermedia systems for education and examines the evolution and weaknesses of eLearning systems.

2.1. INTRODUCTION

The World Wide Web or commonly known as web, as passed through an evolution process. From the early days of the ENQUIRE Project from Sir Tim Berners-Lee, putting together hypertext and the Internet, to currently emerging new concept semantic Web or Web 3.0 (Berners-Lee, 1999).

Thus, it is important to observe this evolution and make an analysis of the characteristics, main aspects and applications areas (W3, 2001).

At the same time as the Web evolves, several technologies have appeared and been developed too.

By this mean it has appeared technologies regarding design and representation aspects like Hypertext Markup Language (HTML), Cascade Style Sheets (CSS) and client-side scripting like Javascript. Also, technologies regarding server-side scripting as programming languages like PHP, ASP.NET and Java Server Pages. For the storage and management of data that circulates in the web, technologies like MySQL, Microsoft SQL Server, also introduced this concept in the web.

More recently, technologies like Extensible Markup Language (XML) (Bray, Paoli, Sperberg-MacQueen, Maler, & Yergeau, 2004) for data interchange and Asynchronous Javascript and XML (AJAX) for client-side interactive applications have appeared (Peck & Doricott, 1994).

Also, concepts regarding to Internet systems and applications are arisen. By this mean, web systems or web-based systems can be divided in following main types, regarding the context of application:

- eCommerce websites - Electronic commerce, commonly known as e-commerce or e-business consists of the buying and selling of products or services over electronic systems such as the Internet and/or computer networks (Chaudhury & Kuilboer, 2002);

- ❖ Content Management sites - A web content management (WCM) system is a CMS designed to simplify the publication of web content to web sites and mobile devices, in particular, allowing content creators to submit content without requiring technical knowledge of HTML or the uploading of files (Kyrnin, 2010);
- ❖ Intranet systems- By definition, an intranet is a private computer network that is accessible from within an organisation. An intranet is a private computer network that uses Internet Protocol to securely share any part of an organization's information or network operating system within that organization (GetStarted, 2010);
- ❖ Extranet - An extranet on the other hand is accessible from outside an organization (GetStarted, 2010);
- ❖ Portals - A web portal, also known as a links page, presents information from diverse sources in a unified way. Tipically a portal offer standard search engine feature, but also offer other services such as e-mail, news, stock prices, information, databases and entertainment (About.com, 2010);
- ❖ Third Party Integration - Reusable software component developed to be either freely distributed or sold by an entity other than the original vendor of the development platform. Hardware or software developer not directly tied to the primary product that a consumer is using (ThirdParty, 2010);
- ❖ Communities Sites & Social Networks - Virtual community is a social network of individuals who interact through specific media, potentially crossing geographical and political boundaries in order to share mutual interests or goals. One of the most pervasive types of virtual community include social networking services, which consist of online communities (Rheingold, 2000);
- ❖ Collaborative Applications - A web application that allows its users to collaborate with each other (Dewan, 1997).

But, the main concept regarding these systems and websites is the information that they gather, store, exchange amd publish.

This concept regarding information systems or at this case web/web-based information systems, that for definition is that uses Internet web technologies to deliver information and services, to users or other information systems/applications. It is a software system whose main purpose is to publish and maintain data by using hypertext-based principles.

A web information system usually consists of one or more web applications, specific functionality-oriented components, together with information components and other non-web components. Web browser is typically used as front-end whereas database as back-end.

As in stand-alone or desktop applications, this kind of systems also view in the web a new mean of spreading amd mainly an extense domain of application, being the web a worldwide mean of communication.

Thus, from business to leisure, from utility to health, different systems appeared for several contexts of application.

But, this thesis focuses on the education area and more specifically in the eLearning trend.

A simple working definition of the term eLearning or e-learning is "learning or training that is prepared, delivered, or managed using a variety of learning technologies and that can be deployed either locally or globally" (MASIE, 2003). The promise of eLearning is that it provides leadership with powerful new tools for improving capability development, speed, and performance whether their organization operates in one geography or many. Just as the rise of information technologies fundamentally changed the nature of how work gets done in organizations, the emergence of learning technologies is fundamentally changing the nature of how people learn to do that work.

From the perspective offered by the experience in the development and exploitation of eLearning platforms and from a quality perspective, Garcia Peñalvo (2008) offers its own definition of eLearning as "the effective acquisition of a suit of skills, knowledge and competences by students, by means of developing appropriate learning contents given with a sum of efficient web tools supported via a net of value-added services, whose process - from content developing to the acquisition of competences and the analysis of the whole intervention - is ensured by an exhaustive and personalized evaluation and certification process, and it is monitored by a human team practicing a strong and integral tutorial presence through the whole teaching-to-learning process".

Currently it is producing a revolution in educational applications with the widespread adoption of Internet as a distribution platform (eLearning).

Elearning is having much importance in various domains of society, both in the education sector as aa business through training and coaching.

Because of this, to contextualize this proposal, this chapter provides an analysis of key aspects of eLearning, among which is their state-of-the-art with meaning and characteristics; the operation of such systems and its possibilities and technical factors to consider teaching to be used efficiently to any changes; the educational theories that support such systems with strategies that help achieve the objectives of learning in a non-face environment; and finally, the advantages of eLearning in the process of teaching and learning.

Thus, in this chapter is going to be study information systems web trends, data availability and representation, adaptation, interoperability of data, collaboration among users, and more specifically its application in the field of eLearning. Thus, starts by analyzing in parallel the evolution of web and elearning, their characteristics, systems and tools.

So, let's look at the Web, adaptive hypermedia systems, data representation on the Internet through standards, recommendation systems, and their application to eLearning, and even some tools and eLearning systems. Finally, the trends in improvement and development are summarized.

2.2. WEB AND ELEARNING

The evolution of Web and eLearning has walked side by side during the years.

Table 2 presents some of the main characteristics regarding these evolutions and the relation between them.

Table 2. Web and eLearning evolution

WEB AND ELEARNING						
Version	**Web**			**elearning**		
Nº	Concept	Technologies	Functionalities/User orientation	Concept	Technologies	Functionalities/User orientation
1.0						
	Write	HTML, URI, HTTP	Disponibilization	Resources disponibilization	CBT	Resources availability
	Web for everyone	Internationalization	Web of Documents	Content deployment centered	CBT with forums	Unidirectional activities
		Global Participation	Accessibility	Classroom	eBook	
		Web Accessibility	Security	Distance learning	LMS	
				Unidirectional activities		
2.0						
	Write/read	Server-sice scripting	Information	LMS and LCMS	LMS and LCMS	
		databases storage		Blearning		Synergy elearning
				student-content interactivity	LO Repository	
				biddirecional activities	chats	Bidirectional activities
					Forums	
	Web on everything	Community	Media sharing	Share resources	Social networks	
		Conection	DOPA	Communication tools	Video-Conferencing	
		Wiki	Rich Web, Voice	Digital content		
		Blogging	InteractionTechnologies	construction content-centered		
		Social Network	Mobile Web	Content Authoring		Multimedia contents
		Mass Collaboration	Expose user data and server data	Standardization of resources	Learning Object and units	
		Information displopment	Widgets		XML	
		Technologies	Podcast		Standards ans specs	
			AJAX			
			XML			
3.0						
	Write/read/request	Semantic Web	Knowledge	Learner-centered	Personal Learning Environments	
		Technologies	XML	Technologies	XML	
			RDF		RDF	
			OWL		OWL	

Version	Web			elearning		
3.0						
	Wef of Data and Services	Context Search	Linked Data	Knowledge representation		
		Advanced Mobile		Extended smart mobile technology	Cross-platform Apps	
		Intelligent Web		Distributed computing		
		Machine Learning				
		Artificial Intelligence		Collaborative intelligent filtering		
		Openness	Open Source	Ubiquitous learning		
			OpenID	Peer-learning group		
		Interoperability				
		Global Database	Connect database into one only Database			
		Social Web		Collaborative learning	Social semantic web	
		3D	Second Life	3D visualisation and interaction	Second Life	
			Personalized Avatars			
		Virtual World				
		Control of Information				
		Recommendation	Based on user preferences	Adaptation	Data Mining	Adaptation suggestion
			Users' interests		Attribute relevance	

As shown in the Table 2 the main characteristics regarding the evolution of web are mainly:

- Concept.
- Involved Technologies.
- Public Coverage.
- Data.

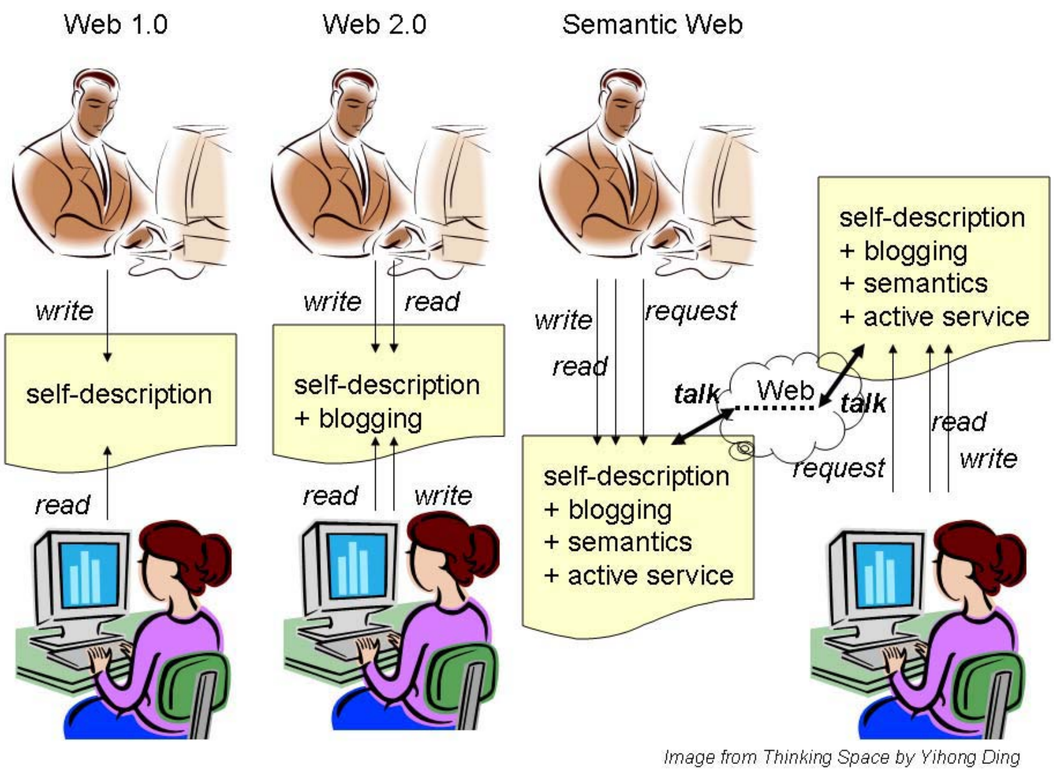


Figure 4. Simple abstraction of Web evolution

Yihong-Ding (2007) refers at the Thinking Space to Web evolution, defining three stages as presented in Figure 4.

First stage - The traditional World Wide Web, also known as Web 1.0, is a Read-or-Write Web.

In general, authors of web pages write down what they want to share and then publish it online. Web readers can watch these web pages and subjectively comprehend the meanings. Unless writers willingly release their contact information in their authored web pages, the link between writers and readers is generally disconnected on Web 1.0. By leaving public contact information, however, writers have to disclose their private identities (such as emails, phone numbers, or mailing addresses). More briefly, Web 1.0 connects people to a public, shared environment - World Wide Web. But Web 1.0 essential does not facilitate direct communication between web readers and writers.

The second stage of web evolution is Web 2.0. Though its definition is still vague, Web 2.0 is a Read/Write Web.

At Web 2.0, not only writers but also readers can both read and write to a same web space. This advance allows establishing friendly social communication among web users without obligated disclosure of private identities. Hence it significantly increases the participating interest of web users. Normal web readers (not necessarily being a standard web author simultaneously) then have a handy way of telling their viewpoints without the need of disclosing who they are. The link between web readers and writers becomes generally connected, though many of the specific connections are still anonymous. Whether there is default direction communication between web readers and writers is a fundamental distinction between Web 1.0 and Web 2.0. In short, Web 2.0 not only connects individual users to the Web, but also connects these individual uses together. It fixes the previous disconnection between web readers and writers.

Third stage – ideal semantic web is a Read/Write/Request Web?

It is not known precisely what the very next stage of Web evolution is at this moment. However, many people believe that Semantic Web must be one of the future stages. Following the last two paradigms, an ideal Semantic Web is a Read/Write/Request Web. The fundamental change is still at web space. A web space will be no longer a simple web page as on Web 1.0. Neither will a web space still be a Web-2.0-style blog/wiki that facilitates only human communications. Every ideal semantic web space will become a little thinking space. It contains owner-approved machine-processable semantics. Based on these semantics, an ideal semantic web space can actively and proactively execute owner-specified requests by themselves and communicate with other semantic web spaces. By this augmentation, a semantic web space simultaneously is also a living machine agent. The name of Active Semantic Space (ASpaces) has been proposed (Ding, Ding, Embley, & Shafiq, 2007). In short, Semantic Web, when it is realized, will connect virtual representatives of real people who use the World Wide Web. It thus will significantly facilitate the exploration of web resources.

A practical Semantic Web requires every web user to have a web space by himself. Though it looks abnormal at first glimpse, this requirement is indeed fundamental. It is impossible to imagine that humans still need to perform every request by themselves on a Semantic Web. If there are no machine agents helping humans process the machine-processable data on a Semantic Web, why should this kind of semantic web be built from the beginning? Every semantic web space is a little agent. So every Semantic Web user must have a web space. The emergence of Semantic Web will eventually eliminates the distinction between readers and writers on the Web. Every human web user must simultaneously be a reader, a writer, and a requester; or maybe we should rename them to be web participators.

In summary, Web 1.0 connects real people to the World Wide Web. Web 2.0 connects real people who use the World Wide Web. The future semantic web, however, will connect virtual representatives of real people who use the World Wide Web. This is a simple story of Web evolution.

2.2.1. WEB 3.0

The next Web Generation involves Search Context for online information.

The war of words between technology evangelists about Web 3.0 continues and, in particular, as a proof of that a series of blog posts were exchanged between Tim O'Reilly (2010) and Nova Spivack (2007) about the merits of "Web 3.0."

So, what is the difference between Web 3.0 and Web 2.0?

While O'Reilly believes that Web 3.0 is an extension of Web 2.0, Spivak - regarded as a champion of the term Web 3.0 - believes it will be a third generation web approximately between 2010 and 2020. In order to understand Web 3.0, we must balance it against the existing Web 2.0. In the Web 2.0 universe, searching Google for "Gary Price" will yield a plethora of unrelated hits. Web 3.0 solves this problem by providing context to searching for online information (O'Reilly, 2010).

Allan Cho (2008) refers that it can help differentiating the two, by analysing the following concepts:

- Intelligent Web.
- Openness.
- Interoperability.
- A Global Database.
- 3D Web & Beyond.
- Control of Information.

Intelligent Web

Web 2.0 is about social networking and mass collaboration with the blurring of lines between content creator and user whereas Web 3.0 is based on "intelligent" web applications using:

- Natural language processing.
- Machine-based learning and reasoning.
- Intelligent applications.

The goal is to tailor online searching and requests specifically to users' preferences and needs. Although the *intelligent web* sounds similar to artificial intelligence, it is not quite the same.

Openness

Web 3.0 is about *openness*. By "opening" application programming interfaces (APIs), protocols, data formats, open-source software platforms and open data, it opens up possibilities for creating new tools. Although unlike openness can result in identity theft, Web 3.0 attempts to remedy this through:

- Open identity.
- OpenID.

- Open reputation.
- The ability for roaming portable identity and personal data.

Interoperability

By opening up access to information, Web 3.0 applications can run on any device, computer, or mobile phone. Applications can be very fast and customizable. Unlike Web 2.0, where programs such as Facebook and MySpace exist in separate silos, Web 3.0 allows users to roam freely from database to database, program to program.

A Global Database

Conceptually, Web 3.0 should be viewed as one large database. Dubbed "The Data Web", web 3.0 uses structured data records published to the Web in reusable and remote-queriable formats. XML technologies such as RDF Schema, OWL, SPARQL will make this possible by allowing information to be read across different programs across the web (W3CSW, 2009).

3D Web & Beyond

Web 3.0 will use a three dimensional model and transform it into a series of 3D spaces. Services such as Second Life and the use of personalized avatars will be a common feature of the 3D web. Web 3.0 will extend beyond into the physical; imagine a Web connected to everything not only your cellphone but your car, microwave and clothes, thus truly making for an integrated experience.

Control of Information

Where Web 3.0 is about control of information Web 2.0 is about information overload. The most obvious example is in the sheer explosion of programs and passwords on the Web which claim to encourage networking and socialization. Web 3.0 attempts to bring order and allow users to be more accurate in searching and finding precisely what they want.

Semantic Web versus Web 3.0

Both are conceptual entities. However, rather than competing spaces they should be viewed as successive layers that are developing. By adding the semantic web to Web 2.0, we move conceptually closer to Web 3.0. The underlying technologies of the Semantic Web, which enrich content and the intelligence of the social web, pull in user profiles and identities, and must be combined for Web 3.0 to work (Catone, 2008).

Nova Spivack's Twine (2010) was one of the first online services to use Web 3.0 technologies. Its goal was to organize, share and discover information about a user's interests in networks of like-minded people. Using semantic technologies, and powered by semantic understanding,

Twine automatically organizes information, learns about users' specific interests and makes recommendations. The more users use Twine, the better the service gets to know its users and the more useful it becomes. Twine is an example of Web 3.0 at work, combining the social elements of Web 2.0 with user-specific Semantic Web tools (Cho, 2008).

Concluding, the new main trends in the new generation of Web and its relation with elearning, can be identified as:

- Semantic web.
- Mobile.
- Colaboration.
- Artificial Intelligence.

2.2.1.1. SEMANTIC WEB

The word semantic stands for the meaning of. The semantic of something is the meaning of something. The Semantic Web equals a Web with a meaning (W3CSW, 2009).

The Semantic Web is a Web that is able to describe things in a way that computers can understand. For instance:

- The Beatles was a popular band from Liverpool.

- ❖ John Lennon was a member of the Beatles.
- ❖ "Hey Jude" was recorded by the Beatles.

Sentences like the ones above can be understood by people. But how can they be understood by computers?

Statements are built with syntax rules. The syntax of a language defines the rules for building the language statements. But how can syntax become semantic?

This is what the Semantic Web is all about - Describing things in a way that computers applications can understand it (Semweb, 2011).

Contrasting the Semantic Web is not about links between web pages, is about describing the relationships between things (like A is a part of B and Y is a member of Z) and the properties of things (like size, weight, age, and price).

The term "Semantic Web" refers to W3C's vision of the Web of linked data. Semantic Web technologies enable people to create data stores on the Web, build vocabularies, and write rules for handling data. Linked data are empowered by technologies such as RDF, SPARQL (Query Language for RDF), OWL (Ontology Web Language), and SKOS (Simple Knowledge Organization System) (W3CSW, 2009).

"If HTML and the Web made all the online documents look like one huge book, RDF, schema, and inference languages will make all the data in the world look like one huge database", (Berners-Lee, 1999).

The Semantic Web uses RDF (Resource Description Framework) to describe web resources that is a language for describing information and resources on the Web, which permits an intelligent search of information. By structuring information into RDF files, makes it possible for computer programs ("web spiders") to search, discover, pick up, collect, analyze and process information from the web (RDF, 2004).

If information about music, cars, tickets, etc. were stored in RDF files, intelligent web applications could collect information from many different sources, combine information, and present it to users in a meaningful way.

Information like this:

- ❖ Car prices from different resellers.

- ❖ Information about medicines.
- ❖ Plane schedules.
- ❖ Spare parts for the industry.
- ❖ Information about books (price, pages, editor, year).
- ❖ Dates of events.
- ❖ Computer updates.

The main problem with RDF application is being worlwide understand by users.

One of the reasons for that is its learning curve because RDF was developed by people with academic background in logic and artificial intelligence. For traditional developers it is not very easy to understand.

By this mean the Semantic Web is not a very fast growing technology.

2.2.1.2. SOCIAL SEMANTIC WEB

The concept of the Social Semantic Web subsumes developments in which social interactions on the Web lead to the creation of explicit and semantically rich knowledge representations. The Social Semantic Web can be seen as a Web of collective knowledge systems, which are able to provide useful information based on human contributions and which get better as more people participate.

The Social Semantic Web combines technologies, strategies and methodologies from the Semantic Web, Social Software and the Web 2.0 (SocialSoftware, 2010).

The Social Web and the Semantic Web complement each other in the way they approach content generation and organization. Social web applications are fairly unsophisticated at preserving the semantics in user-submitted content, typically limiting themselves to user tagging and basic metadata. Because of this, they have only limited ways for consumers to find, customize, filter and reuse data. Semantic web applications, on the other hand, feature sophisticated logic-backed data handling technologies, but lack the kind of scalable authoring and incentive systems found in successful social web applications. As a result, semantic web applications are typically of limited scope and impact.

A new generation of applications is envisioned that combines the strengths of these two approaches: the data flexibility and portability of that is characteristic of the Semantic Web, and the scalability and authorship advantages of the Social Web.

The social-semantic web (s2w) aims to complement the formal Semantic Web vision by adding a pragmatic approach relying on description languages for semantic browsing using heuristic classification and semiotic ontologies. A socio-semantic system has a continuous process of eliciting crucial knowledge of a domain through semi-formal ontologies, taxonomies or folksonomies (Garshol, 2004). S2w emphasize the importance of humanly created loose semantics as means to fulfil the vision of the semantic web. Instead of relying entirely on automated semantics with formal ontology processing and inferencing, humans are collaboratively building semantics aided by socio-semantic information systems. While the semantic web enables integration of business processing with precise automatic logic inference computing a cross domains, the socio-semantic web opens up for a more social interface to the semantics of businesses, allowing interoperability between business objects, actions and their users.

Socio-semantic web was coined by Manuel Zacklad and Jean-Pierre Cahier in 2003 (Zacklad, 2003) and used in the field of Computer Supported Cooperative Work (CSCW) (Grudin, 1994). It recently gained wider appeal after the release of Peter Morville's book *Ambient Findability* (Morville, 2005). Here he defines the socio-semantic web as; relying on "the pace-layering of ontologies, taxonomies, and folksonomies to learn and adapt as well as teach and remember". An increasing use of folksonomies on the Web, and a corresponding decrease in the use of hierarchical taxonomies. Morville (2005), the recognized librarian and information architect writes; "I'll take the ancient tree of knowledge over the transient leaves of popularity any day". There is undoubtedly scepticism towards the widespread and bushfire like adoption of folksonomies.

The socio-Semantic Web may be seen as a middle way between the top-down monolithic taxonomy approach like the Yahoo! Directory (2011) and the more recent collaborative tagging (folksonomy) approaches (Pink, 2005).

The socio-Semantic Web differs from the Semantic Web in that the Semantic Web often is regarded as a system that will solve the epistemic interoperability issues we have today.

While the Semantic Web will provide ways for businesses to interoperate across domains the socio-Semantic Web will enable users to share knowledge.

Morville is vague in his definition of the socio-semantic web and does not lay out any proposed models.

Thus, it can be identified three possible social approaches for solving the problems of user driven ontology evolution for the semantic web.

- First, users could create a folksonomy (flat taxonomy). With Social Network Analysis (SNA) (Freeman, 2006) in conjunction with automated parsers, the ontology could be extracted from the tags and this ontology could be entered into a Topic Map/TMCL or RDF/OWL ontology store (Garshol, 2004).
- Secondly a set of ontology engineers or ontologists could manually analyze the tags created by the users and by using this data, create a more sound ontology.
- The third approach is to create a system for self governance where the users themselves create the ontology over time in an organic fashion.

All of these approaches could start out with an empty ontology or be seeded manually or with an existing ontology, for example the WordNet ontology (Miller, Beckwith, Fellbaum, Gross, & Miller, 1990). Social Networks Ontology is the most important concept in social web (S2W, 2010).

Thus, it will be interesting in bringing together the best of the worlds, semantic web "world" and the social web "world" to promote the collaborative development and deployment of semantics in the World Wide Web context.

2.2.2. eLearning

The World Wide Web provides both teachers and students many learning opportunities, allowing students to learn at their own pace, improving skills writing and communication, develop problem-solving skills of high order; and feeding critical reflection (Peck & Doricott, 1994).

The mediated learning technologies to the network, according to Mir (2003) begins to receive from 1995 on various terms, covering a spectrum that ranges from instructional packages in paper or CD with online tutors to learning modules based on the Web (WBL - Web Based Learning). As he sees it, this variety of concepts associated with online learning is that many times the various possibilities of learn through the Network are focused according to Internet facilities Learning and not processing involved in learning via the Internet.

But that is eLearning? For eLearning if understood as the effective learning process created by the combination of digital content with deployment of (learning) services and support (learning). There are some important words here:

- Efective: There are many types of learning processes, some of which are ineffective. It has no sense to apply a definition to something that fails.
- Combination: A combination that makes the difference, not the individual parts – each part is as valid by itself.
- Contents deployed digitally: It has been excluded such as paper materials being half while perfectly valid for learning, not eLearning.
- Support: Theoretically, a program based on CD/DVD-ROM may be echo or time anywhere, but many are not support under tutors, while it may be used (Waller, Vaughan, & Wilson, 2001).

The form and structure for teaching and learning are changing because of rapid developments in communications. Changes in the global economy and advances in communications and technology have great impact on society. Regarding universities, Le Grew (1995) constructed a table "paradigm shift" to show the transformation needed to keep institutions such developments. The necessary change is next.

1. Industrial society to information society - Because knowledge and information are the basis for economic growth, then the companies include information technology (IT) event in the learning process thrives in XXI century (Bates, 1995).
2. Central technology for multimedia peripherals - Having a media center (which is enabled by technological peripherals) focused in education, the learning experience of participants is higher with text, video, sound and images. This enables a learning experience gained and deserved more.

3. Institutional focus for the student focus - Universities are starting to see the students such as customers (Santosus, 1997) and the education system must be student-centered.

Given the exponential growth of the Internet, almost two billion users are connected by the year 2011. The importance of mobile access to data is the notorius trend of the future.

Figure 5 presents the infrastructure components of IT that allow the "paradigm shift". Video-conferencing to facilitate an interactive discussion among participants without the need to be physically present at particular location. That ended with the sweep of the location and facilitated distance learning (Jackson, 1998). Electronic mail (e-mail) is quicker and cheaper than traditional media such as fax, telephone and mail. It also facilitates distance learning. Also newsgroups and chat services and online discussion quickly and inexpensively allow interaction among participants independent of physical location.

With the databases based on knowledge spread worldwide, the Internet provides information quickly and cheaply from any source. For example, many journals publish their articles online, allowing access to Internet users.

With web programming languages such as PHP, perl, the markup languages like HTML or XML and Java, which is independent of operating system and as the TCP/IP which is based on the Internet, which this world expanded so quickly, then sharing data and information is easier through businesses, homes and other computer sites.

As costs decreases as storage media increase, then it becomes very economical to store and manipulate data electronically.

As the bandwidth increases, gave the possibility to have central data repository where information is maintained, so that can be downloaded when needed.

All these technologies enable on-demand learning, i.e. independent of time or location, and available in all states of a person's life.

In addition, the current trend is to go to models focusing on the learner who need to offer high quality content tailored to their needs (Sancho, Martínez-Ortiz, & Fernández-Manjón, 2005).

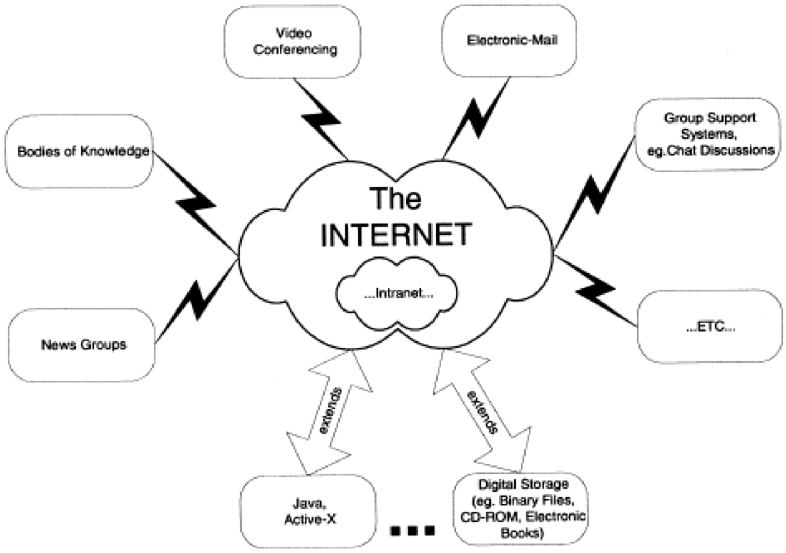


Figure 5. IT infrastructure centered in the Internet (Jackson, 1998)

However, they identified earlier problems such as high cost of developing courses for these systems, and low possibility of reuse/adaptation of content when you change some factor such as, for example, the platform or the educational context (Fernández-Manjón & Fernández-Valmayor, 1997). From these basic needs, there is a model for course design that is rooted in the paradigm of object-oriented programming: called Educational Object Model (Learning Object Model) (Koper, 2001). The model basically consists in designing the courses as aggregates of independent, reusable learning objects, in the manner of a puzzle or a mechanic. The combination of the Internet as a platform to develop these new models of course design and the use of marking technologies (e.g. XML and related standards), simplify the creation of new educational systems and propose to enhance the educational paradigm based on the maxim "the student is the center" (Koper, 2001). It is, in essence, that the learning process can adapt to the characteristics of each student, and not vice versa as is customary in traditional teaching methods. Under this view, there are two key features that enable a learning environment to meet this goal:

1. Quality educational content and reusable. The proposal is to increase the efficiency of mechanisms for reuse: the existance of a huge amount of educational material available on the network, is absurd to start each course from scratch. It is able to identify what existing content are suitable for use in a particular context clearly leads to an increase in the quality of the courses.

2. Custom Learning Systems. Education suited to the needs under three different angles:
    a. Level of student's initial knowledge.
    b. Objectives of student knowledge.
    c. Learning method preferred by the student.

New elearning trends

The eLearning community are quickly embracing many modern Web technologies, including XML, XML Schema, P3P, and other Web technologies from the W3C and elsewhere. The educational technology standardization movement has also grown to become a significant force, including such organizations as IMS Global Learning Consortium (IMS, 2011), IEEE (IEEELOM, 2002), Dublin Core (DC, 2010), ISO (JTC1/SC36, 2007), ADL (SCORM, 2009), which are standardizing important base technologies for eLearning applications. Examples include metadata, content structure, digital repositories, and many more (Liu, 2009).

A good example of the level of acceptance these eLearning standards are meeting is the MIT Open Knowledge Initiative (OKI, 2007), an effort to bring most of the courses offered by MIT online. The OKI is being developed in close cooperation with these standardization movements. Many, if not most, eLearning applications follow the same track, and are either compliant to these standards, or will soon be (Rego et al., 2005). A recent example is the Basic Learning Tools Interoperability LTI (BasicLTI, 2011) developed by the IMS Consortium, to allow remote tools and content to be integrated into a Learning Management System (LMS).

At the same time, it has become increasingly evident that the educational community will not be accepting Semantic Web technology for metadata very quickly, although the potential benefits are many. For example, only recently has the popular IEEE LOM (Learning Object Metadata) has been expressed in RDF (2004), and in spite of this, most implementors and researchers remain with XML Schema-based technology for metadata.

Additionally, many eLearning applications are highly monolithic and seriously lacking in flexibility (Rego et al., 2005). The kind of intelligent computer support enabled by Semantic

Web descriptions, such as software agents and self-describing systems, is not taken into account in the design.

In short, it could be possible somewhat surprising and perhaps paradoxical situation that the eLearning community is lacking in knowledge representation technology. For this reason, Semantic Web technology has not been extensively used and studied for educational applications, and there is therefore a need for a detailed analysis of the needs of the eLearning community concerning Semantic Web infrastructures.

Even though this work focuses on the specific benefits of next generation web technologies bring to eLearning, and the demands eLearning puts on web technologies, it seems to us that many of the lessons learned are applicable to implementations in other fields as well (Rego, Moreira, Morales et al., 2010) (Liu, 2009). Figure 6 illustrates the eLearning evolution, in terms of concepts and technologies.

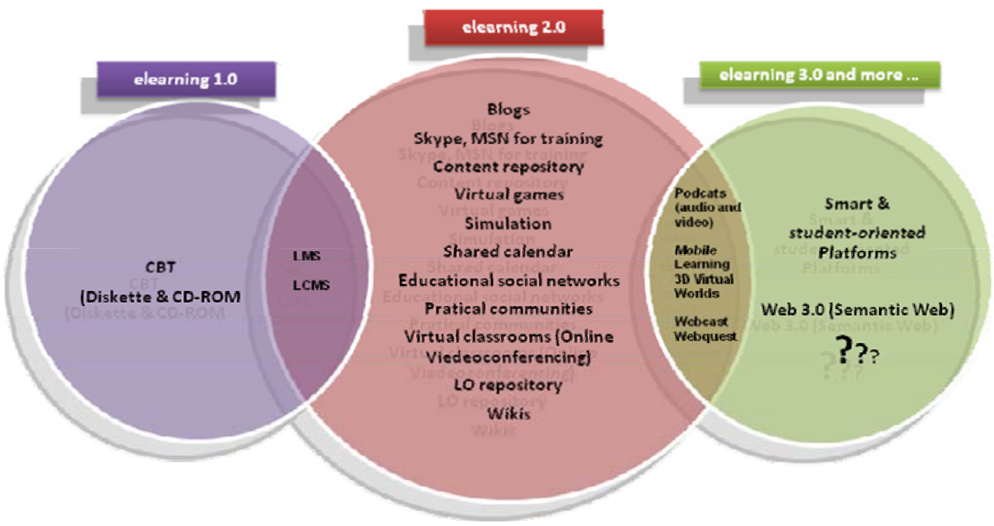


Figure 6. eLearning evolution

2.2.2.1. ELEARNING 3.0

What will eLearning look like in a few years time? When Stephen Downes laid down his manifesto for eLearning 2.0 in 2005, he tapped into the zeitgeist of emerging social technologies and theorised a number of possibilities (Downes, 2005). Six years on technology is moving ever more rapidly, and a reappraisal of learning within digital spaces is overdue.

As stated by Sue Waters (2010) and Darcy Moore (2010), in a discussion of what learning would look like in a Web 3.0 world, and how it might differ from current learning. This led to revisit some thinking about what for the sake of convenience we will call "eLearning 3.0". We will try to encapsulate some of these thoughts and attempt some (hopefully not too dangerous) predictions.

eLearning 3.0 will have at least four key drivers (Wheeler, 2009):

1. Distributed computing.
2. Extended smart mobile technology.
3. Collaborative intelligent filtering.
4. 3D visualisation and interaction.

Firstly, in a Web 3.0 world we will not only tap into the semantic web with all it promises, but eLearning 3.0 will transgress the boundaries of traditional institutions, and there will be an increase in self-organised learning. Why? It is easier to access to the tools and services that enable us to personalise our learning, and these will be aggregated more easily too. Additionally, with new cloud computing and increased reliability of data storage and retrieval, the mashup is a viable replacement for the portal which will lead to less reliance on centralised provision. This in turn may hasten the death of the ailing institutional VLE. However, Cohen (2010) states that turning the information more available, enhance collaboration and social networking are driving a new breed of learning management and thus reinvent the future of the LMS. By embracing and encouraging adoption of these technologies, learning organizations have a significant opportunity not only to deliver learning in new ways, but also to pair informal learning with formal training, drive improved productivity and deliver increased value to learners.

Secondly, many commentators such as Derek Baird believe that Learning 3.0 is all about mobile technologies (Baird, 2007). Mobiles will play a big part in the story of eLearning 3.0. There will need to be ubiquitous access to tools, services and learning resources, including people - peer learning group, subject specialists and expert support. With smart phone devices and better connectivity through constantly improving line-of-sight (satellite and wireless) networking services, there is little to stop learners everywhere from accessing what they need on the move, from virtually anywhere on the planet. Digital divides of the future will not focus on "have and have not" socio-economic divides, but will more likely be "will and will not" psychological divides, and "can and cannot" skills divides. Conde and Peñalvo (2011, 2008) from the GRIAL research group are working in this revolution of Learning Process, for instance by applying processes and techniques of software engineering for defining a mLearning solution based in HTML 5.0.

Thirdly, truly collaborative learning will be possible in all contexts. Through predictive filtering and massively multi-user participative features, eLearning 3.0 will make collaborating across distance much easier. With the best will in the world, very little collaborative learning occurs through the use of wikis and blogs, whilst social networks generally connect people but often superficially, and can also isolate. In a recent post entitled Is Twitter the Semantic Web? It is possible to speculate on Twitter's functionality and suggest that through its primitive filtering tools such as RT, DM, @ and #tagging, some of the early semantic have been witnessed that enable users to work smarter and more collaboratively. Intelligent agents will take this a lot farther.

Finally, 3D visualisation will become more readily available. Quicker processing speeds and higher screen resolutions will provide opportunities for smoother avatar-driven 3D interaction. Multi-gesture devices which will operate in 3D space will also become more widely available, reminiscent of the opening scenes of the science fiction film Minority Report. Touch surface interfaces are already here (very common in laptops) and multi-touch versions too (for example presented in iPhones or iPads devices) which will ultimately signal the demise of the mouse and keyboard. 3D multi-touch interfaces will make a whole range of tasks easier including file management, fine motor-skill interaction, exploration of virtual spaces and manipulation of virtual objects (Wheeler, 2009).

If Web 1.0 was the "Write Web" and Web 2.0 is the "Read/Write Web", then Web 3.0 will be the "Read/Write/Collaborate Web". But it will not only promote learning that is more richly collaborative, it will also enable learners to come closer to "anytime anyplace" learning and will provide intelligent solutions to web searching, document management and organisation of content.

These are some sights on what eLearning 3.0 could be. The most importance is to discuss and see what it is possible to come up with to extend and/or perfect this wish list – collaboratively (Manohar, 2007).

2.2.2.2. ELEARNING SYSTEMS AND TOOLS

Nowadays, there are several solutions to support eLearning, where some are more content-centred and others more students centred. There are typical course management systems like the Learning Management Systems (LMS) and the Learning Content Management Systems (LCMS) more focus on content management. There are also tools for authoring and packaging contents and tools to associate metadata to the Learning Object.

Now, some of these tools are going to be introduced.

2.2.2.2.1. Current eLearning approaches

In general a typical LMS or LCMS (Learning Content Management Systems) must support the following tools:

- Communication – Tools that permit the communication among users of the platform. (i.e. chat, forum, etc.).
- Administration – Tools that allow the user profile management, reports and statistics.
- Resources management - Regarding resource management like creation, editing and authoring.
- Course management – Tools that allow to define units of learning, activities and their sequence.
- Evaluation – Management of the assessment, types of tests and questionnaires permitted.
- Adaptation - Regarding user personalization, adaptation and customization.

Thus, there are several types of platforms in the market, from commercial platforms like Blackboard (Bb, 2010), former WebCT(Bb Learning System) (WebCT, 2010), IntraLearn (2010), Angel (2010) to freeware/open-source like Atutor (2010), Moodle (2010), Sakai (2010) and dotLRN (2010).

In Table 3 some of the current commercial and open source eLearning platforms is presented.

Table 3. Analysis of eLearning platforms/systems

Tools/Features	Platforms							
	Commercial				Open Source			
	BB	WebCT/Bb Learning System	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 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

Analysing the Table 3 data, the majority of the eLearning 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, 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, the commercial ones have more difficulty in integrating with other systems and supporting different kinds of pedagogies and of course the costs. The detailed analysis can be seen in Appendix A.

Table 4 resumes the strong points and weaknesses of studied eLearning systems.

Table 4. Strong points and weaknesses of eLearning 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, adaptation and extensibility of the platforms, meeting some of our study goals presented before.

To solve these problems and from the comparison between commercial and open-source/freeware platforms, a need for an open source solution focused on issues like adaptation, LO and Metadata management and quality evaluation is required.

2.2.2.2.2. Instructional design tools

Before presenting the proposed LD tool characteristics, it could be relevant to introduce the necessary tools to work with IMS LD, and subsequent mention some publishers that have been developed to work with this specification and identify the current needs.

IMS LD tools

To work with instructional designs that follow the IMS LD specification requires different tools for the management of LU (Learning Unit). These ones include tools to create, validate software, run applications and store LU. Therefore, these tools can be classified as follows in Table 5 (Berlanga & García, 2006):

Table 5. Factors for authoring tools evaluation

LD Tools	
Classification	
IMS LD Editors	Basic (or editors attached to the specification)
	Advanced (or editors not attached to the specification)
Applications	Runtime calls players, running an LU for each user
LU repositories	That store and allow managing
Software (called engine)	That processes, validates, sync, control, and customizes the flow of learning containing a LU
Evidence of compliance (or compliance testing)	To verify the interoperability between applications using IMS LD

Following, a more detailed description of these tools, including some examples, is presented:

- ❖ IMS LD editors. Although an expert user can use any XML editor to create a LU, there are specialist editors. According to their level of attachment to the specification, they are divided into:

    a. Basic (or editors attached to the specification). Tools that enable users to create a LU without having knowledge of markup languages, but whose interface is not far from the specification. Examples of such editors are tools that use the metaphor of the tree to handle the specification as the Reload Learning Design Editor (2010), featuring user interface like ASK-LDT (Sampson & Zervas, 2011) (Sampson, Karampiperis, & Zervas, 2005) (see Figure 7), using windows in web environments as aLFanet Editor (2010) (Rosmalen & Boticario, 2005) (see Figure 8), or using windows but as stand alone environments HyCo-LD (Berlanga, 2008; Berlanga & García, 2006)(see Figure 9 and Figure 10). In addition, there are extensions of the Reload LD Editor, such as Collage (2010) and Prolix (PROLIX, 2010).

    b. Advanced (or editors not attached to the specification). Authoring tools that do not show to the end user the specification. Examples of such editors include tools with graphical interface as MOT+ (MOT+, 2010) (Paquette, Teja, Léonard, Lundgren-Cayrol, & Marino, 2005), and those that have templates to work with the specification as eLive Learning Design Suite (eLive GmbH) (2009) (see Figure 11).

- ❖ Applications (runtime calls players) running an LU for each user, coordinating students and teachers in their different roles, monitoring its performance, presenting learning activities and resources, and implementing services that support the process. A example of player available at this time is the Reload Learning Design Player (2010) (see Figure 12).

- ❖ LU repositories that store and allow managing, searching and incorporating them into different courses.

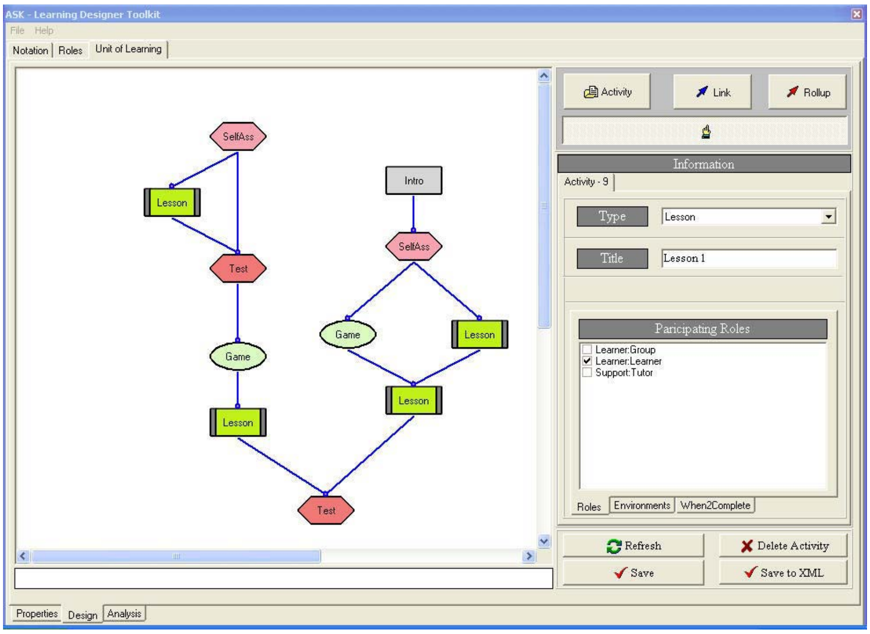


Figure 7. ASK-LDT: Interface

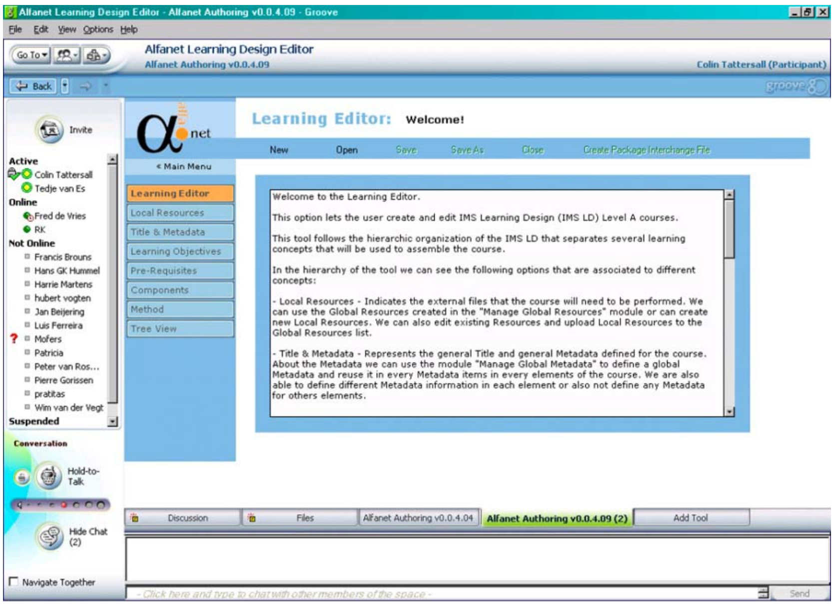


Figure 8. aLFanet: Interface

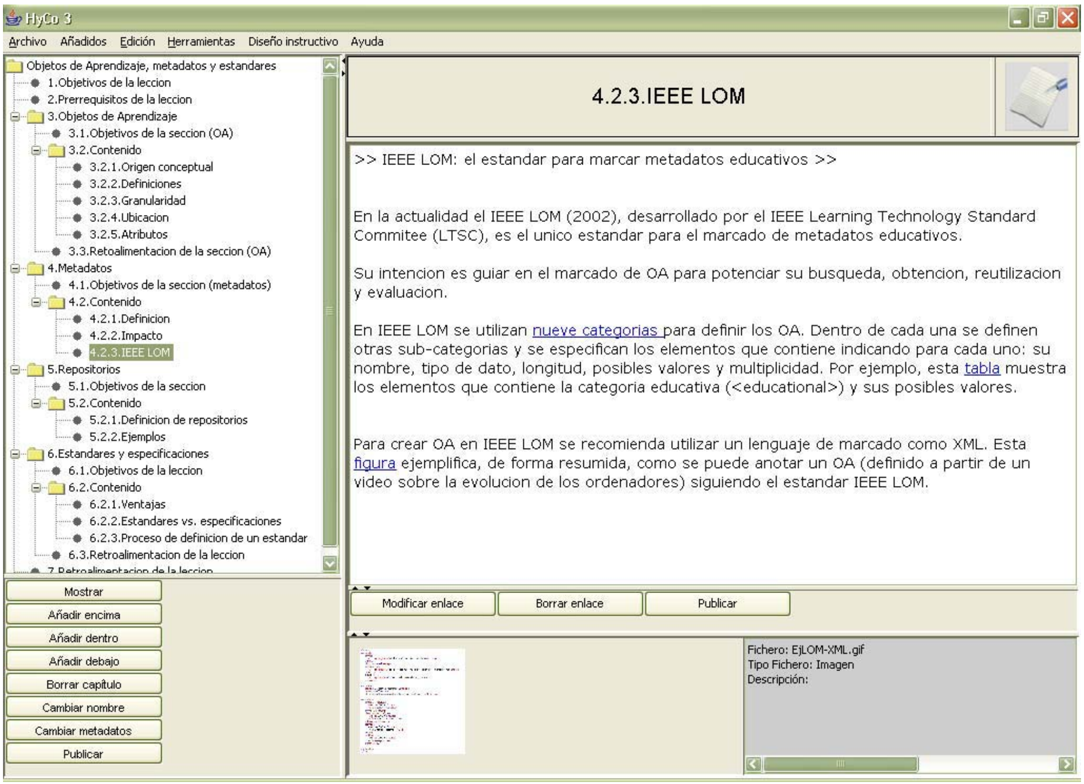


Figure 9. HyCo Interface

Figure 10. HyCo-LD main menu

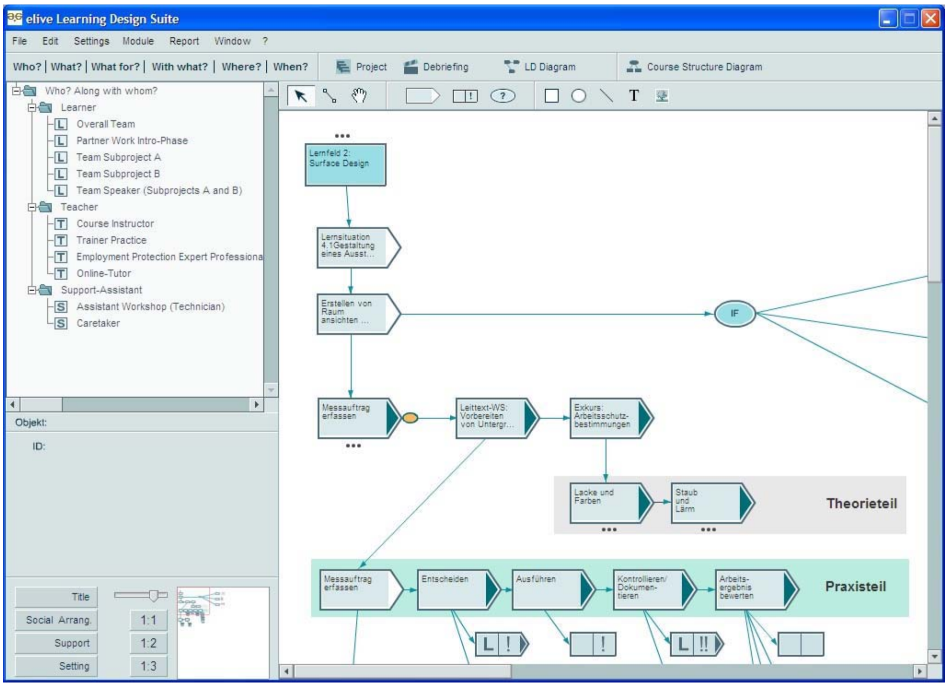


Figure 11. eLive Learning Design Suite: Interface

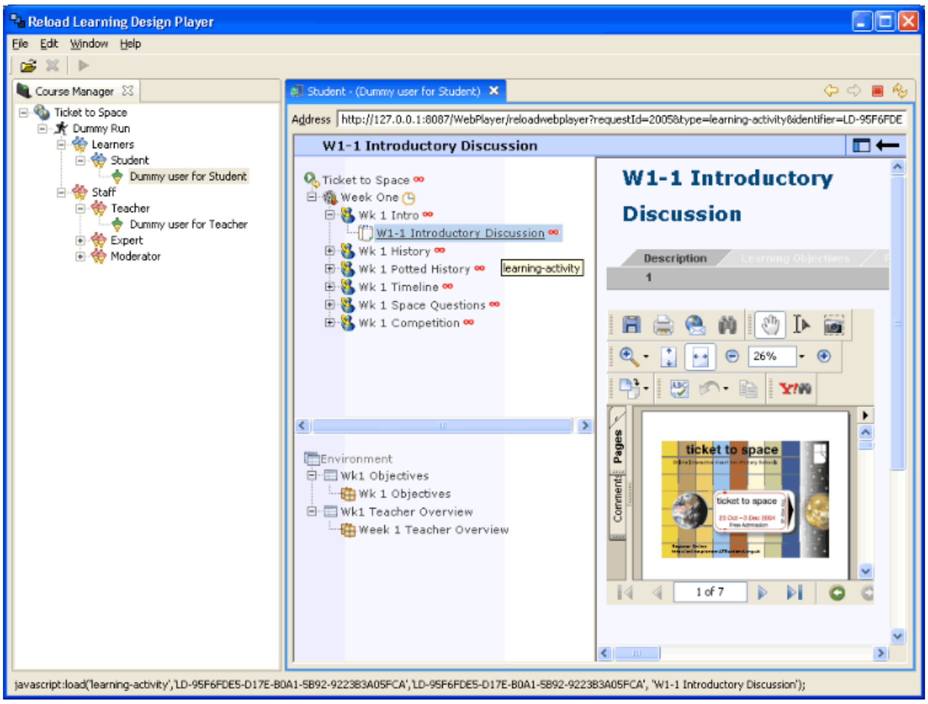


Figure 12. Learning Design Reload Player: Interface

- Software (called engine) that processes, validates, sync, control, and customizes the flow of learning containing a LU, for which works closely with the runtime players. Coppercore (2009) (see Figure 13) and SLED (2009) are two examples of this kind of engines.

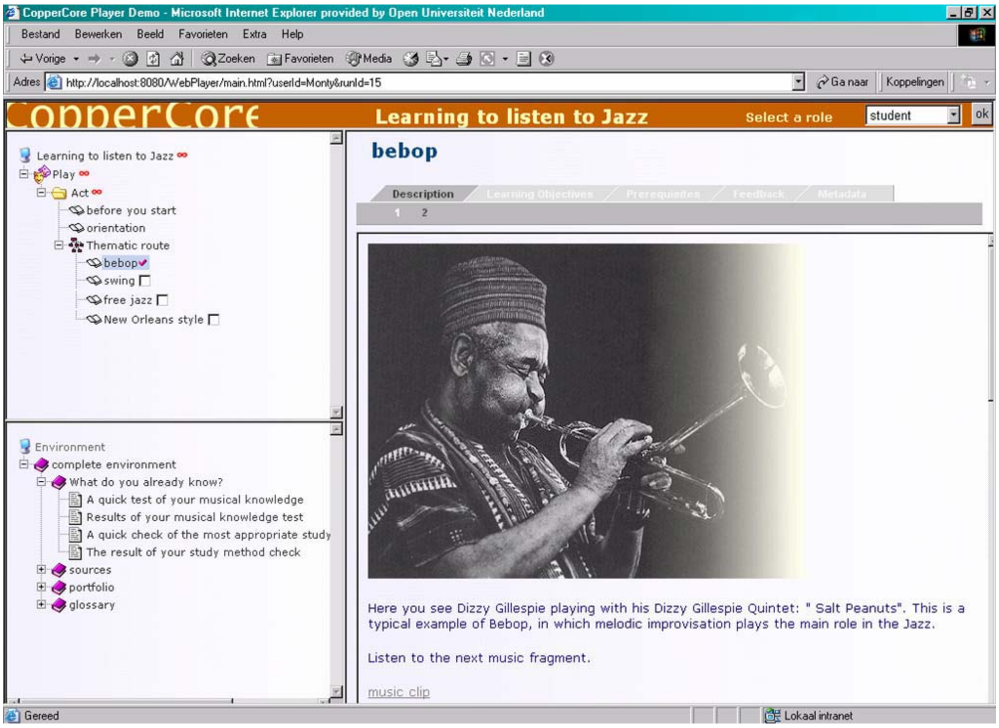


Figure 13. CopperCore: Interface

❖ Evidence of compliance (or compliance testing) to verify the interoperability between applications using IMS LD. An example in this direction is the software and battery of tests that were developed within the European project Telcert (2010).

It is clear that from the number of examples available for each case, the current status in the development and implementation of tools for working with IMS LD is in an evolution phase. Now the focus is on developing software for processing editors and LD, LU repositories, or evidence of compliance with the specification, which delves into the IMS-LD editors.

Editors for IMS LD

Table 6 contains some publishers to work with IMS LD. It shows its commitment to the specification (Basic or Advanced) and their level of compliance (A, B, C) also indicates the type of user is directed to its knowledge of IMS LD (i.e. expert, intermediate, novice), its status, and the project, university or institute that develops.

Table 6. Editors to work with IMS LD

Name	Level	IMS LD Level	User	Interface features	Status	Developed by
Reload Learning Design Editor (2010)	Básic	A, B, C	Intermediate	It uses a tab structure to separate the elements of IMS LD (properties, roles, methods, activities, etc.). Within each tab uses the tree metaphor to group items of the specification.	Available *Open source*	JISC Project (United Kingdom): University of Bolton and the University of Strathclyde
aLFanet Editor (2010)	Básic	A, B, C	Expert	Web-based. It uses screens to display and separate the elements of the specification. Groups of IMS LD elements into substructures.	Available *Open source*	EU Project: OUNL (Netherlands), UNED (Spain), Software AG (Spain)
CopperAuthor (2010)	Básic	A	Intermediate	It uses the metaphor of the tree. It includes different views for the LU: Design, XML, Play, manifest, etc. Coppercore Integrates an engine that allows previewing of the LU	Available *Open source*	OUNL (Netherlands)
ASK-LDT and customized version eAccess II (2005; Sampson & Zervas, 2011)	Básic	A, B	Rookie	Graphical editor that allows connecting the elements by dragging with the mouse. To identify the visual elements it can use a default notation or create their own notations.	Available	EU Project: Informatics and Telematics Institute (Greece)
Mot+(2010)	Advanced	A, B	Inexperienced	Graphic Editor. It uses generic and specific symbols according to the MISA method (MOT+, 2010) (Paquette et al., 2005).	Available (Griffiths, Blat, Elferink, & Zondergeld, 2005)	Centre de recherche LICEF. Télé-Université (Canada)
eLive LD Suite (2009)	Advanced	A, B	Rookie	Graphic Editor. Similar modeling approach to business process modeling to design concepts and structures.	Available Proprietary, commercial product	eLive GMBH (Germany)

This analysis illustrates some weaknesses and at the same time some trends to a LD tool. Some examples of these trends are the design support and reuse, but also the representation, as the method used by designers to represent and record their learning designs. Finally, the inclusion of collaboration features in the learning design process (Cross, Conole, Clark, Brasher, & Weller, 2008).

2.2.2.2.3. LOM Tools

Also, it is relevant to make a comparative analysis of the current approaches in LOM tool applications, in an empirical mode, like the level of feature support. For instance, comparing similar tools, how users catalogue the LO with metadata, with and without the help of the automation metadata process, where it packages LO metadata through the 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 evaluation features to evaluate the LO.

Regarding the qualitative level, some key features of learning object metadata tools have been analyzed (LOM Editor (2008), ADL SCORM (2010), Reggie (2008) and EUN(2008)). To make this analysis, a set of tasks have been defined, mapping it to the study goals, like described on Table 7, and tested if the different tools support them.

Table 7. LOM Tools

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

The Advanced Distributed Learning (ADL) Sharable Content Object Reference Model (SCORM) Metadata Generator (ADLMG, 2010) is an application for creating XML metadata files based on SCORM specification providing data validation.

The resource description tool of EUN (2008) is an HTML page where the user can fill a number of fields that represent the EUN proposed specification of educational metadata.

Reggie (2008) metadata editor 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 (LOMEditor, 2008) is an application to create and modify XML metadata files based on a previous version of LOM v1.4.

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.

This analysis illustrates some weaknesses and at the same time some trends to a LOM tool that distinguishes itself from the others by introducing an abstraction level to the user from the technical aspects in terms of the XML language. A tool 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. Also by introducing the quality evaluation, giving the user the possibility to choose the best LO that best fit his educational scenario.

2.3. MARKUP TECHNOLOGIES STANDARDS AND SPECIFICATIONS FOR EDUCATION

As it can be seen during the history with battles by the impulses telephone, the formats for the videotapes, protocols of e-mail and the battles of platforms between Microsoft, Apple, Sun, HP, and others. The companies begin with proprietary technology, which does not work (does not integrates) with others. Many times such technology does not meet the needs of end-users, and then the market directs typically several leaders of the business, academic and government to work together to develop common standards. That allows a variety of products to interconnect and coexist. The convergence of technology is much important for consumers because it allows having a long range of products and better chances of those products have not a rapid obsolescence. In the same way standards as common, metadata, packages of contents, packages of sequences (content sequencing), interoperability of issues and testing (question and test interoperability), profiles of students, interaction in run-time, etc., are prerequisites for the success of the economy of knowledge and the future of learning. Now, there are several versions of that standards and specifications. The question is how to integrate that standards with the plans for the future and with the current projects, and another issue is the reason that interests to a organization: the emergency and convergence of the standards of learning. The reason lies in the fact of the organization wants to increase the remuneration of its investment in learning technologies and with the content and services of learning that has developed. Thousands, if not millions of euros, will be expenditure on these technologies, content and services to improve the knowledge and techniques in those areas (MASIE, 2003). If the systems cannot grow, to be held, run and then distributed to the students, then the investment is not profitable or is completely ineffective.

Standards help to ensure the five capabilities mentioned below and the same to guarantee the investment systems in eLearning done by the organizations:

- Interoperability – A system can operate with another system.
- Reusability - Course resources can be reused (learning objects or pieces).
- Management - (manageability) A system can find appropriate information about a user or a content.
- Accessibility - A student can access to appropriate content in the right time.
- Durability - Technology evolves with the standards to avoid obsolescence.

The proliferation of platforms web designed to withstand educational environments has generated new concepts on how the processes of teaching and learning should be carried out, innovative ideas to establish how must interact agents involved, and new requirements relating to how to define the educational elements to be interoperable, reusable and interchangeable among different systems and platforms.

Before the emergence of the Web, the educational environments were thinking in closed communities in specific contexts, and with proprietary technologies. Current Web trends make mandatory the possibility of exchange and share elements as resources, lessons, courses, or data from the students. To achieve these goals, it is necessary to use a common language that identifies the characteristics of these elements irrespective of their origin.

As a result, different organizations, providers of software and hardware, universities and research centers around the world work jointly defining specifications and standards that define how the training elements should be recorded for interoperability and reusabability. This way, technology supported learning process possibilities are expanded, in order to provide personalized training and automate tasks, in addition to educational resources from various sources and in various formats.

The objective of this section is twofold. On the one hand, presents an overview of the standards and specifications in the marking of educational metadata for web applications related to education and, on the other, explains the main characteristics of the initiative more meaningful to describe standardized processes of teaching and learning, the specifications IMS, which is used as an alternative to characterize learning resouces in the eLearning systems. To achieve this, this section introduces, the first part is regarding technologies for the markings of educational metadata, it explains what a standard, a specification and a implementaron profile are, presents the concepts of learning object and metadata, and mentions the major agencies involved in its development, evaluation and dissemination. Then it approaches briefly the most important standards, specifications and implementation profiles.

The second part focuses on the description of teaching and learning processes. It starts introducing the instructional design concept, its purposes and characteristics, and continues detailing IMS LD (2003). Subsequently, it summarizes the characteristics of other similar initiatives to this specification and compares them. Also, it presents the schema concepts and the mains characteristics of XML schema marking. Finally, the section indicates some weaknesses of these technologies and presents conclusions.

2.3.1. MARKING TECHNOLOGIES FOR EDUCATIONAL METADATA

One of the other things to be considered is the standards compliance of the system.

One of the biggest difficulties of eLearning systems and platforms is to structure content and information using nowadays pedagogical models, so they can reach a wider range of educational systems and obtain a greater quality of teaching.

Among these standards and specifications there are some more focused on the design and structuring of courses and others that try to enclose, in a general way, all the processes of teaching/learning. Among the specifications that first emerged it is interesting to mention *Sharable Content Object Reference Model* (SCORM) (2009), a project from *Advanced Distributed Learning* (ADL), and the specification *Educational Modelling Language* (EML) (Koper, 2003). However these have some problems.

SCORM becomes more a specifications and standards integrator than a standard by itself, thus it is dependent of the standards it integrates. Besides it does not consider the evaluation and characterization of students. EML is a specification that has become obsolete when the IMS (*Instructional Management Systems*) Learning Design (LD) (IMSLD, 2003) 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. Finally, IMS specifications 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 reference that today is. It bases its metadata specification on the IEEE LOM (2002) 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 (Bray et al., 2004). The main objective of these specifications is to be as general as possible, so they can be applied to any process of teaching/learning.

Marking technologies for educational metadata identify and annotate in a uniform manner, techniques, methods and elements related to the formation, with the aim to facilitate their exchange, distribution and reuse in different systems and courses. Through these technologies can be identified, for example, learning resources, students' profiles testing and evaluation, repositories, digital formats for the exchange of resources, expertise, languages modeling, educational or vocabularies and glossaries.

Thus, introduced initiatives aim at defining proposals known as standards, specifications or implementation profiles, expressing how to mark educational elements through the definition of their attributes or characteristics, the so-called metadata educational. Then, this section explains, in broad terms, these proposals, introducing the concepts of learning object and metadata, it also mentions the major agencies involved in the development of this field, and finally, it outlines some of the initiatives in this direction.

2.3.1.1. STANDARDS, SPECIFICATIONS AND APPLICATION PROFILES

In the learning world and long before the sentence eLearning have appeared many were the organizations that begin to work on the creation of specifications for technologies based on the learning and needs as the target data, user profiles, sequence of contents, course materials based on web and intrusions by computer. That work was done by groups such as ARIADNE in Europe, the Dublin Core, IEEE, the committee of the aviation industry CBT or AICC, and the consortium EDUCAUSE IMS. At the beginning those groups focus in different areas of the standards. They work simultaneously but not in coordination. The department of defense took a leadership role to do the integration of the work developed separately by each organization of standards in a reference model called Sharable Content Object Reference Model or SCORM. SCORM is a unified set of specifications and standards for content, technologies and eLearning services.

To understand standards, it is important to know some terms related to their evolution.

Often standard and specification terms are used interchangeably, so it is important to point out their differences.

Specification

A specification is a documented description. Some “specs” become a standard, which means they have received the stamp of accreditation after having proceeded through the four stages outlined below. In some industries, something cannot be sold until it receives a stamp of approval by the government (e.g., electrical devices are accredited by IEEE).

Standard

A standard can be categorized has presented below:

- Standard *de jure* - *de jure*, by right; by law; many times praise to *by fact* (*de facto*). The designation/certification of a state of specification accredited by IEEE LTSC (Learning Technology Standard), ISO/IEC JTC1/SC36, or CEN/ISSS (European).
- Standard *de facto* - *de facto*; existing *by fact* (*de facto*) with legal authorities or not. Typically, when a critical mass or majority decides to adopt a specification. For example: TCP/IP, http, VHS, etc. , are all *de facto* standards.

The ideal state is when a standard *de jure* is a standard *de facto* (for example, HTTP). The specifications evolve over time and become standards and pass through several stages of development before being broadly adopted or becoming *de facto*.

While there is under evolution of a process for the creation of standards *de jure*, you can conceptualise a processual model both general and iterative where they distinguish the following states:

1. R&D (Research and Development) Research and development is led to identify possible solutions. Examples: The federation of learning, general research in universities, enterprises, consortios, etc. such as the Open University of the Netherlands (Open University of the Netherlands, OUNL), which created the specification Educational Modeling Language (OUNL-COLUMN) (OUNL, 2006), or the project PROmoting Multimedia in Education and Training in European Society (PROMETEUS, 2006).
2. Specification Development: When a tentative solution appears to have merit, a detailed written specification must be documented so that it can be implemented and codified. Various consortia or collaborations, such as AICC and IMS, dedicate teams of people to focus on documenting the specifications. Examples: *AICC, IMS,* ARIADNE *(Europe)* and consortia, such as the American initiative

for basic education schools Schools Interoperability Framework (IMS) (SIF, 2007).

3. Testing/Piloting: The specifications are put into use either in test situations or pilots to determine what works, what doesn't, what is missing, customer reactions, etc. Examples: *ADL SCORM plug-fests or co-labs.* Canadian Core Learning Resource Metadata Protocol (CanCore) (CanCore, 2006)

4. Accredited and International Standard Status: The tested and roughly complete specifications are reviewed by an accredited standards body and then made broadly/globally applicable by removing any specifics of given industries, originators, etc., and taken through an open, consensus based process to produce a working draft which is then officially balloted. If approved, the specification receives official certification by the accredited standards body and is made available to all through this body. Examples: *IEEE Learning Technology Standards Committee (LTSC) (IEEELTSC, 2008)*; *ISO/IEC JTC1/SC36 (Joint Technical Committee 1/Sub-Committee #36)* (JTC1/SC36, 2007)*; CEN/ISSS/LT-WS Learning Technology WorkShop* (CEN/ISSS/LT-WS, 2007) *or the British Standards Institution (BSI)* (BSI, 2008).

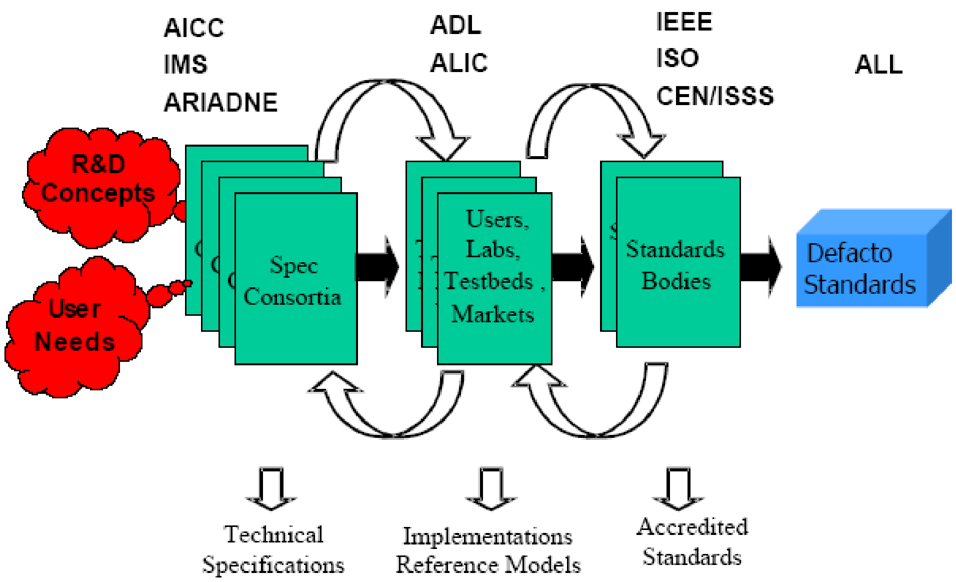


Figure 14. Standard evolution model

Most notably perhaps, Figure 14 shows how the different organizations and groups cited as examples here are not in any conflict or competition with each other, as is often misunderstood. Instead these various organizations have different roles and responsibilities in a very complimentary and holistic model. Each of the standards organizations has specific milestones and project schedules for their initiatives (CETIS, 2005).

In addition, the process is not linear, and the contributions of users and the research communities are considered at all stages, and not only at the beginning of the process (Friesen, 2002).

In many cases the implementation of standards or specifications in specific educational settings requires consideration of different characteristics of each community, region or country. For this reason application profiles have been developed that combine and use one or more standards or specifications to create new schemes aimed at specific situations but, however, they do not add new elements and ensure continued interoperability to standards and original specifications (Duval, 2002).

2.3.1.2. LEARNING OBJECTS AND METADATA

Two important concepts within the standards and specifications are Learning Objects (LO) and the metadata. The term LO, Learning Object, has been defined in different ways:

1. Any entity, digital or not digital, which can be used to learn, educate or train (IEEELOM, 2002).
2. Any appeal digital that can be reused to withstand the learning (Wiley, 2002).
3. An entity that digital can be used, reused and referenced during learning supported by technology (Rehak & Mason, 2003).
4. Any appeal digital, reproducible and likely to be located, which is used to carry out learning activities or support, and available for use by other (Hummel, Manderveld, Tattersall, & Koper, 2004).

5. An instructional unit with a minimum objective of learning associated with a particular type of content and activities for their achievement, characterized by being digital, independent, and accessible through metadata in order to be reused in different contexts and platforms (Morales, García, & Barrón, 2007).

Contrasting these definitions, the marked with the numbers 1 and 2 (i.e. (IEEELOM, 2002), (Wiley, 2002)) are very comprehensive, while the marked with the numbers 3 and 4 (i.e. (Hummel et al., 2004; Rehak & Mason, 2003)) definitions are very similar. From the point of view of the current research, the latter is most suitable, which stipulates that a LO should be a resource digital, not only for learning but also to support the implementation of learning activities, including those who carried out by professor within the process. In addition, it may be remarked that resources must be available for others to use, that is, it is necessary to be able to share.

Some examples of LO are web pages, simulations in computer, documents, figures or digital graphics, e-books, lessons or comprehensive courses. It is likely that in future the LO are a currency, which are stored in repositories from which can be located and reused in different courses, ideally, adapted to different educational models, themes, and levels of study (Littlejohn, 2003).

Part of a Conceptual Content Model

Defining and understanding Learning Objects have been a challenge because they need to be viewed within the context of an overall conceptual model that is based on a hierarchy of granular content objects. The analogy of Lego blocks is often used with the individual Lego pieces representing the smallest piece of "raw content" objects (shown in green in Figure 15). These blocks or objects can be snapped together and pulled apart as needed, which enables almost infinite flexibility to create logical assemblies of individual content objects to meet the learning needs of individuals.

For example, Autodesk has defined their strategy to re-use Learning Objects. The Autodesk model represents a five-level hierarchy depicting the aggregation of learning content from the lowest level raw media assets (shown in Figure 15) up to the course level (shown in blue in Figure 15). The end result is a database of re-usable learning and information objects that can be used for all forms of learning, including eLearning, traditional Instructor-Led Training, or Blended Learning solutions.

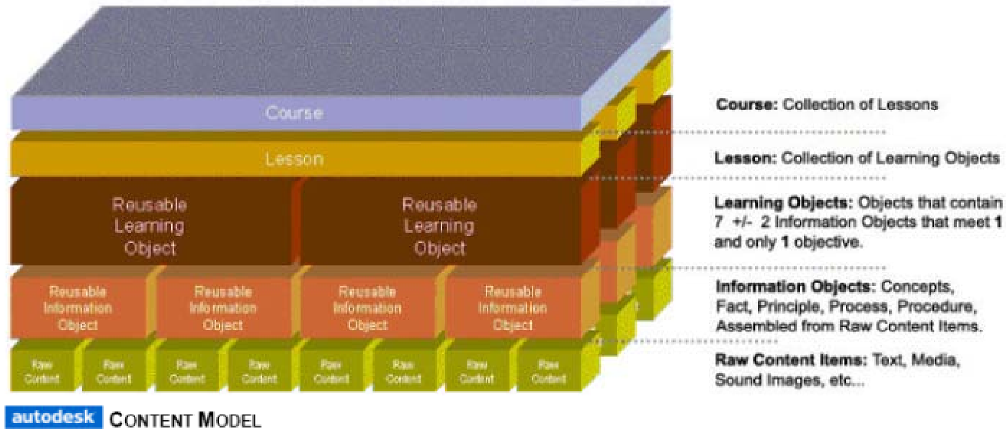


Figure 15. Learning Object - Autodesk Content Model

A LO localized and shared thanks to its metadata (i.e. data about data, in its definition more simple) that identify information on the LO to hear their characteristics. The use of metadata in the field of education has an important role in the development of the LO, because it allows easily manipulate educational resources so that different systems share resources, as for that users seek and reused contents.

What is Metadata?

The field of eLearning is constantly growing, i.e. the vast sources of eLearning information, so it is getting more and more difficult to find and use relevant information. The purpose and usefulness of metadata in eLearning is that it provides the ability to richly describe and identify learning content so that is easier to find, assemble, and deliver the right learning content to the right person at the right time.

Simply defined, metadata is data which describes other data, or information that describes other information, and as such, metadata is a wonderful example of the power of simple things (MASIE, 2003). Metadata could be as objective and straightforward as the author of a book, the file size of an animation, or the location of a file in a database. It can also be as complex and subjective as the learning preferences or styles of an individual, the collective opinion of a group who has seen the same movie, or which quote is the favorite that best captures a profound idea. Content is increasingly being broken down into smaller pieces so that it can be mixed, matched, and assembled into appropriate "Learning Objects" tailored to specific needs. Without metadata, it would be easy to drown in the chaos and inefficiency resulting from an overflowing sea of unidentified Learning Objects and content.

What should metadata mean to you? It is the means to fully describe and identify every piece of eLearning content so that you can efficiently find, select, retrieve, combine, use/re-use, and target it for appropriate use.

Metadata can be, and ideally needs to be, applied to all sizes and types of learning content, from the smallest piece of raw data, or "asset", all the way up to a complete course or curriculum. This way of using metadata allows each level of content to be easily searchable and reusable. For example, it is just as easy to find and reuse one piece of text or illustration, one page in a chapter, one chapter of a course, or an entire course. The same concept of metadata can also be applied to people, places, and things.

For people, this could include the attributes describing something as simple as their name, address, and phone number to more complex characteristics such as their learning preferences, skills, and buying habits. All these are examples of metadata.

It is common for the metadata are viewed as descriptors. However, not only functions of identification, it may also contain information for administrative purposes and structural. Caplan (2003) defines the types of metadata as:

- ❖ Descriptive metadata. To identify how a resource can be distinguished from another, discover how is a resource, and select resources to cover particular needs. This type of metadata also serves to form collections of similar resources, relation (with other resources), and to perform functions of evaluation.
- ❖ Administrative Metadata. Its purpose is record information to facilitate the management of resources, which includes information on when and how it was created the appeal, who is responsible for access or the updating of the content, and technical information such as the version of software or hardware needed to execute it.
- ❖ Structural Metadata. Its aim is to identify the structure of the appeal defining each one of the parties that make it up. For example, an electronic book that contains

chapters and pages, it can be labelled with metadata to identify each party and the relationship among them. Similarly, a course composed of different lessons or learning activities can be labelled with metadata to identify the structure of the content.

It is important to emphasize that the metadata for educational elements are not only for use them with LO. The concept also applies to record methods, techniques or elements related to the learning process as the characteristics of pupils, learning activities, reviews, prerequisites, etc.

It is easy to imagine what happens when metadata is used to filter, select, and assemble just the right bits of learning content, personalized "just right for you" and delivered on just the right device in just the right way! This is the vision of truly personalized learning and living.

2.3.1.3. Brief summary of standards, specifications and application profiles

As already mentioned, the definition of standards and specifications for the marking of educational items cover different aspects related to eLearning environments. Table 8 shows some examples.

The shape and structure of each standard or specification varies, but most include a data model that indicates what elements are needed and what element are optional, and its tags, attributes, multiplicity and type. Most of the media ensure the independence and interoperability of the items defined as a markup language using XML (Bray et al., 2004).

Table 8. Examples of metadata standards and specifications for educational

Point	Standard/Specification/Application profile	Acronym
Description of learning objects	IEEE Learning Object Metadata Standard (IEEELOM, 2002)	IEEE LOM
	IMS Learning Object Metadata (Barker, Campbell, Roberts, & Smythe, 2006)	IMS LOM
	Canadian Core Learning Resource Metadata Protocol (Berlanga & García, 2006)	CanCore
	UK Learning Object Metadata Core (Berlanga & García, 2006)	UK LOM
	Learning Federation Metadata Application Profile (Berlanga & García, 2006)	*n/a*
Student information	IEEE Public And Private Information for learners (PAPI, 2001)	IEEE PAPI
	IMS Learner Information Package (IMSLIP, 2005)	IMS LIP
	IMS ePortfolio (IMS, 2011)	IMS EP
Evaluations	IMS Question and Test Interoperability (IMS, 2011)	IMS QTI

Point	Standard/Specification/Application profile	Acronym
Content Packaging	IMS Content Packaging (IMSCP, 2009)	IMS CP
	IMS Common Cartridge (IMSCC, 2011)	IMS CC
Learning Object Repositories	IMS Digital Repositories Interoperability (IMS, 2011)	IMS DR
Instructional design	Sharable Content Reference Model (SCORM, 2009)	SCORM
	IMS Learning Design (Koper, Olivier, & Anderson, 2003)	IMS LD
	IMS Simple Sequencing (IMS, 2011)	IMS SS

Recent developments

Common Cartridge is a specification being developed by IMS. The Common Cartridge (CC) standard distills state-of-the-art practice in online education and training into an easy-to-follow format for creating and sharing digital content.

Common Cartridge is the first of three major standards that comprise a new generation of Digital Learning Services standards to support a new generation of learning technology. These are:

- ❖ Organized and distributed digital learning content (Common Cartridge - CC)
- ❖ Applications, systems, and mash-ups (Learning Tools Interoperability - LTI)
- ❖ Learner information: privileges and outcomes (Learning Information Services – LIS)

Common Cartridge benefits include (IMSCC, 2011):

- ❖ Greater choice of content: Enables collections of learning resources of various types and sources.
- ❖ Reduces vendor/platform lock-in: Establishes course cartridge native formats endorsed by educational publishers, and supports a wide variety of established content formats, eliminating platform lock-in.
- ❖ Greater assessment options: Explicitly supports the most widely used standards for exchanging assessment items.
- ❖ Increases flexibility, sharing and reuse: Fits within the educational context of enabling Instructors to assemble lesson plans of various resources and publish those as reusable and changeable packages that are easy to create, share, and improve.

The Common Cartridge format includes the following specifications:

- Content Packaging v1.2.
- Question & Test Interoperability v1.2.
- IMS Tools Interoperability Guidelines v1.0.
- IEEE Learning Object Metadata v1.0.
- SCORM v1.2 & 2004 (Essentially common cartridge specification v1.0 DOES NOT include SCORM. As stated in IMS CP 1.1.4 Best Practices and Implementation guide SCORM was considered in development of this new standard).

In Figure 16 the CC Package Interchange Format is presented.

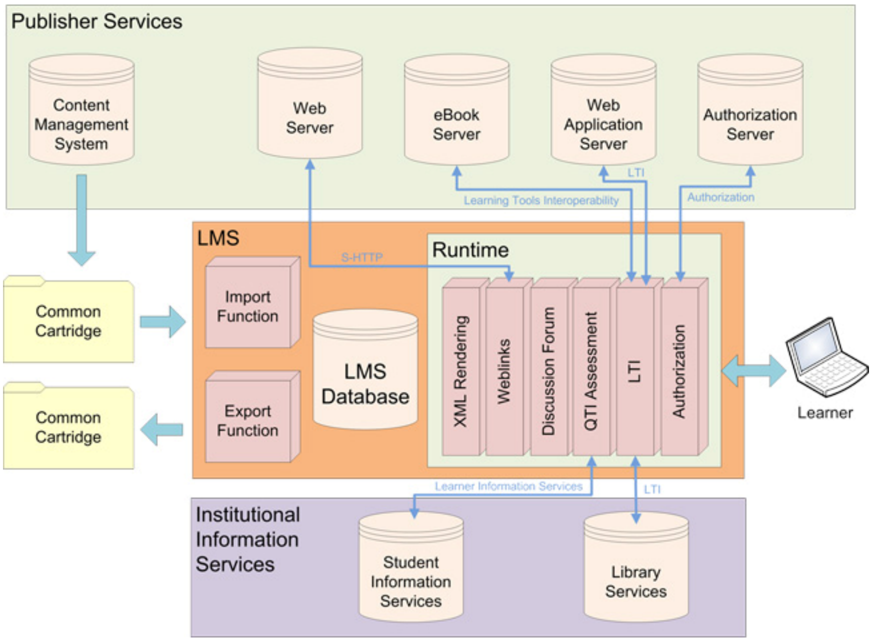


Figure 16. CC Package Interchange Format (IMSCC, 2011)

Once introduced the concept of marking technologies for educational metadata, the following section delves into the standardized description of the processes of teaching and learning. It begins by defining the instructional design and continues presenting IMS LD, a specification formalizes the description of the processes of teaching and learning, describing its purpose, characteristics, elements that compose it. Then other initiatives mentioned in the same direction and make a comparison between them.

2.3.2. STANDARDIZED DESCRIPTION OF THE TEACHING PROCESS

2.3.2.1. INSTRUCTIONAL DESIGN OR THE LEARNING DEFINITION

The term instructional design or learning design refers to the knowledge used by teachers or designers when defining the instruction (Koper, 2005). Traditionally, this knowledge has been applied and disseminated using models that prescribe how to design instruction for students to develop their cognitive, emotional and physical. To Reigeluth (Reigeluth, 1999b) these models:

- Aim at the practice.
- Describe educational methods and the situations to be used.
- Consist of various features and components that can be represented in different ways (i.e. types of methods) and explain the criteria to be followed.
- Have probabilistic nature. That is, since there are too many factors that influence the process, the results do not guarantee desired education and training, but the likelihood that such outcomes occurring.
- The values (or philosophy) of the designers play an important role in the process of teaching and learning, and that underlie the objectives pursued and the methods offered.

Emerged during the industrial stage, instructional design is an objectivist worldview that posits that knowledge exists outside the individual and structured entities, attributes and relationships between entities. The world is described by theoretical models and understanding of a person can be specified by exogenous descriptions. Accordingly, under this approach, the goal of instruction is that students describe the knowledge using entities and relationships, reducing learning to the acquisition of information or expert rules in a predetermined pattern. In contrast, the constructivist view of knowledge holds that knowledge exists within the individual, it is he who, based on their experience and prior knowledge, build your own definition of entities, attributes and relationships, so the instruction does not focus on convey principles, rules or procedures, but to develop cognitive skills that students are able to build response plans for each situation presented to them (Duffy & Jonassen, 1992).

These two approaches are heavily influenced by the theories of instruction that are followed or designed in different learning situations. The objectivist approach, the most traditional, includes models, i.e. (Gagné & Briggs, 1979) (Merrill, 1994), (Reigeluth, 1999a) - pointing the way to present the content considering the desired learning outcomes. The constructivist approach, for its part, seeks to facilitate the construction of knowledge through learning activities that allow transfer to real life tasks, i.e. (Spiro & Jihn-Chang, 1990) (Van Merriënboer, 1997).

From the IT perspective, the challenge is to design tools that are not targeted solely on the creation of content and resources, but also support the instructional design modeling to prescribe any particular approach. An additional challenge is at the same time ensuring that the resources and elements defined may be used, shared and exchanged between different lessons or platforms, and reduce the time and resources used.

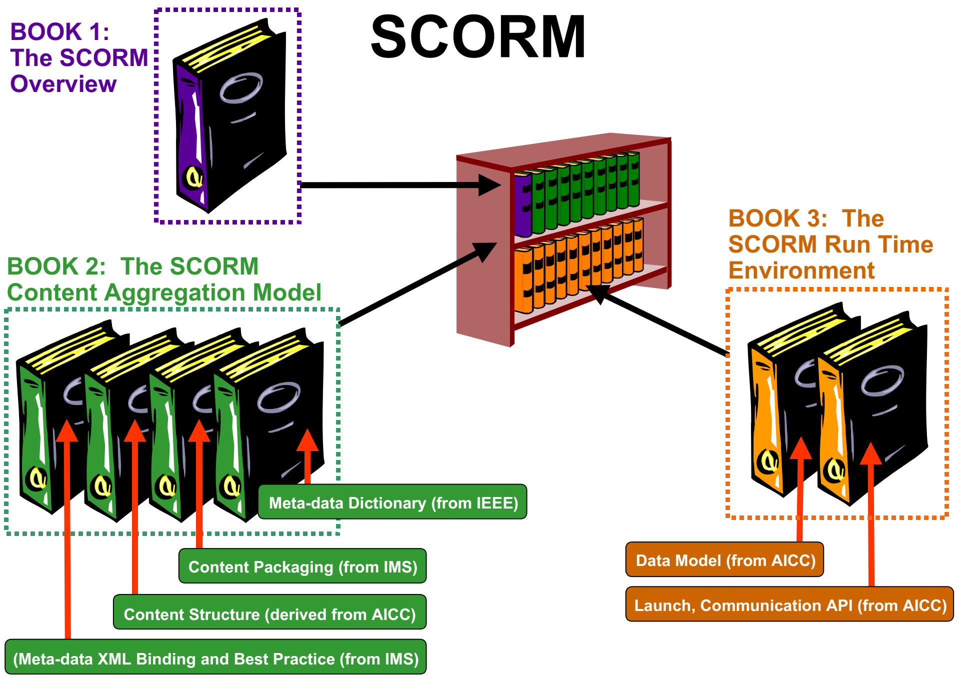


Figure 17. SCORM model (SCORM, 2009)

This is precisely the goal of educational modeling languages. Two examples of such technologies are educational metadata specifications OUNL IMS LD and EML (Koper, 2001). Another popular initiative is the application profile SCORM (2009) (as shown in

Figure 17), but its focus is on defining interoperable content to individual learning environments and to model learning processes (activities, flows, people, etc.).

The remainder of this section explains the most important characteristics of IMS LD, goes on to explain briefly other initiatives in this direction, and ends by comparing them.

2.3.2.2. IMS LEARNING DESIGN (IMS LD)

2.3.2.2.1. Features

IMS Learning Design specification (IMS LD), is a derivative of OUNL-EML, so is an educational modeling language that defines a pedagogically neutral notation for creating different educational designs reusable in different courses or learning contexts. This specification describes processes in order to achieve a learning objective, defining what activities made students and teachers, when, with what resources, training or services, and under what conditions. Specifically, IMS LD aims to:

- Describe the process of teaching and learning of a Unit of Learning (UoL or by its acronym, LU).
- Record the pedagogical meaning and functionality of the elements (i.e. activities, objectives, methods, etc.) of a LU without establishing a particular approach.
- Mark personalization aspects of the activities that can be tailored to the preferences, background or educational needs of users.
- Formalize the description of instructional design to make it possible to process automatically.
- Describe the instructional design abstract to be repeated under different conditions and with different people.
- Identify, decontextualized learning and exchange items and reuse them in other contexts.
- Promote interoperability and use of information between different applications compatible with IMS LD.

Following the common practice of the consortium IMS, the IMS LD consists of:

- ❖ A conceptual model that defines the basic concepts and relationships in a learning design or LD.
- ❖ An information model that describes the elements and attributes through which learning design can be specified with precision.
- ❖ A number of XML schemas where information model is implemented (the so-called binding).
- ❖ A guide to best practices and implementation.
- ❖ A binding document and an XML example that illustrates a set of requirements for learning scenarios and models.

To reduce the complexity of its implementation, this specification is divided into three levels (IMSLD, 2003). Figure 18 shows the information model of IMS LD and highlights the levels at which it is divided.

- ❖ Level A. It is the central part of the specification, contains the basic vocabulary that supports pedagogical diversity, i.e. the elements that make up IMS LD: people, activities, resources, learning methods, executions (called plays), acts and roles. With these elements defined learning activities, which may include learning objects, services and resources to be made by students and teachers.
- ❖ Level B. Add to Level A properties and conditions to design personalized learning environments and collaborative learning models. Properties store information about an individual (preferences, results, etc.), a role, or a learning design. If properties are local, they are called internally and persist for one run. If they are global, they are called externally, and can be accessed from different runs. At any time, the properties state can determine the flow of learning.
- ❖ Level C. Level B adds notifications can be triggered automatically in response to events in the process of learning. For example, if a student submits a job, the teacher may be notified by email.

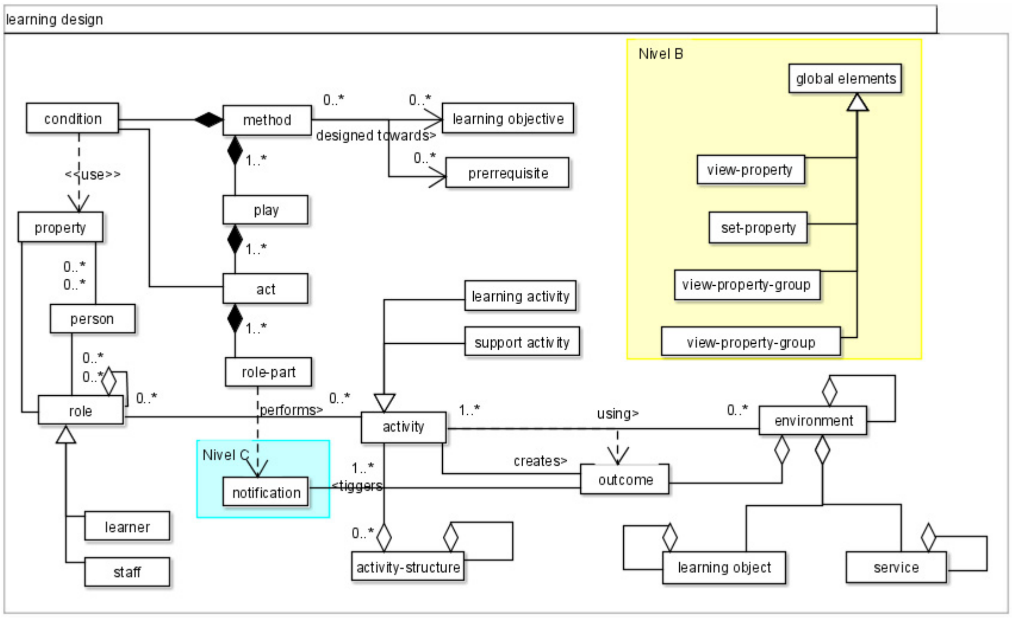


Figure 18. Information model of IMS LD (IMSLD, 2003).

Figure 19 shows the hierarchical elements of IMS LD. These include learning objectives, prerequisites, components (properties, roles, activities, sequence of activities), and a learning method that consists of one play (the way in which the method is executed) and conditions (if-then-statements else).

```
Learning-design
   Learning-objectives
   Prerequisites*
   Components
     Properties*
      Role
         learner*
         staff*
      Activities
         learning-activity*
            environment-ref*
            activity-description
        support-activity*
         activity-structure {sequence |selection}
            environment-ref*
            activity-ref*
            activity-structure-ref*
      Environments
         environment*
            learning object*
            services*{mail-send | conference}
 Method
      Play*
         Act*
            Role-parts*
               role-ref
               activity-ref
      Conditions*
  Metadata
```

Figure 19. Hierarchical structure of the elements of IMS LD (2003)

```
<learning-design identifier="TecEduc">
    <title>Tecnologia Educativa</title>
    <components>
        <roles>
            <learner identifier="R-Estudiante"/>
        </roles>
        <activities>
            <learning-activity identifier="LA-Introduccion"/>
            <learning-activity identifier="LA-Historia"/>
            <activity-structure  identifier="AS-Introduccion"  number-to-
select="2" structure-type="sequence">
                <learning-activity-ref ref="LA-Introduccion"/>
                <learning-activity-ref ref="LA-Historia"/>
            </activity-structure>
        </activities>
    </components>
<method>
        <play identifier="Ply-TecEduc">
             <title>Evento de Aprendizaje</title>
                <act identifier="Act-Intro">
                    <title>Informacion inicial</title>
                    <role-part identifier="RP-Inicial">
                    <role-ref ref="R-Estudiante"/>
                    <activity-structure-ref ref="AS-Introduccion"/>
…
</learning-design>
```

Figure 20. Example of markup using IMS LD

Figure 20 shows a basic example of IMS LD notation.

2.3.2.2.2. Main elements

The following explains in general the main elements of IMS LD (2003) (Olivier & Tattersall, 2005). However, there are elements of the specification which are not relevant to the context of this proposal, they will not be detailed in this section. These elements include those not needed to define the domain structure or the adaptation of AEHS and communication services or indexing (Berlanga & García, 2006).

Learning Unit (LU)

A LU is a complete training unit and self-contained, for example, a course or a lesson. It contains, in addition to LD, all resources associated with it, including tests or examinations, learning resources, and information to configure services (i.e. video conferencing, email and indexes). The definition of LD includes only the teaching and learning, but does not define or contain materials or resources that the process used. This requires defining a LU that is responsible for linking the LD and associated resources using a mechanism for packaging, IMS LD recommends for this purpose following the IMS CP and including in its manifest the LD and associated facilities and then create a package (i.e. including all elements in a compressed file format zip) to facilitate the sharing and reuse of a LU. A package under the IMS CP is considered a LU only if it contains at the organization (within the manifest) a valid IMS LD element. Consequently, a LU with a manifest, a LD, resources, (sub) manifests, and physical files. Figure 21 shows the structure of a LU using IMS CP.

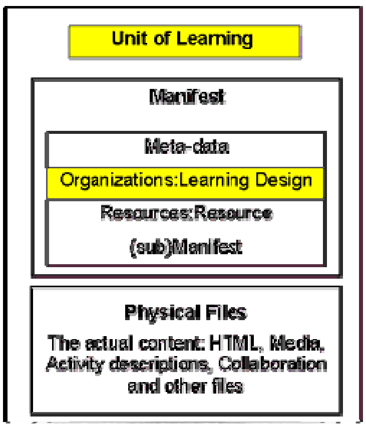


Figure 21. Structure of an IMD LD LU included in a IMS CP (2009)

Learning Design (LD)

A LD describes a teaching method that will enable students, through the implementation of certain activities within a context for instructional purposes, achieve certain learning objectives.

IMS LD is considered a meta-language because it does not prescribe any approach to instructional design in particular and to create a flexible teaching streams covering different needs and interests. Consequently, with this specification, the instructional designer can define teaching processes using their own teaching principles, knowledge domain variables and the context it deems necessary. The LD element is the root component of the specification. It provides a semantic structure of the education and resources partners.

2.3.2.3. OTHER INITIATIVES RELATED TO IMS LD

This section briefly explains some of the initiatives that seek to formalize computer-assisted learning design process. In particular, following initiatives are presented: the SCORM reference model developed by the Advanced Distributed Learning (ADL), the EML OUNL modeling method developed by the Open University of the Netherlands (OUNL) and AGR-010 recommendation developed by the Aviation Industry Computer –based on Training Committee (AICC).

Table 9 shows the major characteristics of IMS LD and other initiatives to describe the processes of teaching and learning discussed in this section. Besides, it is important to note that (Berlanga & García, 2006):

- IMS LD is directed to learning process based on activities and is open to any theory of learning. Both features are essential to define the learning experience.
- SCORM, as its name suggests, is a reference model therefore acts as an application profile integrating other standards and specifications. Use the data model to consider the evaluation and student characteristics. However, their approach is technical, not model collaborative learning processes and does not have an instruction guide for design or evaluation. However, since it is an initiative sponsored by the U.S. government, has considerable amounts of investment for development and dissemination.

Table 9. Characteristics of different initiatives that describe the process of teaching and learining through metadata

	IMS LD	SCORM	EML	AICC AGR–010
Instructional features				
Focused	Instructional design	Content structure and sequence of content.	Units of study	Course structure and assessment
Modeling of the learning process	Learning activities	To some extent (activities, objectives, etc.).	Learning activities	Not defined
Learning theory	Open to any learning theory	Allows different instructional designs	Open to any learning theory	Not adressed
Pedagogical features	Prerequisites	Objectives associated to the SCO in the data	Prerequisites	Prerequisites
	Objectives	Activities	Objectives	Objectives
	Method	IEEE LOM derivatives (e.g. type of interactivity, level of interactivity, etc.).	Method	
	Components (e.g.activities, sequences, roles, etc).		Content (e.g. activities, sequences, roles, etc.).	
	IEEE LOM derivatives (e.g. type of interactivity, level of interactivity, etc.).			
Content structure	None	*Assets*	Learning objects (knowledge objects) which may include images,audio,tables,properties,etc.	Assignable unit, block, target.
		SCO	May include references to external resources on the Internet.	
		Content Organization		
Student characteristcs	No (You can use IMS LIP).	To a certain extent (you can use the Preferences item in the data model).	Yes	Yes (demographic).
Monitoring student	Yes	Yes	Yes	Yes
Student assessment	No (You can use IMS QTI)	To a certain extent (you can use the item data store model).	Yes	Yes
Technical features				
Semantic web	Yes	Yes	Yes	No
Part of a collection of standards / specifications	Yes	No	No	Yes (to some extent).
Battery of tests (Test suite)	No	Yes	Yes (*player*)	Yes
Communication	Web-based	Web-based	Web-based	File-based, HTTP API.
Other features				
Defined by	Academy, vendors, IEEE LTSC, ADL.	U.S. Department of Defense, academy, vendors, AICC, IEEE LTSC, IMS.	Academy (OUNL)	U.S. Government, vendors

- ❖ OUNL-EML models the process of learning based on learning activities and is open to any theory of learning, although a more comprehensive approach than its predecessor IMS LD, it is also more complex. Integrates aspects as sequences of activities, roles, characteristics, monitoring and evaluation of students, and annotation of educational content. However, since February 2003 when it approved the final specification of IMS LD-EML OUNL stopped developing and maintained (Tattersall & Koper, 2003).
- ❖ AICC AGR-010 specification is the oldest. Its initial focus was to distribute instructional content on microcomputers and mainframes. This is why it is file-based and oriented to the structure of courses. Set and keep courses as a set of files is complicated and difficult to administer. In addition, this specification does not take into account the learning process, so it can not be regarded strictly as an EML. Although designed for aviation training has also been used in other learning contexts.

2.3.3. SCHEMAS

Schemas can be diagrammatic representations, an outline, a model or simply an organization of concepts, a structure or set of rules/constraints to follow. Can also be a specific knowledge structure or cognitive representation of the self. But, in the world of web and specifically in markup, can be a set of rules for document structure and content.

XML Schema is an XML-based alternative and successor to DTD that describes the structure of an XML document. The XML Schema language is also referred to as XML Schema Definition (XSD).

What is an XML Schema?

An XML schema is a description of a type of XML document, typically expressed in terms of constraints on the structure and content of documents of that type, above and beyond the basic syntactical constraints imposed by XML itself. These constraints are generally expressed using some combination of grammatical rules governing the order of elements, boolean predicates that the content must satisfy, data types governing the content of elements and attributes, and more specialized rules such as uniqueness and referential integrity constraints.

XML Schema is a W3C recommendation.since 02-May-2001 (XMLSchema, 2001).

The purpose of an XML Schema is to define the legal building blocks of an XML document, just like a DTD (elements, attributes and child element that can appear in a document, their order, number, data types and values).

XML Schemas will be used in most web applications. The main reasons are:

- extensible to future additions;
- richer and more powerful than DTDs;
- written in XML;
- support data types;
- support namespaces.

One of the greatest strength of XML Schemas is the support for data types making easier to describe allowable document content, to validate the correctness of data, to work with data from a database; to define data patterns and to convert data between different data types.

Another great strength about XML Schemas is that they are written in XML and benefits from XML syntax:

- no need to learn a new language;
- use the XML editor to edit Schema files;
- use XML parser to parse the Schema files;
- manipulate the Schema with the XML DOM;
- transform the Schema with XSLT.

XML Schemas implements Secure Data Communication, so that when sending data from a sender to a receiver, it is essential that both parts have the same “expectations” about the content.

With XML Schemas, the sender can describe the data in a way that the receiver will understand (e.g. a date like: “03-11-2004” will, in some countries, be interpreted as 3.November and in other countries as 11.March.

However, XML elements with a data type like this: *<date type="date">2004-03-11</date>* ensures a mutual understanding of the content, because the XML data type “date” requires the format “YYYY-MM-DD”.

Through XML, the XML Schemas are extensible and by this mean, makes possible to reuse the Schema in other Schemas; create our own data types derived from the standard types and reference multiple schemas in the same document.

A well-formed XML document is a document that conforms to the XML syntax rules.

Even if documents are well-formed they can still contain errors, and those errors can have serious consequences (e.g. it is ordered 5 gross of laser printers, instead of 5 laser printers). With XML Schemas, most of these errors can be caught by your validating software (XMLSchema, 2001).

Thus, through markup language and XML the teachers can define a set of rules for learning resources structure and content.

2.3.4. WEAKNESSES

So far, the use of specifications and standards among the possible potential users (i.e. teachers, instructional designers, vendors, educational institutions, etc.) is not widespread. Their spread and therefore long-term success depends on its quality, practicality and value in the “real world” (Walker, 2003), issues that, in most cases, are to be proven, as many specifications have been recently approved and are in the initial phase of implementation, as in the case IMS CC, or recently adopted as IMS LD and SCORM latest version.

Accordingly, assume the utility of standards for the marking of educational metadata for eLearning environments is risky, and there are several issues on which the matter should reflect. First, it is clear the confusion over the meaning of LO, the extent and degree of granularity. The differences between the proposed definitions causing confusion among potential users (Friesen, 2009) (Friesen & Nirhamo, 2003), causing not understand or misunderstand their purpose, or deemed to be exclusively a matter of research, away from the practical contexts (Friesen, 2009).

In addition to this, and because there are too many organizations involved in the process of developing a standard, potential users find it difficult to understand how cooperating with each other, if a standard or specification may become obsolete, and/or what is more suitable for a particular situation (Koper, 2004). For this reason, standardization of resources and materials used in learning processes supported by technology is perceived as an issue away from real learning contexts. Also, it must not lose sight that marking technologies for educational metadata is a relatively recent area of research. Thus, the degree of adoption is still growing and the technical complexity is beyond the present reach of non-experts.

One of the main problems for the adoption of this technology is unquestionably the lack of authoring tools to define educational elements that meet the standards or specifications, which, in turn, are easy to use and hide Metadata from users (Duval & Hodgins, 2004). In this vein, some studies suggest developing tools to search, recommend, classify, and automate delivery of LO similar to those designed for commercial purposes, for example, Google, Amazon or eBay (Duval & Hodgins, 2004). Ideally, metadata should not worry about end users, but only bring benefits.

The importance of the above is that, erroneously, often seeks to disseminate and present the standards and specifications and technologies to any audience. These technologies are actually oriented instructional design experts and computer specialists, and a way for the computer to automatically process the information but it is not expected the common user, used directly, for this reason mechanisms to facilitate their work without necessarily be aware of its existence must be developed.

As for the educational attributes of marking technologies, Friesen and Nirhamo (2003) argue that a specification "pedagogically neutral", as defined by IEEE LOM, SCORM or IMS LD can not be both pedagogically relevant.

For its part, Downes (2003) argues that there is an incompatibility with the principles of instructional design as an instructional design can not be reused in other contexts because the initial definition is intended for a specific learning experience that uses specific learning objects for specific contexts. Although these findings are contrasted sharply with the reuse of specifications such as IMS LD and SCORM, from Berlanga (2008) perspective is important to note that a specification is defined as "pedagogically neutral" because it does not prescribe any particular teaching approach, which allows the design of learning flows as necessary. The pedagogical relevance is in the logic design and learning how to perform the process, not the specification used. In addition, although it is better to define learning processes specific to the type of students and the context to which they are addressed, it is also true that it is possible to reuse components designed for other courses-anything that happens in practice very often, and modify designs and resources created by others to incorporate them into their own.

On the other hand, research in the field of standards is a cornerstone for their development and maturity. For example, there have been evaluations of IEEE LOM stating that there are problems to encode the values and search using metadata (Farance, 2003). It has also been shown that the labels related to educational issues, although it is a standard for LO, are rarely used (and (Friesen, 2009) (Friesen & Nirhamo, 2003). This is because a standard is complex, made up of many elements that can be simplified (i.e. smaller elements and without so many sub-elements) using notation other schemes such as Dublin Core (DCMI Metadata Terms) (DCMI, 2010).

They are also necessary enhancements in research to define mechanisms that generate automatic metadata for LO, and that intelligently managed using techniques of filtering, collaborative filtering, data mining, pattern recognition or social recommender (Manouselis, Drachsler, Vuorikari, Hummel, & Koper, 2011). Similarly, empirical studies are needed on the implementation, use and reuse of specifications, LO, instructional design and user profiles. It is also hoped that the use and adoption of standards and specifications in different situations and contexts generate proposals to optimize them.

It seems clear, finally, that organizations and associations involved in the development of standards and specifications should organize and fund outreach programs and training and evaluation workshops and working groups where improvements are proposed.

2.3.5. EDUCATIONAL MARKUP CONSIDERATIONS

Although both the adoption research in the area of marking technologies are in their early stages of development, and it is an illusion to pretend that there is a single standard to record all aspects and conditions that can be given in each educational context it is undeniable that significant benefits would be obtained if instead of the metadata record labels created by each developer, the option to use any specification, standard or existing application profile.

It is important do not forget that, in general, the next generation of systems and learning must be based, in one way or another, on mechanisms for the exchange, reuse and customization of educational elements. This will give added value to these systems, rewarding benefits to students, teachers, institutions and investors.

Introducing the IMS LD specification, this section established its features, and justified its choice for the annotation of learning in elearning systems over other initiatives, also discussed in this section, based on several features.

First, IMS LD can record the pedagogical meaning and functionality of instructive without defining any particular approach at the same time, aims to define teaching as a process where students and teachers interact with activities and learning objects, and not just content. It also has elements of personalization that let you adjust the flow of learning according to the criteria that the instructional designer deems appropriate. Another important feature of IMS LD, related to this research, is the separation and independence established among the content, structure and instructional design elements, so to identify them, decontextualized and exchange in other contexts.

Defining eLearning systems according to IMS LD specification also allows interoperating with other systems using this specification, and incorporate them in other applications.

These are the features that this thesis aims to provide to eLearning systems. Thus, on one hand, these systems consider the instructional design and, second, they may be exchanged and reused being different courses and contexts.

The Value Curve

There is a tension between reusability and context, but both contribute positively to the value of an object. Figure 22 represents a coordinate system with context as the x-axis and reuse as the y-axis. This is meant to be a heuristic based on a conceptual representation; it is not claimed to have reasonable quantitative measures of context or reuse at the current time, although anecdotal evidence suggests the value of further exploration. To each point in the x-y-plane it is possible to assign the value of an information (or learning) object with that degree of reuse and context. This means that the classes of objects with the highest worth are those represented by points in the fourth quadrant of Figure 22.

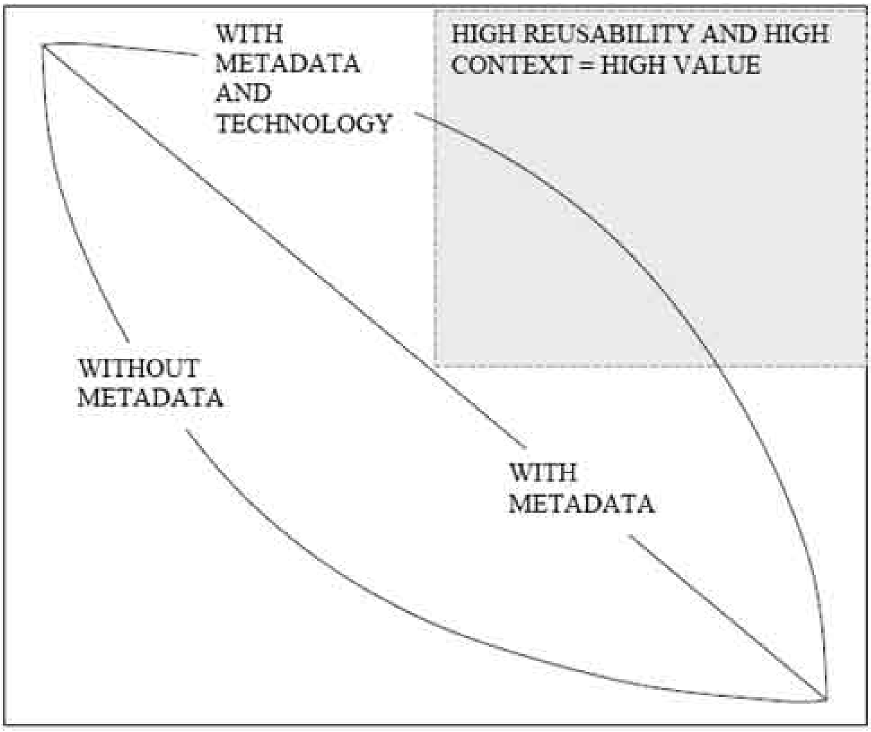


Figure 22. The relantionship among reuse, context and value (Robson, 2003)

The curve on Figure 22 represents the inverse relationship between reuse and context. Again, there is no real idea of the shape of these curves, and the diagram is meant to be heuristic only. However, it is suitable to believe them to be passable representations of the current situation.

Under appropriate conditions, an interesting consequence of the existence of an inverse relationship between reuse and context, plus the positive dependence of value on both variables, is that there are points along any one of the curves where maximum value can be obtained.

The curve labeled "Without Metadata" on Figure 22 does not pass through the area of the x-y-plane where value is highest. This represents the situation in the absence of metadata. LO without sufficient metadata are sufficiently expensive to contextualize that even the optimal value that can be derived from a LO is less than desirable. The ones that are rich in context are too hard to reuse and the ones that are easy to reuse do not carry enough context to make them truly valuable.

The addition of metadata to LO does not alter the relationship between reuse and context but changes the shape of the value curve. This pushes it up a bit, moving the maximum closer to the high value area. The right type of technology can push the curve even higher, as diagrammed in Figure 22. This is what some learning content management systems do when they integrate learner profiles and roles directly into the structure of LOs.

2.4. ADAPTIVE HYPERMEDIA SYSTEMS

The great expansion in recent years have had hypermedia systems should be, first, to the popularization of the Web (Berners-Lee, 1996), and partly to its ability to structure pieces of information associatively disparate nature, which can simulate, to some extent, the process of relationship and connection that makes the human mind.

However, hypermedia systems "classics" do not consider the characteristics, interests or goals of users, but interact in the same way, always show the same information and links to all users, and do not have mechanisms to assist in the navigation or in the search for relevant information.

By contrast, the Adaptive Hypermedia Systems (AHS) can configure applications that present information and routes suitable for the characteristics of each user, guiding them in navigation and in the discovery and management of relevant information. This represents the goals, preferences and knowledge of each user through a model that used to carry out the adaptation, which change depending on user interaction with the system.

Among the different areas of implementation of the AHS is education. Adaptive Hypermedia Systems for educational purposes (AEHS) personalize the learning process with the intention of facilitating the acquisition of knowledge, presenting educational content and courses appropriate to the educational goals, previous training, individual characteristics or level of knowledge of each student. One of the objects of study in this thesis is the definition of learning and adaptation techniques in such systems. Before delving into its application in education, it is desirable to provide an overview of the AHS. Accordingly, the section explains the nature, characteristics, application areas, component items, methods and techniques used, taxonomy, and advantages and disadvantages. After that, AEHS are introduced and different adaptation factors are analyzed, including its main features and adaptation techniques. Also, it summarizes the evolution in the development of such systems, its weaknesses, and draws on design considerations. It ends with a series of conclusions and discussion points around this topic.

2.4.1. CONCEPT

The purpose of an AHS is that the system conforms to the characteristics of the user and not vice versa, as in the hypermedia "classic", which show the same content and links to all users (Bra, Brusilovsky, & Houben, 1999). To achieve construct a model that represents the goals, preferences, characteristics and knowledge of each user who used to perform the adaptation, and change it according to the interaction with the system. In this way these systems are able to adapt both the content and links to the specific needs of each user, Brusilovsky (1996) calls the first adaptive presentation and adaptive navigation support to the latter.

The presentation adds adaptive explanations for the issues that are prerequisites, provides comparisons with other topics described on pages that have not been seen before, and/or provide additional information to advanced users. In other cases, it changes the format and presentation style, selects different media (text, images, audio, video, etc.), or it alters the amount of information shown. The adaptive navigation support, in turn, adds, changes, deletes, orders or notes, links and/or destinations to which they are directed (Berlanga & García, 2004b).

It is important to note that the crucial difference between an AHS and an adaptive system is that the latter offers users the ability to customize the system by modifying the color, font, font size, etc., or by choosing different interfaces according to their level (e.g. expert, novice, etc..), while an AHS employs a user model to provide automatic adaptation (Bra, Brusilovsky et al., 1999).

An AHS contains three main components: knowledge domain, user model, and model of adaptation. Figure 23 shows a general outline of how they interact.

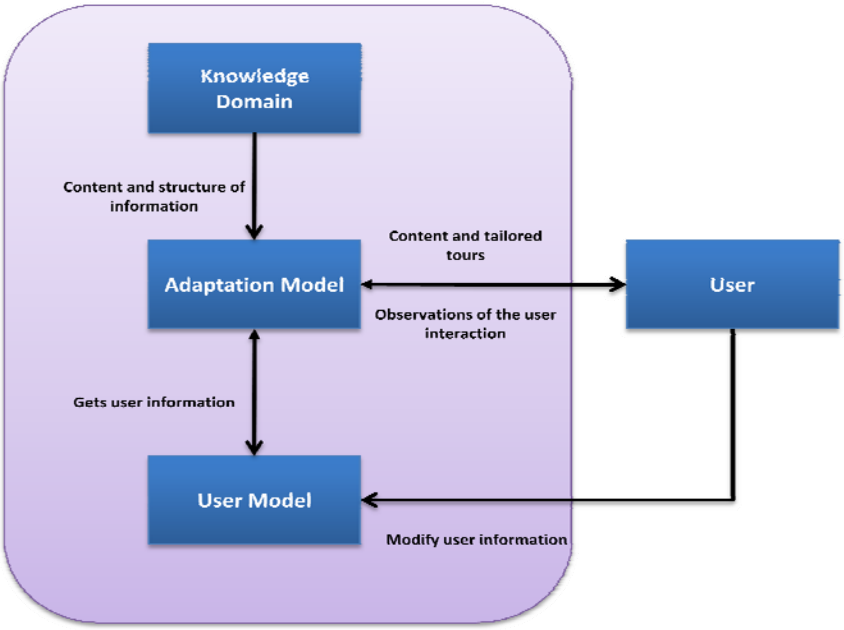


Figure 23. AHS components (Berlanga & García, 2006)

The domain model is the structure stored in the form of pages or nodes of information, knowledge or field of study of the system. The user model contains user information and their characteristics, interests, objectives, or data on the interactions made with the system. The model of adaptation, however, considers the user model to adapt the content and consistent runs and modifies it when the subject interacts with the system.

To model such systems, the most popular model proposals are AHAM (Adaptive Hypermedia Application Model) (Bra, Houben, & Wu, 1999; Wu, 2002), based on the Dexter model (Halasz & Schwartz, 1990) - and the Munich reference model (Koch, 2000). Both approaches argue that it is important a clear separation among the three components that make up the AHS.

Along the same line, Henze and Nejdl (2003) define a AHS as a quadruple that in addition to the above components, add a new one (labeled as Observations) related to the information obtained from user interaction with the system (Berlanga & García, 2004a).

2.4.2. APPLICATION AREAS

Before the spread of Web, application areas of the AHS were educational hypermedia, information systems, online information retrieval, online help and for managing personalized views of information, as well as institutional hypermedia. In all these application areas, educational hypermedia and information systems covering two-thirds of the research (Bra & Brusilovsky, 2009) (Brusilovsky, 1996).

Currently, these areas continue to dominate. Since 2001 the area of information retrieval, which includes systems for managing personalized views-making boom thanks to the web community's interest in the subject. However, more has to be developed in the field of online help systems or institutional hypermedia.

Here are the main areas of application of the AHS (Bra & Brusilovsky, 2009) (Berlanga & García, 2004b, 2006):

- ❖ Educational Hypermedia. This area, the most popular, is the product of the meeting and evolution of the AHS and intelligent tutoring systems. Reasons that students understand the learning material in a given time, for it considers their knowledge and demonstrate their proficiency in the subject of study. Systems within this category include: ELM-ART (2006), INTERBOOK (2007), METOD (Kocbek, Kokol, Mertik, & Povalej, 2007) AHA! (2008), KBS-Hyperbook (Henze, Naceur, Nejdl, & Wolpers, 1999), ALICE (2011), Metalinks (2005) (Murray, Shen, Piemonte, Condit, & J. Thibedeau, 2000), KnowledgeSea II (2007), ALE (Specht, Kravcik, Klemke, Pesin, & Hüttenhain, 2002) and INSPIRE (Papanikolaoua, Grigoriadoua, & Magoulas, 2003). Some of these systems are summarized in a section below.
- ❖ Online Information systems. Its aim is to provide users with different levels of knowledge on the subject, reference information to help them navigate and find relevant pieces of information. This classification covers a wide range of applications such as electronic encyclopedias, the online documentation systems, information kiosks, virtual museums, notebook guides, and electronic commerce systems. An example of this category is the LISTEN system (Zimmermann & Lorenz, 2008) (Zimmermann, Lorenz, & Specht, 2003), using headphones as the

interface guidelines of a museum, take into account the position of the visitor, the time and the object seen to adapt information considering listening preferences, interests and movements. Another example is CiteSeer (CiteSeer, 2010; Farooq, Ganoe, Carroll, & Giles, 2009) (Ballacker, Lawrence, & Giles, 2000) that automatically generates references to scientific literature found on the Web and use a recommendation system to adapt to user's interests.

- Hypermedia information retrieval. It presents the user with links to respond to queries about a specific set of hypermedia documents or the Web, which automatically calculates, links the subject and proposed notes to identify the most relevant. This application area includes: search-oriented systems that create lists of links to documents whose content meets your search criteria; Systems-oriented navigation, where users suggest links that might be interesting to explore; Systems for managing personalized views that organize the information found according to certain characteristics, parameters, objectives or interests; Information services that collected over a long period of time similar documents from an open corpus of documents. They work in communities of users, giving them the opportunity to learn from them and all the documents.

  Among the examples are AHA (2008), ELM-ART (2006) for navigation support and presentation, NetCoach (2007) for personalization and Amazon.com (2011) for searching and recommendation.

Koch (2000) proposes an AHS classification that, like that of Brusilovsky (Brusilovsky, 1996, 2001), includes instructional hypermedia systems, search engines, and online information systems, but adds online help systems and personal assistants. First aids user when he/she has problems or concerns with an application or computer system and therefore always linked to other tools or applications - one known example of this type of system is the wizard of Microsoft Word. Personal assistants individually managed large volumes of changing information, helping the subject to identify useful information.

2.4.3. TAXONOMY

Brusilovsky (2001), reviews his own classification (Brusilovsky, 1996), in order to include adaptive hypermedia technologies as shown in Figure 24.

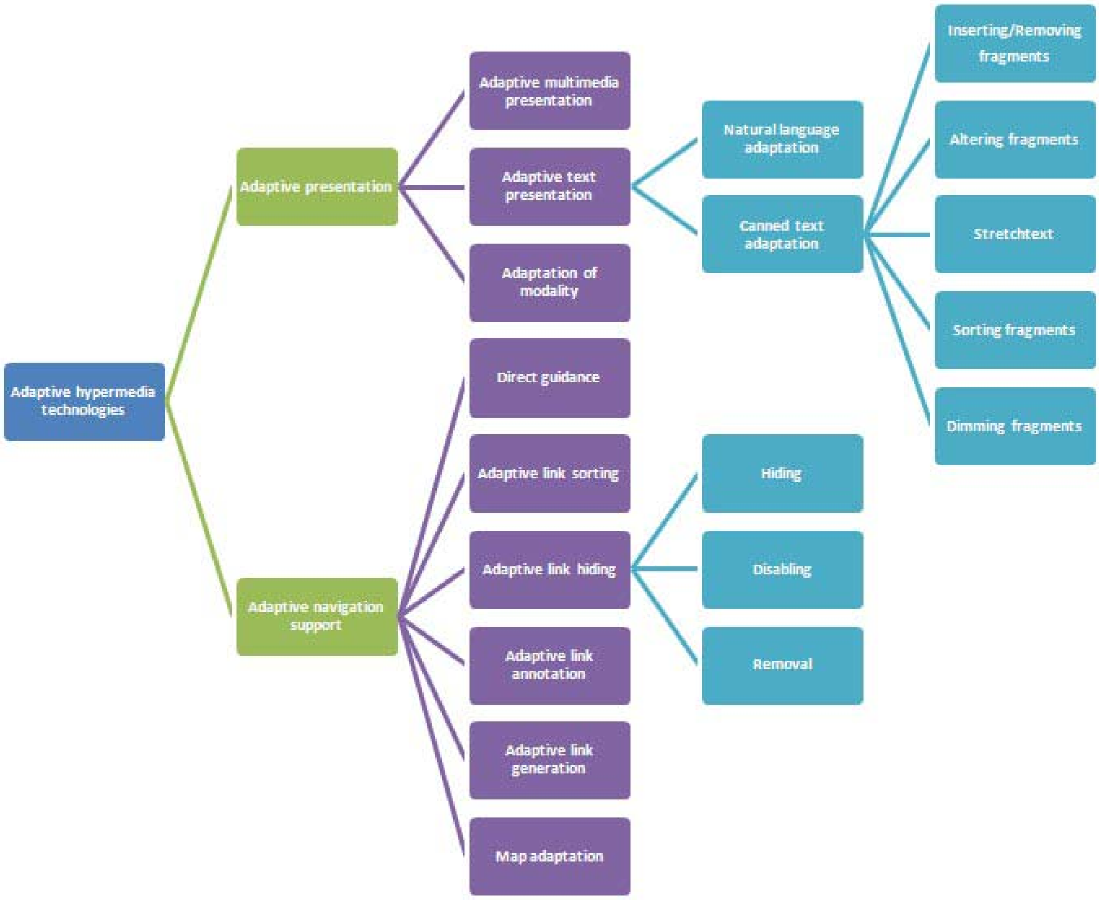


Figure 24. Brusilovsky Taxonomy (Berlanga & García, 2006)

This proposal is widely used and referenced in the field of AHS. However, Bailey, Hall, Millard and Weal (2002) note that, from their perspective, dividing the classification of adaptation technologies according to content and links is not entirely appropriate since both really speak of a sequence adaptation where the content fits within the document linearly, and navigation between the documents hyperstructuraly appropriate. In addition, the classification of natural language adaptation applies not only in content but also in navigation, which further strengthens the idea that the first level of taxonomy (presentation and navigation) is not adequate.

These authors also note that all subcategories of adaptive hiding of links are structurally equivalent, since the implementation of a means to perform the others. On the other hand, a number of adaptive presentation technologies related to the text apply to various media. In addition to this, the adaptation of the method can be viewed as an alteration of fragments, as having several representations in different media means selecting the best type of environment, which is actually a process of selection of fragments.

Also, they argue that technology adaptation is vague and confusing maps, because from a strict point of view, adapting a map requires adaptive techniques related links and alteration of fragments. This idea is comparable to that described by Koch (2000), which states that the only distinguishing feature of this technique is that it relates to graphic display of the navigation structure.

Berlanga (2006) states that is true as regards the separation of adaptive presentation of text and multimedia material, then text can be seen as other multimedia elements, and in counterpart the multimedia material can be adapted by the insertion, alteration, or management. It follows that there is no difference between adapting the text or multimedia material, because in reality it is an adaptation of elements or content objects.

There are other proposals for the classification of adaptive hypermedia technologies, such as Koch and Rossi (2002). These authors classify adaptive techniques (called personalization) separating content from presentation, not as in the case of Brusilovsky's taxonomy which includes these two items, and considering the customization of links. Furthermore, the presentation of content, called personalization of the presentation, considers adaptive characteristics (not adaptive). Each category is defined as follows:

- Customizing content. Select a type of information (text, images, videos, animations, etc.), depending on the user model.
- Customizing the presentation. Show different interface designs by selecting different media types, colors, font size and type or size of the images. Methods of customizing the presentation are that of multi-language, which is related to the preference of the preferred language of the user interaction, and alternative method of composition or design that has to do with different ways of presenting information (eg colors, sizes, fonts, etc.). On the other hand, content personalization techniques, except for extended text, are the same as that of adaptive presentation, although there is an additional technique called style guide (styleguiding) that is to define presentation templates for use with alternative technique of composition (Koch, 2000).
- Working with links. Modify the appearance, quantity or the order they are presented anchors, or the goal which the link. Note that this classification makes

a distinction between bond and anchorage, where both concepts are usually handled as link adaptation.

Another proposal, focused exclusively on the adaptive learning spaces, is (Paramythis & Loidl-Reisinger, 2004) that establishes a categorization scheme focused on the function that performs the adaptation. This classification considers the adaptation of the courses and, as the proposal of Koch and Rossi (2002), adaptive issues that do not change the contents (e.g. changes in the rate and size of letters). It also includes adaptive technologies that have developed in recent years for searching and finding learning materials located in distributed repositories, and creating adaptive collaborative spaces to facilitate interaction and communication among different people and potentially foster collaboration towards common goals.

2.4.4. ADVANTAGES AND DISVANTAGES

Given AHS set of features, capabilities and application areas, it is crucial to determine its advantages and disadvantages.

The most outstanding advantage of these systems is, as mentioned, its ability to act in different ways according to the user, thus providing a forum to interact according to their characteristics. Thus, for each user content and navigation options is relevant and understandable, and meaningful tours and information show "ready" to be found (i.e. the subject has the necessary knowledge to understand and the presentation style or format suitable for him). In addition, this allows users some freedom in the order in which to explore the information. In contrast, the nature and purpose of these systems bring difficulties should not lose sight during its design.

Although the user model is able to evolve (through user interaction with the system, it "learns" from the user) and ensure that the system behaves according to subject characteristics, they vary with time, which is possible for the AHS this content and links differently in other sessions. This should be taken into consideration in designing interfaces that minimize the potential for confusion or disorientation of the user.

Another disadvantage is that the creation of content in such systems demand the author to define different versions of pages or nodes of information, knowledge structure properly, and determine which version suits better each user (Bra, 2000). This makes it a difficult process, capable of mistakes, which takes time and involves high costs.

Finally, the definition and verification of the mechanisms of adaptation and observation using the user model is a complicated process. While in many cases simply a table used to record user interaction, others employ artificial intelligence techniques that require a high degree of specialization on the part of developers and lots of time to verify their accuracy. Once detailed the significant attributes of the AHS, the rest of this topic focuses on showing the features and limitations of one of the most popular implementation of the AHS, educational hypermedia.

2.4.5. ADAPTIVE HYPERMEDIA FOR ELEARNING SYSTEMS

Because the hypermedia structure associatively-disparate pieces of information that simulates, to some extent, the process of relationship and connection that makes the human mind, using systems that can be considered an effective alternative to reinforce and support processes teaching and learning, and so try to match the structure of knowledge to be conveyed to the way in which students associate and relate the concepts or, better yet, encourage them to build their knowledge through hypermedia links.

This, coupled with the characteristics and possibilities of adaptive hypermedia, learning environments can set content and courses that have adapted to the aptitudes, interests and preferences of students.

The remainder of this section presents a summary of different AEHS, noting their characteristics and differences. On this basis then it raises its evolution and points out its weaknesses.

2.4.5.1. BACKGROUND SYSTEMS – CURRENT APPROACHES

This collection details the components, technical adaptation and, where applicable, the processes and tools available to create content and adaptive rules, as Berlanga (2006) outlined in more detail.

Table 10 summarizes those examples and shows the domain of knowledge that are addressed and the elements to consider for adaptation.

Table 10. AEHS: Factors to consider for adaptations

AEHS	Domain	Factors to consider for adaptation
NetCoach (2007)	Domain independent Adaptive courses authoring	Student's prior knowledge of other programming languages Preference of students in the presentation of content
ELM-ART II (ELM-ART, 2006)	Computer Science Programming in LISP	Student knowledge State of learning
InterBook (Interbook, 2007) (Berlanga & García, 2006)	Domain independent Adaptive content authoring	Prerequisites Student knowledge State of learning
METOD (Kocbek et al., 2007)	Domain independent	Student knowledge Student preferences (objectives, preferred learning strategy, learning styles, learning paths)
AHA! (AHA, 2008)	Domain independent Authoring tools to create adaptive applications	Attributes associated with concepts (e.g. access, knowledge, interests, visited, learning styles, etc.).
KBS-Hyperbook (Henze et al., 1999)	Domain independent Books hypermedia	Prerequisites Student knowledge User preferences.
KnowledgeSea II (KnowledgeSea, 2007)	Computer Science Programming in C	Student interactions with the system Student knowledge Community's knowledge Adaptation based on the history of activities
MetaLinks (Metalinks, 2005) (Murray et al., 2000)	Domain independent Learning content authoring	Student interactions with the system, pages visited and the tools he used.
INSPIRE (Papanikolaoua et al., 2003)	Computer Science Computer Architecture	Student knowledge (inadequate, mediocre, competent, advanced). Learning styles.
ALE (Berlanga & García, 2006)	Domain independent (architecture and design) *Learning Management System*	Student knowledge. Student preferences (eg learning style, language). Learning style.
ALICE (2011)	eLearning service-oriented architecture Specific Educational domain	Learning experiences customized on specific learner needs and preferences Combine collaboration, personalization and simulation aspects within an affective/emotional based approach knowledge Model Contextualisation, Upper Level Learning Goals, Semantic Connections Between Learning Resources

Table 11 summarizes the adaptive technologies used by the analyzed AEHS. As noted, the employed techniques in the presentation are adaptive variants of pages or text fragments and conditional, while, in the section on adaptive navigation support, the most used techniques are the direct guidance or sequencing the curriculum, and annotation of links.

Table 11. AEHS: Adaptation technologies used

	NetCoach	ELM-ART II	InterBook	METOD	AHA!	KBS-Hyperbook	KnowledgeSea II	MetaLinks	INSPIRE	ALE
Adaptive Presentation										
Expandable text	X			X				X		
Conditional text	X	X	X	X						
Variants or fragments of pages.	X			X	X				X	
Adaptive Navigation										
Direct Guide (or sequencing of the curriculum)	X	X	X	X		X	X		X	X
Management links.		X	X							
Hiding links	X			X			X			
Annotation of links	X	X	X	X	X	X	X	X	X	X
Generation of links			X							

2.4.5.2. EVOLUTION

Viewing the outlined systems in the previous section, it is interesting to note the evolution of adaptive hypermedia systems applied to the field of education.

ELM-ART II (2006), is dedicated to teaching a specific topic of study, students used a more elaborate model, known as multi-layered model. This AEHS was the basis for the researchers who devised to design systems as INTERBOOK (2007) that deals and creates content for AEHS.

AHA! (2008) ventures into the definition of a generic model for building applications with adaptive features based on the creation of concepts and rules. In this line, KBS-Hyperbook was a precursor to consider the pedagogical aspect, using an approach based on constructivist learning, and the inclusion of student learning goals, also separates the conceptual model, metadata, information units and structure, this allows its use for different domains.

Metalinks (Metalinks, 2005) is an example of a simple and functional architecture, which uses a database for end users, and a historical model for adaptation. Another important feature of this AEHS is its authoring tool which is oriented to create contents easily, thus it does not define adaptive rules.

INSPIRE and ALE (Specht et al., 2002) (Berlanga et al., 2006), emphasize the importance of a standard annotation for learning objects, as well as the need to identify the elements of the domain structure at different levels of knowledge (concepts, units course, learning units, materials, etc.). In the case of INSPIRE, it is also important to note that includes instructional design theories to structure knowledge. ALE, in turn, uses the metadata of learning objects for adaptation, and has an advanced authoring tool for creating courses and use templates graphically, a characteristic that emphasizes the desirability of these systems evolve toward greater ease of use.

KnowledgeSea II (2007) is a system for personalized information access. It offers various methods of accessing information, including two-level visualization, hypertext browsing, recommendation and social search. Personalization is provided by social navigation support which is an approach for browsing-based and recommendation-based information access. KnowledgeSea II includes an adaptive search facility combining a common vector search engine and social navigation. By that every user may benefit from the whole community's knowledge; search results are adapted to the user based on the history of activities.

METOD (MetaTool for Educational Platform Design) (Kocbek et al., 2007) is a European Union funded project basically aiming at creating a general paradigm for educational platform development. Part of the project's results is MetaTool that allows creating METOD projects storing various kinds of content and (meta) information, e.g. topics, student types, learning styles, exercises and learning paths. The projects can then be exported to various Content Management Systems that have to support a specific METOD plugin in order to provide adaptive learning.

NetCoach (2007) is a further development of ELM-ART containing an own authoring system that allows the development of adaptive courses. Generally all material belonging to a course is organized in a tree structure and can be freely browsed by the learner.

Additionally, the system offers personalization of courses by adaptive curriculum sequencing and adaptive link annotation.

ALICE (2011) (Adaptive Learning via Intuitive/Interactive Collaborative and Emotional systems) is a project co-funded by the European Commission under the 7th Framework Programme, basically building an adaptive environment for eLearning, combining personalization, collaboration and simulation spects within an affective/emotional based approach. It aims to provide learning experiences customized on specific learner needs and preferences also starting from requests made in natural language and dealing with different contexts and complex learning resources

2.4.5.3. WEAKNESSES

The identified AEHS key problems are currently they receive little consideration adapting the teaching strategy, the definition of unique models to design components and educational elements, and the inability to share or reuse educational elements.

By observing the evolution of AEHS, two aspects are clearly highligted and they concentrate the efforts of researchers. On the one hand, the development of tools that allow not specialized users in adaptive hypermedia to create content and courses, which facilitates the dissemination of these systems. Furthermore, the inclusion in the field of AEHS current trends in web development (i.e. use of standardized metadata and identifying the structure of knowledge-domain), results in expanding its capabilities and functionality.

Disturbingly, however, the little that has been considered the pedagogical and didactic issues in the development of the analyzed systems (except for ALICE (2011)), and, by contrast, the close attention they receive regarding technical issues, as well as the tendency to see the process of teaching as a simple transfer of concepts. In this regard, the creation of AEHS is essential to consider the educational objectives to be achieved, learning theory to be used, and the process by which students acquire knowledge. These aspects should be analyzed and detailed in interdisciplinary teams formed by computer, but also by educators and instructional designers.

With the exception of ALICE (2011) also, so far the definition of adaptive behavior is the system level. Only permitting sequencing the curriculum through predefined forms, and specifying conditions that only allow modifying the values assigned to the concepts. In both cases, adaptive techniques used are predefined, and adaptations are linked to the concepts and do not pass the learning process.

Finally, note that each of the analyzed AEHS follows its own patterns of modeling and annotation of the elements, and the definition of the logic of adaptation is usually within the pages or nodes that represent the knowledge.

Therefore, it is almost rare to think at the moment, in a context of sharing and reuse of educational resources with adaptive characteristics between different systems or applications. This is another aspect that should give special attention to new AEHS design proposals, it will minimize its cost and development time and facilitate its dissemination in the broader contexts of application, while the students are provided with educational resources and educational perspectives from different sources.

Other aspect that lack consideration in the current approaches is the use of collaboration tools and features for the adaptive process. Also in the automation part of the adaptive systems is the use of recommendation tools suggesting adaptation regarding resources and users attributes.

2.4.6. AEHS CONSIDERATIONS

A summary of different presented examples of AEHS in this topic shows that, while the first AEHS determine knowledge of the student taking into account only the pages visited by him, using the latest evidence and consider their style of learning to perform adaptation; also there is necessity to develop tools for application development with adaptive characteristics, and include learning objects and metadata standards. It also reveals that, despite these developments and several years of field development, there is little experience of implementing AEHS real learning situations, which determines that there are few evaluations to prove their benefits. This scenario justifies ever more attention to authoring tools and the process of creating the elements of an AEHS.

In addition to this, due to each AEHS has its own definitions used to characterize the elements, there is no common language to facilitate these systems to process and share the semantics of adaptive techniques flows, education, mastery of knowledge, or teaching resources.

Without doubt, the next step in the design and development of AEHS is to extend its possibilities by including homogeneous notations, enabling the sharing and reuse of its components. But it would seem advisable that future developments of these systems explore the use of collaboration and recommendation features contributing to the application of Social Semantic Web concept. Thus, in the next section are going to be analyzed these concepts.

2.5. COLLABORATION AND RECOMMENDATION SYSTEMS

This section is devoted to present the main aspects regarding collaboration and recommendation systems.

2.5.1. COLLABORATION

The Collaborative software (also referred to as groupware, workgroup support systems or simply group support systems) is software designed to help people involved in a common task achieve their goals.

The design intent of collaborative software (groupware) is to transform the way documents and rich media are shared in order to enable more effective team collaboration.

Collaboration in Education can be seen as two or more co-equal individuals voluntarily bring their knowledge and experiences together by interacting toward a common goal in the best interest of students' needs for the betterment of their educational success.

One type of collaborative management tools is workflow systems, which main goal is to facilitate and manage group activities (Brickley, 1995).

In the following topic the main aspects regarding workflow systems are introduced.

The Workflow concept definition by the Workflow Management Coalition (WfMC, 2010) is "*The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.* Participant represents here resource (human or machine).

Typically a workflow system has three main components (see Figure 25):

- ❖ Persons involded in the process;
- ❖ Bussiness Component - Logic that controls the transitions between tasks of the process;
- ❖ Data Component – Data of the workflow process.

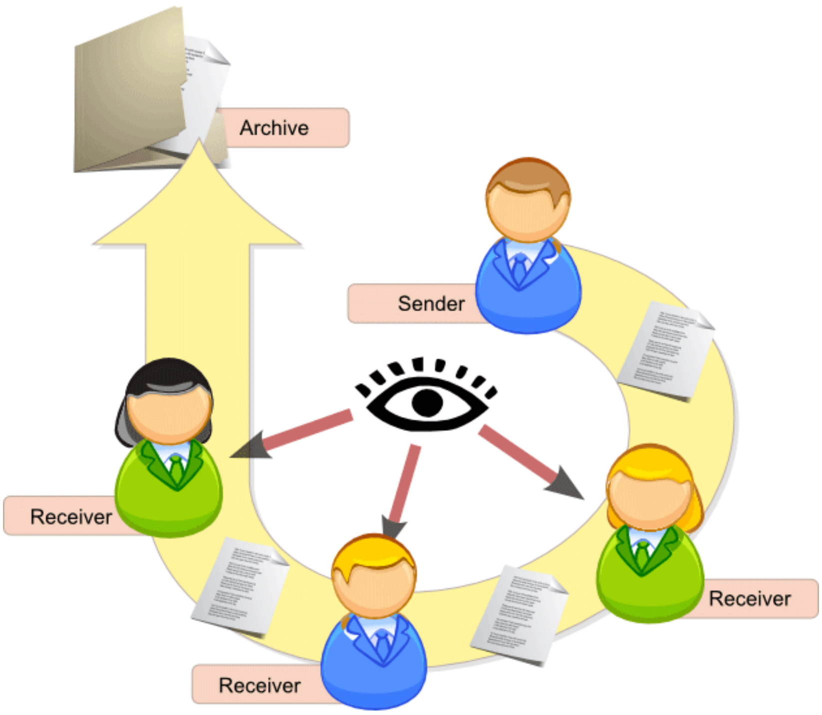


Figure 25. Typical Workflow

The evolution of workflow management consists of the automation of business procedures or "workflows" during documents, information or tasks are passed from one participant to another in a way that is governed by rules or procedures.

Workflow software products, like other software technologies, have evolved from diverse origins. While some offerings have been developed as pure workflow software, many have evolved from image management systems, document management systems, relational or object database systems, and electronic mail systems (WfMC, 2010)(see Figure 26).

Vendors who have developed pure workflow offerings have invented terms and interfaces, while vendors who have evolved products from other technologies have often adapted terminology and interfaces. Each approach offers a variety of strengths from which a user can choose. Adding a standards-based approach allows a user to combine these strengths in one infrastructure.

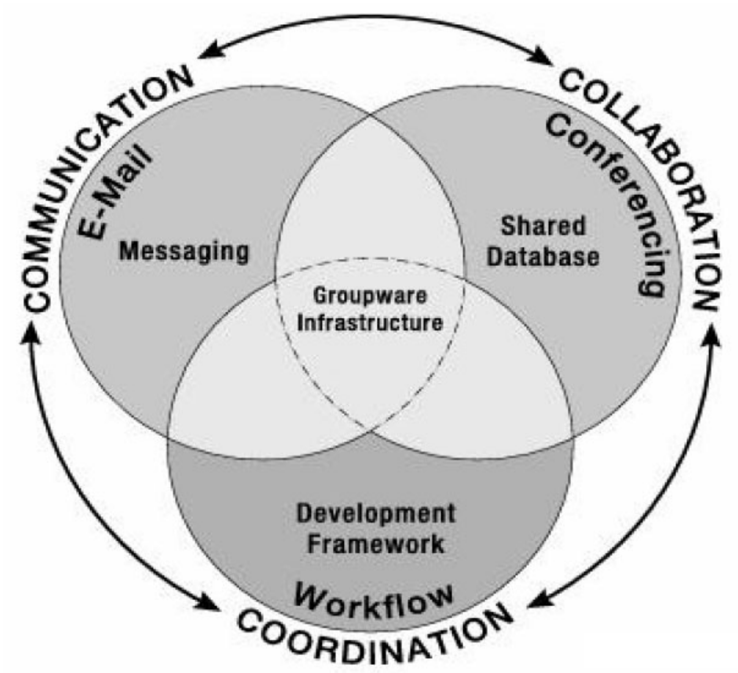


Figure 26. Workflow Framework (WfMC, 2010)

Thus, the workflow key benefits are:

- ❖ Improved efficiency - Automation of many business processes results in the elimination of many unnecessary steps.
- ❖ Better process control - Improved management of business processes achieved through standardizing working methods and the availability of audit trails.
- ❖ Improved customer service – consistency in the processes leads to greater predictability in levels of response to customers.
- ❖ Flexibility and adaptation – Software control over processes enables their redesign in line with changing business needs.

- ❖ Business process improvement - Focus on business processes leads to their streamlining and simplification.

On the other hand, some of the main risks are:

- ❖ Resistance of the workers;
- ❖ Definition and implementation of procedures and management systems.

2.5.2. RECOMMENDATION

Recommendation, more specifically recommendation systems or recommender systems, may be seen as a specific type of information filtering (IF) technique that attempts to present information items (movies, music, books, news, images, web pages, etc.) that are likely of interest to the user (Hanani, Shapira, & Shoval, 2001). Typically, a recommender system compares the user's profile to some reference characteristics, and seeks to predict the "rating" that a user would give to an item they had not yet considered (Gediminas & Alexander, 2005). These characteristics may be from the information item (the content-based approach) or the user's social environment (the collaborative filtering approach).

When building the user's profile a distinction is made between explicit and implicit forms of data collection (Fournier, 2010).

Examples of explicit data collection include the following:

- ❖ Asking a user to rate an item on a sliding scale.
- ❖ Asking a user to rank a collection of items from favorite to least favorite.
- ❖ Presenting two items to a user and asking him/her to choose the best one.
- ❖ Asking a user to create a list of items that he/she likes.

Examples of implicit data collection include the following:

- ❖ Observing the items that a user views in an online store.
- ❖ Analyzing item/user viewing times.
- ❖ Keeping a record of the items that a user purchases online.

- ❖ Obtaining a list of items that a user has listened to or watched on his/her computer.
- ❖ Analyzing the user's social network and discovering similar likes and dislikes.

The recommender system compares the collected data to similar data collected from others and calculates a list of recommended items for the user.

These kind of systems are useful alternative to search functionalities since they help users discover items they might not have found by themselves. Interestingly enough, recommender systems are often implemented using search engines indexing non-traditional data.

Some common algorithms are:

- ❖ One of the most commonly used algorithms in recommender systems is Nearest Neighborhood approach. In a social network, a particular user's neighborhood with similar taste or interest can be found by calculating Pearson Correlation, by collecting the preference data of top-N nearest neighbors of the particular user (weighted by similarity), the user's preference can be predicted by calculating the data using certain techniques (Fournier, 2010).
- ❖ Another family of algorithms that is widely used in recommender systems is Collaborative Filtering. One of the most common types of Collaborative Filtering is item-to-item collaborative filtering (people who buy x also buy y), an algorithm popularized by Amazon.com's recommender system.

2.5.2.1. RECOMMENDER SYSTEMS

A great recommendation system can retain and attract users to the service. For example when a user returns a movie, he/she is recommended another movie they might like - which increases the likelihood of return business.

Furthermore recommendations are generally based on an "information item (the content-based approach) or the user's social environment (the collaborative filtering approach)" (MacManus, 2009b).

Xavier Vespa (2008) analyzed 3 different approaches to recommendation engines on the Web. He identifies that Pandora uses "deep structural analysis of an item" for its recommendations, Strands focuses on "intensive social behavior analysis around an item" and Aggregate Knowledge does "structural analysis of an item, paired with behavioral analysis around the item" (MacManus, 2009b; Vespa, 2008).

Browsing and Recommendations

A good recommendation engine can make a difference for any online business or activity. This is because there are two fundamental activities online - SEARCH and BROWSE. When a consumer knows exactly what he/she is looking for, he/she searches for it. But when he/she is not looking for anything specific, he/she browses. It is the browsing that holds the golden opportunity for a recommendation system, because the user is not focused on finding a specific thing - she is open to suggestions.

During browsing, the user's attention is up for grabs. By showing the user something compelling, a web site maximizes the likelihood of a transaction. So if a web site can increase the chances of giving users good recommendations, it makes more money. Obviously this is a difficult problem, but the incentive to solve it is very big.

A couple of years ago, Alex Iskold outlined what he saw as the four main approaches to recommendations (MacManus, 2009b). The main approaches fall into the following categories:

- ❖ Personalized recommendation - Recommend things based on the individual's past behaviour.
- ❖ Social recommendation - Recommend things based on the past behavior of similar users.
- ❖ Item recommendation - Recommend things based on the thing itself.
- ❖ A combination of the three approaches above.

2.5.2.2. EXAMPLES OF RECOMMENDATION SYSTEMS

Different approaches are explored by looking at how Amazon and others systems like Google, Pandora and del.icio.us use recommendations.

Amazon - The King of Recommendations

Alex Iskold (2007) analyzes what Amazon.com - probably the canonical example of recommendations technology on the Web - uses to power its recommendations. Unsurprisingly, he finds that Amazon used all three approaches (personalized, social and item). Amazon's system is very sophisticated, but at heart all of its recommendations "are based on individual behavior, plus either the item itself or behavior of other people on Amazon" (Iskold, 2007). What it is more, the aim of it all is to get you to add more things to your shopping cart.

Amazon is considered a leader in online shopping and particularly recommendations. Over the last decade the company has invested a lot of money and brain power into building a set of smart recommendations that tap into your browsing history, past purchases and purchases of other shoppers - all to make sure that the user buy things. Several examples of Amazon's recommendation system are commented to get an insight on how they work. Figure 27 and Figure 28 show the sections that are shown in the main area of my Amazon account when login:

Figure 27. Amazon Social recommendations

Section on Figure 27 represents Social recommendations. Notice that it is very analytical, giving a statistical reason for why a person should buy this item. Also note that this recommendation is also a personalized recommendation, since it is based on an item that the person clicked recently.

Figure 28. Amazon Item recommendation

Section Figure 28 introduces an item recommendation based on New Releases. Clicking on the "Why is this recommended for you?" link takes to a view of the personal purchasing history. So this recommendation is also a personalized recommendation, since it is based on the past behavior.

There are four more sections offered on the page and each of them leverages different combinations of the personalization mechanisms described above. They are summarized in Figure 29.

Amazon Personalized	Recommendations System
Your Browsing History	Your Purchase History
Actual Items	**New releases** (Item recommendation)
Related Items (Item recommendation)	**Related Items** (Item recommendation)
Others Purchased (Social Recommendation)	**Others Purchased** (Social recommendation)

Figure 29. Amazon Personalized recommendation

Not surprisingly, the system is symmetric and comprehensive. All recommendations are based on individual behavior, plus either the item itself or behavior of other people on Amazon. Whether the user likes to buy something because it is related to something that he/she purchased before, or because it is popular with other users, the system drives the user to add the item to the shopping cart.

The Amazon is quite a established system. It is a genius of collaborative shopping and automation that might not be possible to replicate. This system took a decade for Amazon to build and perfect. It relies on a massive database of items and collective behavior that also "remembers" what the user has done years and minutes ago, making it difficult to compete with.

Accordingly to Alex Iskold (2007) surprisingly, there is a way. The answer is found in a subject that has little to do with online shopping - genetics. As it is known, this science studies how pieces of DNA, called genes, encode human traits and behavior. For example, members of a family look and behave alike because they share a certain subset of genes. Genetics as a science has been around for over 150 years and has been a powerful tool for both medicine and history. But on January 6, 2000 things took an unexpected turn - Tim Westergren (2010) and his friends decided to apply the concepts of genetics to music in The Music Genome Project.

Pandora - The Recommendation System Based on Genetics

The Music Genome Project was launched to decompose music into its basic genetic ingredients. The idea behind it is that we like music because of its attributes - and so why not design a music recommendation system that leverages the similarities between pieces of music. This kind of recommendation engine falls into the item recommendation category. But what is new and profound here is that similarity of an item like a piece of music needs to be measured in terms of its "genetic" make up (Westergren, 2010).

Figure 30. Pandora recommendation system

After years of struggle and processing massive amounts of music, the project accumulated enough data and launched the service called Pandora (see Figure 30). Pandora becomes a hit because of its precision and low cost of entry. The user just needs to pick one artist, or a song, to create a station that instantly plays similar music.

This kind of instant gratification is difficult to resist. The fact that Pandora understands what makes music similar allows it to hook the user without having to learn what this user likes. Pandora does need the user's tastes or memory, it has its own - based on music DNA. Sure, sometimes it might not be perfect, as the user's taste might not be perfectly addressed. But it is considered to rarely be wrong.

The natural question is can this genes-based approach be applied to other areas - like books, movies, wines, restaurants or travel destinations? What constitutes genes for each category? For example, can the user say that for wine, the genes might be things that describe how wine tastes: blackberry, earthy, fruity, complex, blend, etc. And for a book, can the genes be phrases that describe the plot? So if the genes are the attributes of the object that make it unique in user's mind, user should have no problem coming up with genes for various things. In the past few years users have been doing this a lot online. It is called tagging.

Del.icio.us - Can Tags Become Genes?

Pandora had a big startup cost, because thousands of pieces of music had to be manually annotated. The social bookmarking phenomenon del.icio.us took a different approach - let people annotate things themselves. This self-organizing approach has worked really well, and del.icio.us quickly became popular among early adopters. Today, del.icio.us is considered to be more than bookmarking destination - it is also a news site and a search engine (Delicious, 2011). But is del.icio.us a recommendation system?

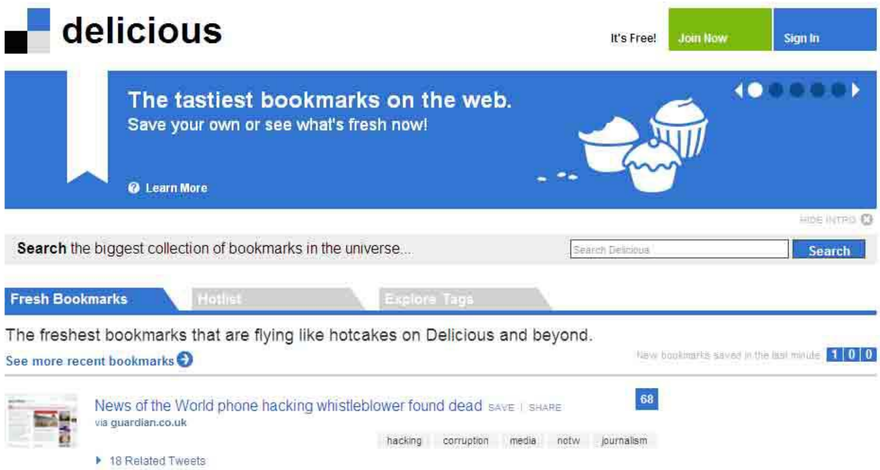


Figure 31. Del.icio.us recommendation system

The answer is afirmative. There is a basic recommendation system based on one gene - a single tag. For example, in Figure 31 is possible to see popular links for the Linux tag and we also see related tags like OPEN SOURCE and UBUNTU. But a much more exciting recommendation system is based on matching multiple tags. Unfortunately, the current heuristic does not always work, which is why it is not obvious.

So the del.icio.us approach holds intriguing possibilities of self-organizing classification and recommendation systems. With enough users and more tweaking, social tagging can result in a system that works equally well for books, wine and music. Provided, of course, that tags are so good that they become genes!

Google: Focus on Personalized Recommendations

The most successful Internet company of this era has without a doubt been Google. It too has been using recommendation technologies to improve its core search product. MacManus (2009b) refers that there are two ways that Google does this:

- Google customizes your search results "when possible" based on your location and/or recent search activity.
- When the user signs in to his Google Account, he "may see even more relevant, useful results based on your web history" (MacManus, 2009b).

So Google is using both your location and your personal search history to make its search results supposedly stronger. This is very much the personalized recommendation approach - and indeed personalization has been a buzzword for Google in recent years (Linden, 2007). However, the two other types of recommendation are also present in Google's core search product:

- Google's search algorithm PageRank is basically dependent on social recommendations - i.e. who links to a webpage.
- Google also does item recommendations with its "Did you mean" feature.

There are surely other ways recommendations technologies are being deployed in Google search - not to mention the range of other products Google has. Google News, its start page iGoogle, and its ecommerce site Froogle all have recommendation features (MacManus, 2009b).

2.5.2.3. CONCLUSIONS RECOMMENDATION

Concluding, recommendation engines are important pieces of online commerce systems and their user experience. Retailers have a big incentive to provide recommendations to those users who are “just browsing”, to drive them towards a transaction. Amazon.com, the leader in the space, has a very compelling personalization offering. The problem that other retailers face is lack of user information and infrastructure.

Also, recent approaches to recommendation engines, like the genetics-inspired Pandora and social tagging pioneered by del.icio.us, are intriguing. These approaches hold the promise to provide instant gratification, without asking the user to reveal her preferences and past history. Regardless of how things unfold in the future, Amazon, Pandora and del.icio.us are examples considered as excellent recommendation technologies (Grossman, 2010).

2.5.2.3.1. Adaptive Recommender System the Next Generation?

There are cases like Baynote, a recommendations company that focuses on real-time community behavior instead of personalization (MacManus, 2009a). Others like a company that takes a broader approach: richrelevance uses personalization extensively, plus the wisdom of the crowds when relevant. richrelevance claims that its approach is “adaptive AI” and that customers such as Sears and KMart are using its technology.

Every company in this market - including those which create their own platform, like Amazon and Netflix - have differing approaches and ideas on what makes a good recommendation engine. The key to richrelevance’s approach acccording to Selinger (richrelevance founder and CEO), is that people does not shop the same and so different recommendation types will be used for each shopper. This is markedly different from Baynote’s approach, which specifically excludes a user’s past shopping behavior and instead focuses on real-time community patterns.

In the worldview of richrelevance, shoppers at Amazon are different to the ones at Sears - one of the companies using richrelevance's technology. Furthermore, a person who has a shopping history at a store is different from someone who is totally new to that site. So, unlike Baynote, richrelevance takes into account a user's purchase history - if known (MacManus, 2009c).

As for the technology behind richrelevance, David Selinger (MacManus, 2009c) has termed it "ensemble learning". David Selinger wrote that "no single algorithmic approach can hope to keep up with today's ever-changing consumer mindset", so richrelevance does not try to force retailers and consumers "into a single bucket". Instead Selinger says that richrelevance has "built a system that adapts to the retailer and to each customer in real-time", which is done via "an adaptive type of artificial intelligence called Bayesian Ensemble Learning". Selinger claimed that "algorithms like collaborative filtering are a thing of the past" and that ensemble learning is the next generation beyond that.

2.5.2.3.2. Weaknesses

From the analysis of the recommender systems it can de identified five main problems or weaknesses (MacManus, 2009b).

1. Lack of Data

   Perhaps the biggest issue facing recommender systems is that they need a lot of data to effectively make recommendations. It is no coincidence that the companies most identified with having excellent recommendations are those with a lot of consumer user data: Google, Amazon, Netflix, Last.fm. As it is illustrated in Figure 32, a good recommender system firstly needs item data (from a catalog or other form), then it must capture and analyze user data (behavioral events), and then the magic algorithm does its work. The more item and user data a recommender system has to work with, the stronger the chances of getting good recommendations. But it can be a chicken and egg problem - to get good recommendations, a lot of users are needed, so a lot of data for the recommendations are gathered.

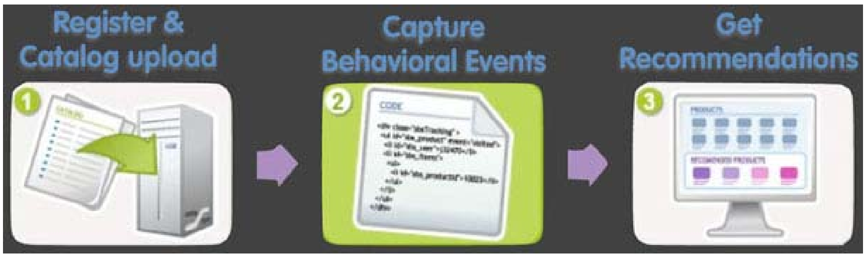


Figure 32. Recommendation system schema

2. Changing Data

   This issue was pointed out by Paul Edmunds (2010), CEO of intelligent recommendations company Clicktorch. Paul suggested that systems are usually "biased towards the old and have difficulty showing new".

   An example of this was blogged by David Reinke of StyleHop (Reinke, 2008), a resource and community for fashion enthusiasts. David noted that "past behavior [of users] is not a good tool because the trends are always changing". Clearly an algorithmic approach will find it difficult if not impossible to keep up with fashion trends. Most fashion-challenged people rely on trusted fashion-conscious friends and family to recommend new clothes to them.

   David Reinke went on to say that "item recommendations don't work because there are simply too many product attributes in fashion and each attribute (think fit, price, color, style, fabric, brand, etc) has a different level of importance at different times for the same consumer".

3. Changing User Preferences

   Again suggested by Paul Edmunds (2010), the issue here is that while today user has a particular intention when browsing e.g. Amazon - tomorrow user might have a different intention. A classic example is that one day one user is browsing Amazon for new books for himself, but the next day he will be on Amazon searching for a birthday present for his sister.

4. Unpredictable Items

   For example, the type of movie that people either love or hate, such as Napoleon Dynamite. These type of items are difficult to make recommendations on, because the user reaction to them tends to be diverse and unpredictable.

Music is full of these items. Would the system guess for a user that is a fan of both Metallica and The Carpenters?

5. This Stuff is Complex!

   Figure 33 illustrates that it takes a lot of variables to do even the simplest recommendations (and it is easy to imagine the below variables only scratch the surface).

Figure 33. Example of variables for recommendation

   So far only a handful of companies have really gotten recommendations to a high level of user satisfaction - Amazon, Netflix, Google are some names that spring to mind. But for those select few success stories, there are hundreds of other websites and apps that are still struggling to find the magic formula for recommending new products or content to their users.

There are many other issues that can happen with recommender systems - some offer up too many “lowest common denominator” recommendations, some do not support The Long Tail enough and just recommend obvious items, outliers can be a problem, and so on (Fournier, 2010).

2.6. WEAKNESSES OR OPPORTUNITIES FOR IMPROVEMENT

The found weakness are mainly related to problems regarding interoperability, reusability, quality of learning resources, learning domain independence and extensibility of the systems, meeting some of our study goals presented before.

Table 12 points out some of the weaknesses, but mainly opportunities of improvement, on web and eLearning systems/tools, but also in adaptation and standardization of resources.

Table 12. Weaknesses or Opportunities for improvement

WEAKNESSES OR OPPORTUNITIES FOR IMPROVEMENT		
	WEAKNESSES	**OPPORTUNITIES FOR IMPROVEMENT**
eLearning systems	Resource management & portability	Interoperability
	Adaptability and personalization	Reusability
	Lack of Quality of resources	Evaluation of quality of resources
	Development of new components	Extensibility
	Diversity of pedagogies and applications	Learning domain independence
	Costs (Comercial Plataforms)	Openness
eLearning Tools		
LD Tools	Support of different standard or spec	Standards compliance
	Support of learning theory	Facilitate annotation
	Lack on functionalities regarding the user's needs to characterize several learning environments	Users feedback
	Independence of learning domain	Context of application
LOM Tools	Lack of educational orientation, by not providing a list of available educational metadata	Introducing an abstraction level to the user from the technical aspects in terms of the XML language
	Require that the person who edits metadata must know XML	For the user to reuse the LO in another scenarios
	Lack on functionalities regarding the user's needs to characterize several learning environments	Tool 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
	They do not provide management of the resources.	Introducing the quality evaluation, giving the user the possibility to choose the best LO that best fit his educational scenario
Marking Standards & specs	Worldwide spread and adoption degree	
	Technical complexity is beyond the present reach of non-experts	Studies suggest developing tools to search, recommend, classify, and automate delivery of LO
	Pratical use of LO concept, confusion over the meaning of LO	Ideally, metadata should not worry about end users, but only bring benefits

	WEAKNESSES	OPPORTUNITIES FOR IMPROVEMENT
	User cooperation in the development of standards	These technologies are actually oriented instructional design experts and computer specialists, and a way for the computer to automatically process the information but do not expect the common user, used directly, but that has mechanisms to facilitate their work without necessarily be aware of its existence
	Complexity of metadata labels	Necessary research to define mechanisms that generate automatic metadata for LO, and that intelligently managed using techniques of filtering, collaborative filtering, data mining, pattern recognition or social recommender
		Empirical studies are needed on the implementation, use and reuse of specifications LO, instructional design and user profiles.
AHS	Adapting the teaching strategy	Development of tools that allow users not specialized in adaptive hypermedia to create content and courses to facilitate the dissemination of these systems
	Collaborative adaptation	Other aspect that lack consideration in the current approaches is the use of collaboration tools and features for the adaptive process
	Qualified information	Also in the automation part of the adaptative systems is the use of recommendation tools suggesting adaptation regarding resources and users attributes.
	Definition of unique models to design components and educational elements	Inclusion in the field of AEHS current trends in the development of Web-as the use of standardized metadata and identifying the structure of knowledge-domain, resulting in expanding its capabilities and functionality
	Inability to share or reuse educational elements	
Collaboration and Recommendation systems	Lack of data	Feedback
	Changing data	Advanced Collaboration
	Changing user preferences	Social Recommendation
	Unpredictable items	Collaborative adaptation of learning resources and design
	Complexity	
Semantic Web and Social Web	Problems of user driven ontology evolution for the semantic web	A system for self governance where the users themselves create the ontology over time in an organic fashion
	Social web applications are fairly unsophisticated typically limiting themselves to user tagging and basic metadata	Inclusion of learning social networks. Increase interaction between users. Simplfying reusability
	There are only limited ways for consumers to find, customize, filter and reuse data	Scalability and authorship advantages of the social web
	Semantic web applications lack the kind of scalable authoring and incentive systems found in successful social web applications	Data flexibility and portability of that is characteristic of the Semantic Web
	Semantic web applications are typically of limited scope and impact	

These problems and opportunities set the pieces for the main topics of the current research and consequently the development of the proposal, which is going to be introduced in the following chapter.

3. TOWARDS WEB 3.0: A PROPOSAL

Once presented the main characteristics of eLearning systems and tools, and identified their weakenesses, this chapter presents the research proposal by making use of technologies and tries to innovate and define a new type of system using as support the educational standards and specifications, mainly the IMS specifications. The main goal lies to address the main problems with interoperability, reusability, but also to contribute to the adaptation and mobility of resources and dissemination of these systems.

The core of the proposal focuses on learning design and instructional managing tools, but also in the adaptation process of resources, taking advantage of collaboration and learning social networking.

This chapter justifies the approach, the features of the tools developed and presented, and the application scenarios.

Finally, sets out the conclusions of this chapter.

3.1. INTRODUCTION

As it was exposed in the previous chapter, eLearning systems are constantly evolving and developing.

Therefore, the weaknesses pointed out in the systems analysis became in this study goals, and by this mean it is tried to blend different technologies to achieve a new concept and develop the research proposal.

Figure 34 illustrates this proposal in a schematic view, in terms of the technologies and main features considered to implement the system innovation.

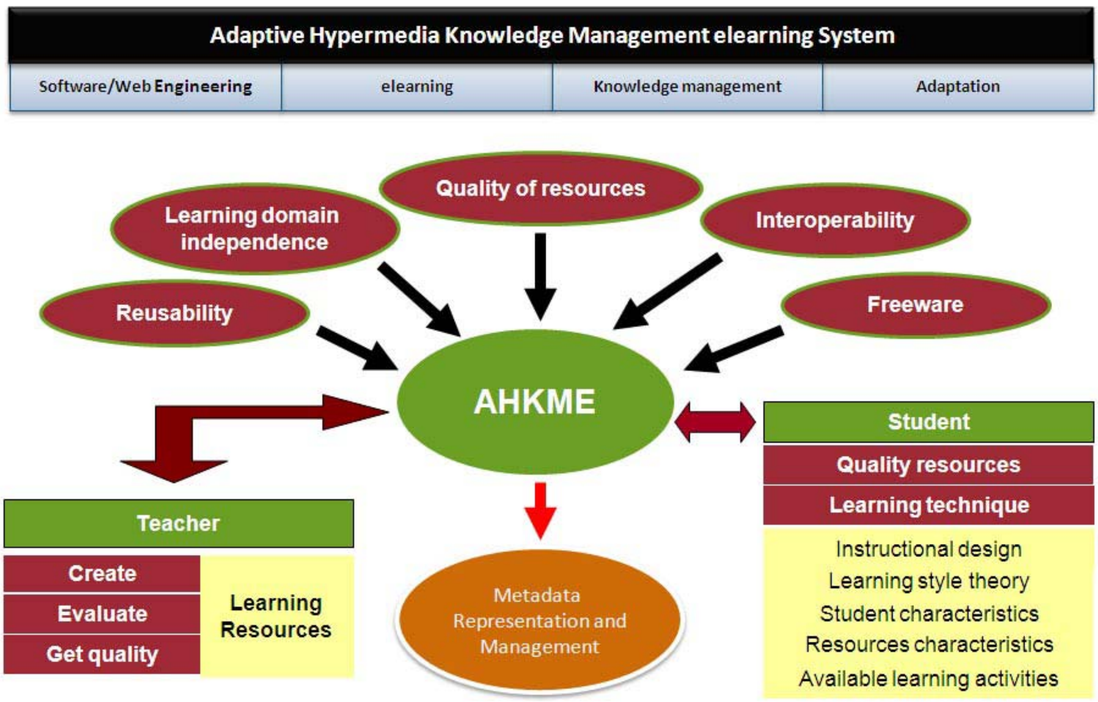


Figure 34. Proposed model

Concept

The proposal of this study is to address the problems and weakness found in eLearning systems and in order to give solutions to them towards Web 3.0.

For this purpose the goals of the proposal have dual coverage:

- ❖ Innovate the existent systems and tools in concept and features.

- ❖ Improve the existing functionalities in performance and usability.

So, an eLearning system development is proposed that prepares eLearning stakeholders for the web 3.0 shift. It is a kind of Web/eLearning 2.5 system, a middle layer, which main goal is not the technologies used but to prepare the users towards the new paradigm.

Thus, instead on focuses in the knowledge that the users have to work with tools, it focuses on simplifying and reusing the learning resources and strategies for similar learning contexts. Based on the metaphor, "Simple is better" or "Keep it simple", workable and then get it better.

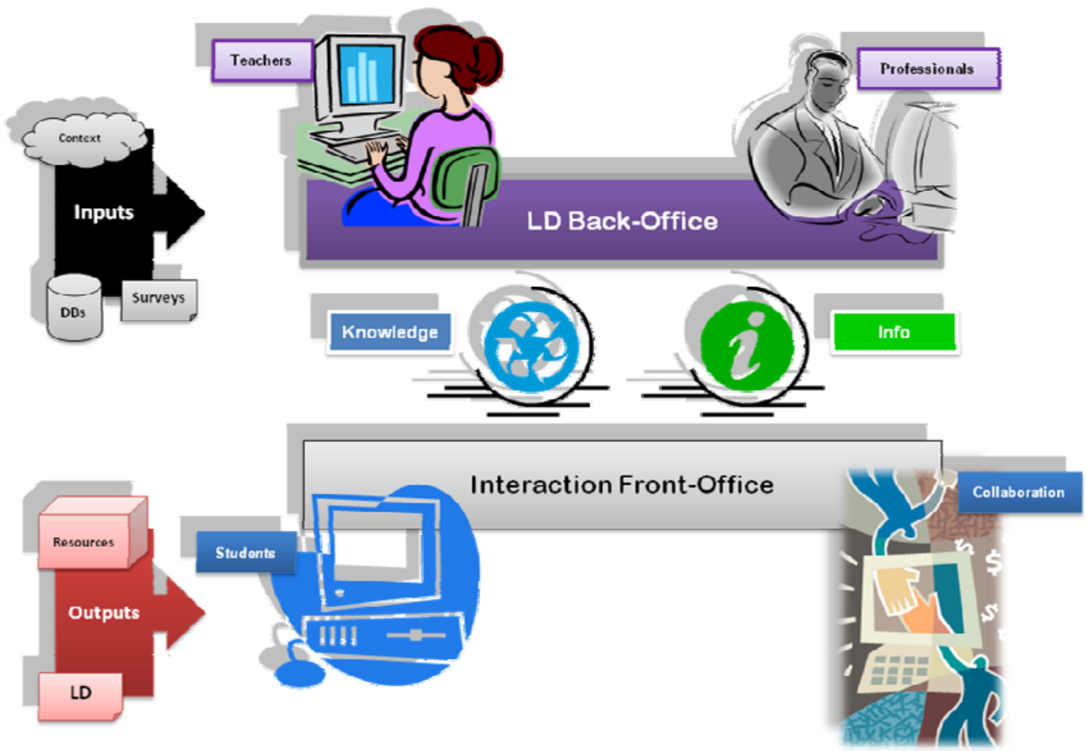


Figure 35. LD Back-Ofifice and Interaction Front-Office system

As shown in Figure 35, the system will work simultaneously as a learning design back-office system for teachers and instructors and also as the front-end for the presentation of learning resources and for collaboration. Also for inputs, the system will have the context of learning, feedback surveys and data stored in support databases, and for outputs the learning resources and design taking into account the inputs and the processing done by teachers and professionals for achieving information and ultimately knowledge, giving quality to the resources and publishing them in an interaction front-office, where collaboration and sharing are the main features.

By this mean, it introduces concepts regarding:

- Interoperability.
  - Mobility of resources – Independently of the context.
  - Global database – Gathering and interacting all the learning data and information.
- Machine learning.
  - Data mining – Extract patterns and information from data.
- Advanced collaboration.
  - Workflow - Automation of process, documents or resources.
  - Chat/forum/blog – Synchronous and asynchronous tools.
  - Multimedia tools – Videos, photos and music.
  - Social networking – Social web learning communities.

Thus, it tries to introduce a first version of the technologies and concepts regarding the Semantic Web or Web 3.0, making the Web machine-readable by annotating data on the Web based on its meaning (EmergingTech, 2011).

Other innovation is to give independence to Learning designers related to educational technological standards:

- Importing external learning structures using XML schemas.
- Customizing existing schemas.
- Creating their own learning structures.

Thus, the combination of these concepts working together is the main innovation of the current proposal.

Figure 36 illustrates this structure.

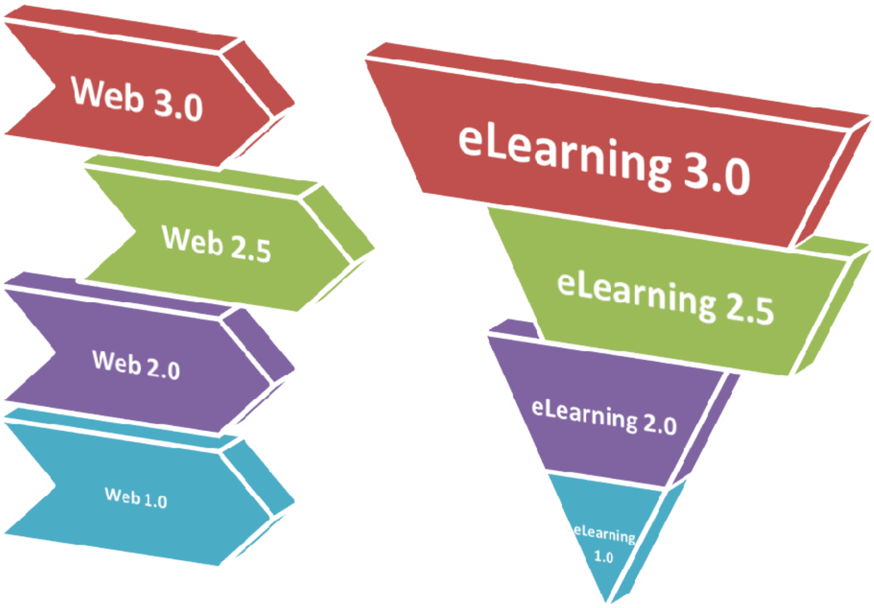


Figure 36. eLearning and web mapping

The goal of the system is trying to get together teachers and eLearning technologies, making use of nowadays web emerging concepts regarding Social Web and networking.

3.2. MAIN CONTRIBUTIONS

The main contributions of this proposal are related to the application of an evolution in eLearning systems (Figure 37), through the following features:

- The possibility for teachers to create or customized their learning designs, their schemas or ontologies. Also, this structure is stored into database and indirectly into classes. It can be passed the ontology from database into classes.
- The inclusion of social network concept and functionalities giving the possibility to teachers and students to interact.
- The inclusion of advanced collaboration with workflow functions available to teachers for the instructional design and adaptation of resources.
- The adaptation of resources through collaboration and recommendation systems.

- The implementation of a "middleware", middle version or bridge between web 2.0 and Web 3.0 systems, because of the difficulty to implement the Web 3.0 through the advanced technologies involved for the majority of the users. The implementation of a kind of Web 2.5 concept to prepare the students and teachers for the new features and technologies involved.
- The interoperability introduced by the use of standards in terms of educational structuring and technologies.
- Intelligent applications with the goal of tailoring online searching and requests specifically to users' preferences and needs. Although the *intelligent web* sounds similar to artificial intelligence, it is not quite the same. It involves also concepts regarding natural language processing, Machine-based learning and reasoning, besides intelligent applications.

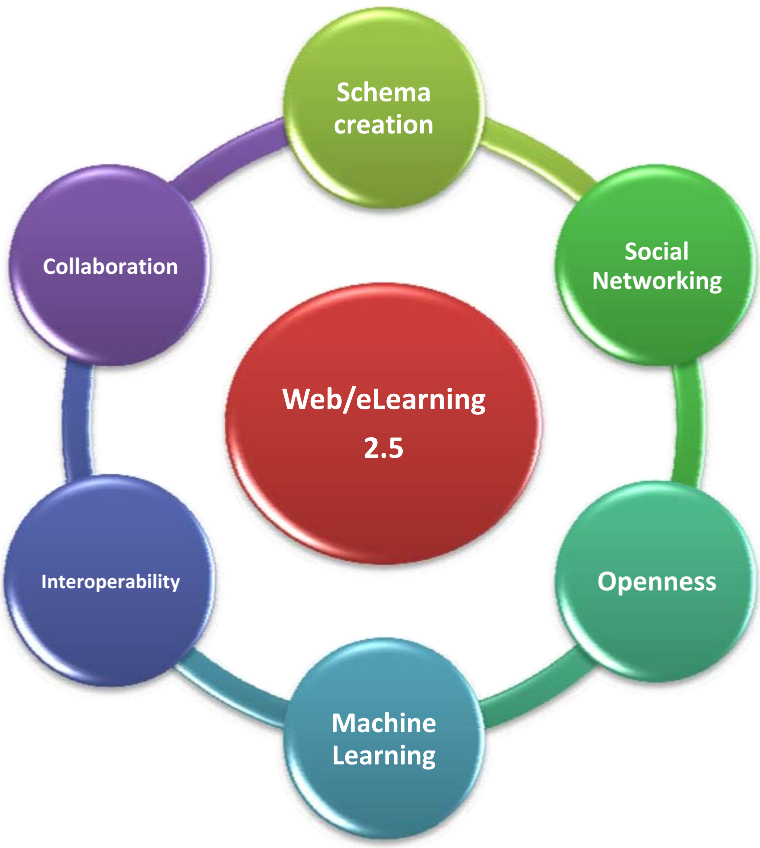


Figure 37. Web/eLearning 2.5 concepts

Thus, the objective is to contribute for the development and application of the concept in a more straightforward and consistent manner.

3.3. STANDARDS AND SCHEMA PROPOSAL

One of the objectives of the proposal is to give independence to teachers in the learning design process. However it has to follow a specific structure; so to work as a basis for the design or customization of the learning strategy IMS specifications have been chosen.

3.3.1. STANDARD AND SCHEMA ADOPTION CHOICE

Both the eLearning systems and the context of application are important in the standards adoption choice.

Quite often, eLearning implementers know that they should be aware of standards but are not sure exactly which standards they should know about and how standards should be addressed with potential eLearning systems.

Thus, it is important to consider the conformance and compliance to the standards.

It should still question the implementers about their ability to integrate and ensure interoperability with other systems. Some good questions include:

- ❖ What level of involvement do you have with the various standards activities?
- ❖ Is anyone from your organization/research group on any of the standards working groups? If so, what have they contributed?
- ❖ What are your plans for conforming with the accredited standards and the specifications as they emerge? Which specific standards or specifications does your system conform to (i.e., content metadata, content packaging, etc.)?
- ❖ How can your organization assist with our transition strategy if new standard make your existing system obsolete?

It is strongly recommended evaluating systems to check how they will provide the functionality that you seek and require that to identify the exact specification that is associated with enabling that specific functionality. Look for examples of how they have incorporated emerging standards into their existing system. And, if possible, see how technology accomplishes the functionality specified by the standard. In this way, it is possible to see their level of conformance with the specification that affects the functionality is needed.

When it comes to standards, it is important to pay attention to how a system level of alignment with the various standards. Three terms often used are compliance, certification, and conformance (MASIE, 2003).

It is all well and good to be aware that standards are being defined and that eLearning suppliers are beginning to conform to those standards, but what does this mean within an implementing organization?

Often, a company may own one, two, or even more LMS, several web-based libraries, off-the-shelf content, and custom courseware authored in a variety of different tools. Figuring out how to make all of this work together and share information through a common database can be challenging. Furthermore, trying to integrate this data with an ERP system, like PeopleSoft or SAP, can be daunting. Thus, the questions must be considered (MASIE, 2003):

- How do learning metadata standards relate to other metadata standards that may exist within the organization? It is possible to consider developing a metadata schema specifically for the organization.
- What are the minimum requirements within the organization concerning what data needs to be captured on each learner?
- Should all custom content be authored in the same tool or at least conform to a certain set of design and meta-tagging standards?
- Should the organization have a common repository for all content, and if so, what rules will govern how the system is used?
- Will any governance structures be needed to help ensure adherence to standards within an organization? Can these be monitored and implemented by the systems and infrastructures?

When implementing standards within an organization, to ensure interoperability of web-based courseware and systems, be sure to gain support from senior levels of the organization. Think about whether standards need to be adhered to across the organization from the outset or whether areas within an organization should be phased into conformance as the need for interoperability increases.

Sometimes it is easier to gain support for standards after some benefits can be shown, rather than trying to enforce standards on all areas all at once. It should be important to keep in mind that this is a long-term and strategic approach that will evolve and develop over a long period of time.

3.3.2. WHY IMS?

The use of standards has become very useful not just for the sake of saying that an institution uses a standard, but because the use of a standard or standards 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 it is possible to choose to model the proposed system, like described on the following Table.

Table 13. 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		✓			

Following specifications have been analyzed: IMS Specifications (2011), AICC (2010), SCORM (2009) and Dublin Core (2010), regarding the following (Rego et al., 2005):

- 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.

Then, having present the specifications for structuring the metadata of learning resources which would be the best choice for structuring of resources for an eLearning system, and more specifically to a system for managing metadata of learning objects.

From this analysis, it is able to verify that IMS specifications cover most of the aspects analyzed.

This choice is supported by the GRIAL research group, specifically the educational and pedagogical related members, who already are working with these specifications (Berlanga, 2008; Morales, García, & Barrón, 2008) (Barbosa, García, & Rodriguez-Conde, 2010).

Thus, it is based on this standard, IMS, which sought to build the structure of educational content and develop an eLearning system, multi-purpose and allowing the reuse and interoperability among systems, as based on the storage structure information in XML files, packages of content, with manifest files, XML files and their schemas (IMSCP, 2009).

Factors that have influenced the choice:

- Based on the IEEE LOM standard.
- Interoperability and reusability - It stores metadata in XML files.
- Creating packages within a manifest file, with schemas, XML files and resource files.
- They have specifications for modeling large part of the learning process:
    - Learning Resource Metadata.
    - Learning Design.
    - Learning Information Package.
    - Content Packaging.
- They provide a specification of the future and that are developing guidelines and specifications for RDFS.

Although, the system permits to import different schemas or customize/create their own, it is important to make it easier the learning design process to the teacher, avoiding the technical knowledge regarding educational technologies.

Figure 38 illustrates the use of educational specifications and structuring of the learning design and resources behind the eLearning system proposal regarding the application of these concepts.

Figure 38. Web/eLearning 2.5 Standards and data structuring

3.4. AHKME

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

So standardization is indispensable, because it provides a semantic representation of the knowledge through ontologies in which concepts are clearly and unambiguously identified, providing a set of semantic relation types which allows representing meaning by linking concepts together (Berners-Lee, Hendler, & Lassila, 2001; Mendes & Sacks, 2001).

At this point AKHME is introduced, a system that supports both knowledge representation (KR) and management (KM) based on metadata described by the IMS specifications, whose goals and main contributions are: learning resources management and quality evaluation, where some kind of Intelligence has been considered through intelligent agents; IMS specifications are used to standardize the resources of the system; system adaptation to students/teachers' characteristics and new contexts is allowed by the interaction and feedback among all AHKME subsystems.

The timely and correct knowledge management becomes a sustainable source of competitive advantage, as well as a way to connect people to quality knowledge as well as people to people in order to peak performance. In the educational area KM and advanced systems can be used to explore how technologies can leverage knowledge sharing and learning and enhance performance (Chatti, Jarke, & Frosch-Wilke, 2007; Grace & Butler, 2003). Colomo-Palacios has been working towards this concept with the developing of the MAS educational platform for people with intelectual disabilities (Colomo-Palacios, Paniagua-Martín, García-Crespo, & Ruiz-Mezcua, 2010) and also the SOLE Project by applying semantics and Social Web to support Technology Enhanced-learning (Colomo-Palacios, Jiménez-López, García-Crespo, & Blanco-Iglesias, 2010). AHKME is a system that adapts itself to students and teachers characteristics and to new contexts, using metadata management, KR and KM by capturing user behavior and interaction with the system, allowing decision makers to check which resources, course formats and learning strategies will have best or worst results in determined contexts, helping them to define strategies on how to address certain types of students and contexts.

Then firstly an overview and the context of the system are presented then different subsystems and tools of the system are explored with more detail. Finally, some conclusions of this section are discussed.

3.4.1. INTRODUCTION

First it would be relevant to explain the meaning behind the name AHKME that stands for:

- AH: Adaptive Hypermedia.
- KM: Knowledge Management.
- ME: Personalization, user-centered.

❖ E: elearning, eletronic, web.

Thus, as is possible to see in Figure 39 there is a symbology behind the choice of the name that by itself represents the scope of the current study.

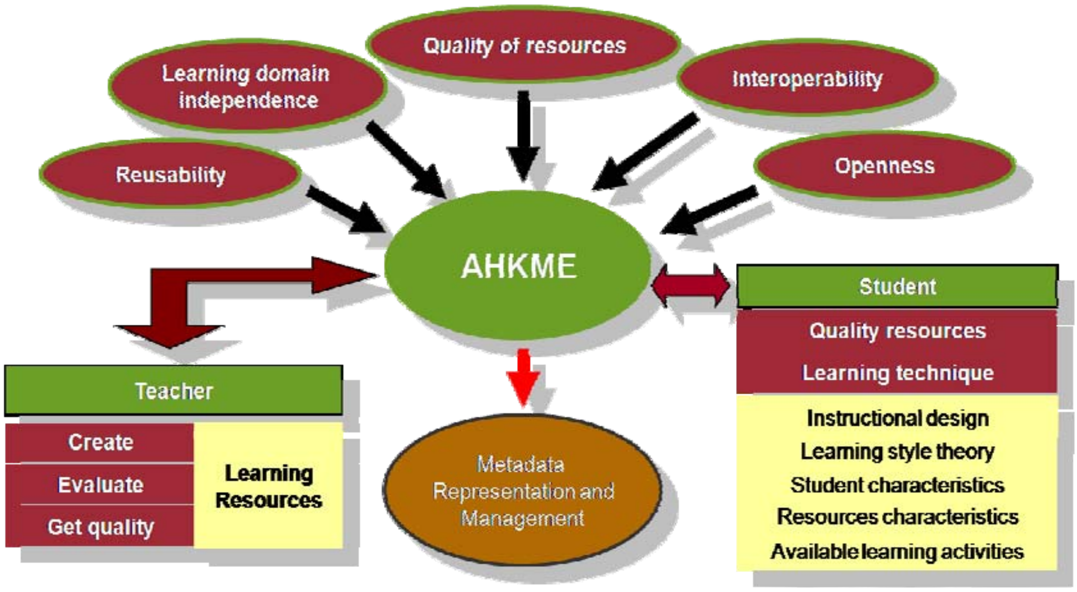


Figure 39. AHKME concept

As illustrated in Figure 39, the concept behind AHKME, is addressing issues regarding interoperability, reusability, learning domain independence, quality of resouces and openness, it gives the possibility to teachers to design and evaluate the learning resources and at the same time, the students can learn from quality resources and the appropriate learning techniques, according to their characteristics, instructional design and learning activities.

The main characteristics from this system are:

❖ Simplify and generalize the educational and instructional design – Giving access to a set of tools that simplify and approximate teachers to the educational technological standards, but also the freedom to create their own learning structures or ontologies.

❖ Facilitate the application and transition to Web 3.0 – By creating a middle layer, like an eLearning 2.5, adapting and evolving the eLearning tools to this concept, making them more "intelligent" and interoperable.

- ❖ Mobility – By giving access to a set of tools for making the resources more interoperable among systems.
- ❖ Openness – The tools are developed and supported by open source technologies, this is meant to be integrated and used with other eLearning systems and tools.

AHKME is an eLearning system that is divided in four different subsystems: Learning Object Manager and Learning Design; Knowledge Management; Adaptive/Adaptation; Visualization and Presentation subsystems, as shown in Figure 40.

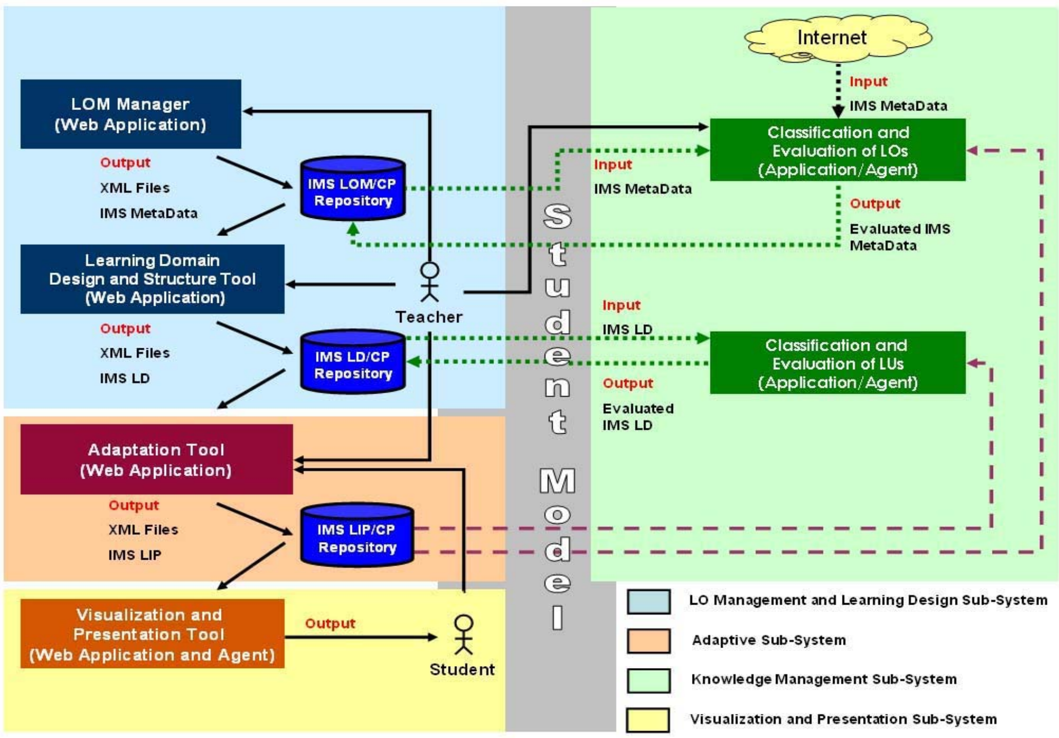


Figure 40. AHKME overview

These subsystems are structured taking into account a line of reasoning, where first is LO creation and management process, which is followed by the course creation process through learning design (LD). In parallel with these two processes, the KM subsystem evaluates the LO and courses quality. Then, it pass through an adaptive process based on the students' characteristics and teacher's collaboration, to be presented to the student.

The component diagram in Figure 41 includes both business and technical architecture aspects of AHKME, demonstrating the architectures of the software components, their dependencies and inter-relationships. There are several features to note about this diagram:

- As internal components of AHKME there are LOM & LD, Adaptation, Presentation and Knowledge management subsystems, interacting between them and with the Resources and Standards & Specs components.
- As external component there is the External systems and as external interfaces there are the interfaces provided to the User.
- Then there are the ILOM, ILD interfaces provided by the LOM & LD component and provided to the User.
- The IRecommendation and ICollaborative provided interfaces by the Adaptation component and provided to the User.
- The ISocial Network and ILD Back-Office as provided interfaces by the Presentation component and provided to the User.

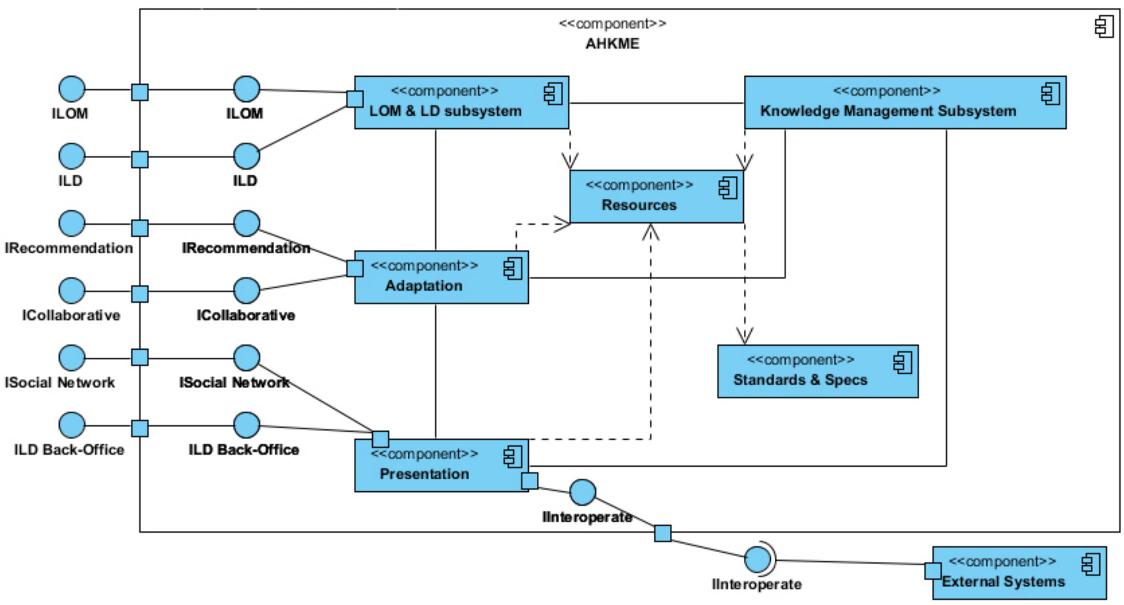


Figure 41. AHKME Component diagram

Those software components include run-time components, executable components also the source code components.

The system implements different profiles with specific features and tools:

- Learning designer profile – Learning designers could be teachers or simply educational, IT professionals that deal with instructional design and learning resources.

- Learning instructor profile – Learning instructors could be teachers or assistant teachers that work and apply the instructional design and learning resources to theis courses.

- Student profile – The student interact with the courses and indirectly with the learning design and resources.

- Administrator profile – To manage the system parametrization, users and permissions, and also tools and template administration.

Table 14 presents the profile features distribution list.

Table 14. Profile features distribution

PROFILE FEATURES ASSOCIATION					
No	TASK	PROFILE			
		Learning Designer	Insctructor	Student	Administrator
	General				
1	General :: Login/Registration	✓	✓	✓	✓
2	General :: Navigation	✓	✓	✓	✓
3	General :: Tool finding	✓	✓	✓	✓
4	General :: Help	✓	✓	✓	✓
5	Profile	✓	✓	✓	X
6	Student Feedback	x	X	✓	X
	Instructional manager				
7	Schema :: import	✓	X	x	X
8	Schema :: select	✓	✓	x	X
9	Schema :: generate/personalized	x	✓	x	x
10	Schema :: create	✓	x	x	x
11	Schema :: list	✓	✓	x	x
12	Schema :: edit	✓	✓	x	x
	Workflow				
13	Wf :: create	✓	x	x	x
14	Wf :: pending	✓	✓	x	x
15	Wf :: circulation	✓	✓	x	x
16	Wf :: history	✓	✓	x	x
	Surveys				
17	Surveys :: create	✓	x	x	x
18	Surveys :: edit	✓	✓	x	x
19	Surveys :: publish	✓	✓	x	x
20	Surveys :: use	✓	✓	✓	x
21	Surveys :: list	✓	✓	✓	x
	Adaptation				
22	Recommendation :: view attribute importance	✓	x	x	x
23	Recommendation :: view decision tree	✓	x	x	x
	Quality				
24	Quality :: view attribte importance	✓	x	x	x
25	Quality :: view decision tree	✓	x	x	x
	LOM				
26	LOM :: Generate	x	✓	x	x
27	LOM :: Edit	x	✓	x	x

PROFILE FEATURES ASSOCIATION					
28	LOM :: publish	x	✓	x	x
29	LOM :: use	x	✓	x	x
30	LOM :: list	x	✓	x	x
	LD				
31	LD :: Generate	x	✓	x	x
32	LD :: Edit	x	✓	x	x
33	LD :: publish	x	✓	x	x
34	LD :: use	x	✓	x	x
35	LD :: list	x	✓	x	x
	Reources				
36	Resources :: upload	✓	✓	x	x
37	Resources :: edit	✓	✓	x	x
38	Resources :: my resource	✓	✓	✓	x
39	Resources :: search	✓	✓	✓	x
40	Resources :: list all resources	✓	✓	x	x
41	**Search**	✓	✓	x	
42	**Communication & Sharing**	✓	✓	✓	
	Interoperability				
43	Interoperability :: Create/Export Package	✓	x	x	x
44	Interoperability :: List	✓	x	x	X
45	Interoperability :: Import Package	✓	x	x	X
	Administration				
46	Administration :: Users & Tools Access	X	x	x	✓
47	Administration :: Resources Manager	X	x	x	✓
48	Administration :: Templates	X	x	X	✓

Following some screenshots of the main screens for the profiles described above are presented.

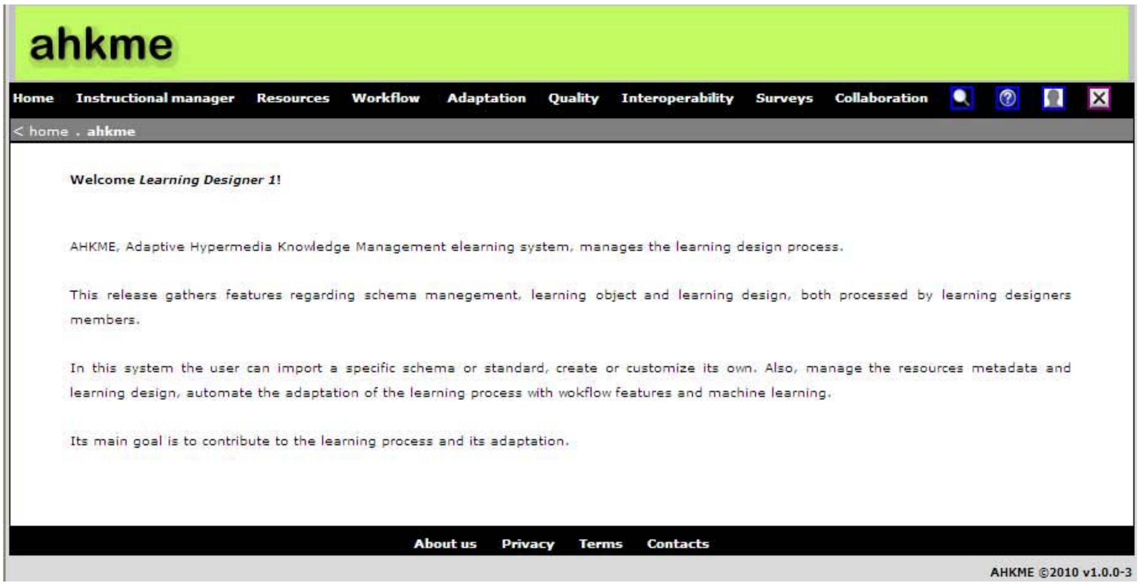


Figure 42. Learning designer profile main screen

Figure 42 shows the main screen of AHKME Learning designer profile with the menu that includes the main features.

Figure 43 shows the main screen of AHKME Learning instructor profile.

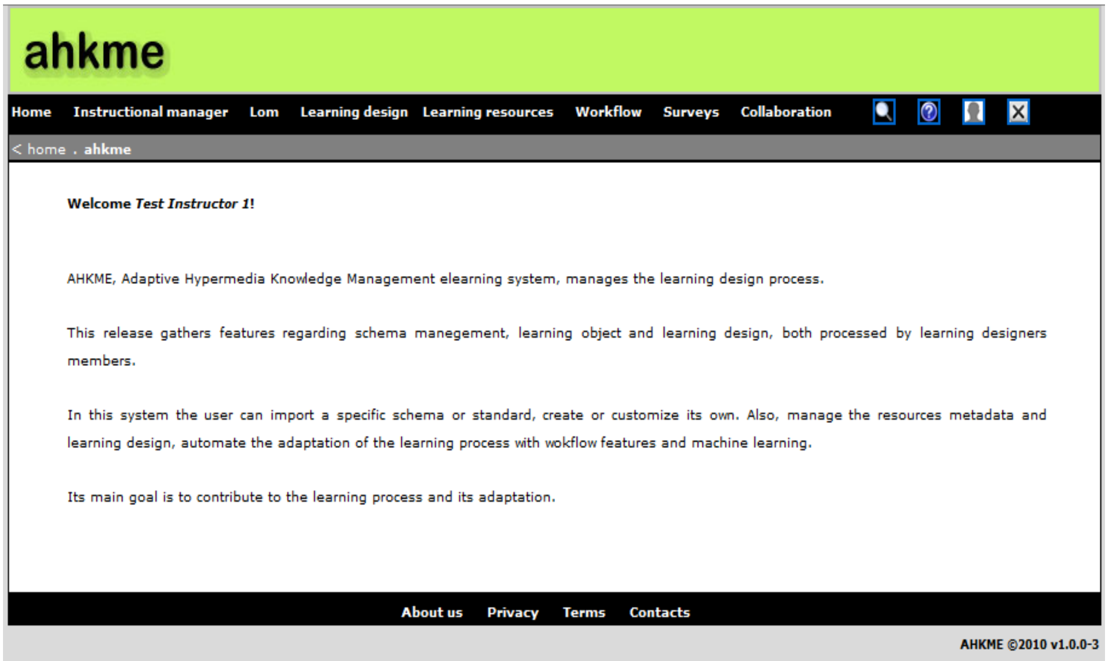


Figure 43. AHKME Learning instructor main screen

Figure 44 presents the main screen of AHKME Student profile.

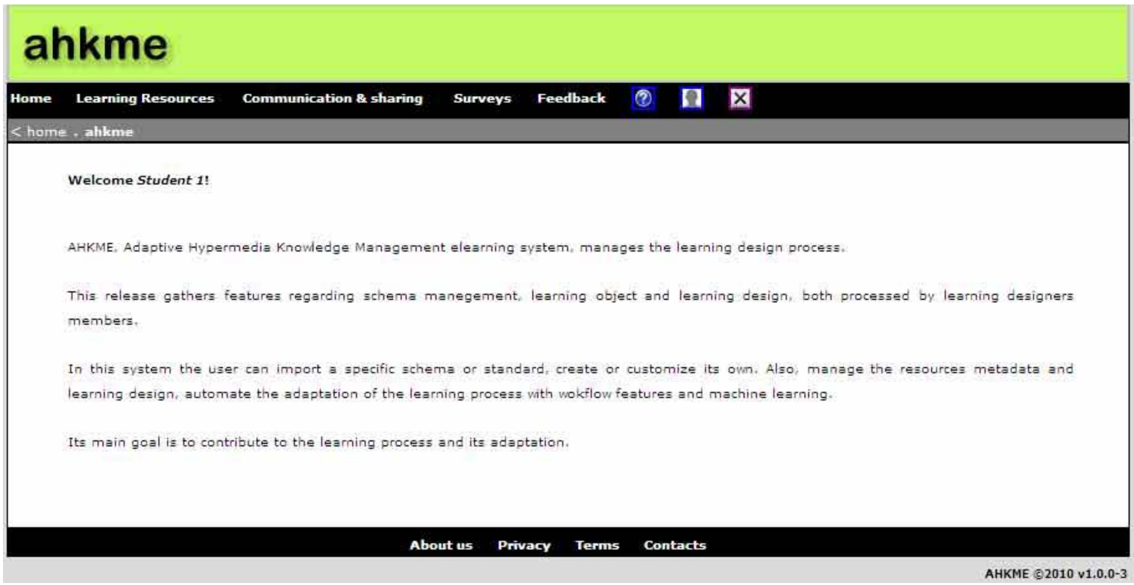


Figure 44. Student profile main screen.

Figure 45 shows the main screen of AHKME administrator profile.

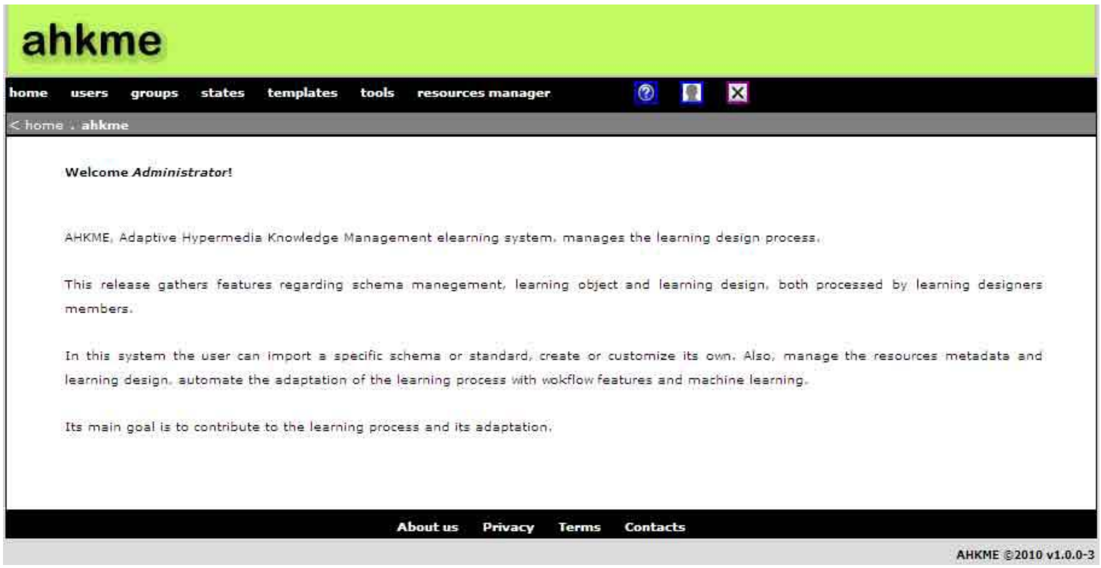


Figure 45. Administrator profile main screen.

Now, the different AHKME subsystems are introduced, which compose this system giving more focus on the system components that provide management, design and adaptation of resources through their metadata - the Learning Object Manager (LOM) & Learning Design (LD) subsystem, the Adaptation subsystem and also the Presentation subsystem. The knowledge management subsytem will be out of focus because the main core of that work is being done by other coleague of the GRIAL research group (Rego, Moreira, Morales, & García, 2008).

At first step, a mapping between the tools and the associated subsystems is presented in Table 15.

Table 15. Mapping tool to subsystem

MAPPING TOOL TO SUBSYSTEM	
Tool	**Subsystem**
ADMINISTRATION	Cross-cut
INTEROPERABILITY	LOM and LD
QUALITY	Knowledge Management
RECOMMENDATION	Adaptation
SURVEY	Feedback
LOM	LOM and LD
LD	LOM and LD
GENERAL	Presentation
INSTRUCTIONAL MANAGER	LOM and LD
WORKFLOW	Cross-cut
RESOURCES	Presentation
COMMUNICATION & SHARING	Presentation
SEARCH	Cross-cut

As shown in Table 15, the majority of the tools integrate only one subsystem, but there are also some tools that cross-cut the whole system. What stands out in these tools is the fact that they are used for specific application in different subsystems as it will be explained later in this chapter.

3.4.2. SUBSYSTEMS AND TOOLS

In the next topic AHKME subsytems, tools, and the main features which constitute to the system proposal are described in a more detailed way.

3.4.2.1. AHKME-LEARNING OBJECT METADATA MANAGEMENT AND LEARNING DESIGN SUBSYSTEM

This subsystem is the main core of AHKME and of the proposal because it gives the teacher the possibility to structure and design the instructional process and the resources.

Thus, it integrates several tools and features:

- ❖ Learning Object metadata manager tool (LOM).
- ❖ Learning Design (LD) tool that manages learning units and courses.
- ❖ Instructional Manager tool commonly known here as schema manager.

It also includes features from some transversal tool and features like the workflow tool that helps in the learning design process and also the searching feature.

3.4.2.1.1. AHKME-LOM: Learning Object metadata management

The Learning Objects Manager tool allows teachers to define/create metadata to describe LO. It uses the IMS Learning Resource Metadata (IMSLRM) specification (Barker et al., 2006) as a core support for metadata annotation.

This specification is based on the IEEE LOM standard that allows the KR/KM through LO (IEEELOM, 2002). A tool overview is illustrated in Figure 46.

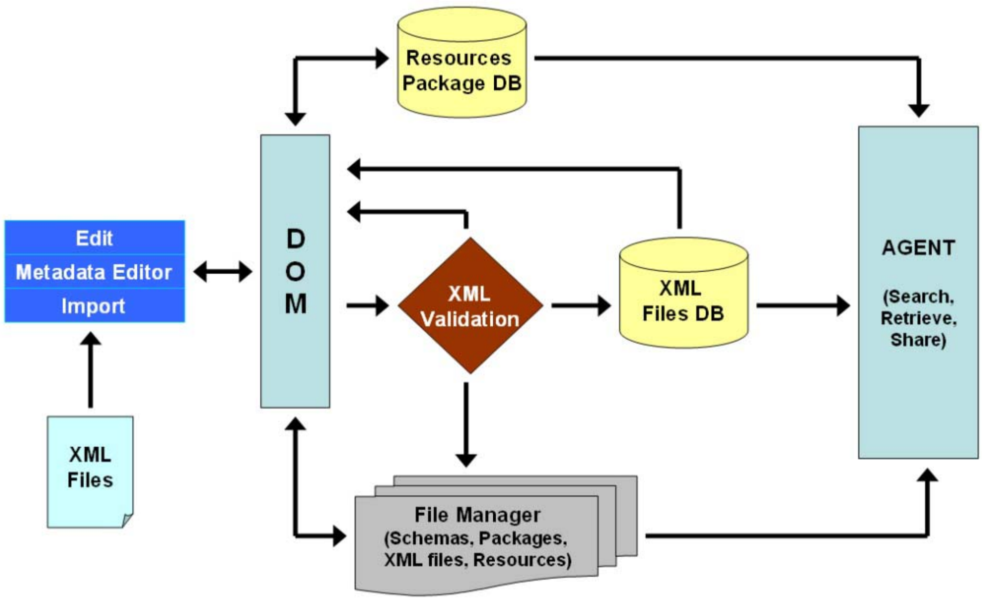


Figure 46. LOM overview

This tool allows the user to edit LO and associate descriptive metadata, according to metadata standards and specifications. It can be seen a screenshot of this tool in the Figure 47.

This tool passes the information into a XML manifest, which gathers all the XML files with their metadata and all the resources used by a LO. Besides, it has an information packaging feature that gathers their manifests with the LO and stores them in a database, which enables the management of these packages that will be used in course design.

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

All these information pass through a validation process to check the conformance with the standard or specification (e.g. IMS specifications), and all the communication among tools and databases is done through XML parsing algorithm.

Figure 47. LOM Tool

The LO are in constant evaluation made by the KM subsystem that has tools that communicate with the LO Manager through the usage of the standard/specifications (i.e. IMS specifications) for LO, which main advantage is that through the association of descriptive tags, it is better index, find, use and reuse them.

In order to facilitate the insertion of metadata an automation to this process is provided, advising the most commonly used values for the elements on the LO cataloging in order to describe LO through the most adequate metadata elements.

In order to improve LO searching and retrieving, this subsystem is endowed with a search engine, since one of the most common problems that teacher face are how to locate, select and semantically related suitable learning resources (Andric, Devedzic, Hall, & Carr, 2007). Thus, the LOM tool uses a cross-cut search tool, because the search of LO is a very important task in order to reach reusability, going towards the so long desired sustained and continuous improvement of learning resources, with an emphasis on the use and reuse of dynamic, relevant, and high quality materials over time (Petrides, Nguyen, Jimes, & Karaglani, 2008). The descriptive metadata associated to LO become now more important than ever. The search engine is based on an intelligent agent that receives as inputs the metadata elements from IMSLRM (Barker et al., 2006) for their search and retrieval. 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. These metadata fields may vary depending on the frequency in which they are used. Otherwise, if the teacher chooses an advanced search, he may choose whatever elements he wants to search for. Finally, the search engine presents LO according to the teacher's search query with the respective quality evaluation allowing him to choose the more qualified LO to integrate them into the courses he is creating.

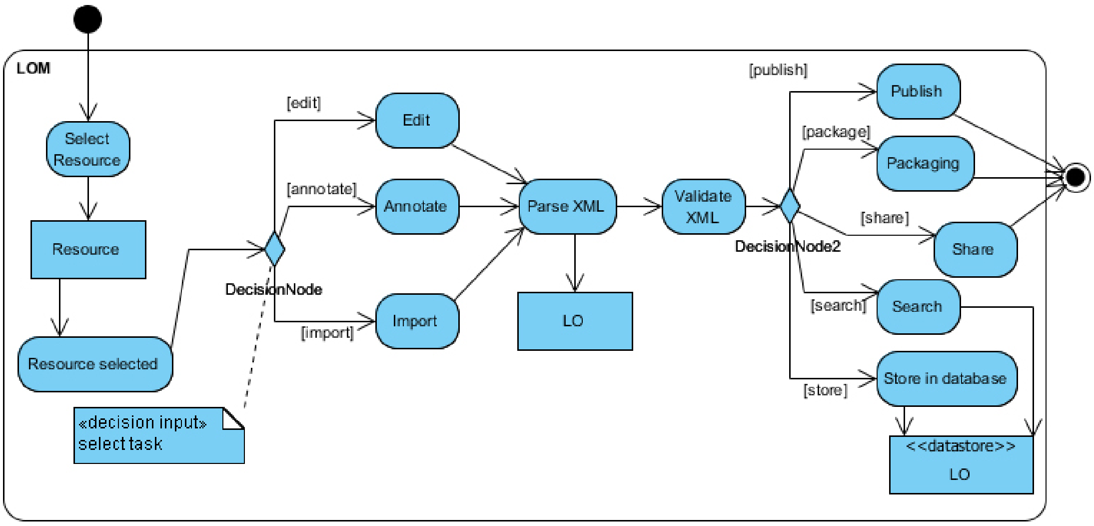


Figure 48. LOM activity diagram

The workflow presented in the activity diagram in Figure 48 indicates as starting point the selection of the resource, then it can be alternatively chosen the edit, annotate or import option, after this choice the XML of the LO is parsed and validated according the XML schema, and finally can follow different ways, depending of the feature choice – publish, share, packaging for end point or as alternative stored in database or be searched for reuse.

The component diagram in Figure 49 illustrates the technical architecture of the LOM tool with both logical and physical components, along with the artifacts that implement them and the nodes on which they are deployed and executed:

- ❖ Web Application component using a .Net XML Class for the XML Schema manipulation and also a .Net SQL Class for the database operations. This component required these interfaces to implement the XML Schema Parser.
- ❖ LOM Rendering component uses a Treeview Class, a MSSQL Database and the schema parser for the LOM Rendering.

❖ User interacts with the LOM Tool, specifically through the LOM editing interface.

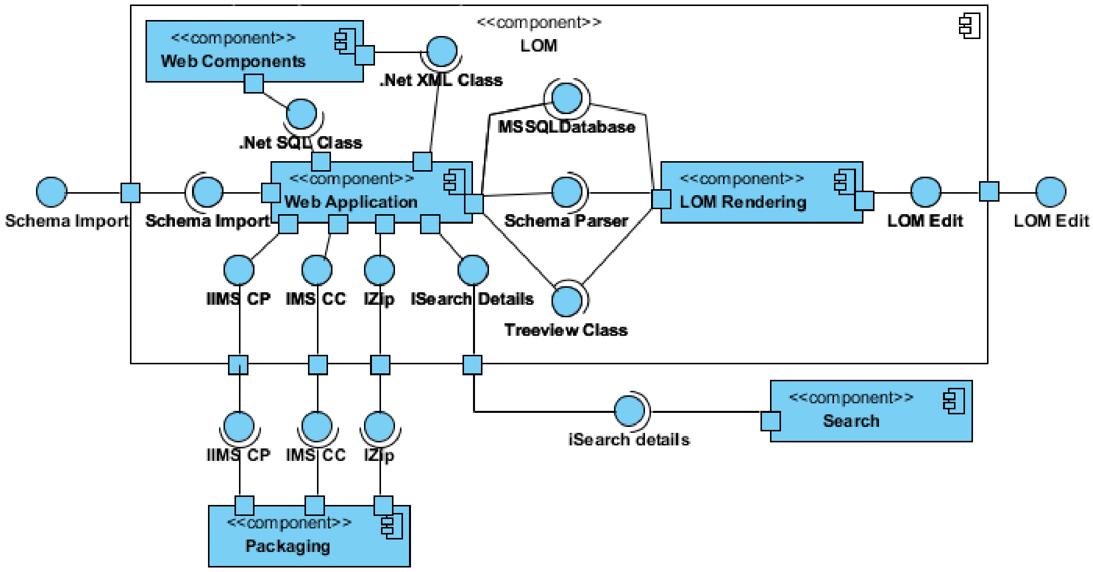


Figure 49. LOM Component diagram

❖ Search component that uses an interface to implement the search mechanism (explained later in this chapter).

❖ Packaging component uses the IMS and zip interfaces to implement the packaging creation feature.

In the snippet of Figure 50 is presented the implementation of the LOM Rendering software component with the design of the Treeview using as nodes the element rows collected from the database. In the process it uses a Treeview Class, a Folders tree Object and the database parser to implement the LOM Rendering.

```
<script language="javascript">
var desig = new Array()
var obj = new Array()
foldersTree = gFld("<b><?php echo $row['name']; ?>:</b>",
"schema_frameless.php?id=<?php echo $row['idnode']; ?>")
desig.push('<?php echo $row['name']; ?>')
obj.push(foldersTree)
foldersTree.treeID = "Frameless"
</SCRIPT>

<?php
schema_design($idnod,$par,$parent_ant,$idparent);

function schema_design($idnode,$parent,$parent_ant,$idparent){
        $query3 = "SELECT * ";
        $query3 .= "FROM tb_node_template ";
        $query3 .= "WHERE idnode >".$idnode;
        $result3 = mssql_query($query3);
```

```
        $numRows3 = mssql_num_rows($result3);
        while($row3 = mssql_fetch_array($result3))
        {
                $query4 = "SELECT * ";
                $query4 .= "FROM tb_node_template ";
                $query4 .= "WHERE name ='".$row3['idparent']."'";
                $result4 = mssql_query($query4);
                $row4=mssql_fetch_array($result4);
                if ($row3['idparent'] == $idnode){
                                if (($row3["type"] != NULL) || ($row3["type"] != '')){?>
                                        <SCRIPT LANGUAGE="JAVASCRIPT">
                                                var tam = desig.length
                                                for (i = 0; i < tam; i++){
                                                        if (desig[i] == '<?php echo
$parent; ?>'){
                                                                f1 = obj[i]
                                                        }
                                                }
                                                aux1 = insFld(f1, gFld("<?php echo
$row3['name']; ?>", "schema_frameless.php?id=<?php echo $row3['idnode']; ?>"))
                      </SCRIPT>
                                        <?php
                                }else{ ?>
                      <SCRIPT LANGUAGE="JAVASCRIPT">
                                                var tam = desig.length
                                                for (i = 0; i < tam; i++){
                                                        if (desig[i] == '<?php echo
$parent; ?>'){
                                                                f1 = obj[i]
                                                        }
                                                }
                                                aux2 = insFld(f1, gFld("<?php echo
$row3['name']; ?>", "schema_frameless.php?id=<?php echo $row3['idnode']; ?>"))
                                                desig.push('<?php echo $row3['name']; ?>')
                                                obj.push(aux2)
                      </SCRIPT>
                      <?php
                                        $pare=$row3['name'];
                                        $idn=$row3['idnode'];
                                        $parent_ant=$row4['parent'];
                                        $idpar=$row3['idparent'];
                                        schema_design($idn,$pare,$parent_ant,$idpar);?>
<?php
                                }
                        }
        }
}
```

Figure 50. Snippet of the LOM rendering

XML parsing feature

One of the main contribuition of this tool, but mainly of this research, technically speaking, is the XML schema parsing feature.

There are two de facto XML parsing API, DOM, a Tree-traversal API accessible from a programming language and SAX, a Stream-oriented API accessible from a programming language. SAX reads the whole document and generates a sequence of events according to the nesting of the elements, and hence it is not possible to skip reading parts of the document as this would change the semantics of the API. On the other hand, DOM allows users to explicitly navigate in the XML document using methods like `getFirstChild()` and `getNextSibling()`. DOM is the most popular interface to traverse XML documents because of its ease of use. But there are also other existing XML programming interfaces like XML data binding (which provides an automated translation between an XML document and programming-language objects) and Declarative transformation languages such as XSLT and XQuery. An alternative to SAX streaming interface is also Pull Parsing (XMLAPI, 2011).

Because there are several XML parsing techniques, involving different techniques from Simple API for XML (SAX) to XML DOM, getting of eXtensible *Stylesheet* Language for Transformation (XSLT) to take care of the style presentation. But one thing that is missed is as simple way to read an XML schema, perceiving its structure and types, and present it to the user, in an understanding view.

Thus, an algorithm that reads the XML schema into a database has been developed, recreating its structure herarchical into a database and then rendering into a layout. So, it takes uses of XML Reader to read the main elements and types, and then through a recursive algorithm getting deep into the hierarchical structure, but its through an agent that the software makes its decision to go deeper into the structure and also keeping the track of the type of element navigated.

For the algorithm it has been used a recursive-descent type, top-down parser, which mimics a tree structure and stores in a database. It is an adaptation of parsing algorithms, Pull parser. The innovation/improvement that is sought to introduce is the fact that it is applied to an XSD Schema file in a web application.

Figure 51 presents the activity diagram of the workflow for the XML parsing feature, where it implements the pull parsing algorithm adaptation for this system.

Pull parsing treats the document as a series of items which are read in sequence using the Iterator design pattern. This allows for writing of recursive-descent parsers in which the structure of the code performing the parsing mirrors the structure of the XML being parsed, and intermediate parsed results can be used and accessed as local variables within the methods performing the parsing, or passed down (as method parameters) into lower-level methods, or returned (as method return values) to higher-level methods.

Examples of pull parsers include StAX in the Java programming language, XMLReader in PHP and System.Xml.XmlReader in the .NET Framework.

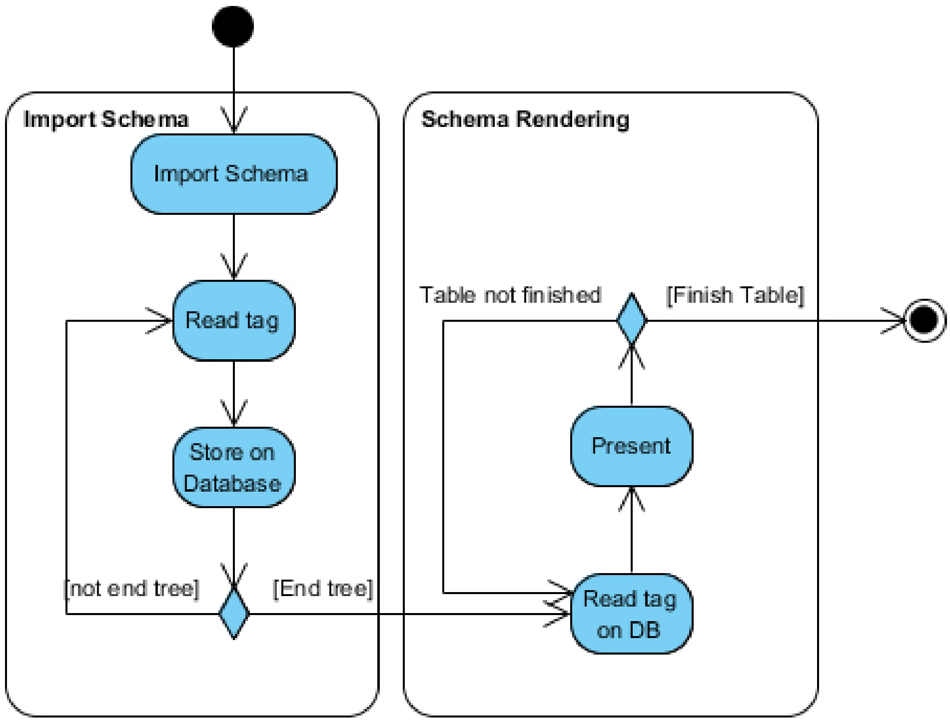


Figure 51. XML Parsing activity diagram

A pull parser creates an iterator that sequentially visits the various elements, attributes, and data in an XML document. Code which uses this iterator can test the current item (to tell, for example, whether it is a start or end element, or text), and inspect its attributes (local name, namespace, values of XML attributes, value of text, etc.), and can also move the iterator to the next item.

The code can thus extract information from the document as it traverses it. The recursive-descent approach tends to lend itself to keeping data as typed local variables in the code doing the parsing, while SAX, for instance, typically requires a parser to manually maintain intermediate data within a stack of elements which are parent elements of the element being parsed. Pull-parsing code can be more straightforward to understand and maintain than SAX parsing code (XMLAPI, 2011).

Using Streaming interfaces, like the one provided by XmlTextReader, give better performance and scalability, compared to loading large XML documents into the

XmlDocument or XPathDocument classes and then using DOM manipulation (Microsoft, 2011).

The DOM creates an in-memory representation of the entire XML document. The XmlTextReader is different from the DOM because XmlTextReader only loads 4-kilobyte (KB) buffers into memory. If used the DOM to process large XML files, it can be typically consumed memory equivalent to three or four times the XML document size on disk (Microsoft, 2011).

Thus, for this process it uses an ASP.Net Web Application, using the XML Class for the XML Parser, XmlTextReader and its properties and methods, like GetAttribute(), Read(), LocalName(),IsStartElement(), among ohters methods. In Figure 52 is presented a snippet of the parsing code illustrating the technical details of the feature.

```
        Dim str As String = ""
        Dim cont As Integer = 0
        Dim m_xmlr As XmlTextReader
        Dim m_xmlr2 As XmlTextReader
        'Create the XML Reader
        m_xmlr = New XmlTextReader("c:\imsmd_v1p2p4.xsd")
        m_xmlr2 = New XmlTextReader("c:\imsmd_v1p2p4.xsd")
        m_xmlr.WhitespaceHandling = WhitespaceHandling.None
        m_xmlr2.WhitespaceHandling = WhitespaceHandling.None
        'read the xml declaration and advance to family tag
        While Not m_xmlr.EOF
            m_xmlr.Read()
            If  (m_xmlr.LocalName.ToString  =  "element")  And  (m_xmlr.IsStartElement  =
True) Then
                Try
                    If m_xmlr.GetAttribute("name").ToString() <> "" Then
                        If str = "" Then
                            str = m_xmlr.GetAttribute("name").ToString()
                        Else
                            str = str & "," & m_xmlr.GetAttribute("name").ToString()
                        End If
                        cont += 1
                    End If
                Catch ex As Exception
                    Continue While
                End Try
            End If
        End While
        m_xmlr.Close()
        '----------------------------------------
        Dim val(cont - 1) As Boolean
        Dim str_val() As String = str.Split(",")
        Dim str2 As String = ""
        Dim nodi As String = ""
        Dim nodo As String = ""
        Dim str_ref As String = ""
        Dim raiz As String = ""
        Dim nodo_ind As String = ""
        Dim i As Integer 'tip As Integer
        For i = 0 To cont - 1
            val(i) = False
        Next i
        While Not m_xmlr2.EOF
```

```
            m_xmlr2.Read()
            If (m_xmlr2.LocalName.ToString = "element") And (m_xmlr2.IsStartElement =
True) Then
                Try
                    If m_xmlr2.GetAttribute("ref").ToString() <> "" Then
                        For i = 0 To cont - 1
                            If (m_xmlr2.GetAttribute("ref").ToString() = str_val(i))
Then
                                val(i) = True
                                Exit For
                            Else
                                str2 = str2 & str_val(i)
                            End If
                        Next i
                    End If
                Catch ex As Exception
                    Continue While
                End Try
            End If
        End While
        'close the reader
        m_xmlr2.Close()
        Dim ra As String = ""
        For i = 0 To cont - 1
            If val(i) = "False" Then
                ra = str_val(i)
                raiz = str_val(i) & ",0"
                nodo_ind = "0"
            End If
        Next i
        nodo = raiz
        Dim para As Integer = 0
        Dim nodo_type As String = ""
        Dim par As Object = System.DBNull.Value
        insert_schema()
        insert_db(nodo_ind, ra, par, nodo_type)
        define_hierarq(nodo_ind, raiz, nodo, para)
    End Sub
```

Figure 52. Snippet of the XML parsing feature

Besides, uses the SQL Class and methods, like SQL Conection, SQLCommand and SQLParameter for the database operations like connection, command execution and definition of parameters, as presented in the snippet of the Figure 53.

This snippet presents an example of these commands for the insert Schema root operation.

```
    Private Sub insert_db_root(ByVal nodo_index, ByVal newroot, ByVal root_current,
ByVal node_type)
        Dim ndpar As Integer
        Dim cn As New SqlConnection
        Try
            cn.ConnectionString = "Data Source=SERVER7\SQLEXPRESS;Initial
Catalog=schemamap;Integrated Security=True;Pooling=False"
            cn.Open()
            ndpar = select_node_par(root_current, cn)
            Dim cmd As New SqlCommand
            cmd.Connection = cn
            cmd.CommandType = Data.CommandType.Text
            cmd.CommandText = "INSERT INTO
tb_node_template_person([id],[nodeind],[name],[type],[control],[parent],[idparent],[no
deval])values(1,@r,@nm,@ty,@c,@p,@ip,NULL)"
```

```
        Dim p2 As New SqlParameter
        p2.Direction = Data.ParameterDirection.Input
        p2.SqlDbType = Data.SqlDbType.VarChar
        p2.ParameterName = "@r"
        p2.Value = nodo_index
        Dim p3 As New SqlParameter
        p3.Direction = Data.ParameterDirection.Input
        p3.SqlDbType = Data.SqlDbType.VarChar
        p3.ParameterName = "@nm"
        p3.Value = newroot
        Dim p4 As New SqlParameter
        p4.Direction = Data.ParameterDirection.Input
        p4.SqlDbType = Data.SqlDbType.VarChar
        p4.ParameterName = "@ty"
        p4.Value = node_type
        Dim p5 As New SqlParameter
        p5.Direction = Data.ParameterDirection.Input
        p5.SqlDbType = Data.SqlDbType.VarChar
        p5.ParameterName = "@c"
        p5.Value = ""
        Dim p6 As New SqlParameter
        p6.Direction = Data.ParameterDirection.Input
        p6.SqlDbType = Data.SqlDbType.VarChar
        p6.ParameterName = "@p"
        p6.Value = root_current
        Dim p7 As New SqlParameter
        p7.Direction = Data.ParameterDirection.Input
        p7.SqlDbType = Data.SqlDbType.Int
        p7.ParameterName = "@ip"
        p7.Value = ndpar
        Dim p8 As New SqlParameter
        p8.Direction = Data.ParameterDirection.Input
        p8.SqlDbType = Data.SqlDbType.VarChar
        p8.ParameterName = "@v"
        p8.Value = root_current

        cmd.Parameters.Add(p2)
        cmd.Parameters.Add(p3)
        cmd.Parameters.Add(p4)
        cmd.Parameters.Add(p5)
        cmd.Parameters.Add(p6)
        cmd.Parameters.Add(p7)
        cmd.Parameters.Add(p8)
        cmd.ExecuteNonQuery()
    Catch ex As SqlException
        If (cn.State = Data.ConnectionState.Open) Then
            cn.Close()
        End If
    Catch ex As Exception
    End Try
End Sub
```

Figure 53. Snippet of the XML to Database operations

The algorithm is also applied in the descent recursive path but for the presentation of the tags in a Treeview as web controls (i.e. textboxes, legend, etc.).

It reads the database for the tag and the type, and maps the type with a specific web control (i.e. string – textbox, etc.).

Figure 54 presents a diagram with the concepts involved in the algorithm.

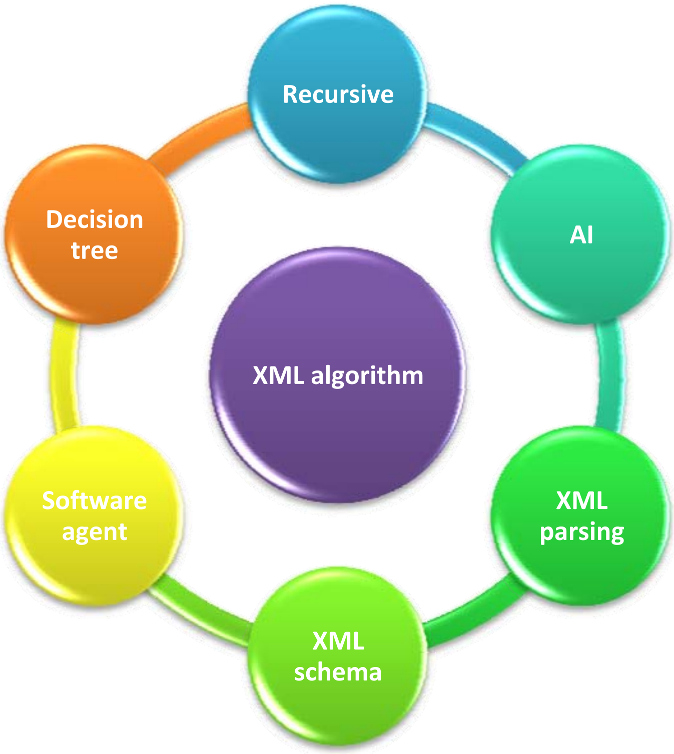


Figure 54. XML algorithm

This tool is also used in the AHKME LD for parsing the LD XML schema for structuring the learning units.

3.4.2.1.2. AHKME-LD: Learning Design

The part of the subsystem referring to the Learning Design provides a tool (see Figure 57) where teachers can define learning design components, create and structure courses using standards and specifications (e.g. IMS LD specification) to define activities, sequence and users' roles, and to define metadata to describe the courses.

The component diagram in Figure 55 illustrates the technical architecture of the LD tool with both logical and physical components, along with the artifacts that implement them and the nodes on which they are deployed and executed:

- ❖ Web Application component using a .Net XML Class for the XML Schema manipulation and also a .Net SQL Class for the database operations. This component required these interfaces to implement the XML Schema Parser.

❖ LD Rendering component uses a Treeview Class, a MSSQL Database and the schema parser for the LD Rendering.

❖ The User interacts with the LD Tool, specifically through the LD editing interface.

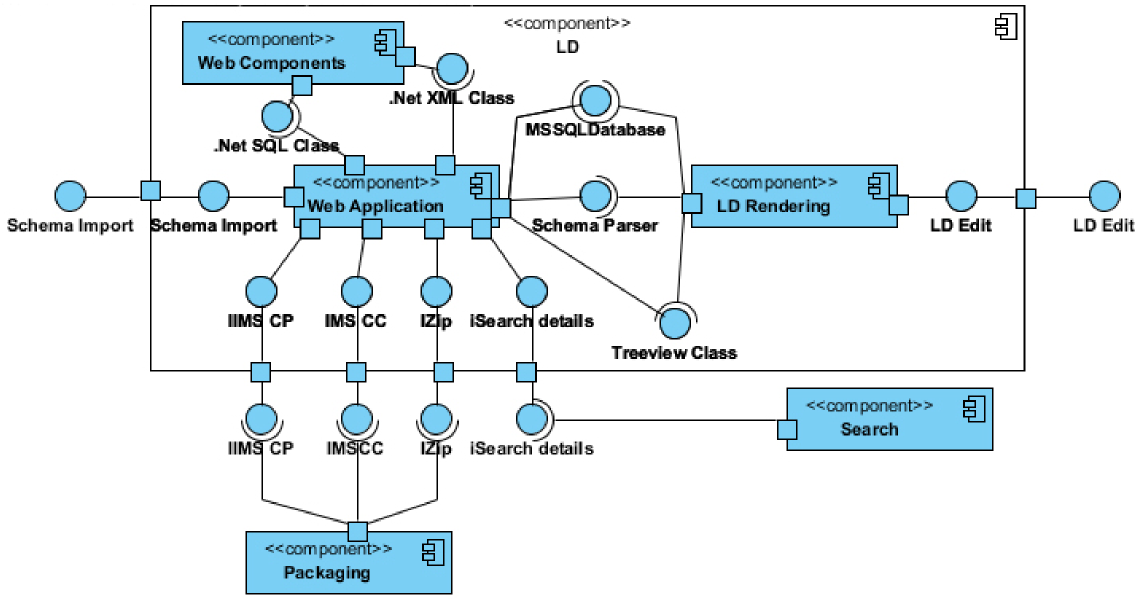


Figure 55. LD component diagram

❖ Search component that uses an interface to implement the search mechanism (explained later in this chapter).

❖ Packaging component uses the IMS and IZip interfaces to implement the packaging creation feature.

In the process of course creation a XML manifest is generated gathering all the XML files associated with the course, as well as all the LO, metadata and resource files needed for the course.

The system through this tool, described on Figure 56, allows the design of learning units where the participants can assume different roles.

These roles can be student or staff, it makes possible collaborative and group learning, whose importance is recognized at the training and educational levels (Graf & List, 2005).

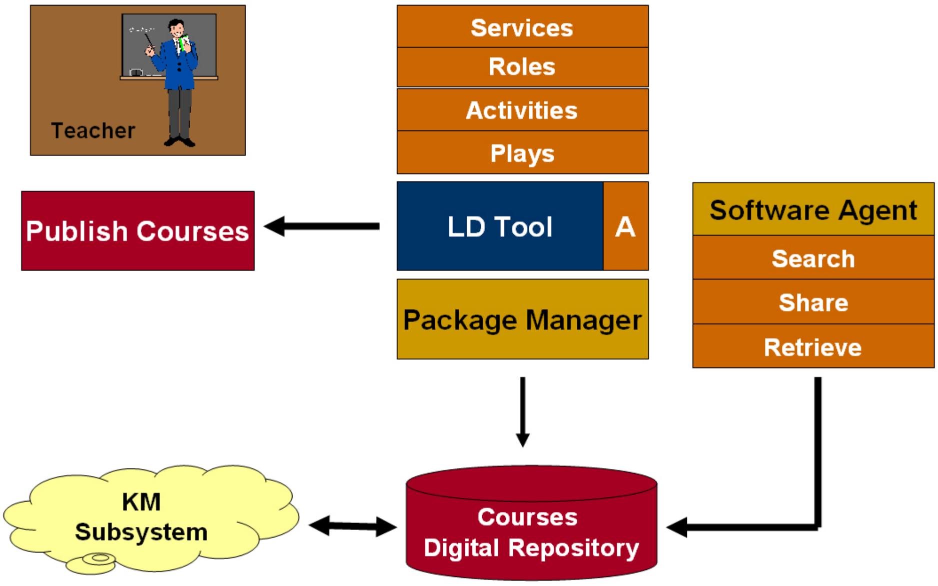


Figure 56. LD tool overview

The use of the IMS LD (Koper et al., 2003) 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 elearning systems like the *Learning Management Systems* (LMS). In Figure 57 is presented as screenshot of this tool.

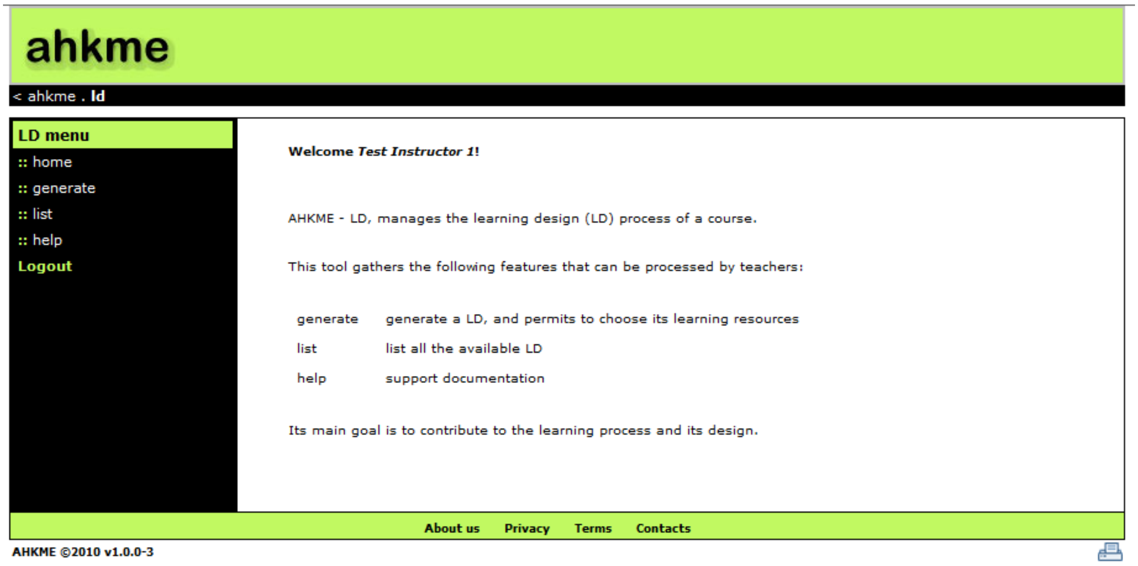


Figure 57. LD tool

This tool also provides the creation of packages with the courses that are also stored in a data repository, to reach a more efficient management and communicates with the knowledge management subsystem in order to evaluate the courses.

After the evaluation, this tool allows the restructuring of courses allowing the user to interact with the LD process.

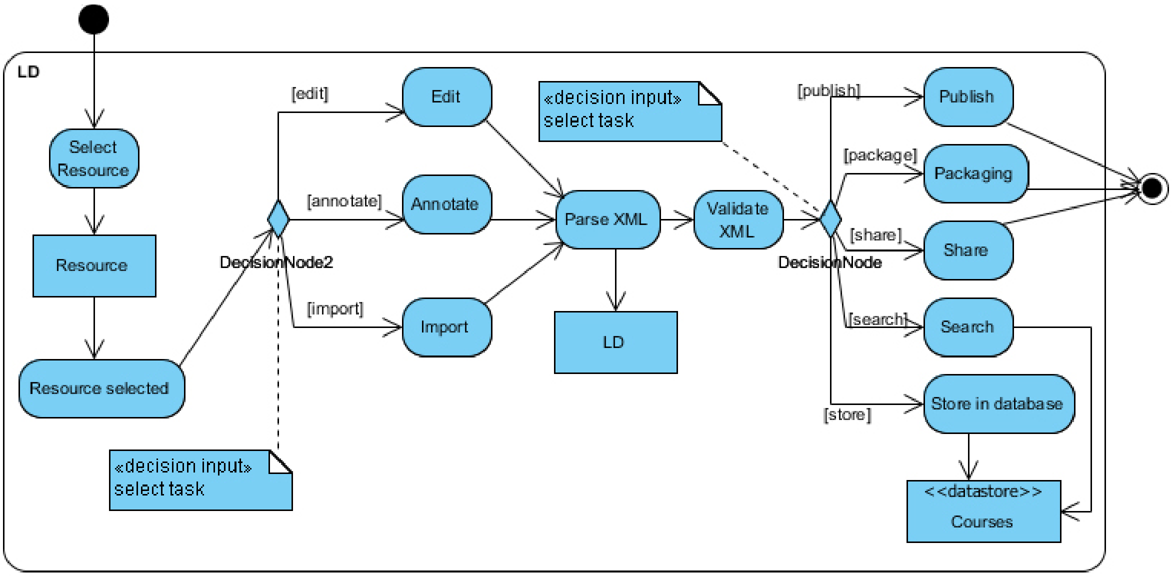


Figure 58. LD activity diagram

The workflow presented in the activity diagram in Figure 58 indicates for starting point the selection of the resource then can be alternativelly chosen the edit, annotate or import option, after this choice the XML of the LD is parsed and validated according the XML schema, and finally can follow different paths, depending of the feature choice – publish, share, packaging as ending point or as alternative stored in database or be searched for reuse.

3.4.2.1.3. AHKME-Instructional Manager

This tool introduces some new features to the elearning systems state-of-art, because it permits to manipulate and manage the schemas of the educational standards and even to create new schemas or customize the existing.

Figure 59 shows the workflow of the instructional management in the activity diagram.

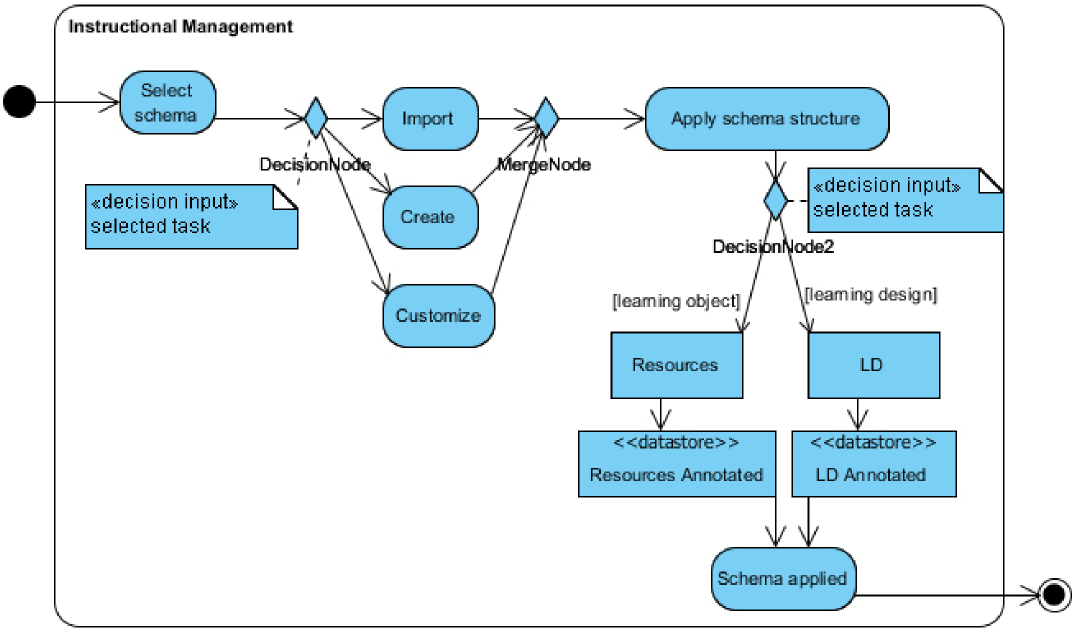


Figure 59. Instructional management activity diagram

The workflow starting point is the selection of the schema then is alternativelly chosen the edit, annotate or import option, finally for end point, the schema structure is applied for the annotation of the resource or LD.

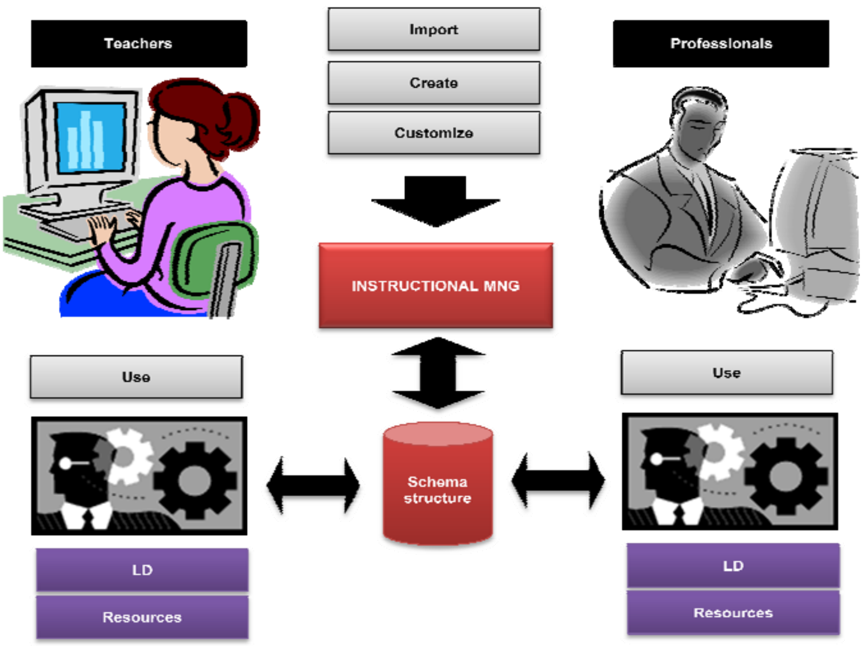


Figure 60. Instructional manager tool sctructure

Figure 60 shows this tool, where teachers and professionals have features for managing the learning structure and also database access to the data structure.

In AHKME this tool has a combination of import, use, create and list main features and gives at the main screen an overview of what teachers have at their disposal, as illustrated in Figure 61.

Figure 61. Insctructional manager main screen

As shown in Figure 62 this tool gives the possibility to import a schema file from a specific educational standard or specification, use it to structure the learning design or customize it to adapt it ro the teachers, student or context characteristics.

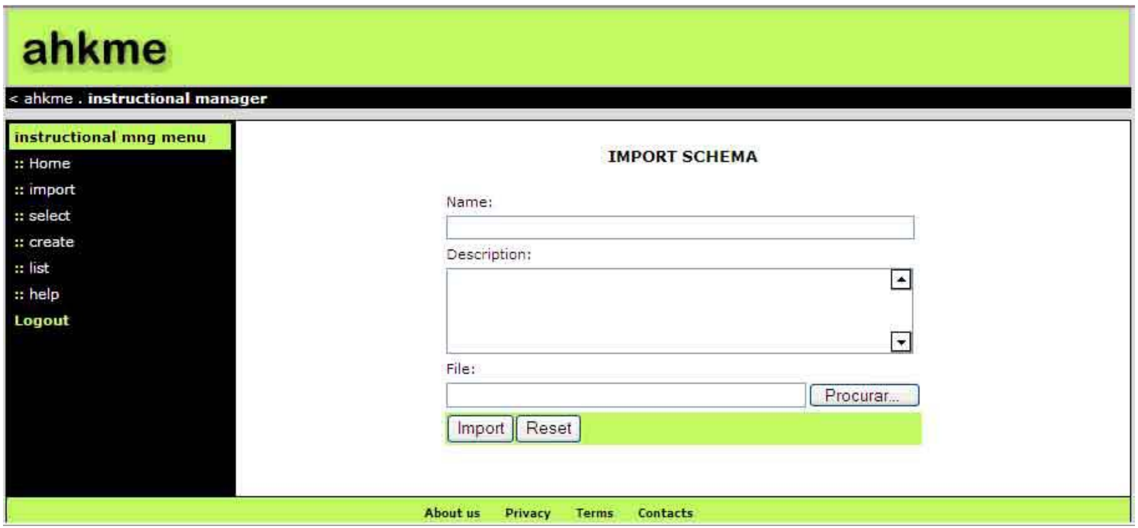


Figure 62. Import schema feature

Plus, it already integrates the IMS specifications as support for teachers to structure their learning resources (see Figure 63).

Also, if any of these features satisfy the teacher's needs or expectations in terms of flexibility or learning design, it permits the creation of a new schema for use in a new learning design and resources.

Figure 63. Schemas list

3.4.2.1.4. Other features

This subsystem integrates also features regarding collaboration and search mechanism.

Thus, for facilitate the collaboration among teachers it uses the workflow tool (explained later in this chapter), creating workflow process that passes from teacher to instructors to help to optimize the learning design and instructional process.

Also, it take use of the search tool (explained later) to find specific learning objects and learning designs for reusing for specifc application, like similar contexts, customization, or simply reuse for the same learning context.

3.4.2.2. AHKME-ADAPTATION SUBSYSTEM

First, it is important to go over the concepts, Adaptivity versus Adaptability, their difference and contribution to this subsystem.

An interesting aspect of adaptive hypermedia is that it makes distinction between adaptation (system-driven personalisation and modifications) and adaptability (user-driven personalisation and modifications). One way of looking at it is that adaptation is automatic, whereas adaptability is not. From an epistemic point of view, adaptation can be described as analytic, a-priori, whereas adaptability is synthetic, a-posteriori. In other words, any adaptable system, as it "contains" a human, is by default "intelligent", whereas an adaptive system that presents "intelligence" is more surprising and thus more interesting. This conforms with the general preference of the adaptive hypermedia research community, which considers adaptation more interesting. However, the truth of adaptive hypermedia systems is somewhere in the middle, combining and balancing adaptation and adaptability (Adaptive-hypermedia, 2009).

Taking this aspect into account, we develop the adaptation subsystem, balancing these concepts, by one side a more automatic tool and by the other a collaborative tool. By this mean we have a software agent that apply data mining techniques for doing adaptation recommendations more content-centered, and by the other side we have a more collaborative tool, implementing mainly a workflow process for the adaptability of the learning design and resources, more user-centered.

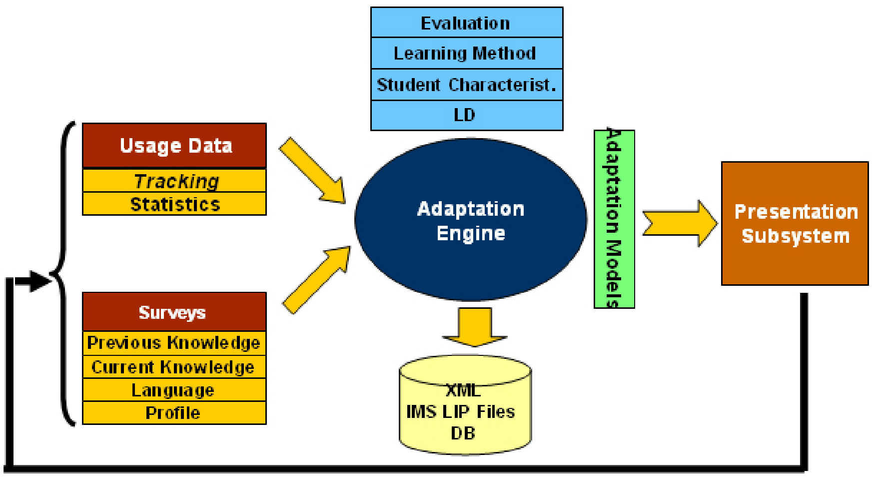


Figure 64. Adaptation tool architecture

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

One feature provided by this subsystem allows the user to fill inquiries, based on data and metadata about the student, defined by the standard/specification (e.g. IMS Learning Information Package - LIP specification) like described in Figure 64.

Based on the standard/specification schema (e.g. IMS LIP specification) it describes the characteristics (language, previous and actual knowledge about a certain context, etc.) of the students, necessary for general management and storage of historical data about learning, objectives and tasks developed (Smythe, Tansey, & Robson, 2001) (Smythe, 2005).

Based on the results of the inquiries an agent automatically generates adaptive recommendations, to generate models of adaptation that will reflect on the presentation of the resources. This information is stored in XML files and this subsystem allows the creation of packages with this information, which is stored in a data repository to facilitate its management (Brusilovsky & Nejdl, 2004).

These adaptive systems along with knowledge management system can provide information for teachers to rethink the content and structure of their courses and resources, and help them to customise the courses according to the students' needs (Jovanović, 2008).

Thus, an agent registers the feedback of students and teachers regarding course usage, according to specific schema structure, so that this information feeds the adaptive subsystem in order to be considered on the LD process in similar contexts.

3.4.2.2.1. Recommendation tool

The recommendation tool works as a suggestion feature giving Learning designers tips of what to adapt in learning resources. Thus, it uses some data mining techniques like decision trees and classification algorithms to reach the attribute importance according to educational specification or metadata of the resource.

As shown in Figure 65, according to the metadata stored in databases, this tool applies data mining techniques, by creating decision trees to find the more important attribute.

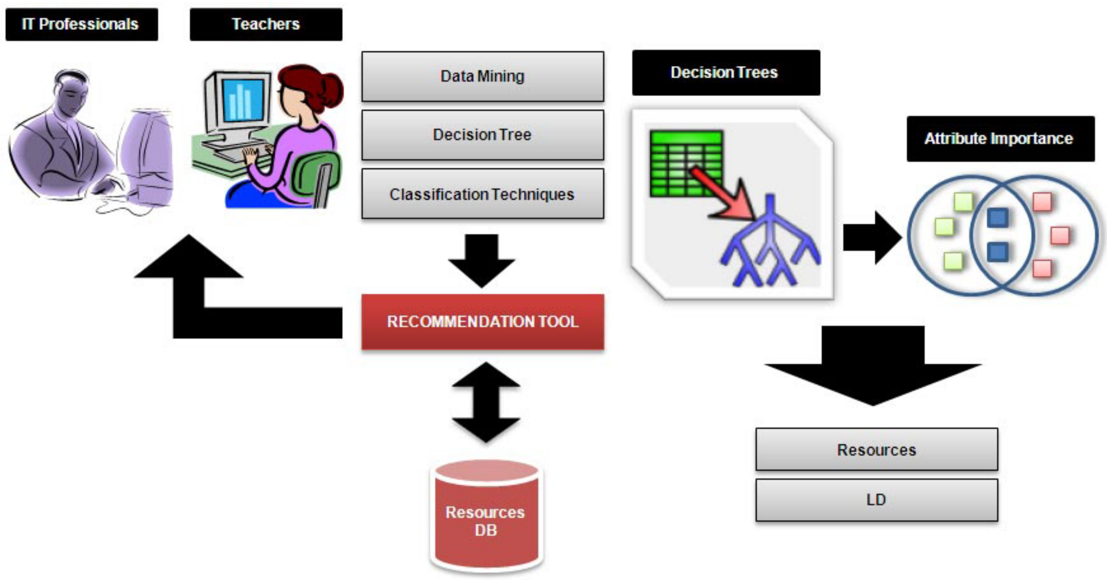


Figure 65. Recommendation tool structure

Figure 66 illustrates this feature, specifically the attribute importance.

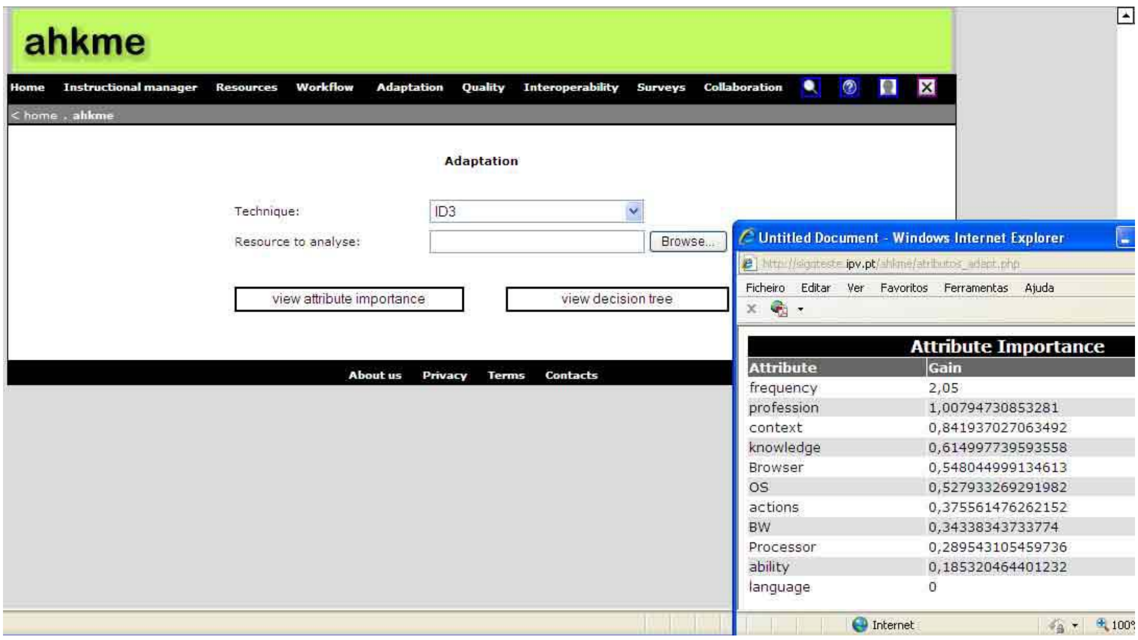


Figure 66. Adaptation tool - Attribute importance

Fot this purpose it implements three different types of alghoritms:

- ❖ ID3 - In decision tree learning, ID3 (Iterative Dichotomiser 3) is an algorithm used to generate a decision tree invented by Ross Quinlan.
- ❖ C4.5 - C4.5 is an algorithm used to generate a decision tree developed by Ross Quinlan. C4.5 is an extension of Quinlan's earlier ID3 algorithm (Quinlan, 1993).

- CHAID - CHAID is a type of decision tree technique, based upon adjusted significance testing (Bonferroni testing) (Hawkins & Kass, 1982).

The ID3 algorithm can be summarized as follows (Colin, 1996):

- Take all unused attributes and count their entropy concerning test samples.
- Choose attribute for which entropy is minimum (or, equivalently, information gain is maximum).
- Make node containing that attribute.

C4.5 made a number of improvements to ID3. Some of these are (Quinlan, 1993):

- Handling both continuous and discrete attributes - In order to handle continuous attributes, C4.5 creates a threshold and then splits the list into those whose attribute value is above the threshold and those that are less than or equal to it.
- Handling training data with missing attribute values - C4.5 allows attribute values to be marked as ? for missing. Missing attribute values are simply not used in gain and entropy calculations.
- Handling attributes with differing costs.
- Pruning trees after creation - C4.5 goes back through the tree once it's been created and attempts to remove branches that do not help by replacing them with leaf nodes.

The acronym CHAID stands for *Chi*-squared Automatic Interaction Detector. This name derives from the basic algorithm that is used to construct (non-binary) trees, which for classification problems (when the dependent variable is categorical in nature) relies on the *Chi*-square test to determine the best next split at each step; for regression-type problems (continuous dependent variable) the program will actually compute F-tests (Hawkins & Kass, 1982).

Thus, it can be summarized as:

- Preparing predictors. The first step is to create categorical predictors out of any continuous predictors by dividing the respective continuous distributions into a number of categories with an approximately equal number of observations.

- ❖ Merging categories. The next step is to cycle through the predictors to determine for each predictor the pair of (predictor) categories that is least significantly different with respect to the dependent variable
- ❖ Selecting the split variable. The next step is to choose the split the predictor variable with the smallest adjusted *p*-value,
- ❖ Continue this process until no further splits can be performed (given the alpha-to-merge and alpha-to-split values).

In Figure 67 is shown the possibility for selection of these three algorithms to apply for classification purposes.

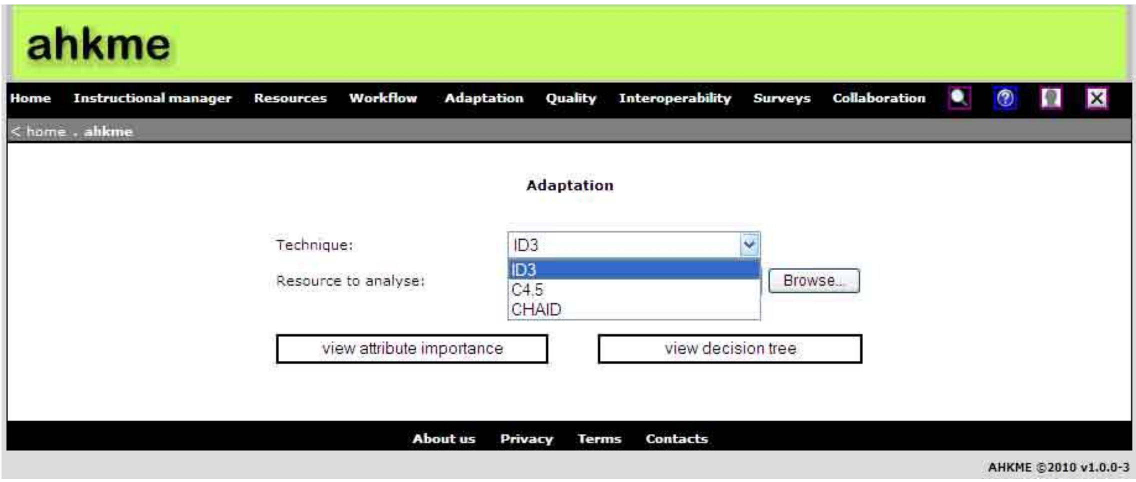


Figure 67. Adaptation tool – Alghoritms

This tool has been used to determine the most important attributes that the users should take into account in order to adapt the resources regarding the quality evaluation that the resources had.

In this case it starts to gather metadata from attributes regarding presentation of the resources like context, language, or performance like browser, processor, or user knowledge, profession, etc, as base cases and applies the data mining technique, to reach the decision tree and finally the most important attribute for the definition of the tree.

First, it transforms the XML file of the resources, the base cases, into a table so the attributes can be easily manipulated. It starts to import the table as a set.

For each attribute of the set it begins to calculus the entropy and the information gain in order to find the one to create a decision node. It then creates the node and stores this information on a file.

Then creates a subset of the previous set without the attribute selected for the decision node and recursively finds the following decision nodes and stores them a file.

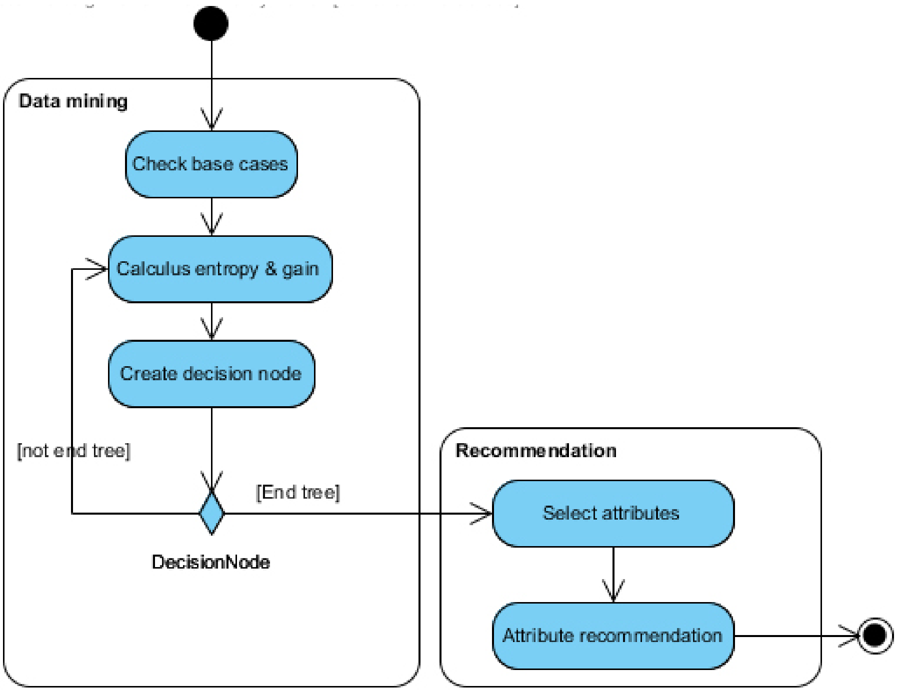


Figure 68. Reccommendation tool activity diagram

The most important attributes are considered for recommendation to use in process of adaptation of the resources that is based on the initial calculus of the information gain of the attributes that determines a ranking of the most significant attributes to evaluate the resources. When the information gain is calculated it is stored on file so it can be presented to the users.

Figure 68 presents the activity diagram of the workflow for the recommendation feature process.

In pseudocode, the general algorithm for building decision trees and recommendation is:

1. Collect set of base cases.
2. For each attribute of the set.
    a. Calculus entropy and information gain.

3. Create a decision node that splits on the attribute with the highest information gain.
4. Recurse on the subset obtained by splitting on the attribute with the highest information gain, and add those nodes as children of node.
5. Selects and recommends attributes based on their highest information gain ranking.

In Figure 69 is presented a snippet with an example of the implementation of this pseudocode to the calculus of the entropy of the attributes.

```
Public Function calcula_entropia(ByVal val As ArrayList, ByVal total_reg As Integer,
ByVal arrElementos As ArrayList, ByVal elemento As String, ByVal valores_elem_class
As ArrayList) As Double
        Dim entrop As Double = 0
        Dim ratio As Double = 0
        Dim logaritmo As Double = 0
        Dim  posicao_elemento  As  Integer  =  retorna_posicao_elemento(arrElementos,
elemento)
        For i As Integer = 0 To valores_elem_class.Count - 1
            ratio                    =                  (retorna_num_amostras_valor(val,
valores_elem_class.Item(i).ToString, posicao_elemento) / total_reg)
            If ratio = 0 Then
                logaritmo = 0
            Else
                logaritmo = System.Math.Log(ratio, 2)
            End If
            entrop = entrop + ((-ratio) * logaritmo)
        Next
        ratio = Nothing
        logaritmo = Nothing
        posicao_elemento = Nothing
        Return entrop
    End Function
```

Figure 69. Snippet of the function to entropy calculus

In this function is calculated the entropy with an algorithm with the following steps:

1. Receives the following parameters:

- ❖ Array of the values of the set or subset.
- ❖ The total number of registers of the set or subset.
- ❖ Array of the attributes of the set or subset.
- ❖ Name of the attribute for which the entropy is being calculated.
- ❖ Array of values for which attribute the entropy is being calculated.

2. Gets the position on the attribute array of the attribute for which the entropy is being calculated.

3. For each value of the attribute that the entropy is being calculated as "*ab*":

- ❖ Calculus the ratio between the number of registers that have the value "*ab*" on the set or subset of the selected attribute and the total number of registers of the set or subset.
- ❖ Calculus the logarithm taking into account the ratio.
- ❖ Calculus the entropy.

4. Return the entropy value.

In Figure 70 is presented the generation of the attribute with the most gain, in the process of recommendation of the most attribute importance for adaptation.

```
    Public Function retorna_atributo_com_maior_ganho(ByVal valores As ArrayList,
ByVal elementos As ArrayList, ByVal total_registos As Integer, ByVal entropia As
Double, ByVal elemento_classificacao As String, ByVal valores_elem_class As
ArrayList, ByVal nivel As Integer) As String
        Dim i As Integer
        Dim ganho As Double = 0
        Dim ganho_tmp As Double = 0
        Dim ele As String = ""
        For i = 0 To elementos.Count - 1
            If elementos.Item(i).ToString <> elemento_classificacao Then
                Dim str_valores As ArrayList = New ArrayList
                Dim entropia_elem As Double = 0
                Dim posicao_elemento As Integer = retorna_posicao_elemento(elementos,
elementos.Item(i).ToString)
                str_valores = retorna_valores(valores, posicao_elemento)
                ganho = calcula_ganho(valores, elementos, total_registos, entropia,
elemento_classificacao, str_valores, posicao_elemento, valores_elem_class)
                If nivel = 0 Then
                    gera_ficheiro_output("atributos.txt", elementos.Item(i).ToString
& ";" & ganho)
                End If
                str_valores = Nothing
                entropia_elem = Nothing
                posicao_elemento = Nothing
                If ganho > ganho_tmp Then
                    ganho_tmp = ganho
                    ele = elementos.Item(i).ToString
                End If
            End If
        Next
        ganho = Nothing
        i = Nothing
        Return ele
    End Function
```

Figure 70. Snippet of the function that generates the attribute with the most gain

In this function is calculated the entropy with an algorithm with the following steps:

1. Receives the following parameters:

   - ❖ Array of the values of the set or subset.
   - ❖ Array of the attributes of the set or subset.
   - ❖ The total number of registers of the set or subset.

- The entropy value.
- The classification attribute.
- Array of values of the classification attribute .
- Tree level.

2. For each element that is not the classification attribute as "*ab*":
   - Gets the position of "*ab*" on the set or subset of the attributes.
   - Gets the values of "*ab*".
   - Calculus the gain of "*ab*".
   - If the level of the tree is 0 writes the gain of "*ab*" to a file.
   - Stores "*ab*" gain and its name if its gain is the highest.
3. Returns the name of the attribute with the highest gain.

3.4.2.2.2. Collaborative tool

Other tool that gives a great contribution to the adaptation subsystem is the workflow tool, because it permits and introduces a concept of collaboration adaptability among teachers and instructors.

Figure 71. Collaborative tool

As illustrated in the Figure 71, the teachers and instructors initiates a workflow process for LD or LO adaptability purposes, then it passes through a collaboration process among these professionals to reach a more adaptive user-centered LD or LO.

In Figure 72 the activity diagram shows this workflow starting the collaboration process by sending the resource for adaptation from the Learning designer to the Instructors, then each teacher contributes in the adaptation and the process repeats until the collaboration finishes.

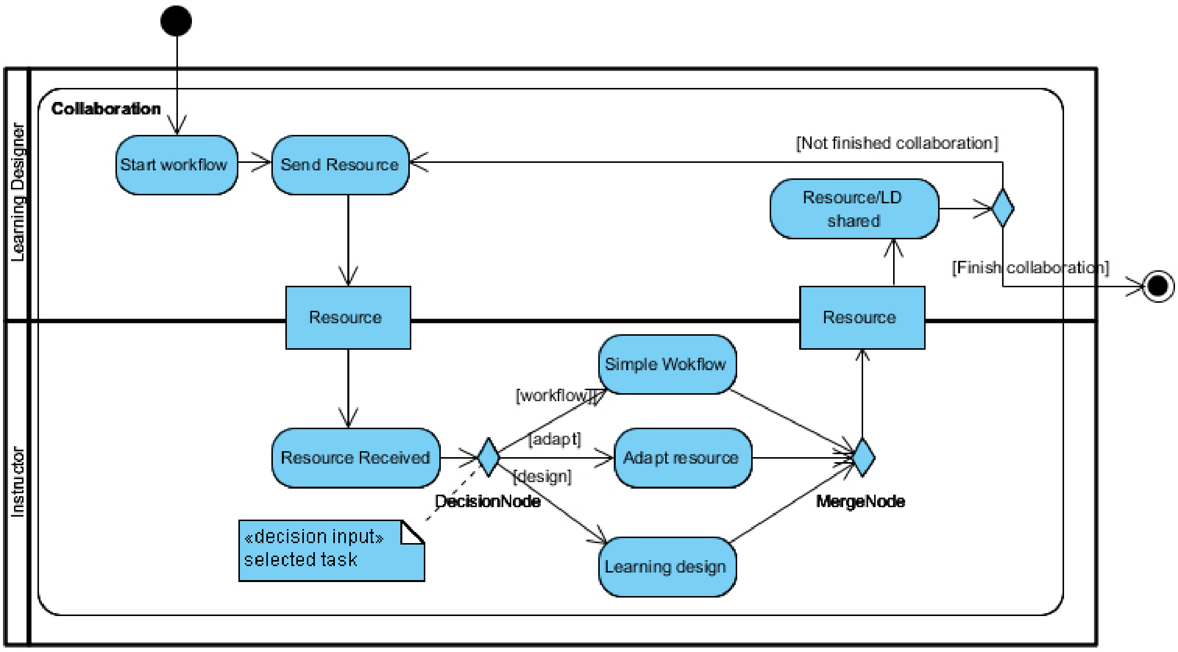


Figure 72. Collaborative tool activity diagram

3.4.2.3. Cross-cutting tools

As presented before, there are several cross-cutting tools in AHKME that work to complement the subsystems.

These tools are organized in two blocks:

- ❖ Collaboration tools.
    - o Workflow.
    - o Communication and sharing.

- Feedback/Survey.

- ❖ Funcional tools.
  - Search, Help, Interoperability and Administrative tools.

3.4.2.3.1. Collaboration tools

In AHKME the collaboration tool gives the possibility for users to collaborate in the learning and teaching process.

Thus, there are different collaboration tools regarding the application context:

- ❖ Communication and sharing tools, for interaction experience.
- ❖ Workflow tool, for organization purposes.
- ❖ Survey tool, for feedback purposes.

3.4.2.3.1.1. Communication and sharing tools

These tools permit the user to communicate to other ones, but also to share resources and learning experiences.

Thus, there are several features regarding these tools:

- ❖ Communication tools.
  - Syncronous tool, Chat and Board/White Board.
  - Assyncronous tool like Foruns.
- ❖ Sharing tools.
  - Resources.
  - Groups (see Figure 73).
  - Multimedia features – Photos, Music, Videos, Blogs, Polls and People.

Figure 73. Communication & sharing tool – Groups

3.4.2.3.1.2. AHKME-feedback

AHKME feedback comes mainly from surveys and more specifically the tool (see Figure 74) that gives the possibility for Learning designers, Instructors to get feedback from Students about their learning process and the resources interaction.

Figure 74. Survey tool

The feedback data are stored to be used later in the learning design process.

3.4.2.3.1.3. AHKME-workflow

AHKME has also core collaboration features, in this case a workflow tool that gives the possibility to users to collaborate in the learning design process.

A workflow tool as illustrated in Figure 75 permits the automation of a business process, person-to-person passing of documents, tasks, for taking actions, according to specific procedural rules.

In this case, the workflow works for the automation of the learning process, during which, information, resources passes from teacher to instructor, for taking specific learning design actions.

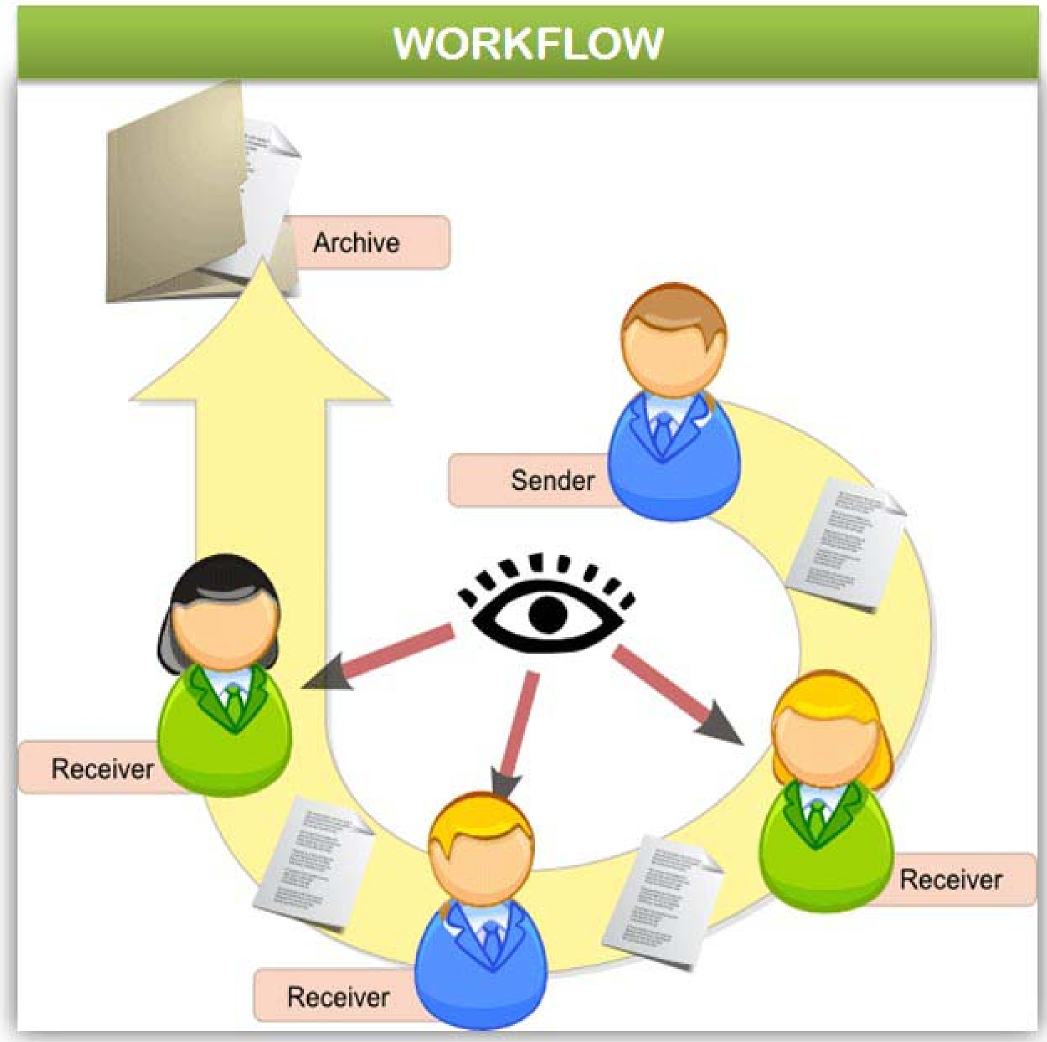


Figure 75. Workflow process overview

Thus, this tool, illustrated in Figure 76, can act in different ways:

- Learning design collaboration – Permit passing the working resource from teacher to teacher to structure the learning design for a specific context.
- Learning resource adaptation - Permit passing the working resource from teacher to teacher to adapt a learning design or resource according to specific context or feedback suggestion.
- Simple workflow process – Basic workflow feature at disposal of teachers for instructional purposes.

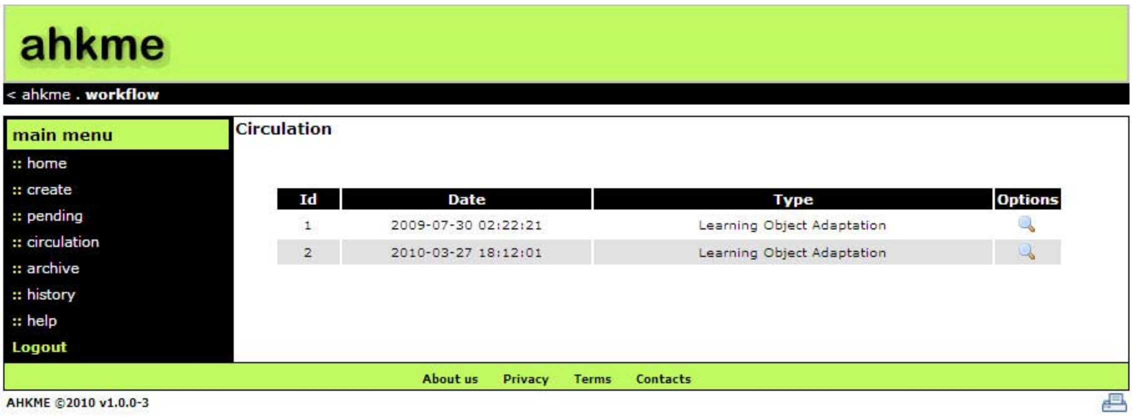


Figure 76. Workflow tool

3.4.2.3.2. Functional tools

The functionals tools that are present at the whole system are mainly two:

- Search tool, for searching functionaties.
- Help tool, for helping the user support.

The other functional tools are the interoperability and the administrative tools respectively.

3.4.2.3.2.1. Search tool

This tool is multifunctional because it works for teachers and instructors to search for learning objects, but also learning designs, schemas and learning resources.

As shown in Figure 77, this tool searchs both in XML files and databases, using metadata, keywords or SQL statements for this purpose.

Figure 77. Search tool diagram

Figure 78 presents the searching tool main screen.

Figure 78. Search tool

The search engine is based on an intelligent agent that receives as inputs the tag elements for search and retrieval.

As shown in the diagram in Figure 79, as starting point the user enters the keyword, metadata, title and the algorithm implements a tree search in the XML files and/or a SQL search in the database.

Now, examine that tree either from the roots out or from the leaves in. This is how a tree search algorithm works. The algorithm searches a data set from the broadest to the most narrow, or from the most narrow to the broadest. Data sets are like trees; a single piece of data can branch to many other pieces of data, and this is very much how the Web is set up. Tree searches, then, are more useful when conducting searches on the Web, although they are not the only searches that can be successful.

One of the difficulties with a tree search is that it is conducted in a hierarchical manner, meaning it's conducted from one point to another, according to the ranking of the data being searched.

Thus, the tool implements also a SQL search that allows data to be searched in a non-hierarchical manner, which means that data can be searched from any subset of data.

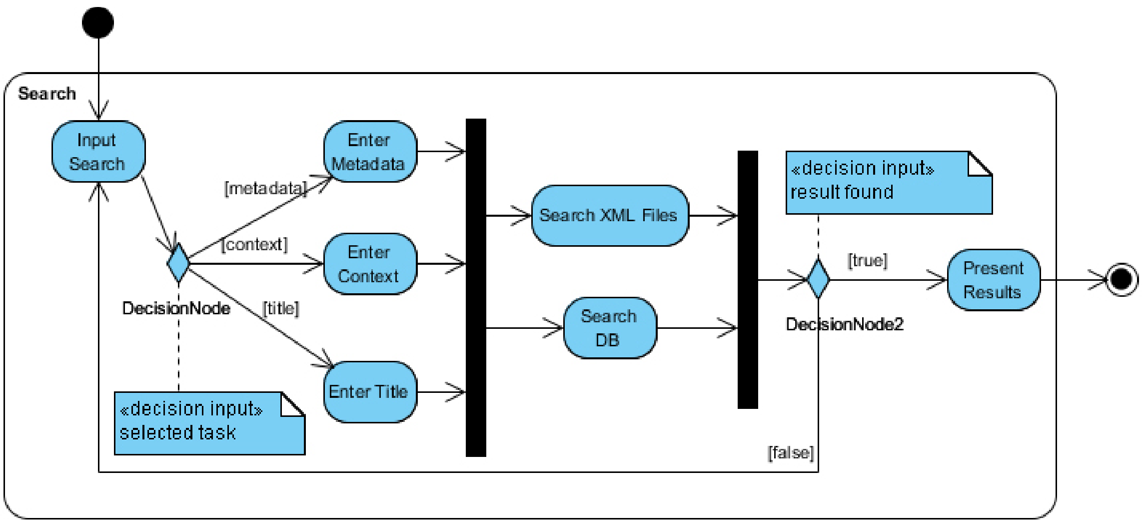


Figure 79. Search activity diagram

Finally, if results are found, are presented to the user the resources according the search terms.

3.4.2.3.2.2. Interoperability tool

For interoperability of the system, AHKME integrates a tool that permits simultaneouly the inclusion of external packages of resources and metadata but also the export feature.

Figure 80 gives an overview of the tool main features.

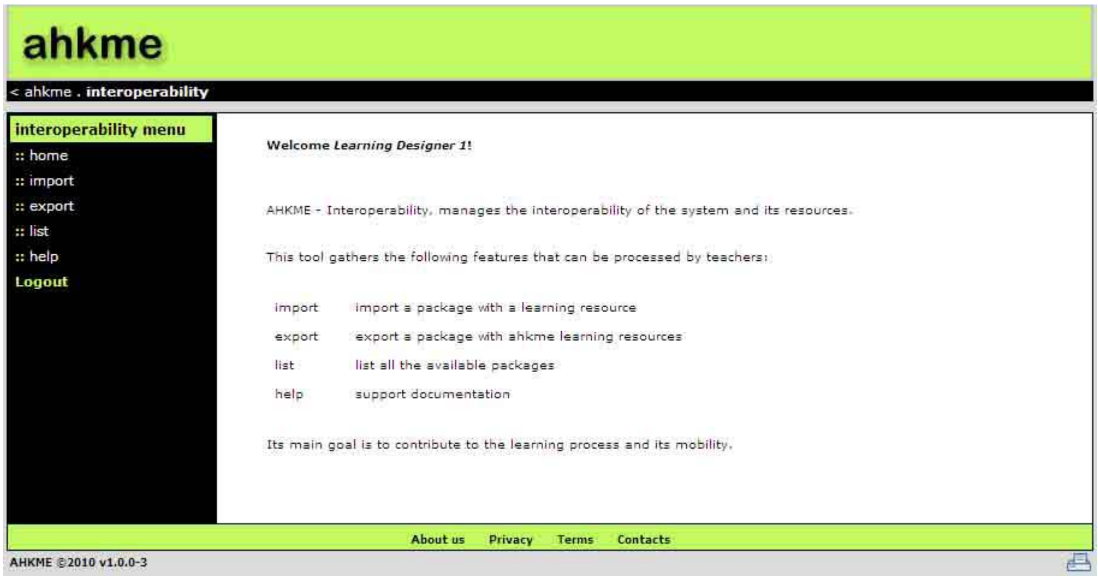


Figure 80. Interoperability main screen

One example of these features is the export package feature shown in Figure 81 that permits the possibility to teachers to export the resources and learning information generated on AHKME.

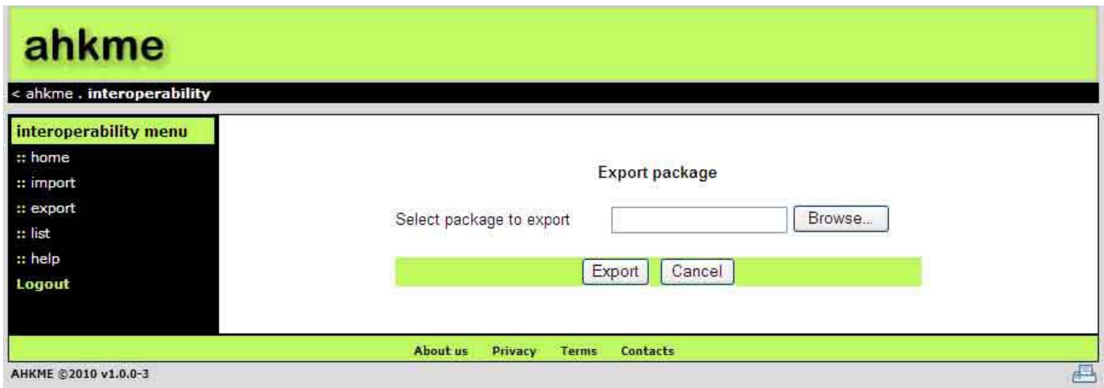


Figure 81. Interoperability tool – Export feature

Thus, to integrate with other tools and to be presented to students and shared with other applications or systems is necessary to generate a package that contains the LD and to include references to the resources it employs. For instance, the package, which follows as basis the IMS CP specification and is created by generating a .zip file selecting the LD you want to package and indicating the location where the file will be generated.

This process provides for each chapter or subchapter which has been included in an LD a LO in a website content support, as well as annotated with IMS CP manifest that contains all the elements of the LD according to IMS LD. Finally set up at the location specified by the user, a .zip file with these items.

3.4.2.3.2.3. Administrative tool

For the administration of the system, AHKME gathers a collection of administrative tools.

The main administrive features are:

- Users manager – Manages the users and permissions.
    - Groups manager.
    - State manager.
- Template manager – Manages the templates of documents, schemas or structures of learning information process.
- Tools – Gives the possibility to manage the access for tools per profile.
- Resource manager – Allows managing the learning resources, at physical level.

Figure 82. User manager tool

Figure 82 illustrates one the main administrative features regarding the users manager and their permissions. In Appendix B is presented more details of behavioural and architectural aspects of this tool.

3.4.2.4. AHKME-Presentation and Front-end Subsystem

This subsystem is divided into two major parts:

- ❖ The AHKME front-end where Learning designers, Instructors and Students interact with the system tools.
- ❖ The AHKME social networking, courses and learning resources playing tools.

Thus, this subsytem works as the front-end for Learning designers and Instructors to manage and design the teaching and learning process. But also, it presents the educational resources for students taking into account the adaptive model generated for the student.

In this subsystem is where is defined the integration with external tools and systems, like collaboration tools, LMS, social networking, LD players, front-end to the students. The objective for this integration is to give an opportunity, for instance to LMS for benefit from AHKME functionalities, as well as to give a front-end to AHKME system.

In Figure 83 is presented a component diagram illustrating the technical architecture of this subsystem. The following software components, interfaces and inter-relationships are available:

- ❖ The Social Network, LD Back-Office and the Player as internal components.
- ❖ The External systems as external component and as external interfaces there are the interfaces provided to the User.
- ❖ The Social network requires the IMultmedia, ICollaboration interfaces and provides them to the User.
- ❖ The LD Back-Office requires the IAdministrative, ILOM, ILD, IInstructional interfaces and provides them to the User.
- ❖ The Player component requires the ICoppercore for implementing the Player.

- The External systems component uses the provided IImport and IExport interfaces to implement the Interoperability feature of this Presentation subsystem.

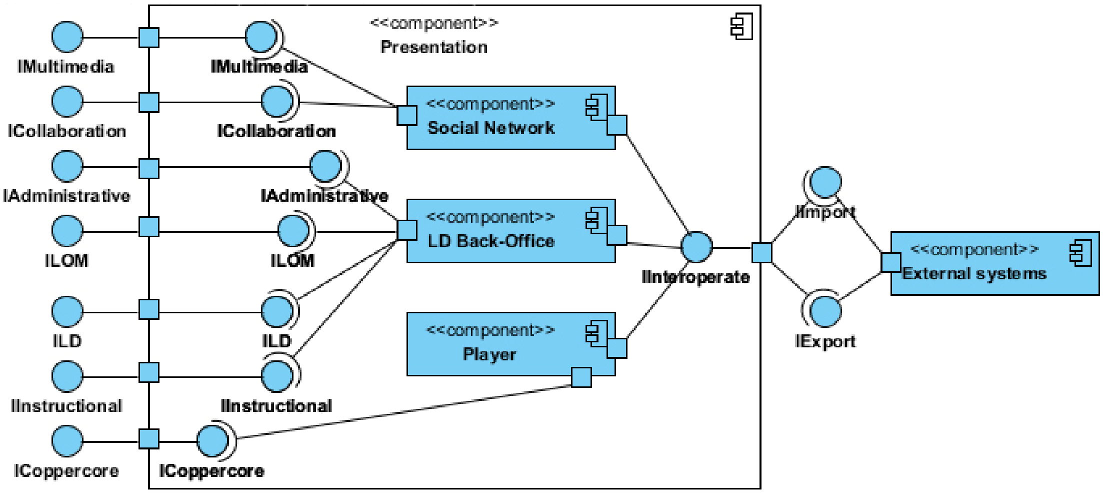


Figure 83. Presentation component diagram

Figure 84 shows the AHKME main front-end where the users can log in, and the ones that have not an account can register. It also presents the main "vision" of the system.

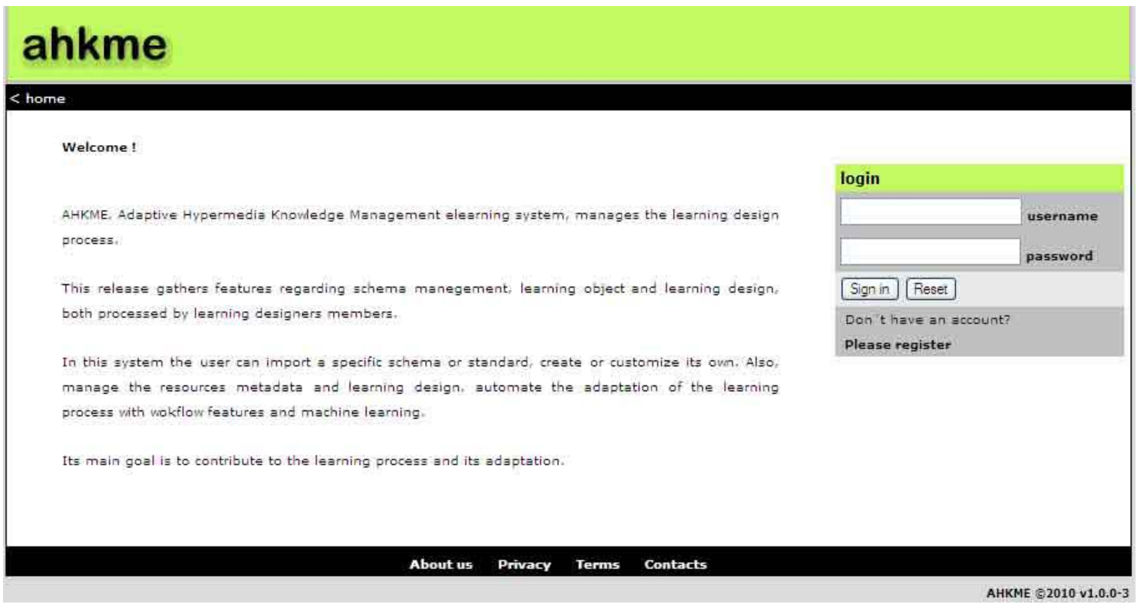


Figure 84. AHKME front-end

The next part of the presentation system is more a kind of integrated system, because it integrates different tools and systems to fit the need in terms of the system applications.

Thus the following integrated front-end tools are available:

- ❖ Learning Social networking tool.
- ❖ Learning Design and LO player tool.
- ❖ Possibility to interoperate with other elearning systems with the interoperability tool (mentioned above in this chapter).

Figure 85. AHKME social networking tool main screen 1

The educational social networking front-end (see Figure 85) is associated with the Communication & sharing and Resources tools, both tools regarding collaboration among users.

Figure 86. AHKME social networking tool main screen 2

By this mean, the social networking feature (Figure 86) is developed upon a free and open source community software called *Dolphin* (2010).

This software is PHP and AJAX mainly based. Also, the databases technologies are open source (MySQL). So, it is a perfect set for integrating with AHKME, and to function as a front-end.

The LD player tool integrates the free-distribution CopperCore (2009), a tool that gives the possibility to publish the learning object and design according to the specification and educational standards.

This is especially useful for the user as a transparent manner, which can see and test how the learning resource behaves.

This integration also allows students to interact with the LU using a browser.

Thus, Figure 87 shows the way a user can access to the resources tool and also play a course.

Figure 87. Resource tool playing feature

Then the user accesses to the LD player as it is illustrated Figure 88, for playing a specific learning unit.

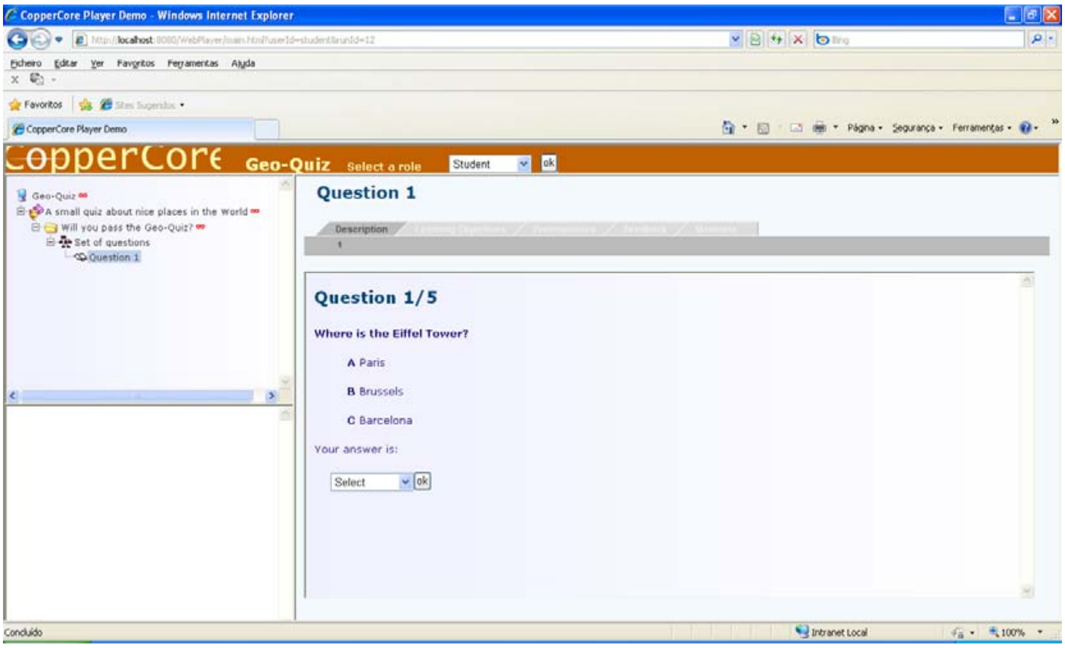


Figure 88. LD player.

As mentioned above, the LD Player option groups the following actions:

1. Start server (Coppercore).
2. Stop server (Coppercore).
3. Post.
4. LU Clear (erase LU).
5. View Player (run LU).

To publish a LU is necessary, first, choose "(1) Start Server" that runs the server Coppercore. Once the server is running, the next step is to use the option "(3) Post" to validate. Zip file that contains the LU and generates the roles, users and requiring Coppercore LD (CopperCore, 2009).

Once validated the file, it should be selected the option "(5) View player" for through Coppercore interface, running the LU.

The main goal of this subsystem is mainly to give a front-end to AHKME system, combining tools from different platforms - collaborative, interactive, communication and community tools.

3.4.3. APPLICATION/INTEGRATION SCENARIOS

The objective of integration with other systems is to give an opportunity for a LMS, LCMS or other elearning system, to benefit from this Learning Design Back-Office system, as well as to give a Front-End to AHKME as presented in Figure 89.

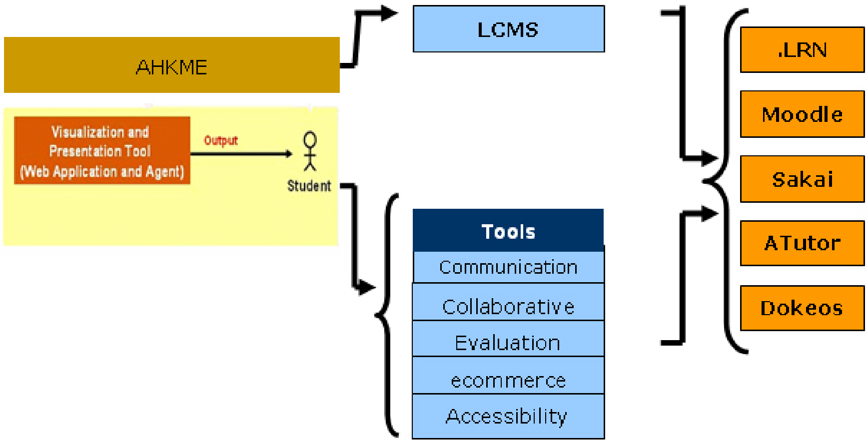


Figure 89. Front-end/Presenation application scenario

The goal is to benefit the system from LMS strong points already mentioned on the state-of-the-art analysis, adding developed tools by merging/integrating systems as being possible depending on the LMSs' integration tools. For instance, if an institution has an open source system, it can be directly integrated.

This integration can be done in different ways. In the case of Moodle being developed in PHP and with a MySQL database, it can be directly integrated into the LMS; in other cases it can be done through a specific profile in the LMS that gives access to this Back-Office to a Course Instructor and Designer.

3.5. CONCLUSIONS

This chapter has presented the proposal that key contribution addresses the main weakenesses of elearning systems and tries to take a step forward by preparing and developing a system to make the transition to new paradigm of the Internet, the Web 3.0.

By this mean, AHKME system has been introduced, detailing how it uses metadata annotation for learning resource management and evaluation.

One major aspect is the application of educational standards and specifications (e.g. the IMS specifications), which use the combination of metadata and XML potentialities, because they are excellent to represent knowledge, dividing information in several meaningful chunks (LO), providing their description through metadata and storage in XML files, facilitating their cataloguing, localization, indexation, reusability and interoperability. These specifications grant the capacity to design learning units that simultaneously allow users with different roles promoting several types of both collaborative and group learning.

AHKME main contributions are: LO management and quality evaluation; the usage of standards (like the IMS specifications) to standardize the resources trying to reach interoperability and compatibility of its learning components; interaction of all subsystems through the feedback among them, allowing the system to adapt to the students and teachers characteristics and to new contexts, using metadata representation and management to grant success to the teaching/learning process.

Thus, it is very important to have the resources well catalogued, available and with quality to create quality courses, but quality courses do not just depend on quality resources, but also in the design of activities to reach learning objectives.

Being a multipurpose system, it can be applied to several kinds of matters, students, and learning strategies, in both training and educational environments being able to be fully integrated with other systems.

4. A PRACTICAL CASE TESTING: EVALUATION OF THE PROPOSAL

This chapter details the testing process conducted to evaluate the proposal of this thesis. It is based on a conceptual model starting from a particular learning scenario, where Learning designers colaborate to design and adapt the resources according to a specific schema or standard, finally Instructors publish the learning resource to be used by Students. This test is done with AHKME to design it, and subsequently implements and verifies in a laboratory context for learning. The objective is to evaluate the validity of the process of creating and adapting the instructional design of the learning units and study the perceptions of teachers and students, by measuring their performance in their interaction with the learning resources and tools.

4.1. INTRODUCTION

This chapter presents the testing process used to evaluate the proposal of this thesis. For this purpose it follows specifc test scenarios where the teachers interact with AHKME different tools, regarding features like the possibility to create a schema, use it to annotate a specific learning object, design from a specific learning lesson, and later implement and evaluate in a test context for learning.

Thus, the first part of this chapter describes the conceptual design, explaining the techniques and methods for the test scenarios, both qualitative and quantitative approachs.

The following section explains how AHKME is used to structure, design and adapt the learning objects, and explains how is implemented in different scenarios for testing in a laboratory context, for both learning and teaching environment. Finally, the last sections introduce the set of tests performed, the results, the analysis and conclusions of this chapter.

4.2. CONCEPTUAL DESIGN

For the proposal evaluation has been made a study of some of the techniques and methods for software evaluation and more specifically of web information system.

By this mean, three main evaluation techniques have been identified:

- Heurístics.
- Usability Tests.
- Performance tests.

Heuristics analysis

Analysis based on a heuristic methodology has as main precursor Nielsen, specifically with its set of ten heuristics for evaluating software. It is an analysis that can be performed by a group of specialists and that evaluates a aystem in a qualitative way, and that can work as a reference, both as beginning to identify possible functional deficiencies of the system or its prototype, or during the various stages of the process development and implementation (Nielsen, 2005a, 2005b).

Usability tests

Usability tests consist in generic terms to evaluate the usage of the system by a sample of users in a specific context and through a set of metrics, and seek to identify system major problems and errors as well as recommendations for improvement.

While this kind of testing can assess the level of satisfaction of users, their opinions, this type of assessment provides a more subjective information of the system in terms of acceptance and quality of the system (Nielsen, 1993).

In this sense differs from the approach given by more objective reporting of results obtained by users through un usage scenario and a set of metrics.

In addition, current approach has used another type of tests - **performance tests** - which in the case of web systems may be relevant, since its operation is based on the Internet, is subject to the physical and network bandwidth, conditioning Response and Download time of the system.

By this mean it can distinguish two types of approaches:

- Quantitative - with the objective metrics defined for usability testing and performance testing of the system.
- Qualitative - with the measurement of satisfaction level and heuristic analysis by experts.

Sauro (2004) gives preference for one type of analysis more quantitative, with well-defined metrics and evaluation based on statistical analysis.

4.2.1. USABILITY

ISO 9241 defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

Shackel (1991) and Nielsen (1993) have described an approach to measuring usability using five different scales which do not include utility. They are in short:

- Task time.
- Errors.
- Learning.
- Relearning.
- Satisfaction.

ISO 9241 adds goal achievement to the set, which as a usability criterion is referred to by a number of terms like utility, functionality or effectiveness.

The basic idea in these criteria is that usability can be measured by finding out how well the task that should be done with the product is completed in practice. For a user to be able to complete tasks with a product, two conditions have to be met.

- First, the communication between the user and the product has to function.
- Second, the functionality of the product has to be sufficient in relation to the tasks.

It seems that the first relation clearly belongs to usability and is included in all major approaches in the form of catastrophic errors that prevent users from completing the tasks. The second condition is a matter of disagreements. Excluding goal achievement from usability is reasonable in the sense that it is not purposeful to measure the usability of a product for tasks that the product is not meant for. A product can be usable only in the tasks for which it has been designed or should have been designed. If the tasks cannot be completed due to shortcomings in functionality, the problem does not necessarily lie with the products, but with the evaluator who has selected the wrong product for those tasks. If goal achievement is included in the battery of usability criteria, it might be said after a usability study that a mobile phone is not usable for text editing because essential features are missing. If goal achievement is excluded, it can be said that text editing with a mobile phone is extremely laborious and frustrating, or just state the test to be invalid. It is not clear which tasks should be completed with a product for it to be usable. Mobile phones are certainly not text editors, but in modern phones there are some features which do require textual input. Introducing flexibility to the arsenal of usability criteria introduces the problem of selecting appropriate tasks and conditions as a criterion. The wider the scope of tasks or the better performance with some peripheral tasks, the more flexible and more usable the system is.

In addition to goal achievement, interaction can be measured in terms of productivity. The time to finish a task is a relevant measure whenever the efficiency of interaction is regarded as important. For business applications even a small saving in time becomes important when repeated thousands of times.

Errors are sometimes considered to be the essence of usability (Chapanis, 1991). However, there are conflicting approaches to the practical definition of an error. First, catastrophic errors are those user actions that lead users to problems from which they cannot recover themselves or which lead to incompletely finished tasks. The second way to define error is to regard all deviations from optimal performance as errors (Hollnagel, 1997). It is possible to decrease the number of errors users commit by other means than making the interface more easy to use. For example the users may be punished for making errors. Shneiderman (1986) discusses system response times. It was noticed that longer response times for some functions made people make fewer errors. Systems that work slower should be more usable according to this measure. The real fact is that users consider the long response times as a kind of punishment. If they make an error they have to wait for a long time before they are able to correct it and proceed with the task. So, they are more concerned to avoid mistakes than to proceed fluently with the task, and perhaps to experiment with new functions.

Objectives related to user experience are often illustrated by a learning curve shown in Figure 90. This illustrates the development of user performance as a function of experience. Experienced user performance (EUP) is the level of performance where the improvement of performance has stopped or its enhancement has become notably slower. Learnability is a measurement that describes the rising of the curve from a situation of no experience to EUP or a specified part of the curve. In addition to these, the learning curve illustrates well the concept of guessability, i.e. the level of performance achieved without any experience.

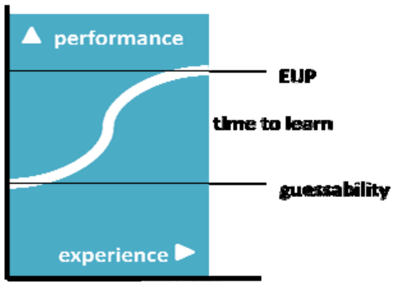


Figure 90. Learning curve. The learning curve is a presentation of the level of users' performance over time. Typical measurements that can be illustrated by the learning curve include guessability, experienced user's performance (EUP) and learning time. (Keinonen, 2007)

If Shackel's and Nielsen's approaches are compared to ISO 9241, major differences emerge. At first glance, satisfaction seems to be the only common scale. ISO 9241 does not recognise learnability, relearnability, task time or errors. Instead, it introduces concepts of effectiveness and efficiency that are not included in Shackel's and Nielsen's models. Why do the approaches seem so different? Is there a common core? The apparent differences are due to different points of view and different strategies for combining basic elements of user-product-task-context interaction. The concepts have to be further discussed to find the basic elements and essence of usability.

Shackel's and Nielsen's approaches unify three different aspects of usability:

- Objective operational measures of usability.
- Usability objectives related to the levels of user expertise.
- A subjective assessment of the product.

The objective criteria are task time and the number or rate of errors, which are – if used in an appropriate manner – effective quantitative variables that enable the use of relative scales. Usability objectives related to user's experience are experienced user performance (EUP), the novice user's ability to learn and the casual user's ability to relearn the use of a product. Learnability might be studied for example by first measuring the initial performance of a novice user in terms of time and errors, repeating the measurements after a period of training, and calculating the differences in performance levels. Thus, it is not an elementary criterion but a combination of criteria.

The ISO 9241 definition is constructed using different views of usability. Effectiveness approaches from the perspective of the output of the interaction, its quality and quantity. Effectiveness observed without paying attention to resources is not sensible, if no reference is made to the match between product functionality and the requirements of the task. Thus, including effectiveness means including the anticipated utility of the system in usability. Efficiency describes the interaction from the process point of view, paying attention to the results and resources involved. Satisfaction refers to the user's point of view.

Figure 91 sums up the approaches presented by Shackel, Nielsen and ISO 9241. These here stick strictly to the interaction. The approaches are weak in giving substance to usability. Instead, they express how to measure something that is thought or known, but it cannot precisely articulate. Nielsen (1993) avoids giving any descriptive definition whatsoever. Bevan and Macleod (1994) link usability to quality. ISO 8402 (2007) defines quality as *"the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs"*. Thus, usability is tied to the users needs, which is conceptually difficult to tame.

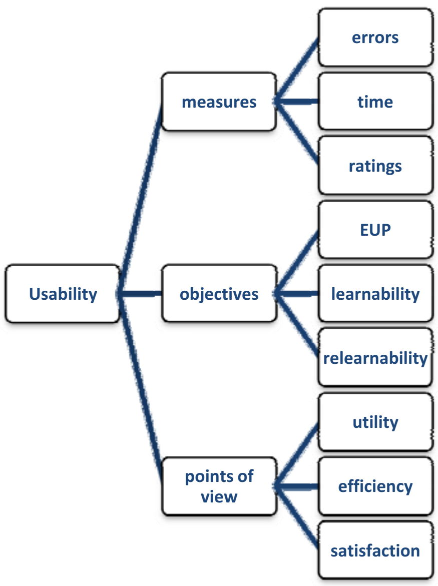


Figure 91. Measurements, objectives and views on usability. It recognises three measures – the number of errors, performance time, and answers on a rating scale or scales; three design objectives – the experienced user's performance (EUP), learnability by novice users, and relearnability or retention over time by casual users; and three views – the process output view, i.e. utility, the resource usage view, i.e. efficiency, and the user's subjective view (Keinonen, 2007).

There are a number of usability criteria available. Are there any instructions that indicate which to use? Shackel, Nielsen and ISO 9241 provide no general rules to decide which combination of criteria should be applied in a specific interaction situation. The use of a number of different approaches simultaneously is recommended.

The emphasis is on objective criteria, but satisfaction is said to be important when usage is voluntary (Bevan & Macleod, 1994). The basic assumption in ISO 9241 is that at least one criterion is applied to reflect effectiveness, efficiency, and satisfaction. However, if objective measurements cannot be obtained, subjective satisfaction may provide indication of them (Bevan, 2006).

The usability of interaction may be evaluated by considering only the subjective satisfaction of a novice user, while the usability of another interaction might be defined as the speed of performance when used by a trained person.

The qualities measured in both cases are called usability, even if they have very little in common. Different user-product-task-context-measurement combinations are all specific cases.

Each time usability is evaluated, something is evaluated that reflects qualities of user–product–task interaction in a context, and each time the test is changed, the evaluated qualities are incomparable. Usability in interaction A may be comprehensively different from usability in interaction B. It seems appropriate to accept that the usability of interactions A and B cannot be compared if A and B involve products from different product categories and/or users with different levels of experience. It cannot be said that a VCR at home used by a six-year-old child is more or less usable than an air traffic control system used by a trained professional.

This reasoning leads asking at what point differences in interaction or contexts force to change the established usability criteria.

If there is no generality among usability measures, the concept refers only to the discipline, its aims and conventions, not to any generic quality of a product or its use. All trials are one-off without possibilities to learn anything for future applications.

The motivation of e.g. ISO 9241 has been to define usability for use in product evaluation in the same definitive way as the physical dimensions of a product, for example. It might be necessary comparing the usability of different products belonging to the same product category. Such a comparison is possible, strictly speaking, only when an identical test can be applied to all the products. Theoretically, the ambiguous selection of very different sorts of criteria may blur the concept of usability. In practice, there seems to be mixed evidence concerning the correlation of usability criteria. Chapanis (1991) suggests that the rate of errors alone provides a good and reliable approximation of usability. Nielsen and Levy (1994) have found that users' subjective assessment of product usability provides a working approximation of objective usability for the purposes of discount usability evaluation. Conflicting views that call for the use of several simultaneous and complementary usability approaches are presented by Rowe et al. (1994), among others.

The criteria do not define the concept of usability. They set only examples of possible interpretations, which may be valuable in practice. Logically they are not satisfactory. Specific problems with the approaches discussed above include, first, the superficial argumentation concerning the relationship between general behavioural response with respect to products and usability. Second, the relationship between subjective product evaluation and concrete product properties is not dealt with care. Third, the nature of attitude, satisfaction, or whatever the subjective component is called, is not clear. The main evaluation criteria of smart product -human interaction, which are either included in usability or are related to it, are, however, made clear on a general level. These are usability, utility, and subjective satisfaction (Keinonen, 2007).

There are also some divergent opinions in relying only on qualitative analysis, like Jeff Sauro, that considers more relevant to employ a mix of both qualitative and quantitative methods when discovering usability problems (Sauro, 2004).

Thus, taking into account the diversity of methodologies in the approach followed in this thesis sought to include both qualitative and quantitative analysis, it aims to achieve both a subjective and behavioral component of the study as a component of performance and intended use system.

4.2.1.1. USABILITY METRICS

The metrics used in usability tests typically are associated with efficiency, effectiveness and satisfaction.

Effectiveness

Effectiveness relates the goals of using the product to the accuracy and completeness with which these goals can be achieved. Common measures of effectiveness include percent task completion, frequency of errors, frequency of assists to the participant from the testers, and frequency of accesses to help or documentation by the participants during the tasks. It does not take account of how the goals were achieved, only the extent to which they were achieved. Efficiency relates the level of effectiveness achieved to the quantity of resources expended (NIST, 2001).

Regarding the efectiveness it can be measure the completion rate and errors.

Completion rate

The Completion rate is the percentage of participants who completely and correctly achieve each task goal.

If goals can be partially achieved (e.g., by incomplete or sub-optimum results) then it may also be useful to report the average goal achievement, scored on a scale of 0 to 100% based on specified criteria related to the value of a partial result. For example, a spell-checking task might involve identifying and correcting 10 spelling errors and the Completion rate might be calculated based on the percent of errors corrected (NIST, 2001).

Another method for calculating Completion rate is weighting; e.g., spelling errors in the title page of the document are judged to be twice as important as errors in the main body of text. The rationale for choosing a particular method of partial goal analysis should be stated, if such results are included in the report. More specifically, the percentage of participants who completely and correctly achieve each task goal.

Errors

Errors are instances where test participants did not complete the task successfully, or had to attempt portions of the task more than once. Scoring of data should include classifying errors according to some taxonomy, such as in (Norman, 1983).

Efficiency

Efficiency relates the level of effectiveness achieved to the quantity of resources expended. Efficiency is generally assessed by the mean time taken to achieve the task. Efficiency may also relate to other resources (e.g. total cost of usage) (NIST, 2001).

A common measure of efficiency is Time on task. Also, it can be measured the Completion Rate/Task time ratio.

Task time

The mean time taken to complete each task, together with the range and standard deviation of times across participants.

Completion Rate/Task time

Completion Rate/Mean Time-On-Task is another measure of efficiency (Norman, 1983). The relationship of success rate to time allows customers to compare fast error-prone interfaces (e.g., command lines with wildcards to delete files) to slow easy interfaces (e.g., using a mouse and keyboard to drag each file to the trash) (NIST, 2001).

Satisfaction

Satisfaction describes a user's subjective response when using the product. User satisfaction may be an important correlate of motivation to use a product and may affect performance in some cases (NIST, 2001).

Questionnaires to measure satisfaction and associated attitudes are commonly built using Likert and semantic differential scales (Trump, 2000).

A variety of instruments are available for measuring user satisfaction of software interactive products, and many companies create their own. Whether an external, standardized instrument is used or a customized instrument is created, subjective rating dimensions such as Satisfaction, Usefulness, and Ease of Use should be considered for inclusion, as these will be of general interest to customer organizations.

A number of questionnaires are available that are widely used. They include: ASQ (After-Scenario Questionnaire), CUSI (Computer Usability Satisfaction Inventory), PSSUQ (Post Study System Usability Questionnaire), QUIS (Questionnaire for User Interaction), SUMI (Software Usability Measurement Inventory), and SUS (System Usability Scale) (NIST, 2001; Trump, 2000). While each one offers unique perspectives on subjective measures of product usability, most include measurements of Satisfaction, Usefulness, and Ease of Use (NIST, 2001; Trump, 2000).

The System Usability Scale (SUS) is a simple, ten-item scale giving a global view of subjective assessments of usability.

SUS is a *Likert scale*. It is often assumed that a Likert scale is simply one based on forced-choice questions, where a statement is made and the respondent then indicates the degree of agreement or disagreement with the statement on a 5 (or 7) point scale. However, the construction of a Likert scale is somewhat more subtle than this.

Whilst Likert scales are presented in this form, the statements with which the respondent indicates agreement and disagreement have to be selected carefully (Brooke, 1996; Usability.gov, 2009).

Besides the usability tests, web performance test have been used.

4.2.2. PERFORMANCE TESTING

Performance testing helps to identify bottlenecks in a system, establishes a baseline for future testing, supports a performance tuning effort, and determines compliance with performance goals and requirements. Including performance testing very early in development life cycle tends to add significant value to the project (Meier, Farre, Bansode, Barber, & Rea, 2007).

For a performance testing project to be successful, the testing must be relevant to the context of the project, which helps to focus on the items that that are truly important.

If the performance characteristics are unacceptable, typically the focus is shifted from performance testing to performance tuning in order to make the application perform acceptably. Also, it is possible focusing on tuning if it is wanted to reduce the amount of resources being used and/or further improve system performance.

Performance, load, and stress tests are subcategories of performance testing, each intended for a different purpose.

Creating a baseline against which to evaluate the effectiveness of subsequent performance-improving changes to the system or application will generally increase project efficiency.

Performance testing is defined as the technical investigation done to determine or validate the speed, scalability, and/or stability characteristics of the product under test. Performance-related activities, such as testing and tuning, are concerned with achieving response times, throughput, and resource-utilization levels that meet the performance objectives for the application under test (Meier et al., 2007).

Performance tests are usually described as belonging to one of the following three categories:

- **Performance testing.** This type of testing determines or validates the speed, scalability, and/or stability characteristics of the system or application under test. Performance is concerned with achieving response times, throughput, and resource-utilization levels that meet the performance objectives for the project or product. In here, performance testing represents the superset of all of the other subcategories of performance-related testing.
- **Load testing.** This subcategory of performance testing is focused on determining or validating performance characteristics of the system or application under test when subjected to workloads and load volumes anticipated during production operations.
- **Stress testing.** This subcategory of performance testing is focused on determining or validating performance characteristics of the system or application

under test when subjected to conditions beyond those anticipated during production operations. Stress tests may also include tests focused on determining or validating performance characteristics of the system or application under test when subjected to other stressful conditions, such as limited memory, insufficient disk space, or server failure. These tests are designed to determine under what conditions an application will fail, how it will fail, and what indicators can be monitored to warn of an impending failure.

Thus, some examples of Performance Metrics are:

- Response time - a measure of how responsive an application or subsystem is to a client request.
- Download time - The time taken by a website or web page to download to a web browser.

4.3. TESTING PROCESS

The defined usability tests follow the "Common Industry Format Test Report" (NIST, 2001).

The Common Industry Format (CIF) for usability test reports specifies the format for reporting the results of a summative usability evaluation. The most common type of usability evaluation is formative, i.e. designed to identify usability problems that can be fixed. A summative evaluation produces usability metrics that describe how usable a product is when used in a particular context of use (Bevan & Macleod, 1994; Macleod, Bowden, Bevan, & Curson, 1997). The CIF report format and metrics are consistent with the ISO 9241-11 (1998) definition of usability:

- The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

The type of information and level of detail that is required in a CIF report is intended to ensure that:

- Good practice in usability evaluation had been adhered to.

- There is sufficient information for a usability specialist to judge the validity of the results (for example whether the evaluation context adequately reproduces the intended context of use).
- If the test is replicated on the basis of the information given in the CIF, it should produce essentially the same results.
- Specific effectiveness and efficiency metrics must be used, including the unassisted Completion rate and the mean Time on task.
- Satisfaction must also be measured.

It is envisaged that a supplier would provide a CIF report to enable a corporate purchaser to take account of usability when making a purchase decision. A purchaser could compare CIF reports for alternative products (particularly if a common set of tasks had been used). The purchaser might specify in advance to a supplier the required values of the usability measures (for example based on the values for an existing product) (NIST, 2001).

The original motivation for the CIF comes from usability staff in purchasing companies who were frustrated at purchase decisions made exclusively on the basis of functionality. These companies experienced large uncontrolled overhead costs from supporting difficult to use software (Blanchard, 1998).

The CIF format is agreed by the IUSR working group (IUSR, 1997) of usability experts from purchasing and supplying companies, including companies such as IBM, Microsoft, Hewlett-Packard, Boeing, US West and Kodak. It was based on collating good practice from the different companies, and aligning this with ISO 9241-11.

Usability Test Template

Also, it is considered the "Usability Test Plan Template", delivered by Usability.gov website (Usability.gov, 2009).

Usability.gov is a one-stop source for government web designers to learn how to make websites more usable, useful, and accessible. The site addresses a broad range of factors that go into web design and development. The site may help to:

- Plan and design usable sites by collecting data on what users need.
- Develop prototypes.
- Conduct usability tests and write up results.
- Measure trends and demographics.

Usability.gov provides a wide range of templates for use. They can be customized for the organization's usability needs. All of the templates are in the public domain and can be freely downloaded (Usability.gov, 2009).

The usability test plan template is used mainly for the usability metrics definition of the the usability testing.

The performance tests have been done with the help of the QEngine tool. ManageEngine QEngine is a test automation tool which supports load testing and functional testing for web applications. In this case is used to measure the response and dowload time.

QEngine performance testing can help to identify bottlenecks in the application code and eliminate them proactively (QEngine, 2009).

4.3.1. HEURISTIC EVALUATION

As this is a prototype was initially developed a heuristic analysis by experts, based on Nielsen's heuristics, in order to detect violations of these heuristics, which can create problems for the use as shown in Table 16 (Nielsen, 2005b).

Table 16. Heuristic evaluation recommendations

RECOMMENDATIONS		
Criteria	**Feature**	**Severity**
Visibility of system status	Difficulties in Navegation Menu, Screen/Info Messages	3
Match between system and the real world	The eLearning system interface should employ more words, phrases and concepts familiar to the learner, rather than system-oriented terms. Wherever possible, the eLearning program utilizes real-world conventions that make information appear in a natural and logical order.	2
User control and freedom	The eLearning program should allow the learner to recover from input mistakes and provides a clearly marked ̀emergency exit to leave an unwanted state without having to go through an extended dialogue.	3
Consistency and standards	The eLearning program should be consistent in its use of different words, situations, or actions and it adheres to general software and platform conventions.	2

Criteria	Feature	Severity
Error prevention	The eLearning program should be carefully designed to prevent common problems from occurring in the first place. Needs Confirmation Messages for users.	3
Recognition rather than recall	The eLearning program makes objects, actions, and options that should be visible so that the user does not have to remember information from one part of the program to another. Instructions for use of the program are visible or easily retrievable. Contextual menu.	3
Flexibility and efficiency of use	The eLearning program is designed to speed up interactions for the experienced user, but also cater to the needs of the inexperienced users. One-click creation options.	3
Aesthetic and minimalist design	Screen displays contain information that is irrelevant, to the eLearning program. Simple forms.	3
Help users recognize, diagnose, and recover from errors	The eLearning program needs to express error messages in plain language (without programmer codes), precisely indicates the problem, and constructively suggests a solution. Clear error messages.	2
Help and documentation	When it is absolutely necessary to provide help and documentation, the eLearning program should provide such information in a manner that is easy to search. Contextual help.	1
	Average	**2,5**

Time estimate for expert

Another objective is to estimate based on this analysis the time to perform the tasks of usage scenarios for usability testing.

For doing this, it should estimate how long it would take an expert (someone on the core team) to complete the task (Snyder, 2003):

- ❖ Ignore any time needed for the system to do its processing and focus on the time spent entering data and clicking buttons.
- ❖ Some tasks, such as composing an email, require time for thinking or creative effort, so we have to allow time for that.
- ❖ In deciding how many tasks his needed to fill the test time, multiply this estimate by an factor appropriate for the interface (typically, a number between 3 and 10).

4.3.2. USABILITY TESTING

The topic describes the test phases, collection of results, findings and recommendations.

4.3.2.1. SUMMARY

AHKME is a system to help teachers in the learning design process. The system is towards Web 3.0, with advanced technologies, like machine learning, interoperability and mobility of resources. The test demonstrated the usability of AHKME tools and features for Designers and Instructors, specifically: learning design and LOM tools; schema customization; adaptation and interoperability features.

The tests have been done with twenty users from different profiles, which is the number that Nielsen recommends when collecting usability metrics (Nielsen, 2006).

Twenty users, including teachers, students and IT people have been provided with a system access account, a user guide, and a test scenario, and asked to perform some tasks. Having spend some time familiarizing themselves with it, they were asked to navigate the system, manage a schema, learning design and LOM, and also to use the adaptation tools and test the interoperability of the system.

The tests have been divided into two separated time phases, with the objective to see the evolution of the system, from one phase to the other. The first test phase was done in the 28 and 29 of December of 2009 (in the morning and afternoon period). The second phase was done in the 15 and 17 of February of 2010 (in the morning and afternoon period).

The tests periods have been divided by profile scenario and have been run according to a schedule presented in Table 17.

Table 17. Testing schecule agenda

Tests Schedule			
Phase	**Day**	**Period**	**Profile/Scenario**
1	28-Dec-2009	Morning	HE Learning Designers and Instructors
1	28-Dec-2009	Afternoon	HS Learning Designers and Instructors
1	29-Dec-2009	Morning	Students
1	29-Dec-2009	Afternoon	Technical
2	15-Feb-2010	Morning	HE Learning Designers and Instructors
2	15-Feb-2010	Afternoon	HS Learning Designers and Instructors
2	15-Feb-2010	Afternoon	HE and HS Learning Instructors LOM and LD Tools Comparison test
2	17-Feb-2010	Morning	Students
2	17-Feb-2010	Afternoon	Technical

HE – Higher Education, HS – High School

The morning period tests lasted 3 hours, started from 9:00 am to 12:30 pm, with a 15 minute break and the test/tasks introduction time.

The afternoon period lasted also 3 hours, from 14:00 pm to 17:30pm, with a 15 minutes break and the test/tasks introduction time. The exception was the 17-February-2010 that lasted 50 minutes more because of the HE and HS Learning Instructors LOM and LD Tools Comparison test.

4.3.2.2. CONTEXT DESCRIPTION

AHKME is a computer vision of teacher's learning design processes. It provides learning design, adaptation and interoperability tools for individuals and work groups.

The primary user group for AHKME are teachers, typical Learning designers and Instructors, but also Students and Technical staff. AHKME is intended for users who have basic knowledge of Windows and Internet browsers (Internet Explorer and Mozilla Firefox).

4.3.2.3. TEST OBJECTIVES

The aim of the evaluation is to validate the usability of learning design, adaptation and interoperability functions, which are the major features of AHKME.

Representative users have been asked to complete typical tasks, and measures were taken of effectiveness, efficiency and satisfaction.

It is expected that general, schema, adaptation, learning design and LOM features would take less than 120 minutes, and that all users could successfully design, adapt and interoperate/deploy the unit of learning in an average time of less than 90 minutes.

All SUS scores should be above the industry average between 65 and 70%.

In terms of Completion rate is expected about 90% or plus as scenario goal. For Error rate the test goal expected is about 20% or less.

Table 18 identifies the usability goals by scenario and for each profile, defining the tasks and features with respective description and time limits (Snyder, 2003).

Table 18. Testing scenarios – Learning designer, Instructor, Student and Technical staff

No	Task :: Feature	Time (min)	Description
	Scenario - Learning Designer		
	General	**6**	
1	General :: Login/Registration		Register yourself and then login
2	General :: Navigation		Familiarize yourself with the system
3	General :: Tool finding		Try to find the profile specific main tools
4	General :: Help		Use the help during the test to see how to do a specific function
5	General :: Profile		Change your profile data
	Schema	10	
6	Schema :: import		Import the Schema test example to the system
1	Schema :: select		Select the imported schema to create a new instance
7	Schema :: create		Create a new schema with the template manager
2	Schema :: list		See in the schema list the details of the imported schema
8	Schema :: edit		Edit the imported schema, change the some element values
	Workflow	6	
9	Wf :: create		Create a LO Adaptation Workflow using the test users for receivers
10	Wf :: pending		Process the existent pending LD Adaptation workflow by pointing out your observation
11	Wf :: circulation		See the existent circulation and the details of your created Workflow
12	Wf :: history		See the history of circulations
	Surveys	7	
13	Surveys :: create		Create a survey based on the template manager, use the survey example
14	Surveys :: edit		Edit the created survey
15	Surveys :: publish		Publish the created survey
16	Surveys :: use		Participate in created survey
17	Surveys :: list		See the existent surveys and the details of your created survey
	Adaptation	5	
18	Recommendation :: view attribute importance		Choose the technique of classification and evaluate the LO example pointing out the most important attributes to adapt
19	Recommendation :: view decision tree		View the decision tree
	Quality	5	
20	Quality :: view attribte importance		Choose the technique of classification and evaluate the LO example quality - Point out the most important attributes

No	Task :: Feature	Time (min)	Description
21	Quality :: view decision tree		View the decision tree
	Resources	8	
22	Resources :: upload		Upload the exampla resource file
23	Resources :: edit		Edit the uploaded resource
24	Resources :: my resource		See your resource list and details
25	Resources :: search		Search for the example resource
26	Resources :: list all resources		See all the list of resources
27	Search	4	Search for the test subject LO and LD
28	Communication & Sharing	6	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste users
	Interoperability	6	
29	Interoperability :: Create/Export Package		Create a Package with the LD test example
30	Interoperability :: List		See the list of packages, and the created test package
31	Interoperability :: Import Package		Import na exmple test package
	Total time	**63**	

	Scenario - Instructor		
No	**Task :: Feature**	**Time (min)**	**Description**
	General	6	
1	General :: Login/Registration		Registe yourself and then login
2	General :: Navigation		Familiarize yoursef with the system
3	General :: Tool finding		Try to find the profile specific main tools
4	General :: Help		Use the help during the test to see how to do a specific function
5	General :: Profile		Change your profile data
	Schema	7	
6	Schema :: select		Select the imported schema to create a new instance
7	Schema :: generate/personalized		Customize the test schema, create new element, and change values
8	Schema :: list		See in the schema list the details of the imported schema
9	Schema :: edit		Edit the imported schema, change the some element values
	Workflow	5	
10	Wf :: pending		Process the existent pending LD Adaptation workflow by pointing out your observation
11	Wf :: circulation		See the existent circulation and the details of your created Workflow
12	Wf :: history		See the history of circulations

No	Task :: Feature	Time (min)	Description
	Surveys	6	
13	Surveys :: edit		Edit the created survey
14	Surveys :: publish		Publish the created survey
15	Surveys :: use		Participate in created survey
16	Surveys :: list		See the existent surveys and the details of your created survey
	LOM	10	
17	LOM :: Generate		Generate LOM instance
18	LOM :: Edit		Edit LO and metadata, change value in elements
19	LOM :: publish		Pubish the LO
20	LOM :: use		Use the LO in a course
21	LOM :: list		See the list of LO and details of LO generated
	LD	15	
22	LD :: Generate		Generate LD instance
23	LD :: Edit		Edit Ld and metadata, change value in elements
24	LD :: publish		Pubish the LD
25	LD :: use		Use the LD in a course
26	LD :: list		See the list of LD and details of LO generated
	Resources	6	
27	Resources :: upload		Upload the exampla resource file
28	Resources :: edit		Edit the uploaded resource
29	Resources :: my resource		See your resource list and details
30	Resources :: search		Search for the example resource
31	Resources :: list all resources		See all the list of resources
32	Search	4	Search for the test subject LO and LD
33	Communication & Sharing	6	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste useres
	Total time	**65**	

	Scenario - Student		
No	**Task :: Feature**	**Time (min)**	**Description**
	General	12	
1	General :: Login/Registration		Registe yourself and then login

No	Task :: Feature	Time (min)	Description
2	General :: Navigation		Familiarize yoursef with the system
3	General :: Tool finding		Try to find the profile specific main tools
4	General :: Help		Use the help during the test to see how to do a specific function
5	General :: Profile		Change your profile data
6	Student Feedback		Give some feedback of your usage experience
	Surveys	8	
7	Surveys :: use		Participate in created survey
8	Surveys :: list		See the existent surveys and the details of your created survey
	Resources	12	
9	Resources :: my resource		See your resource list and details
10	Resources :: search		Search for the example resource
11	Communication & Sharing	9	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste users
	Total time	**41**	

	Scenario - Technical		
No	**Task**	**Time (min)**	**Description**
	General	15	
1	General :: Login/Registration		Registe yourself and then login
2	General :: Navigation		Familiarize yoursef with the system
3	General :: Tool finding		Try to find the profile specific main tools
4	General :: Help		Use the help during the test to see how to do a specific function
	Administration	15	
5	Administration :: Users & Tools Access		Manage a test user, reset passworg and give permission to Learning Design tools
6	Administration :: Resources Manager		Manage the test resources, by deleting and changing some resources
7	Administration :: Templates		Manage templates, deleting and changing some templates
	Total time	**30**	

Besides the usability metrics and respective scenario goals, also performance testing goals have been taken into account. Thus for the Download time is expected less than 10 seconds and for Response time less than 1 second (Nielsen, 1993).

4.3.2.4. METHOD

4.3.2.4.1. Participants

Intended context of use: The key characteristics and capabilities expected of AHKME users are:

- ❖ Familiarity with a PC and a basic working knowledge of Microsoft Windows.
- ❖ A command of the English language.
- ❖ Familiarity with education context tasks.
- ❖ At least 30 minutes a day spent on tasks related to teaching, instructing or studying.

Other characteristics of users which it is expected could influence the usability of AHKME are:

- ❖ Amount of experience with Microsoft Windows.
- ❖ Amount of experience with any other eLearning applications.
- ❖ Attitude towards use of computer applications to support teaching/learning tasks.
- ❖ Job function and length of time in current job.

Table 19 presents the characteristics of the participants in the tests, regarding age, genre name, IT knowledge and educational years of experience, and also educational technology knowledge

Table 19. Table of Participants' characteristics

Participant	Profile	Role	Gender (M/F)	Age	IT Knowledge (years)	Educational Experience (years)	Ed Tech Knowledge
1	HE*- Teacher	Learning Designer	F	30-35	6	4	eLearning Platforms, Tools and standards
2	HE -Assistant teacher	Learning Instructor	M	45-50	3	0	None
3	HE – Teacher	Learning Designer	M	45-50	4	1	eLearning Platforms
4	HE- Assistant teacher	Learning Instructor	F	30-35	4	2	eLearning Platforms
5	HS* – Teacher	Learning Designer	M	50-55	2	0	None
6	HS – Teacher	Learning Designer	F	30-35	5	3	eLearning Platforms and Standards
7	HS - Assistant teacher	Learning Instructor	M	45-50	4	2	eLearning Platform
8	HS - Assistant teacher	Learning Instructor	F	30-35	5	3	eLearning Platform and Tools
9	IT Techinical	Technical	M	30-35	4	2	eLearning Platforms
10	IT Techinical	Technical	M	50-55	3	2	eLearning Platforms
11	Student	Student	M	20-25	6	1	eLearning Platforms
12	Student	Student	F	25-30	7	0	None
13	Student	Student	M	15-20	5	2	eLearning Platforms
14	Student	Student	M	30-35	7	2	eLearning Platforms
15	Student	Student	M	40-45	2	0	None
16	HE - Teacher	Learning Designer	F	30-35	8	3	eLearning Platforms, Tools and standards
17	HS - Assistant teacher	Learning Instructor	F	30-35	7	3	eLearning Platforms, Tools and standards
18	IT Technical	Technical	F	25-30	10	4	eLearning Platforms, Tools and standards
19	IT Technical	Technical	M	40-45	12	2	eLearning Platforms, Tools and standards
20	IT Technical	Technical	M	30-35	8	3	eLearning Platforms and Tools

* HE=Higher Education, HS=High School

4.3.2.4.2. Context of Product Use in the Test

The context of product used in the test takes into consideration the tasks selected, test facility, participants' computing environment and the test administrator tools.

4.3.2.4.2.1. Tasks

Intended context of use: Interviews with potential users have suggested that learning design and schema management are important tasks. Having gained familiarity with the application, other key tasks would be adaptation features for resources and interoperability among systems.

Context used for the test: The tasks selected for the evaluation are presented in Table 20.

Table 20. Tasks used in the test

No	Task *(aka Scenario/Question)*
1	General :: Login/Registration
2	General :: Navigation
3	General :: Tool finding
4	General :: Help
5	Schema :: import
6	Schema :: select
7	Schema :: generate/personalized
8	Schema :: create
9	Schema :: list
10	Schema :: edit
11	Wf :: create
12	Wf :: pending
13	Wf :: circulation
14	Wf :: history
15	Profile
16	Student Feedback
17	Surveys :: create
18	Surveys :: edit
19	Surveys :: publish
20	Surveys :: use
21	Surveys :: list
22	Recommendation :: view attribte importance
23	Recommendation :: view decision tree
24	Quality :: view attribte importance
25	Quality :: view decision tree
26	LOM :: Import
27	LOM :: Generate
28	LOM :: Edit
29	LOM :: publish
30	LOM :: use

No	Task *(aka Scenario/Question)*
31	LOM :: list
32	LD :: Import
33	LD :: Generate
34	LD :: Edit
35	LD :: publish
36	LD :: use
37	LD :: list
38	Resources :: upload
39	Resources :: edit
40	Resources :: my resource
41	Resources :: search
42	Resources :: list all resources
43	Search
44	Communication & Sharing
45	Interoperability :: Create/Export Package
46	Interoperability :: List
47	Interoperability :: Import Package
48	Administration :: Users & Tools Access
49	Administration :: Resources Manager
50	Administration :: Templates

4.3.2.4.2.2. Test Facility

Intended context of use: Online education and training.

Context used for the test: The evaluation has been carried out in a IT Laboratory in Viseu. The test room was configured to represent a closed office with desks, chairs and other office fittings. Participants have worked alone without any interruptions, and have been observed through a one way mirror and monitorized in the room.

4.3.2.4.2.3. Participant's Computing Environment

Intended context of use: AHKME is intended for use on any pentium-based PC running Windows, with at least 512MB free memory.

Context used for the test: The PC used was a DELL DL330 (Pentium Core 2 Duo, 4Gb RAM) in standard configuration, with a DELL mouse and a 19" TFT color monitor at 1280x800 resolution. The operating system was Windows XP. It requires java installed, .NET Framework. The used browser has been Internet Explorer 8.0.

4.3.2.4.2.4. Test Administrator Tools

In the beginning of the test the users filled a questionnaire to characterize them.

Using the Datalogger Usability Tool (Datalogger, 2008), the tasks have been timed, the data collected and the tests have been controlled. Sessions have been monitorized by observers. At the end of each session task, participants have completed a subjective ratings scale - post-task questionnaire and at the end of the test session they completed a SUS satisfaction questionnaire (HotmailUsability, 1999).

4.3.2.4.3. Experimental Design

10 Teachers (5 Learning Designers, 5 Instructors), 5 Technical staff and 5 Students have been tested.

The Mean Completion rate, Mean Completion success, Mean Task time, Error rate, Mean Completion rate efficiency and Mean Confidence have been calculated for the tasks tested.

Procedure

On arrival, participants have been informed that the usability of AHKME was being tested, to find out whether it met the needs of users with similar characteristics such as themselves. They have been told that it is not a test of their abilities. Participants have been shown the evaluation suite, including the control room, and informed that their interaction would not be recorded. They were asked to sign a release form. They have been then asked to confirm the information they had provided about themselves before participating: Job description, IT Experience (years), Education experience (years), Educational Technology knowledge, and Age group. They also scored their attitude towards use of computer applications to support diary and learning design/instructor management tasks, on a scale of 1 to 7, with anchors: prefer to use a computer as much as possible, prefer to use a computer as little as possible.

Participants have been given introductory instructions. The evaluator reset the state of the computer before each task, and provided instructions for the next task. Participants have been told the time allocated for each task, and asked to inform the evaluator (by chat) when they had completed each task. Participants were told that no external assistance could be provided.

After the last task, participants have been asked to complete a subjective ratings scale and the SUS questionnaire.

The evaluator then asked them about any difficulties they had encountered.

4.3.2.4.4. Usability Metrics

A set of usability metrics has been considered for measuring that are presented below (NIST, 2001).

4.3.2.4.4.1. Effectiveness

Completion Rate: Percentage of participants who completed each task correctly.

Mean goal achievement: Mean extent to which each task was completely and correctly achieved, scored as a percentage.

Errors: Errors rate were measured.

Assists: The participants were given assistance.

4.3.2.4.4.2. Efficiency

Task time or Time on task (i.e. Time task): Mean time taken to complete each task (for correctly completed tasks).

Completion rate efficiency: Mean completion rate/mean task time.

Goal achievement efficiency: Mean goal achievement/mean task time.

No of references to the manual: Number of separate references made to the manual.

4.3.2.4.4.3. Satisfaction

Satisfaction has been measured using a subjective ratings scale, a post-task questionnaire and the SUS questionnaire, at the end of the session, giving scores for each participant's perception of: overall Satisfaction, Confidence, need for support, training, complexity, efficiency and learnability.

4.4. RESULTS

In this topic is presented the results of the testing process in terms of usability, satisfaction and performance.

4.4.1. DATA ANALYSIS

The data analysis takes use of a data scoring criteria and also of a results data reduction.

4.4.1.1. DATA SCORING

Completion rate was scored by deducting a specific percentage for each trie/fail(s) for completing a task, taking into account the scoring criteria that are gathered of Table 21.

Table 21. Scoring criteria

Scoring Criteria (for tasks)		
Menu label	**Pass/Fail**	**Description**
Easy	Pass	1st try - no problem
Medium	Pass	2nd/3rd try - observed difficulty
Hard	Pass	3rd/4th try - expressed difficulty
Assist	Fail	Succeeded with assistance
Fail	Fail	Failed or gave up

Error rate has been measured also according the scoring of Table 21, measuring the number of tries and fails in percentage.

The Time on task has been timed.

The Confidence rating has been scored form 1 to 7.

The SUS questionnaire has been scored through the likert scale.

4.4.1.2. DATA REDUCTION

In addition to data for each task, the combined results show the total task time and the mean results for effectiveness and efficiency metrics.

4.4.2. PRESENTATION OF THE RESULTS

At this point is presented the results of the two phases of testing.

Thus, it is shown the usability and satisfaction results, but also the performance results.

The results are presented in tabular views, but also accompanied with graphs to illustrate the difference between measures.

At the end it is also presented the overall results and is made a comparison among the results obtained in the overall, the scenario and study goals.

So, the following structure for the presentation of results will be used:

- First Phase of testing results.
  - Usability results.
    - Tabular presentation of usability results per participant and profile.
    - Graph presentation of usability results per participant and profile.
    - Tabular presentation of usability results per tool and profile.
    - Graph presentation of usability results per tool and profile.
    - Tabular presentation of overall results per profile/scenario.
    - Graph presentation of overall results per profile/scenario.
    - Tabular presentation of overall results per tool.
    - Graph presentation of overall results per tool.
  - Satisfaction results.
    - Tabular SUS results per participant.

        - Tabular SUS score.
        - SUS histogram.
        - SUS histogram Tally.
    - Web performance results.
        - Tabular presentation of performance results per tool.
        - Graph presentation of performance results per tool.
        - Tabular presentation of results obtained in the competitive and progressive performance tests.
    - Overall first phase of testing.
        - Tabular presentation of overall results, usability, satisfaction and performance.
        - Tabular presentation of overall results, usability, satisfaction and performance comparing with scenario goals.
- Second Phase of testing results.
    - Usability results.
        - Tabular presentation of usability results per participant and profile.
        - Graph presentation of usability results per participant and profile.
        - Tabular presentation of usability results per tool and profile.
        - Graph presentation of usability results per tool and profile.
        - Tabular presentation of overall results per profile/scenario.
        - Graph presentation of overall results per profile/scenario.
        - Tabular presentation of overall results per tool.
        - Graph presentation of overall results per tool.
    - Satisfaction results.
        - Tabular SUS results per participant.
        - Tabular SUS score.

        - SUS histogram.
        - SUS histogram Tally.
    - Web performance results.
        - Tabular presentation of performance results per tool.
        - Graph presentation of performance results per tool.
        - Tabular presentation of results obtained in the competitive and progressive performance tests.
    - Overall second phase of testing.
        - Tabular presentation of overall results, usability, satisfaction and performance.
        - Tabular presentation of overall results, usability, satisfaction and performance comparing with scenario goals.
        - Graph presentation of overall results, usability, satisfaction and performance comparing with scenario goals.
- Overall: Two Phases of testing.
    - Overall tabular presentation of results of the two phases of testing.
    - Overall graph presentation of results of the two phases of testing.
    - Overall tabular presentation of comparison results of the two phases of testing, with scenario goals.
    - Overall graph presentation of comparison results of the two phases of testing, with scenario goals.
    - Overall tabular presentation of comparison results per tool to metric goal.
    - Overall graph presentation of comparison results per tool to metric goal.
    - Overall tabular presentation of study goal achievement.
    - Overall graph presentation of study goal achievement.

Besides, other tests comparing AHKME LOM and LD tools are presented. Also, the interoperability in a LD player has been tested.

4.4.2.1. First phase of testing

In this topic the results for the first phase of testing in terms of participants, profile, tools and overall are presented.

The results are explained with the help of tabular and graph views. It is also presented a descriptive analysis of the results.

4.4.2.1.1. Usability results

First results in terms of the usability tests in the first phases of testing are presented.

4.4.2.1.1.1. Usability results per participant in profile scenario

Table 22 shows the results per participant in the Learning designer profile test scenario.

Table 22. Usability results per participant for the Learning designer profile – Fisrt phase of testing

OVERALL LEARNING DESIGNER							
Participant	Time task (min)	Completion Rate (%)	Completion Success (%)	Completion Rate/Task Time	No errors	Error rate (%)	Confidence
Pilot 1	42,18	96,40%	100,00%	2,29%	8	24,24%	6,70
P1	53,55	85,53%	100,00%	1,60%	18	54,55%	6,00
P3	54,01	86,97%	100,00%	1,61%	20	60,61%	6,16
P4	43,80	93,63%	100,00%	2,14%	12	36,36%	6,54
P14	46,94	97,50%	100,00%	2,08%	8	24,24%	6,67
Mean	**48,09**	**92,01%**	**100,00%**	**1,94%**	**13**	**40,00%**	**6,41**
Std Deviation	5,47	5,46%	0,00%	0,32%	6	16,93%	0,31
Std error	2,44	2,44%	0,00%	0,14%	2	7,57%	0,14
Min	42,18	85,53%	100,00%	1,60%	8	24,24%	6,00
Max	54,01	97,50%	100,00%	2,29%	20	60,61%	6,70

In the Table 22 it is shown that for Time on task the participant P3 takes the highet time to complete (54,01 minutes), and Pilot1 takes the lowest time with 42,18 minutes.

Regarding the Completion rate results, there are very good results with an average of 92,01%, which is above the average Completion rate (90%).

The Error rate is a litle worst with an average value of 40,00%.

For the Confidence metric all the participants have very good results scoring an average value of 6,41.

These results are ilustrated in Figure 92 graphs.

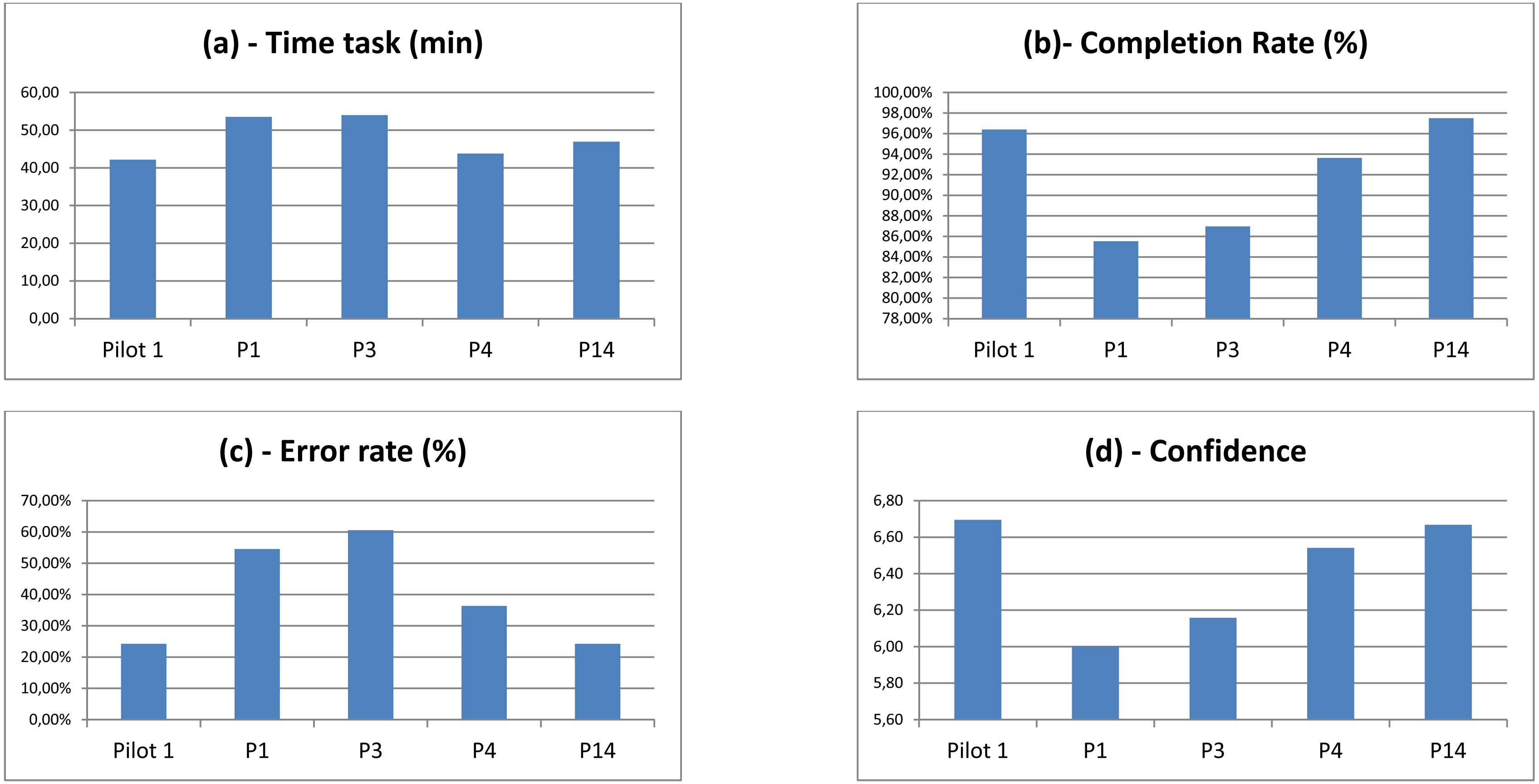


Figure 92. Usability results per participant for the Learning designer profile – Fisrt phase of testing

As it is shown in Figure 92(a), the participant P3 that takes highest time to complete the tasks and at the opposite side is the Pilot 1 participant.

But in terms of Completion rate the situation is a litle bit different. So, in Figure 92(b) participant P14 and also the Pilot 1 had the highest Completion rate. The similarity with Time on task measure is that the P3 participant as one the worst Completion rate, with the exception of P1 participant who had the worsts results.

Also in the Error rate as shown in Figure 92(c), the P3 particpant has shown the worst results, followed by P1 and P4 participants. The P14 and Pilot1 participants had the better results in terms of Error rate, scoring each 24,24%.

The Confidence value is high as presented in Figure 92(d), only with a remark to P1 participant who scored low value compared to the others.

Now, Table 23 has the Learning instructors results.

Table 23. Usability results per participant for the Learning instructor profile – Fisrt phase of testing

OVERALL LEARNING INSTRUCTOR							
Participant	Time task (min)	Completion Rate (%)	Completion Success (%)	Completion Rate/Task Time	No errors	Error rate (%)	Confidence
Pilot2	60,97	93,15%	100,00%	1,53%	13	39,39%	6,27
P2	56,60	93,56%	100,00%	1,65%	10	30,30%	6,55
P5	68,61	93,33%	100,00%	1,36%	12	36,36%	6,25
P6	50,36	93,11%	100,00%	1,85%	11	33,33%	6,46
P15	45,88	95,11%	100,00%	2,07%	4	12,12%	6,61
Mean	**56,48**	**93,65%**	**100,00%**	**1,69%**	**10**	**30,30%**	**6,43**
Std Deviation	8,91	0,83%	0,00%	0,28%	4	10,71%	0,16
Std error	3,98	0,37%	0,00%	0,12%	2	4,79%	0,07
Min	45,88	93,11%	100,00%	1,36%	4	12,12%	6,25
Max	68,61	95,11%	100,00%	2,07%	13	39,39%	6,61

Thus, Table 23 shows that for Time on task that participant P5 takes the highet time to complete (68,61 min), and P15 takes the lowest time with 45,88 minutes. Regarding the Completion rate results, there are very high results.

The Error rate has an average value of 30,30%. More satisfying results are the participant's Confidence scoring with an average value of 6,43.

These results are ilustrated in Figure 93 graphs in terms of Time on task, Completion and Error rate, and also Confidence.

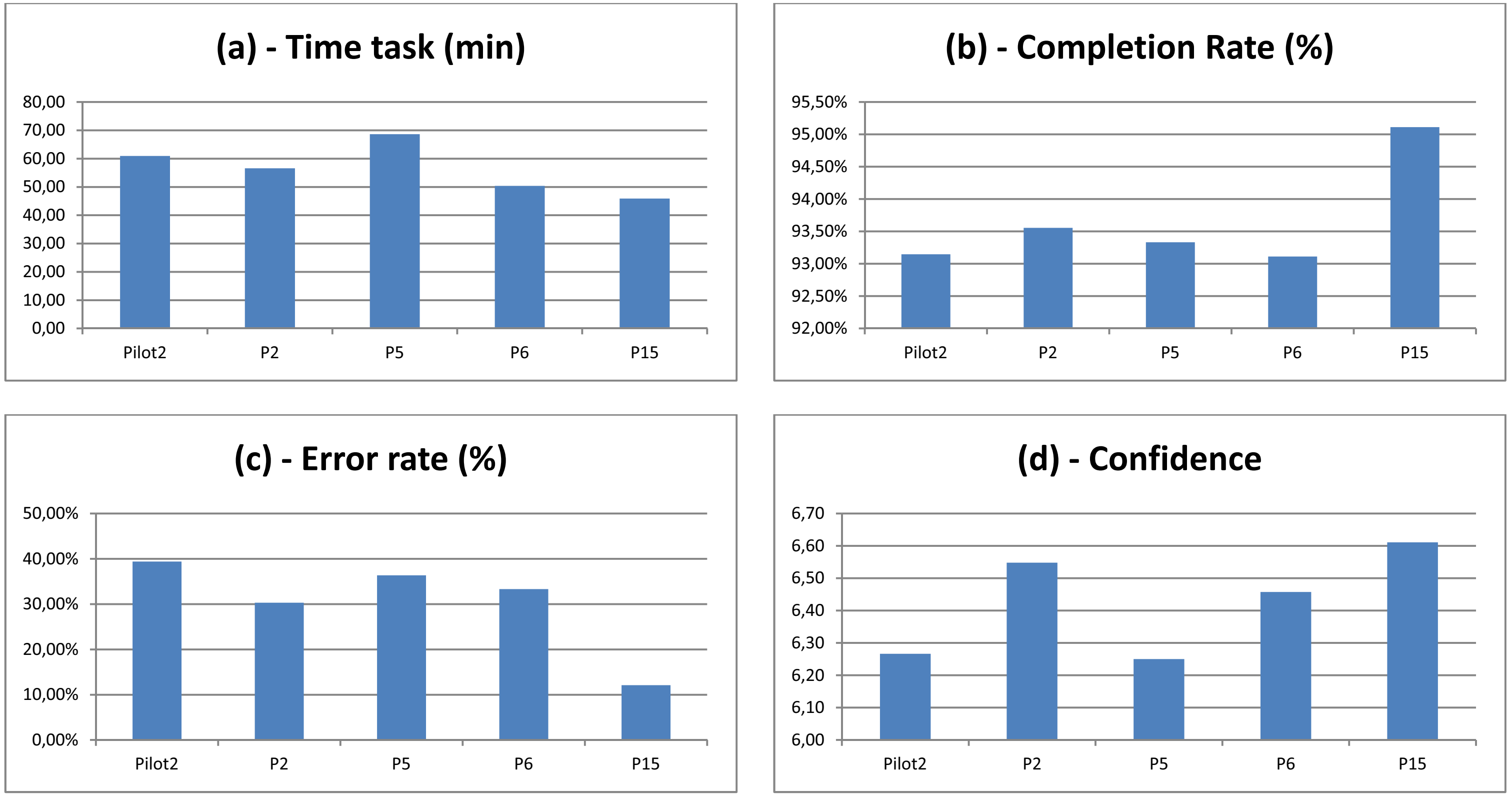


Figure 93. Usability results per participant for the Learning instructor profile – Fisrt phase of testing

As shown in Figure 93(a) the Time on task graph P5 is the participant that takes most time to complete the tasks and at the opposite side is P15 participant.

Thus, in Figure 93(b) the participant P15 had the highest Completion rate.

The worst results are from P6 and Pilot2 participants with the worst Completion rate results, specifically 93,11% and 93,15%.

As shown in Figure 93(c), regarding the Error rate results, Pilot2 participant has the worst result, followed by P5 and P6 participants.

The P15 participant has the better result in terms of Error rate, scoring 12,12%.

The Confidence graph of Figure 93(d) shows that all of the participants have good results with values above of 6.

Table 24 presents' Student scenario participants results.

Table 24. Usability results per participant for the Student profile – Fisrt phase of testing

OVERALL STUDENT							
Participant	**Time task (min)**	**Completion Rate (%)**	**Completion Success (%)**	**Completion Rate/Task Time**	**No errors**	**Error rate (%)**	**Confidence**
P9	54,51	100,00%	100,00%	1,83%	0	0,00%	6,75
P10	19,34	92,00%	100,00%	4,76%	4	36,36%	6,48
P11	35,88	88,00%	100,00%	2,45%	5	45,45%	6,40
P12	35,80	100,00%	100,00%	2,79%	0	0,00%	6,75
P13	39,95	92,00%	100,00%	2,30%	3	27,27%	6,43
Mean	**37,10**	**94,40%**	**100,00%**	**2,83%**	**2**	**21,82%**	**6,56**
Std Deviation	12,55	5,37%	0,00%	1,13%	2	20,93%	0,18
Std error	5,61	2,40%	0,00%	0,51%	1	9,36%	0,08
Min	19,34	88,00%	100,00%	1,83%	0	0,00%	6,40
Max	54,51	100,00%	100,00%	4,76%	5	45,45%	6,75

Thus, Table 24 shows very high results in terms of Completion rates (94,40%), and also some satisfactory results in terms of Error rate, nearly 20% and Confidence (6,56 average).

Figure 94 graphs help to illustrate this situation.

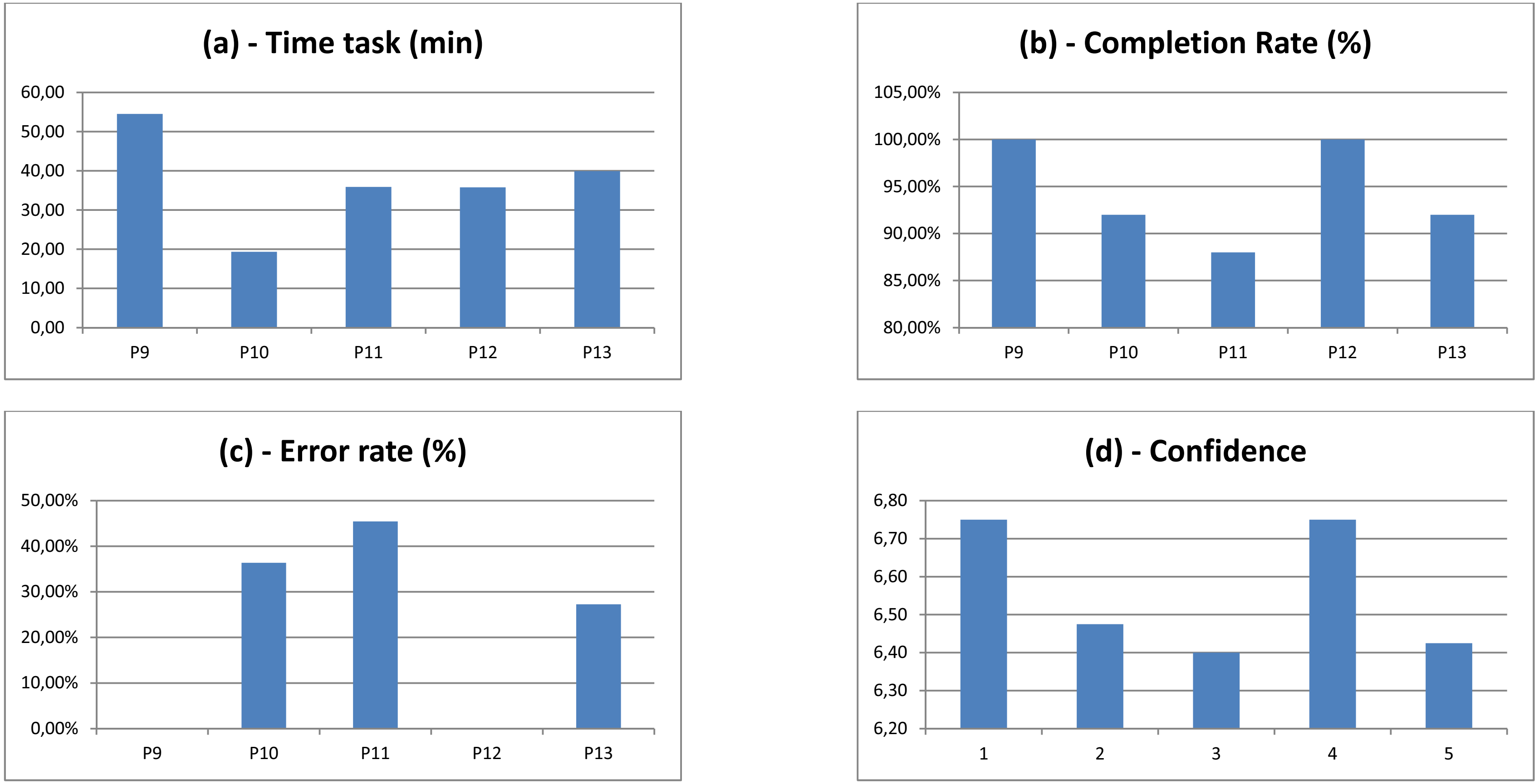


Figure 94. Usability results per participant for the Student profile – Fisrt phase of testing

As shown in Figure 94(a) the participant P9 takes the highest time to complete the tasks and at the opposite side is the P10 participant with the lowest time value (19,24 minutes).

In terms of Completion rate the situation is a litle bit different as presented in Figure 94(b).

Then, in this graph participant P9 and also P12 have the highest Completion rate. P11 has the worst results participant with the worst Completion rate, specifically 88,00%.

As presented in Figure 94(c), regarding the Error rate results, the P11 participant has shown the worst result. P9 and P12 participants have the better results in terms of Error rate, scoring both 0%.

Finally, Table 25 presents the Technical profile results regarding the different test metrics.

Table 25. Usability results per participant for the Technical profile – Fisrt phase of testing

OVERALL TECHNICAL							
Participant	**Time task (min)**	**Completion Rate (%)**	**Completion Success (%)**	**Completion Rate/Task Time**	**No errors**	**Error rate (%)**	**Confidence**
P7	13,19	95,00%	100,00%	7,20%	2	28,57%	6,46
P8	24,10	95,00%	100,00%	3,94%	2	28,57%	6,04
P16	42,70	94,17%	100,00%	2,21%	2	28,57%	6,42
P17	43,06	88,33%	100,00%	2,05%	4	57,14%	5,96
P18	30,82	96,67%	100,00%	3,14%	1	14,29%	6,29
Mean	**30,77**	**93,83%**	**100,00%**	**3,71%**	**2**	**31,43%**	**6,23**
Std Deviation	12,72	3,21%	0,00%	2,10%	1	15,65%	0,22
Std error	5,69	1,43%	0,00%	0,94%	0	7,00%	0,10
Min	13,19	88,33%	100,00%	2,05%	1	14,29%	5,96
Max	43,06	96,67%	100,00%	7,20%	4	57,14%	6,46

As shown in Table 25, the Completion rate has high average value (93,83%), but the average Error rate value (31,43) is at this point also high.

Although, the Confidence of the participants presents a good average value of 6,23.

Figure 95 graphs help to illustrate this situation.

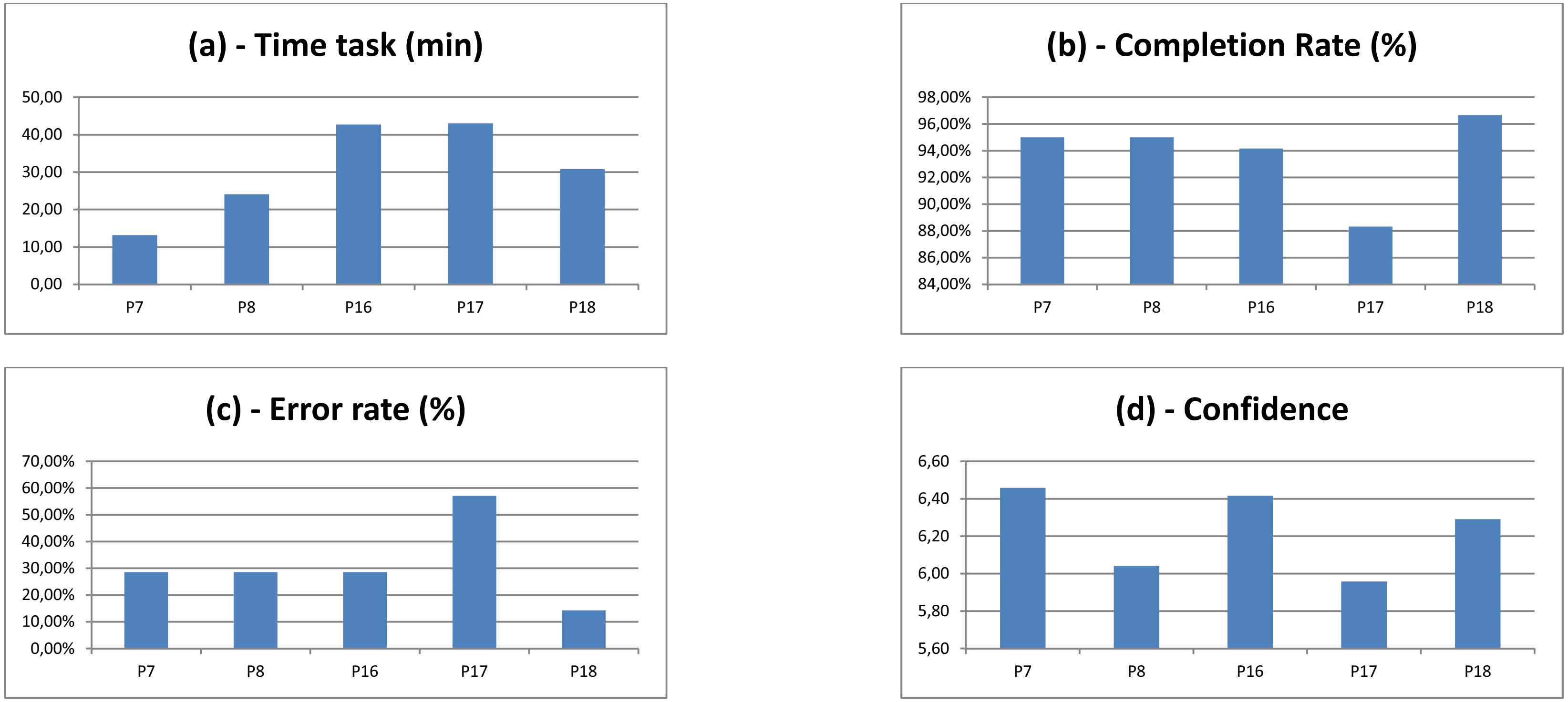


Figure 95. Usability results per participant for the Technical profile – Fisrt phase of testing

As shown in Figure 95(a) participants P17 and P16 take the highest times to complete the tasks and at the opposite side it is P7 participant with the lowest time value (13,19 minutes).

In terms of Completion rate the situation is a litle bit different as presented in Figure 95(b).Then, in this graph participant P18 has the highest Completion rate (96,67%). The worst results are from P17 participant with the worst Completion rate, specifically 88,33%. Regarding the Error rate results, Figure 95(c) shows that P17 participant has the worst result (57,14%). P18 participant has the better results in terms of Error rate, scoring both 14,29%.

In terms of Confidence, Figure 95(d) presents an average value above 6, but P17 participant is below 6.

4.4.2.1.1.2. Usability results per tool for profile

Following tables present the profile scenarios results per tool. Thus, Table 26 presents the results of the Learning designer profile results in terms of tools. These results are illustrated in Figure 96 graphs presenting the Time on task, Completion and Error rate, and also the Confidence metric.

Table 26. Usability results overall Learning designer profile per tool – Fisrt phase of testing

Learning Designer 1ª Phase							
TOOL	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence
TOTAL GENERAL	6,27	94,40%	72,00%	100,00%	15,06%	28,00%	6,44
TOTAL SCHEMA	12,82	89,60%	52,00%	100,00%	6,99%	48,00%	6,16
TOTAL WF	3,10	95,00%	75,00%	100,00%	30,65%	25,00%	6,60
TOTAL QUALITY	2,08	90,00%	50,00%	100,00%	43,28%	50,00%	6,60
TOTAL INTEROPERABILITY	5,14	94,67%	73,33%	100,00%	18,40%	26,67%	6,53
TOTAL RECOMMENDATION	1,42	90,00%	50,00%	100,00%	63,25%	50,00%	6,20
TOTAL COMMUNICATION & SHARING	4,26	96,00%	60,00%	100,00%	22,55%	40,00%	6,60
TOTAL RESOURCES	8,34	91,20%	60,00%	100,00%	10,93%	40,00%	6,48
TOTAL SEARCH	0,62	88,00%	40,00%	100,00%	142,86%	60,00%	6,20
TOTAL SURVEY	4,05	91,20%	60,00%	100,00%	22,54%	40,00%	6,32
TOTAL LEARNING DESIGN	**48,09**	**92,01%**	**59,23%**	**100,00%**	1,91%	**40,77%**	**6,41**
Mean	**4,81**	**0,92**	**0,59**	**1,00**	**0,38**	**0,41**	**6,41**
Std Deviation	3,64	0,03	0,12	0,00	0,41	0,12	0,18
Std error	1,15	0,01	0,04	0,00	0,13	0,04	0,06
Min	0,62	0,88	0,40	1,00	0,07	0,25	6,16
Max	12,82	0,96	0,75	1,00	1,43	0,60	6,60

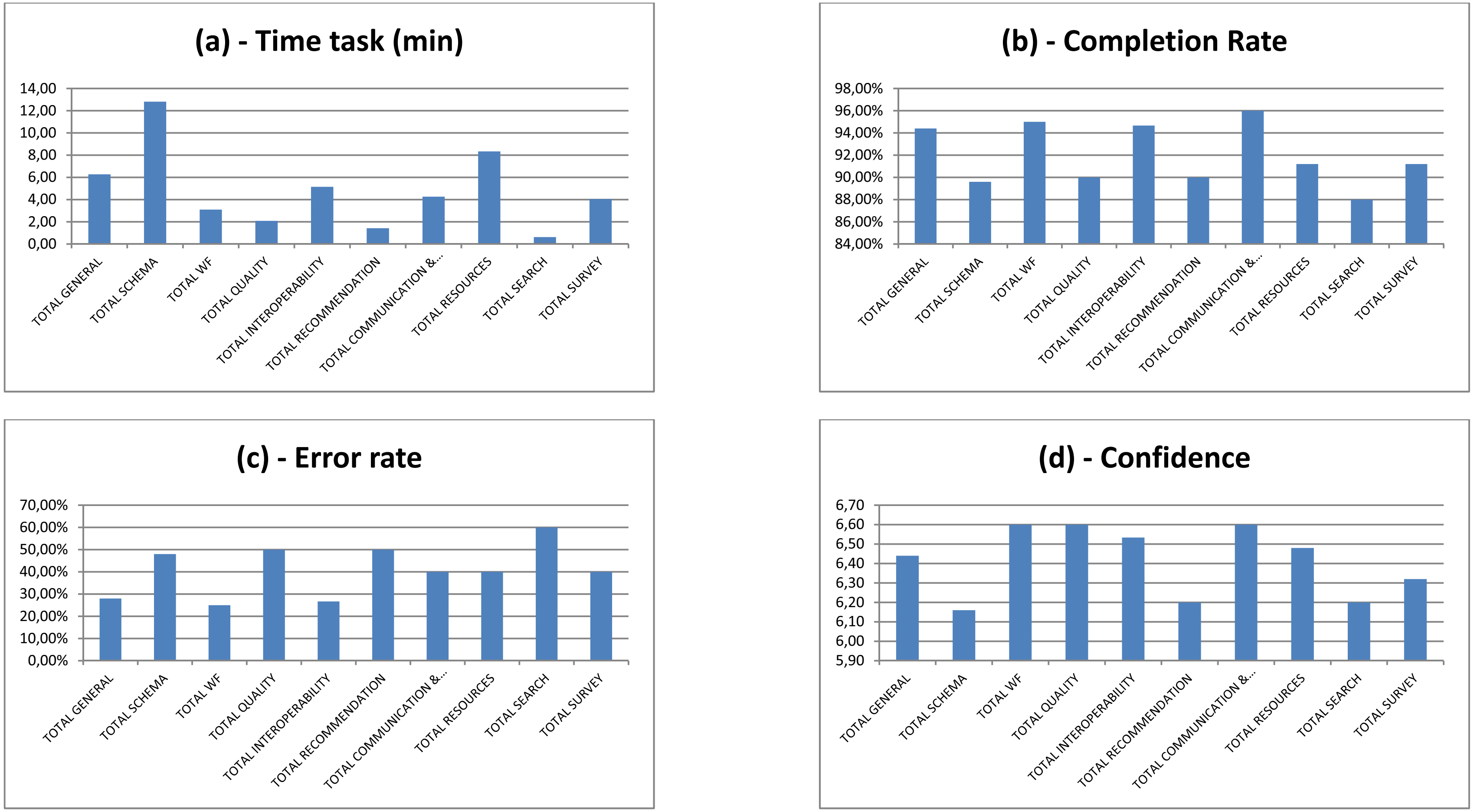


Figure 96. Usability results overall Learning designer profile per tool – Fisrt phase of testing

As shown in Figure 96(a), schema/instructional manager is the task that takes most time to be completed and at the opposite side search task is.

In terms of Completion rate the situation is a litle bit different as shown in Figure 96(b).

In this graph, communication and sharing and also the workflow are the tasks with highest Completion rate.

The similarity with Time on task measure is that the search also as the least Completion rate.

As presented in Figure 96(c), also in the Error rate the search task has the worst results, followed by quality and recommendation tasks.

The workflow and interoperability task had the better results in terms of Error rate, scoring specifically 25,00% and 26,67%.

Table 27 presents the results of the Learning instructor profile in terms of tools.

Table 27. Usability results overall Learning instructor profile per tool – Fisrt phase of testing

Learning Instructor 1ª Phase							
TOOL	**Time task (min)**	**Completion Rate**	**Error-free rate**	**Completion Success**	**Completion Rate/Task Time**	**Error rate**	**Confidence**
TOTAL GENERAL	6,28	96,00%	84,00%	100,00%	15,30%	16,00%	6,40
TOTAL SCHEMA	3,53	94,00%	70,00%	100,00%	26,67%	30,00%	6,25
TOTAL WF	1,21	98,67%	93,33%	100,00%	81,27%	6,67%	6,80
TOTAL SURVEY	5,70	95,00%	75,00%	100,00%	16,67%	25,00%	6,55
TOTAL LOM	8,79	91,20%	56,00%	100,00%	10,37%	44,00%	6,32
TOTAL LD	20,48	88,80%	48,00%	100,00%	4,34%	52,00%	6,16
TOTAL RESOURCES	5,33	95,20%	76,00%	100,00%	17,87%	24,00%	6,56
TOTAL COMMUNICATION & SHARING	4,73	88,00%	40,00%	100,00%	18,59%	60,00%	6,40
TOTAL SEARCH	0,43	96,00%	80,00%	100,00%	222,50%	20,00%	6,40
TOTAL LEARNING INSTRUCTOR	**56,48**	**93,65%**	**69,15%**	**100,00%**	1,66%	**30,85%**	**6,43**
Mean	**6,28**	**0,94**	**0,69**	**1,00**	**0,46**	**0,31**	**6,43**
Std Deviation	5,91	0,04	0,18	0,00	0,70	0,18	0,19
Std error	1,97	0,01	0,06	0,00	0,23	0,06	0,06
Min	0,43	0,88	0,40	1,00	0,04	0,07	6,16
Max	20,48	0,99	0,93	1,00	2,23	0,60	6,80

These results are illustrated in Figure 97 graphs.

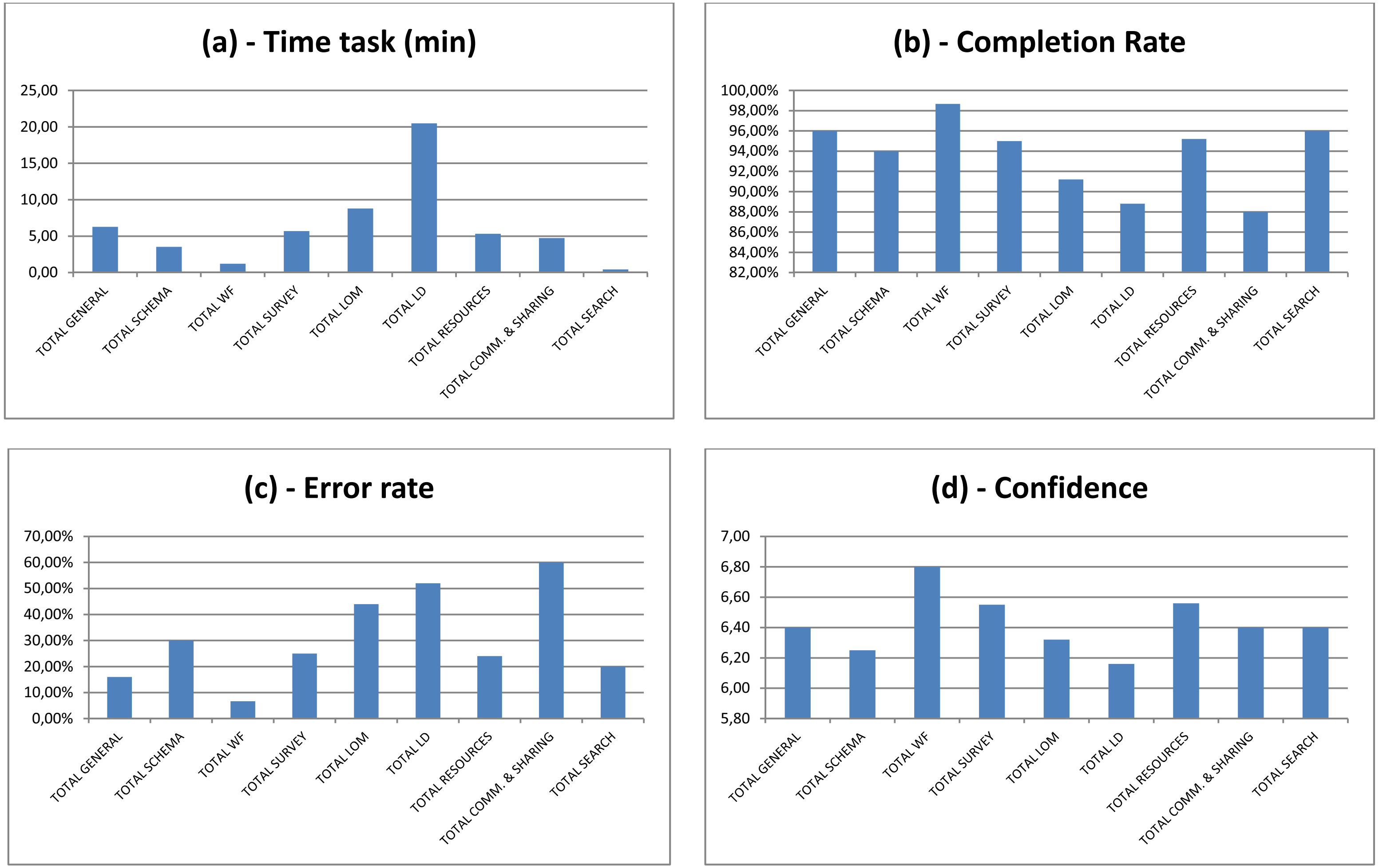


Figure 97. Usability results overall Learning instructor profile per tool – Fisrt phase of testing

As shown in Figure 97(a) the learning design task takes the highest time to complete the task and at the opposite side it is the search task result.

But in terms of Completion rate the situation is a litle bit different as shown in Figure 97(b).

So, in this graph the workflow task has the highest Completion rate (98,67%), followed by search and general task (both 96,00%). The worst result is from the communication and sharing task (88,00%).

As presented in Figure 97(c), also in the Error rate metric communication and sharing task has the worst result (60%), followed by the learning design task.

The workflow and general task have the better results in terms of Error rate, scoring specifically 6,67% and 16,00%.

Table 28 has the Student profile results per tool.

Table 28. Usability results overall Student profile per tool – Fisrt phase of testing

Student 1ª Phase							
TOOL	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence
TOTAL GENERAL	15,87	90,67%	63,33%	100,00%	5,71%	36,67%	6,33
TOTAL SURVEY	6,27	94,00%	80,00%	100,00%	14,99%	20,00%	6,50
TOTAL RESOURCES	13,04	98,00%	90,00%	100,00%	7,51%	10,00%	6,70
TOTAL COMMUNICATION & SHARING	4,59	92,00%	60,00%	100,00%	20,03%	40,00%	6,40
TOTAL STUDENT	**39,78**	**93,67%**	**73,33%**	**100,00%**	2,35%	**26,67 %**	**6,48**
Mean	**9,94**	**0,94**	**0,73**	**1,00**	**0,12**	**0,27**	**6,48**
Std Deviation	5,38	0,03	0,14	0,00	0,07	0,14	0,16
Std error	2,69	0,02	0,07	0,00	0,03	0,07	0,08
Min	4,59	0,91	0,60	1,00	0,06	0,10	6,33
Max	15,87	0,98	0,90	1,00	0,20	0,40	6,70

Time on task metric total value is 39,78 minutes. The average Completion rate is high, 93,67% and the Error rate a little bit off the average 26,67%.

Contrasting there are the satisfactory Confidence values of 6,48.

These results are illustrated in Figure 98 graphs, regarding Time on task, Completion and Error rate, and also Confidence.

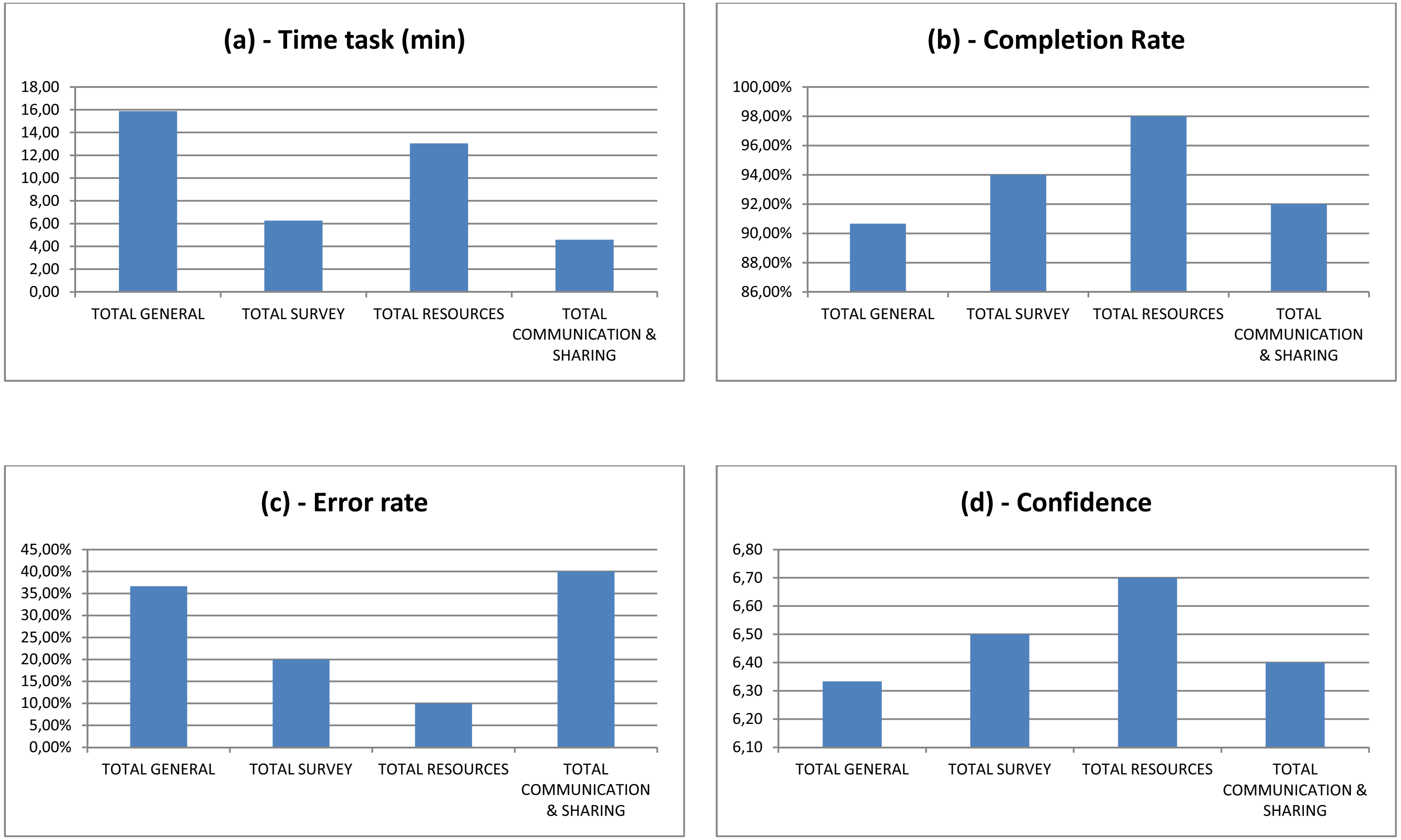


Figure 98. Usability results overall Student profile per tool – Fisrt phase of testing

As shown in Figure 98(a) the general task takes the highest time to complete the task and at the opposite side it is the communcation and sharing task result.

But in terms of Completion rate the situation is a litle bit different as shown in Figure 98(b), where the resources task has the highest Completion rate (98,00%), followed by the survey task (94,00%). The worst result is for general task (90,67%).

As presented in Figure 98(c), also in the Error rate metric the communication and sharing task has the worst result (40%), followed by the general task.

The resources and survey tasks have the better results in terms of Error rate, scoring specifically 10,00% and 20,00%.

Table 29 gathers the results are from the Technical profile.

Table 29. Usability results overall Technical profile per tool – Fisrt phase of testing

Technical 1ª Phase							
TOOL	**Time task (min)**	**Completion Rate**	**Error-free rate**	**Completion Success**	**Completion Rate/Task Time**	**Error rate**	**Confidence**
TOTAL ADMINISTRATION	13,46	94,67%	73,33%	100,00%	7,04%	26,67%	6,27
TOTAL GENERAL	17,32	93,00%	65,00%	100,00%	5,37%	35,00%	6,20
TOTAL TECHNICAL	**30,77**	**93,83%**	**69,17%**	**100,00%**	**6,20%**	**30,83%**	**6,23**
Mean	**15,39**	**0,94**	**0,69**	**1,00**	**0,06**	**0,31**	**6,23**
Std Deviation	2,73	0,01	0,06	0,00	0,01	0,06	0,05
Std error	1,93	0,01	0,04	0,00	0,01	0,04	0,03
Min	13,46	0,93	0,65	1,00	0,05	0,27	6,20
Max	17,32	0,95	0,73	1,00	0,07	0,35	6,27

As Table 29 presents, the Completion and Error rate are high, specifically an average of 93,83% and 30,83%.

Also the Confidence values are high, an average of 6,23.

Figure 99 graphs illustrate these results.

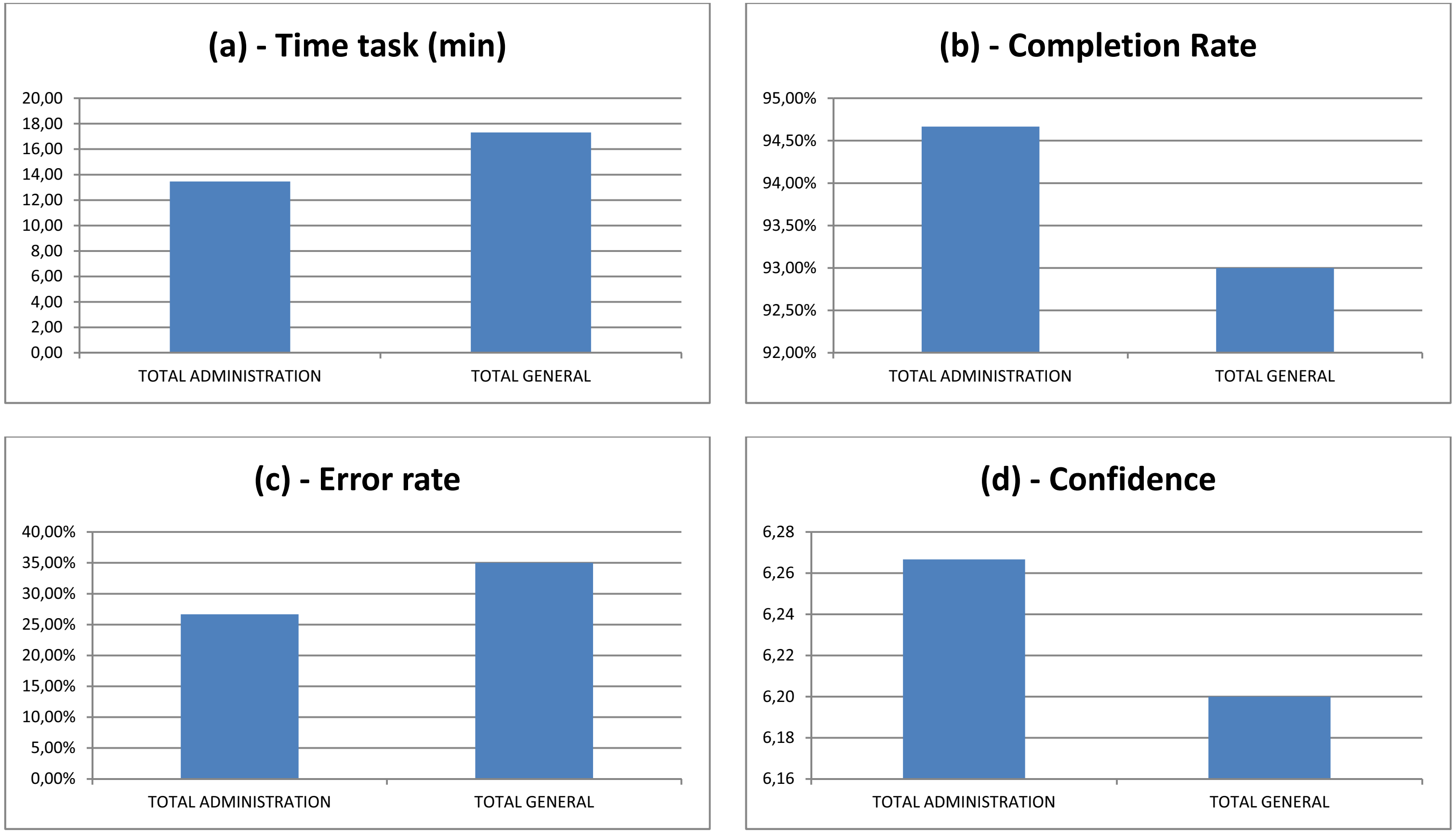


Figure 99. Usability results overall Technical profile per tool – Fisrt phase of testing

As shown in Figure 99(a) the General task takes the highest time to complete the task and at the opposite side the administration task result is 13,46 minutes.

In terms of Completion rate the situation is a litle bit contrasting, as shown in Figure 99(b), the adminsitration task has the highest Completion rate (94,67%).

Also, the general task has a high result in tems of Completion rate with 93,00%.

In the Error rate metric the general task as shown in Figure 99(c) has the worst result in this scenario (35%).

The administration task has the better result in terms of Error rate, scoring 26,67%.

4.4.2.1.1.3. Overall results per profile/scenario

Table 30 presents the overall profiles/scenario information.

Table 30. Overall results per profile/scenario – Fisrt phase of testing

Overall profiles 1ª Phase							
Profile	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence
Technical	30,77	93,83%	69,17%	100,00%	3,05%	30,83%	6,23
LEARNING INSTRUCTOR	56,48	93,65%	68,70%	100,00%	1,66%	30,85%	6,43
LEARNING DESIGNER	48,09	92,01%	51,23%	100,00%	1,91%	40,77%	6,41
STUDENT	39,78	93,67%	73,33%	100,00%	2,35%	26,67%	6,48

As shown in Table 30, the Completion rates are litle high above the average (90%), contrasting with the Error rates that are a little bit above the average 20%.

In terms of the Confidence all the profiles scenarios have satisfactory results.

These results are illustrated in the Figure 100 graphs.

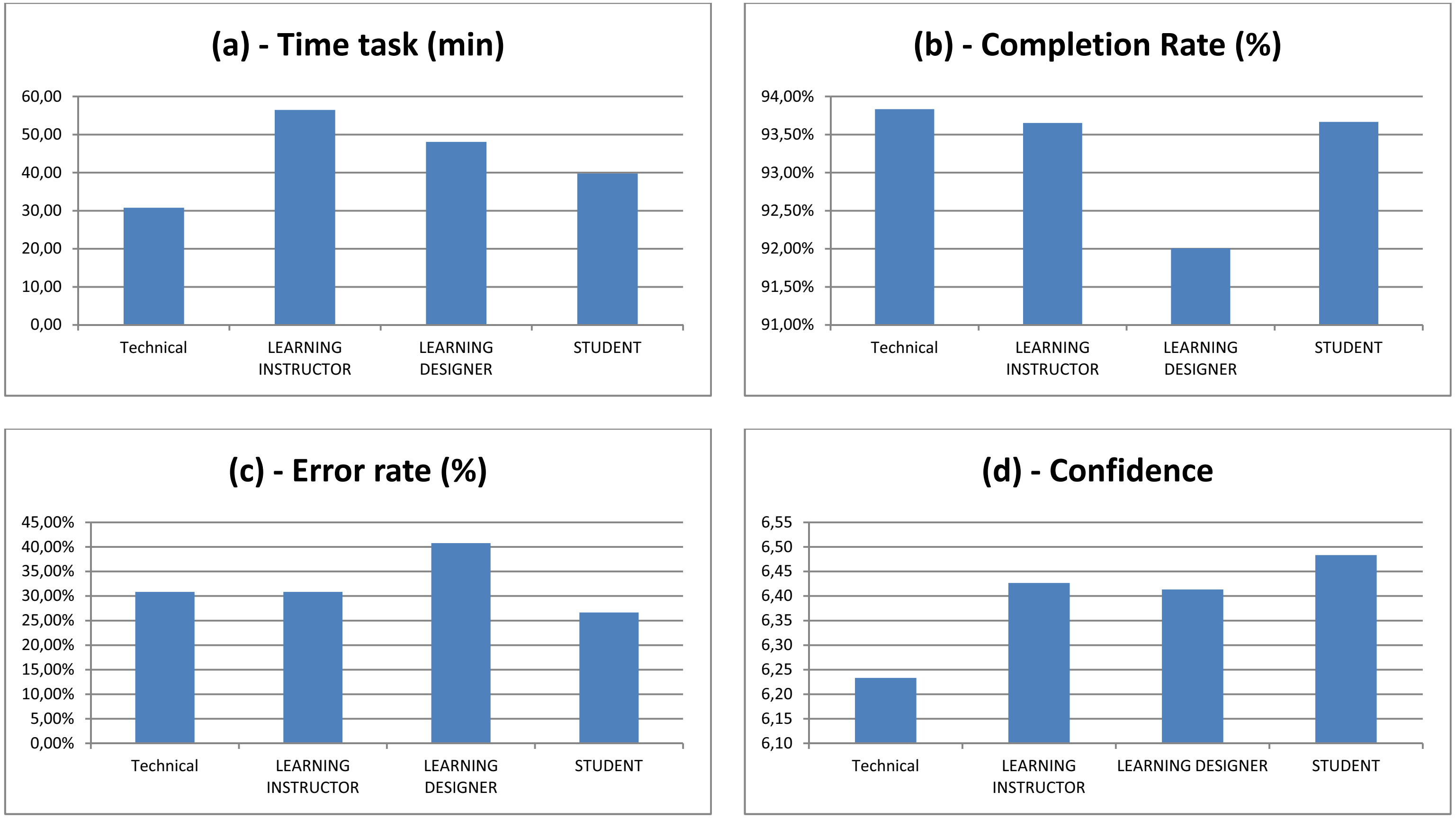


Figure 100. Overall results per profile/scenario – Fisrt phase of testing

As shown in Figure 100(a) Learning Instructors scenario takes the highest time to complete the tasks and at the opposite side is the Technical Profile result.

In the Completion rate graph the Technical profile has the highest Completion rate (93,83%), followed closely by the Student profile (93,67%). The worst result is from the Learning Designer (92,01%)(see Figure 100(b)).

Also in the Error rate metric in Figure 100(c) the Learning Designer has the worst result (40,77%), followed by the Learning Instructor.

The Student profile has the better results in terms of Error rate, scoring 26,67%.

As shown in Table 30, there are no average values, since the profiles have different features so they are not directly comparable.

Therefore, it has been chosen to conduct a mapping by tool, taking into account the profile and participants more representative of certain functionalities.

Criteria of representativeness:

- Tool that exists only in one profile - include results from participants of that profile.
- Transversality of tools – include results from all of the participants.
- Tools with additional features among profiles - include sample of participants with greater breadth of functionality.

Thus, Table 31 has the results for tool/task of AHKME system.

Therefore, it also becomes easier to establish the mapping with the objectives and the hypothesis assumptions of the study, since they are related to the tools being evaluated in these tests.

As shown in Table 31, the average Completion rate 92,65% is a high valuable result. On the other hand, it is the Error rate that is a little high.

In contrast the Confidence result is above 6.

Figure 101 graphs illustrate these results.

Table 31. Overall results per tool – First phase of testing

TOOL	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence
TOTAL ADMINISTRATION	13,46	94,67%	73,33%	100,00%	0,64%	26,67%	6,27
TOTAL INTEROPERABILITY	5,14	94,67%	73,33%	100,00%	0,95%	26,67%	6,53
TOTAL QUALITY	2,08	90,00%	50,00%	100,00%	1,94%	50,00%	6,60
TOTAL RECOMMENDATION	1,42	90,00%	50,00%	100,00%	3,30%	50,00%	6,20
TOTAL SURVEY	5,70	95,00%	75,00%	100,00%	4,72%	25,00%	6,55
TOTAL LOM	8,79	91,20%	56,00%	100,00%	3,88%	44,00%	6,32
TOTAL LD	20,48	88,80%	48,00%	100,00%	1,96%	52,00%	6,16
TOTAL GENERAL	11,43	93,52%	71,08%	100,00%	0,79%	28,92%	6,34
TOTAL SCHEMA	12,82	89,60%	52,00%	100,00%	3,82%	48,00%	6,16
TOTAL WF	3,10	95,00%	75,00%	100,00%	3,01%	25,00%	6,60
TOTAL Resources	13,04	98,00%	90,00%	100,00%	0,60%	10,00%	6,70
TOTAL COMMUNICATION & SHARING	4,53	92,00%	53,33%	100,00%	0,34%	46,67%	6,47
TOTAL SEARCH	0,52	92,00%	60,00%	100,00%	175,67%	40,00%	6,30
TOTAL SYSTEM	**102,53**						
Mean	**7,89**	**92,65%**	**63,62%**	**100,00%**	**11,75%**	**36,38%**	**6,40**
Std Deviation	5,99	0,03	0,13	0,00	0,48	0,13	0,18
Std error	1,66	0,01	0,04	0,00	0,13	0,04	0,05
Min	0,52	0,89	0,48	1,00	0,00	0,10	6,16
Max	20,48	0,98	0,90	1,00	1,76	0,52	6,70

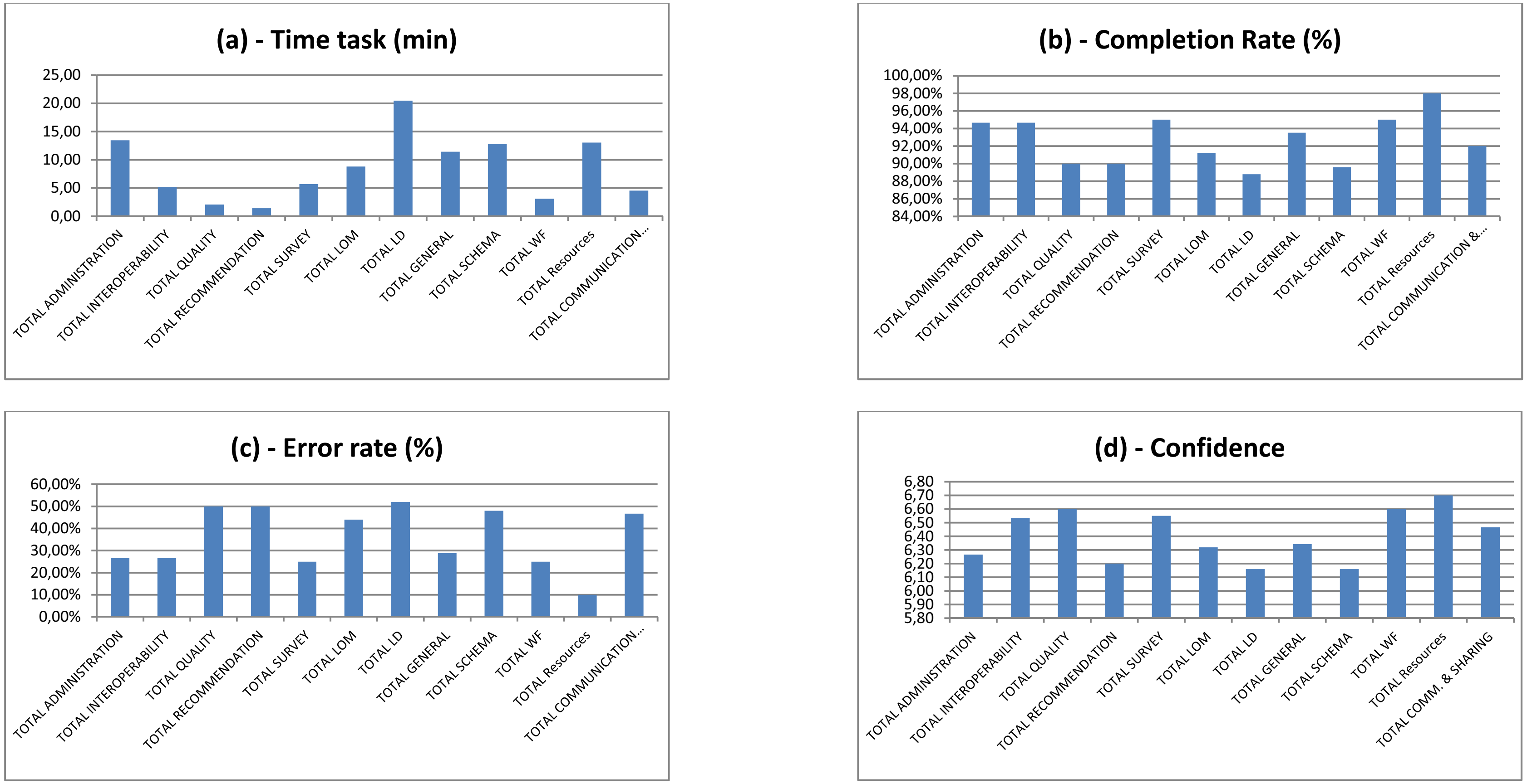


Figure 101. Overall results per tool – First phase of testing

As shown in Figure 101(a) the Time on task the learning design has the worst result, followed by the administration tasks.

The recommendation/adaptation task has the best Time on task result.

In terms of Completion rate, Figure 101(b) shows that the resources task has the better result, at the opposite side is the learning design task is.

The learning design task has the worst Error rate presented in Figure 101(c) whereas the best result is for the resources task Error rate.

As shown in Figure 101(d), the Confidence values are still high for all of the tools.

4.4.2.1.2. Satisfaction Results

Table 32 presents the satisfaction results, obtained with SUS post-test questionnaire.

The average SUS Score at the first phase of tesing presents a good result with 66,13%, but below the scenario goal (70%).

Table 33 has the SUS histogram results.

As shown in the histogram, the distribution of experimental data in terms of frequency, give results that participants concentrate mainly their answers in positive results for the system.

Table 32. Tabular satisfaction results – First phase of testing

SUS																				
Question	**Pilot1**	**Pilot2**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**Avg SUS**
1	3	2	3	4	2	4	2	2	3	2	4	2	2	1	1	4	3	4	2	4	
2	3	3	3	4	2	3	3	4	4	3	4	3	2	2	2	4	4	4	2	4	
3	2	2	2	3	3	3	2	2	3	3	3	2	2	1	1	3	4	3	2	4	
4	3	1	2	2	1	3	3	2	3	2	3	2	2	1	1	3	3	3	2	2	
5	3	4	3	3	2	3	3	3	3	4	4	3	3	2	2	3	3	3	3	3	
6	3	4	4	3	4	3	4	4	3	4	3	3	3	3	3	4	4	3	3	3	
7	2	3	3	2	2	3	1	1	1	2	2	2	2	1	1	2	1	2	1	1	
8	3	3	3	2	4	4	4	4	2	3	4	2	2	2	2	4	4	3	3	3	
9	3	2	3	4	1	3	2	2	2	2	4	2	2	1	1	2	3	3	2	3	
10	2	2	2	3	2	3	2	3	3	3	3	2	2	1	1	3	3	2	2	3	
SUS	67,50	65,00	70,00	75,00	57,50	80,00	65,00	67,50	67,50	70,00	85,00	57,50	55,00	37,50	37,50	80,00	80,00	75,00	55,00	75,00	**66,13**

66,13	**% SUS Score**

Table 33. SUS Histogram – First phase of testing

	System Usability Scale Histogram	Strongly Disagree			Strongly Agree	
		1	2	3	4	5
1	I think I would like to use this software product frequently.					
	I find the product unnecessary complex.					
3	I think the product is easy to use.					
	I think I would need Tech support to be able to use this product.					
5	I find the various functions in this product are well integrated.					
6	I think there is too much inconsistency in this product					
7	I imagine that most people would learn to use this product very quickly.					
8	I find the product very cumbersome to use.					
9	I feel very confident using this product.					
10	I need to learn all about this product before I could effectively use it.					

	SUS Histog am		all			
Item#	1	2	3	4	5	
	0	2	8	4		2
2	8	7	5	0	0	2
3	0	2		8	2	20
4	0	8	8	4	0	
5		0	3	1	3	20
		12	0	0	0	20
7	0	8	9	3	0	20
8		7		0	0	20
		3	9		2	20
10	0	9		2	0	20

4.4.2.1.3. Web Performance Results

For the case of the schema, learning design and LOM tools specifically generate and edit features, it has been also measured some performance results, regarding Response and Download time. Also, it has been done the same tests for the adaptation tools, such as the recommendation features, for the decision tree algorithm.

Table 34. Performance results – First phase of testing

PERFORMANCE				
Tool	**Response Time (msec.)**	**Response Time (sec.)**	**Download Time (msec.)**	**Download Time (sec.)**
Administration	372	0,37	106	0,11
Communication & Share	1243	1,24	307	0,31
General	921	0,92	143	0,14
Interoperability	2271	2,27	1958	1,96
Survey	255	0,26	46	0,05
WF	251	0,25	42	0,04
Adaptive	451	0,45	53	0,05
LD	4543	4,54	1604	1,60
LOM	17807	17,81	14520	14,52
Quality	442	0,44	65	0,07
Resources	875	0,88	9	0,01
Schema	5849	5,85	5220	5,22
Search	447	0,45	148	0,15
Mean	**2748**	**2,75**	**1863**	**1,86**

As shown in Table 34, it may contrast the results, with LOM 17,81 and 14,52 seconds for Response and Download time specifically, and the workflow tool with 0,45 and 0,05 seconds. In the average value for these metrics, the most positive values are 2,75 and 1,86 seconds for Response and Download time.

4.4.2.1.4. Overall First phase of testing

At this point it is presented in Table 35 the overall results of the first phase of testing, in terms of usability, satisfaction and performance.

Table 36 makes a comparison among the results in term of usability, satisfaction and performance for the first phase of the testing process. Analysing the table, it shows that the Time on task is very high comparing to the scenario goal, about 20 minutes more. The Completion rate results are much better 92,65%, with a value above the scenario goal. The Error rate is above the scenario goal limit 20%, with the average Error rate of 36,38%. This can be seen in Figure 102 graphs.

Table 35. Overall results – First phase of testing

Phase	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence	SUS	RESPONSE TIME (sec)	DOWNLOAD TIME (sec)
1	102,53	92,65%	63,62%	100,00%	0,90%	36,38%	6,40	66,13%	2,75	1,86

Table 36. Overall Goals limits comparison – First phase of testing

Phase	Time task (min)	Scenarios Time task (min)	Completion Rate	Scenario Completion rate	Completion Rate/Task Time	Error rate	Scenario Error rate	SUS	Scenario SUS	RESPONSE TIME (sec)	Scenario RESPONSE TIME (sec)	DOWNLOAD TIME (sec)	Scenario DOWNLOAD TIME (sec)
1	102,53	82,75	92,65%	90,00%	0,90%	36,38%	20,00%	66,13%	70,00%	2,75	1,00	1,86	10,00

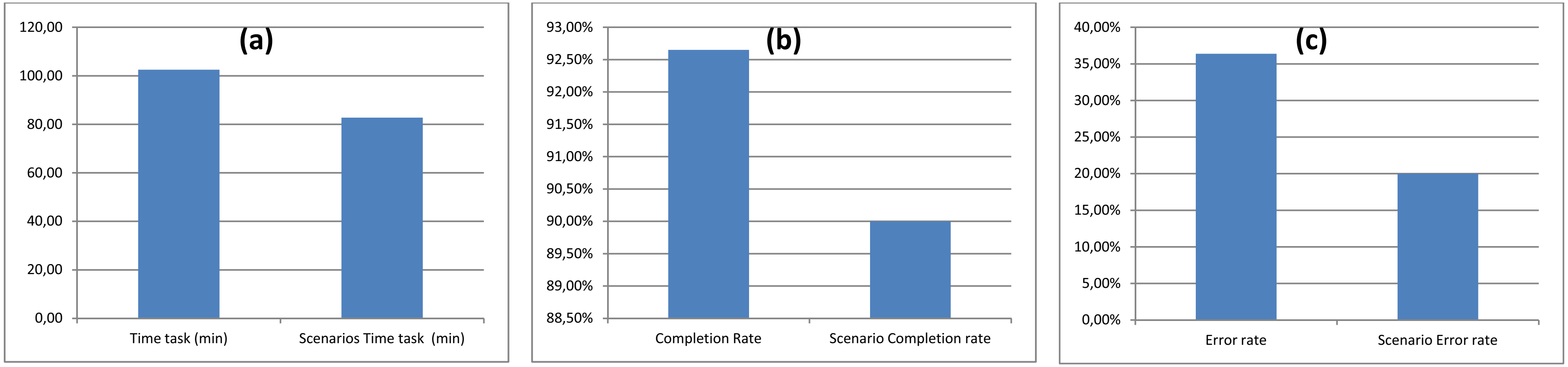


Figure 102. Overall usbility results, time task, completion and error rate comparison to scenario limits – First phase of testing

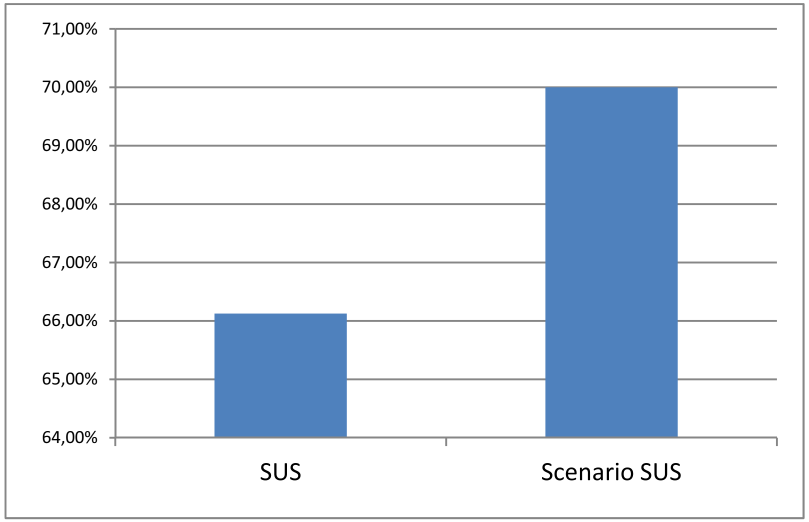


Figure 103. Overall SUS results – First phase of testing

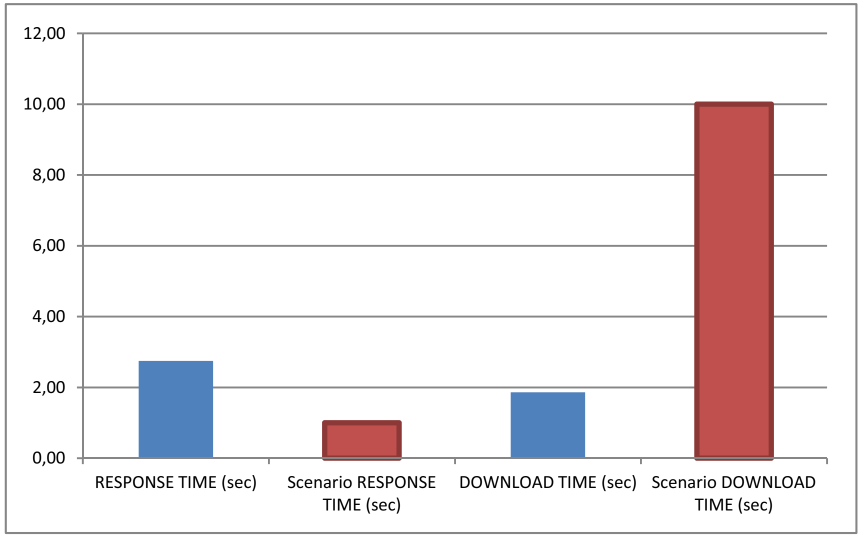


Figure 104. Overall Performance results – First phase of testing

For the satisfaction results, 66,13% are still below the scenario goal - 70% - as it is illustrated in Figure 103.

Figure 104 shows the performance results that are a little contrasting, so the Response time is above the limit, with 2,75 seconds, on the other hand the Download time are below the scenario limit, 10 seconds.

From the results is clear that the tasks should be completed more quickly and with less error.

Also, the users should be more satisfied with the system. About the performance, the system should respond more quickly.

After the first testing phase the results are evaluated in order to find out usability problems.

For evaluating these problems their scope and severity must be taken into account.

Scope and severity problems

After identifying usability problems, it must be rated their scope and severity.

Scope refers to how widespread the problem was throughout the product, and severity codes rate the seriousness of the problem.

Scope

Local problems consist of problems that occurr only in a particular part of the application, while global problems indicate far-reaching design flaws that happend with consistency throughout the product. In general, global problems tend to be critical to correct, because they affect usability of the entire application and have far-ranging effects (HotmailUsability, 1999).

However, some local problems are critical enough to hamper severely the users' ability to perform key tasks.

Severity

The following severity codes are used to classify the seriousness of the discovered problems (HotmailUsability, 1999):

1. Prevent completion of a task.
2. Cause significant delays in completing a task.
3. Cause minor usability problems, but users can complete the task.
4. Minor annoyance – it does not significantly impact usability, but should be corrected if time allows.

Findings and Recommendations – First Phase of testing

Using the evaluation criteria discussed previously, test results are going to be analyzed to develop a set of findings. This topic discusses (HotmailUsability, 1999):

- Usability problems noted during the test (findings).
- Recommendations for improving AHKME;
- Collected feedback we collected from test participants using questionnaires and post-test interviews.

Findings

Table 37 summarizes usability problems noted in the usability tests by participants, ordered by severity level. The narrative description in the table provides recommendations related to the findings.

Given the problems detected the system is evolved, resulting in a new release and the participants being subjected to new testing period.

The results of this second phase are presented in following section, as well as the comparison between phases.

Table 37. Findings – First phase of testing

FINDINGS					
No	**Tool/Task**	**Usability Problems**	**No of Test Partcipants affected**	**Severity level**	**Scope**
1	General :: Navigation	Some difficulty in understanding some menus. Could use another kind of menus. Some transitions tools sometimes seem confusing	4	4	global
2	General :: Tool finding	Some difficulty in finding tools taking into account their names, needs contextualized information. Could be more straighforwarding or grouped	4	3	global
3	General :: Help	Should have tutorials of same features, Some info is confusing, It should have more contextualized information.	5	2	global
		Need to have a search mechanism to find more easily a specific term, difficultty in getting the needed information	2	2	Global
4	Schema :: import	Need to be a litle more quick	2	3	Local
5	Schema :: select	A liitle bit complex for unexperienced users, needs contextualized information	1	4	Global
6	Schema :: generate/personalized	A liitle bit complex for unexperienced users who do not know the standards, needs contextualization	3	3	Local
7	Schema :: create	The users consider the forms could be improved and It's a process that takes some time	3	4	Local
8	Schema :: list	Provides a list of schemas. Needs a search mechanism	1	3	Local
9	Schema :: edit	Provides a treeview of the schema, although interface could be improved. A litlle bit slow, needs to be faster opening the tool. A liitle bit complex for unexperienced users. Gets complex when we do not know the standards or if it was not personalized. Needs knowledge on the schema to edit it	5	2	Global
10	Wf :: create	Some dificulties in understanding some steps of the tool, a little bit complex	3	3	Local
11	Wf :: circulation	Gives the possiblity to see workflows, at first sight didn't understant this option, Very similar to pending	1	4	Global
12	General :: Profile	Dont' understand some fields	2	4	Global
13	General :: Student Feedback	Perhaps it should have an upload file field	1	4	Local
14	Surveys :: create	It seems a very powerfull tool but a little bit complex. Could be more user-friendly. Could be difficult to some inexperienced users	3	3	local
15	Surveys :: edit	As in the creation case it is a little bit complex. Could be more user-friendly	3	3	local

FINDINGS					
No	**Tool/Task**	**Usability Problems**	**No of Test Partcipants affected**	**Severity level**	**Scope**
16	Surveys :: use	Some surveys seem complex, maybe better construct easier surveys	2	3	local
17	Surveys :: list	It would be useful to have a search mechanism	1	4	local
18	Recommendation :: view attribute importance	Provides a list with attributes but I wasn't able to quite understand them very well, needs contextualized information.	2	3	local
19	Recommendation :: view decision tree	Representation can be improved.	3	2	local
20	Quality :: view attribute importance	Provides a list with attributes but I wasn't able to quite understand them very well, needs contextualized information.	2	3	local
21	Quality :: view decision tree	The decision tree representation should be improved. Could have a graphical view	3	2	local
22	LOM :: Edit	Needs to be faster	2	4	local
23	LOM :: list	Needs a search mechanism	1	3	local
24	LD :: Edit	Needs to be faster and is a little bit complex	2	3	local
25	LD :: use	Access to lesson, structure is understandable , need to improve interface. A little complex, some diffiulty in using this tool.	3	3	local
26	LD :: list	Needs a search mechanism	2	3	local
27	Resources :: upload	Understood the objective to catalogue but its a little bit complex	1	4	local
28	Resources :: search	Needs more advanced search mechanisms	1	4	local
29	Search	Must improve the semantic relation of the search result	2	3	local
30	Interoperability :: Create/Export Package	The forms can be improved. The creation process might raise some issues to some users although is simple	3	4	Local
31	Administration :: Users & Tools Access	This feature should be more flexible. It should have tools to integrate with Active Directory or other kinds of users' Directories.	2	3	Local
32	Administration :: Templates	Should have a preview of the templates	1	4	Local

4.4.2.2. SECOND PHASE OF TESTING

In this topic the results for the second phase of testing are presented in terms of participants, profile, tools and overall.

The results are introduced with the help of tabular and graphical views. It is also presented a descriptive analysis of the results.

4.4.2.2.1. Usability results

First, the results in terms of the usability tests in the second phase of testing are introuced.

4.4.2.2.1.1. Usability results per participant for each profile

Table 38 gathers the results per participant in the Learning designer profile test scenario.

Table 38. Usability results per participant for the Learning designer profile – Second phase of testing

OVERALL LEARNING DESIGNER							
Participant	Time task (min)	Completion Rate (%)	Completion Success (%)	Completion Rate/Task Time	No errors	Error rate (%)	Confidence
Pilot 1	36,77	99,20%	100,00%	2,70%	1	3,03%	6,86
P1	50,28	91,80%	100,00%	1,83%	12	36,36%	6,42
P3	47,08	91,17%	100,00%	1,94%	15	45,45%	6,39
P4	39,28	97,23%	100,00%	2,48%	6	18,18%	6,49
P14	40,88	99,60%	100,00%	2,44%	1	3,03%	6,77
Mean	**42,86**	**95,80%**	**100,00%**	**2,27%**	**7**	**21,21%**	**6,58**
Std Deviation	5,63	4,05%	0,00%	0,37%	6	19,28%	0,21
Std error	2,52	1,81%	0,00%	0,17%	3	8,62%	0,10
Min	36,77	91,17%	100,00%	1,83%	1	3,03%	6,39
Max	50,28	99,60%	100,00%	2,70%	15	45,45%	6,86

So, Table 38 shows, on Time task column, that participant P1 takes the highet time to complete (50,28 minutes), and Pilot 1 takes the lowest time with 36,77 minutes. Regarding the Completion rate results there are very high results with an average of 95,80%. The Error rate has an average value of 21,21%. For the Confidence metric the partcipants have good results scoring and an average value of 6,58.

These results are illustrated in Figure 105 graphs.

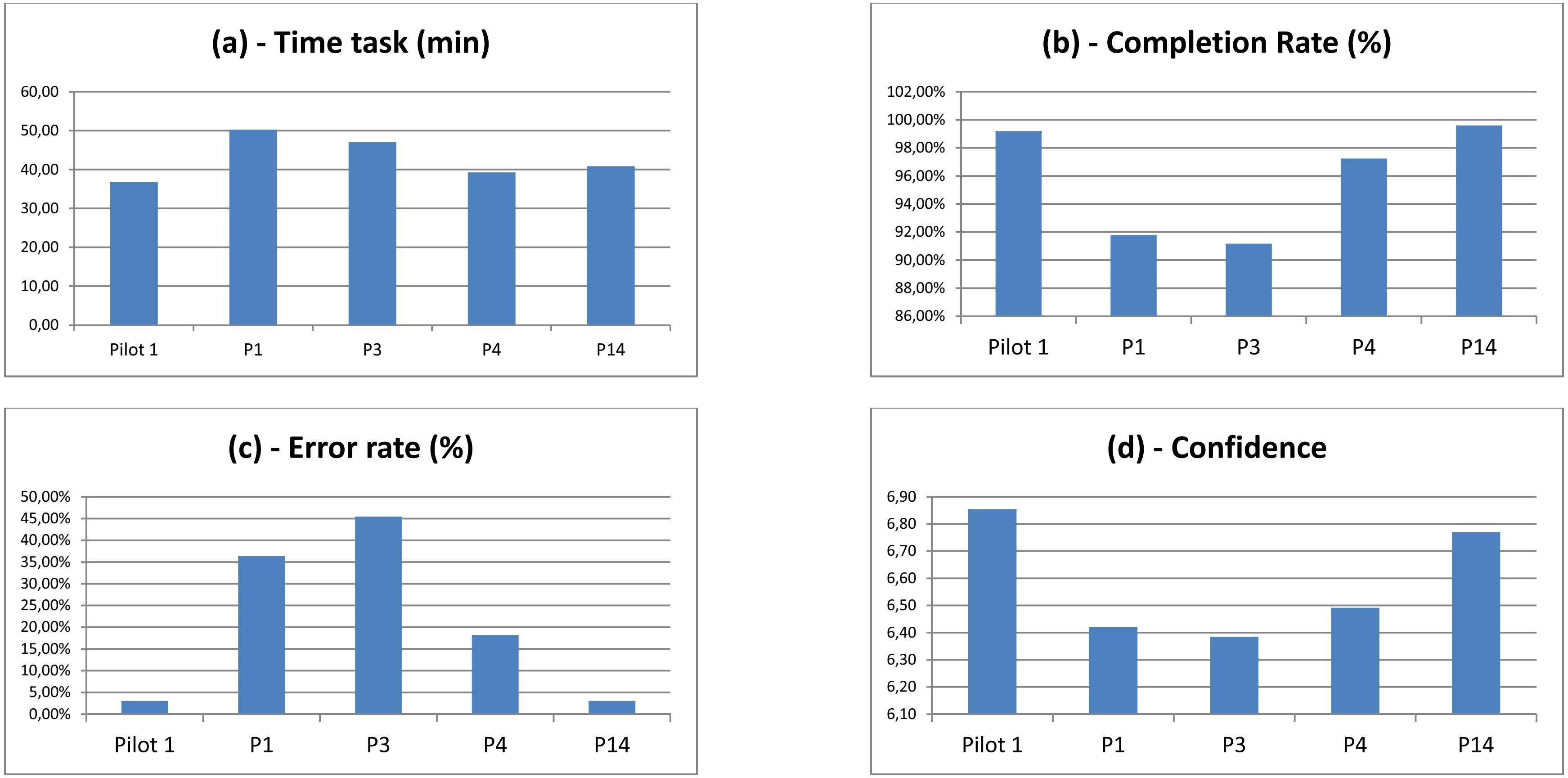


Figure 105. Usability results per participant for the Learning designer profile – Second phase of testing

As shown in Figure 105(a) about Time on task, the participant P1 takes most time to complete the tasks and at the opposite side it is the Pilot 1 participant.

In Figure 105(b) about Completion rate, participant P14 and also the Pilot 1 have the highest Completion rate. At the other side it is the P3 participant with the worst result.

Also in Figure 105(c) Error rate, the P3 particpant has the worst results, followed by P1 and P4 participants.

The P14 and Pilot1 participants have the best results in terms of Error rate, scoring each 3,03%.

In Figure 105(d) the participants Pilot 1 and P14 have the best results in tems of Confidence. In this metric all of the participants have good results, with values above 6.

Table 39 presents the Learning instructors results.

Table 39. Usability results per participant for the Learning instructor profile – Second phase of testing

OVERALL LEARNING INSTRUCTOR							
Participant	**Time task (min)**	**Completion Rate (%)**	**Completion Success (%)**	**Completion Rate/Task Time**	**No errors**	**Error rate (%)**	**Confidence**
Pilot2	52,74	93,37%	100,00%	1,77%	14	42,42%	6,12
P2	52,95	97,33%	100,00%	1,84%	8	24,24%	6,79
P5	62,40	94,44%	100,00%	1,51%	9	27,27%	6,42
P6	36,31	96,33%	100,00%	2,65%	7	21,21%	6,62
P15	35,34	96,89%	100,00%	2,74%	4	12,12%	6,79
Mean	**47,95**	**95,67%**	**100,00%**	**2,10%**	**8**	**25,45%**	**6,55**
Std Deviation	11,74	1,69%	0,00%	0,56%	4	11,05%	0,29
Std error	5,25	0,76%	0,00%	0,25%	2	4,94%	0,13
Min	35,34	93,37%	100,00%	1,51%	4	12,12%	6,12
Max	62,40	97,33%	100,00%	2,74%	14	42,42%	6,79

Thus, Table 39 shows, in Time on task column, that partipant P5 takes the highet time to complete (62,40 min), and P15 takes the lowest time with 35,44 minutes.

Regarding the Completion rate results there are very high results (average 95,67%). The Error rate has an average value of 25,45%.

The Confidence of the participants scores an average value of 6,55.

These results are illustrated in Figure 106 graphs.

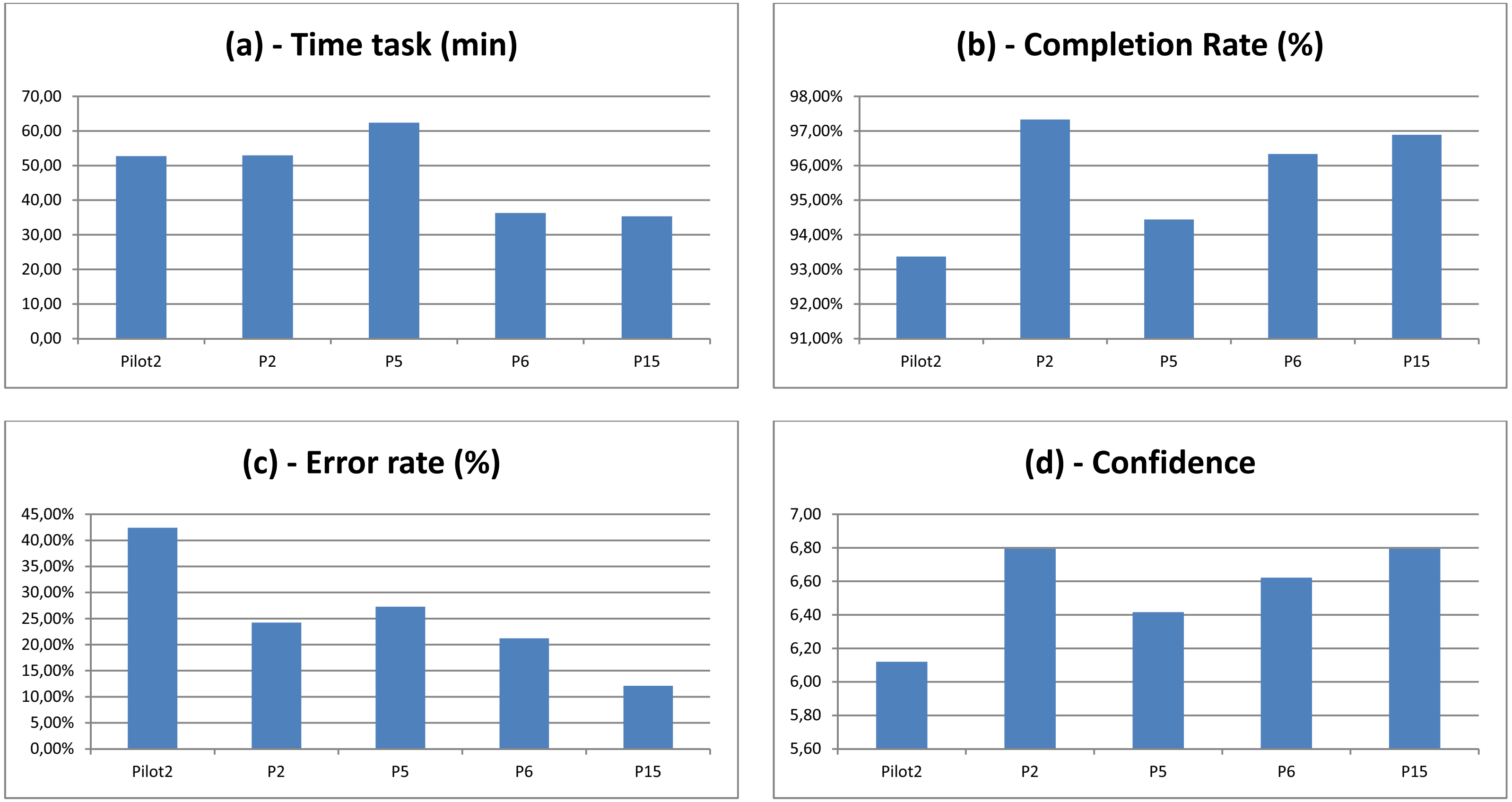


Figure 106. Usability results per participant for the Learning instructor profile – Second phase of testing

As shown in Figure 106(a), the participant P5 takes most time to complete the tasks and at the opposite side it is the P15 participant.

As shown in Figure 106(b), in terms of Completion rate the situation is different, participant P2 has the highest Completion rate.

The worst results are from P5 and Pilot2 participants with the worst Completion rate results, specifically 94,44% and 93,37%.

Regarding the Error rate results, Figure 106(c) presents the Pilot2 participant has the worst result, followed by P5 and P2 participants.

The P15 participant has the better result in terms of Error rate, scoring 12,12%.

Figure 106(d) Confidence graph shows that all of the participants have good results with values above of 6.

In Table 40 is presented the Student scenario participants' results.

Table 40. Usability results per participant for the Student profile – Second phase of testing

OVERALL STUDENT							
Participant	Time task (min)	Completion Rate (%)	Completion Success (%)	Completion Rate/Task Time	No errors	Error rate (%)	Confidence
P9	47,10	99,17%	100,00%	2,11%	1	9,09%	6,67
P10	19,77	92,50%	100,00%	4,68%	4	36,36%	6,58
P11	28,18	93,33%	100,00%	3,31%	4	36,36%	6,38
P12	33,50	100,00%	100,00%	2,99%	0	0,00%	6,71
P13	36,16	93,33%	100,00%	2,58%	3	27,27%	6,46
Mean	**32,94**	**95,67%**	**100,00%**	**3,13%**	**2**	**21,82%**	**6,56**
Std Deviation	10,09	3,60%	0,00%	0,97%	2	16,51%	0,14
Std error	4,51	1,61%	0,00%	0,44%	1	7,39%	0,06
Min	19,77	92,50%	100,00%	2,11%	0	0,00%	6,38
Max	47,10	100,00%	100,00%	4,68%	4	36,36%	6,71

So, Table 40 shows very high results in terms of Completion rates and better results in terms of Error rate values.

Figure 107 graphs help to illustrate this situation.

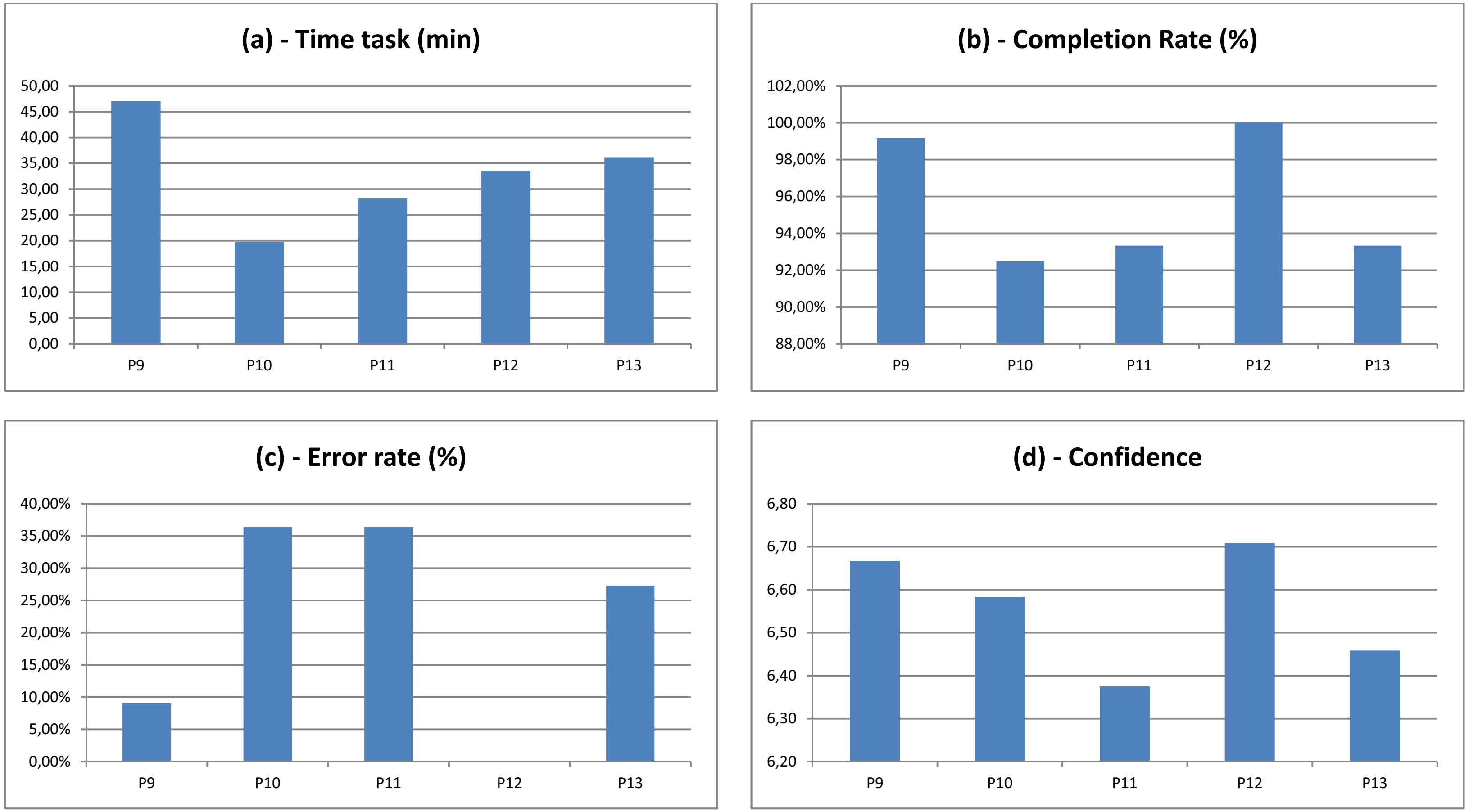


Figure 107. Usability results per participant for the Student profile – Second phase of testing

As shown in Figure 107(a), the participant P9 takes the highest time to complete the tasks and at the opposite side it is the P10 participant with the lowest time value (19,77 minutes).

In terms of Completion rate the situation is a litle bit different as presented in Figure 107(b), with the participants P9 and also P12 scoring the highest Completion rates.

The worst Completion rate are from P10 participant, specifically 92,50%.

As presented in Figure 107(c), regarding the Error rate results, the P11 and P10 participants have shown the worst result.

The P12 participant has the best result in terms of Error rate, scoring 0%.

The Confidence results have revealed the same pattern of the first phase with good results, as presented in Figure 107(d).

Finally, Table 41 gathers the Technical profile results regarding the different test metrics.

Table 41. Usability results per participant for the Technical profile – Second phase of testing

OVERALL TECHNICAL							
Participant	Time task (min)	Completion Rate (%)	Completion Success (%)	Completion Rate/Task Time	No errors	Error rate (%)	Confidence
P7	11,86	100,00%	100,00%	8,43%	0	0,00%	7,00
P8	14,83	96,67%	100,00%	6,52%	1	14,29%	6,58
P16	32,35	100,00%	100,00%	3,09%	0	0,00%	6,75
P17	38,55	91,67%	100,00%	2,38%	3	42,86%	6,58
P18	29,18	100,00%	100,00%	3,43%	0	0,00%	6,75
Mean	**25,35**	**97,67%**	**100,00%**	**4,77%**	**1**	**11,43%**	**6,73**
Std Deviation	11,52	3,65%	0,00%	2,59%	1	18,63%	0,17
Std error	5,15	1,63%	0,00%	1,16%	1	8,33%	0,08
Min	11,86	91,67%	100,00%	2,38%	0	0,00%	6,58
Max	38,55	100,00%	100,00%	8,43%	3	42,86%	7,00

As shown in Table 41, the Completion rate has high average value (97,67%), also the average Error rate value (11,43%) is a very good result at this point.

The Confidence of the participant presents a good average value of 6,73.

Figure 108 graphs help to illustrate this situation.

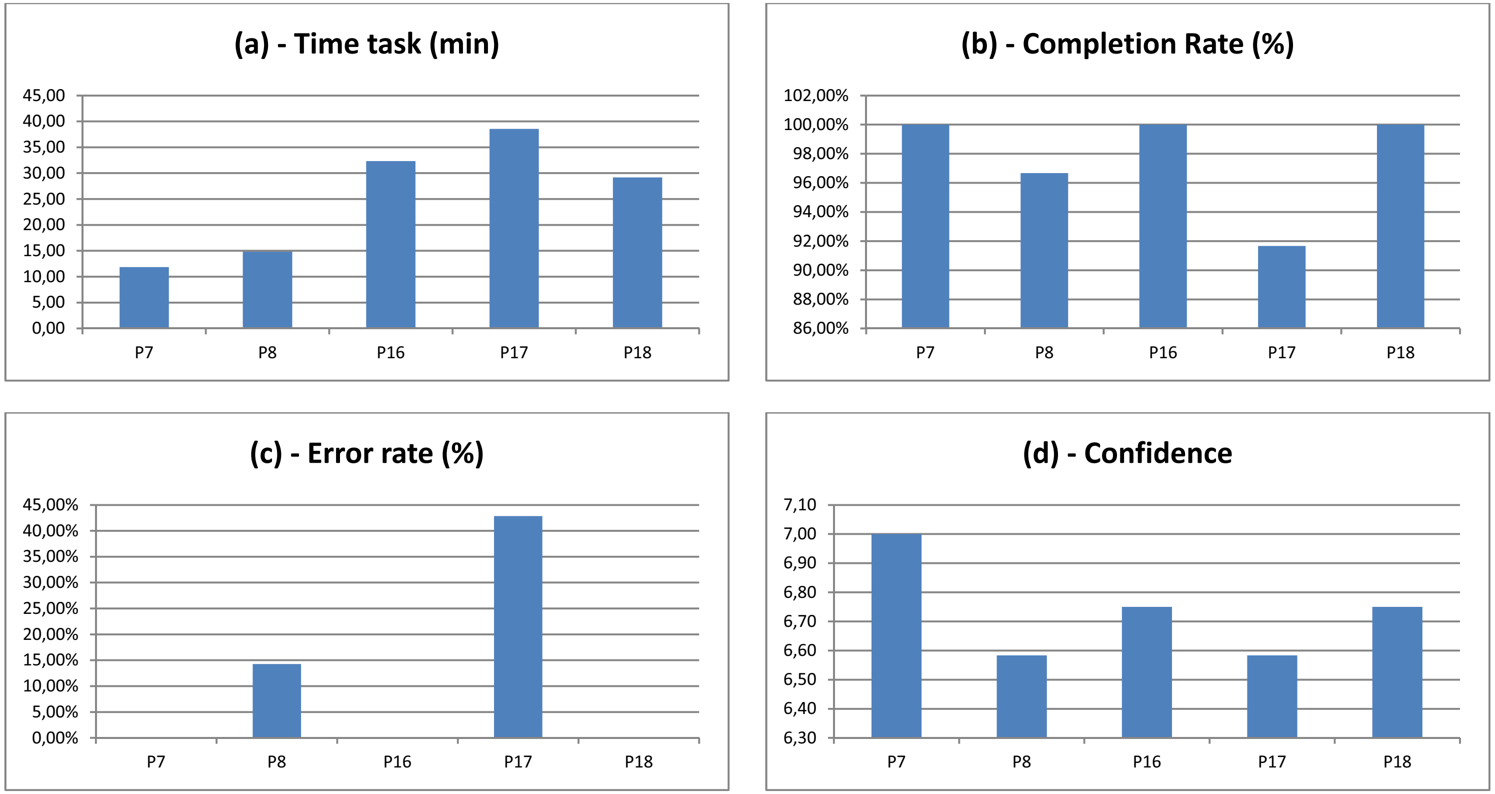


Figure 108. Usability results per participant for the Technical profile – Second phase of testing

As shown in Figure 108(a) the participants P17 and P16 take the highest time values to complete the tasks and at the opposite side it is the P7 participant with the lowest time value (11,86 minutes). In Figure 108(b), the participants P18, P7 and P16 have the highest Completion rate (100,00%). The worst results are from P17 participant with the worst Completion rate, specifically 91,67%. Regarding the Error rate results, Figure 108(c) shows that the P17 participant has the worst result (42,86%). The P7, P16 and P18 participants have the better results in terms of Error rate, scoring 0%. In terms of Confidence, the Figure 108(d) presents an average value above 6.

4.4.2.2.1.2. Usability results per tool for profile

Following tables present the profile scenarios results per tool. Thus, Table 42 presents the results of the Learning designer profile results in terms of tools.

Table 42. Usability results overall Learning designer profile per tool – Second phase of testing

Learning Designer 2ª Phase							
TOOL	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence
TOTAL GENERAL	5,74	97,60%	88,00%	100,00%	17,00%	12,00 %	6,48
TOTAL SCHEMA	10,46	94,40%	72,00%	100,00%	9,03%	28,00 %	6,36
TOTAL WF	2,45	96,00%	80,00%	100,00%	39,18%	20,00 %	6,55
TOTAL QUALITY	1,91	94,00%	70,00%	100,00%	49,20%	30,00 %	6,70
TOTAL INTEROPERABILITY	4,73	96,00%	80,00%	100,00%	20,29%	20,00 %	6,73
TOTAL RECOMMENDATION	1,37	96,00%	80,00%	100,00%	70,02%	20,00 %	6,50
TOTAL COMMUNICATION & SHARING	3,87	96,00%	80,00%	100,00%	24,82%	20,00 %	6,60
TOTAL RESOURCES	7,99	92,80%	68,00%	100,00%	11,61%	32,00 %	6,64
TOTAL SEARCH	0,59	100,00%	100,00%	100,00%	169,72%	0,00%	6,80
TOTAL SURVEY	3,75	95,20%	84,00%	100,00%	25,39%	16,00 %	6,48
TOTAL LEARNING DESIGN	**42,86**	**95,80%**	**80,20%**	**100,00%**	2,24%	**19,80 %**	**6,58**
Mean	**4,29**	**0,96**	**0,80**	**1,00**	**0,44**	**0,20**	**6,58**
Std Deviation	3,09	0,02	0,09	0,00	0,48	0,09	0,14
Std error	0,98	0,01	0,03	0,00	0,15	0,03	0,04
Min	0,59	0,93	0,68	1,00	0,09	0,00	6,36
Max	10,46	1,00	1,00	1,00	1,70	0,32	6,80

Table 42 results are illustrated in Figure 109 graphs, presenting the Time on task, Completion and Error rate, and also the Confidence merric results.

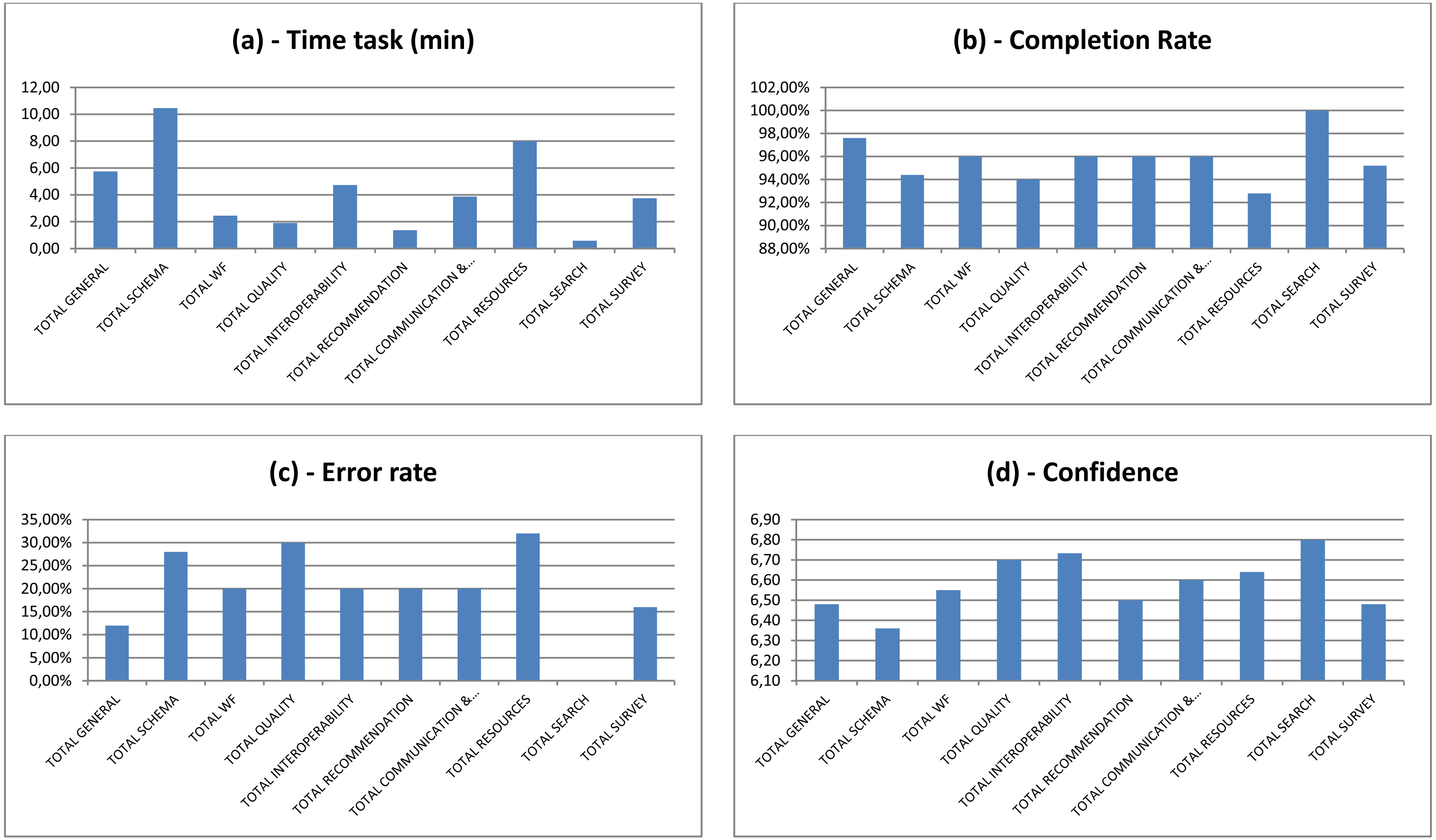


Figure 109. Usability results overall Learning designer profile per tool – Second phase of testing

As shown in Figure 109(a) the schema/instructional manager it is the task that takes most time to complete and at the opposite side is the search task.

But in terms of Completion rate the situation is a litle bit different.

So, in Figure 109(b) Completion rate graph, the search task has the highest completion rate, 100%. The resources task has instead the least completion rate.

Also in terms of Error rate the search task presents the worst result, followed by resources and quality tasks, as shown in Figure 109(c).

The search and general tasks have the best results in terms of Error rate, scoring specifically 0% and 12,00%.

In Figure 109(d) the Confidence graph shows the same tendence of high values.

Table 43 presents the results of the Learning instructor profile results in terms of tools.

Table 43. Usability results overall Learning instructor profile per tool – Second phase of testing

Learning Instructor 2ª Phase							
TOOL	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence
TOTAL GENERAL	5,13	97,60%	84,00%	100,00%	19,02%	16,00%	6,76
TOTAL SCHEMA	3,45	96,00%	80,00%	100,00%	27,81%	20,00%	6,35
TOTAL WF	1,18	98,67%	93,33%	100,00%	83,32%	6,67%	6,87
TOTAL SURVEY	5,27	96,00%	80,00%	100,00%	18,22%	20,00%	6,65
TOTAL LOM	7,26	96,80%	76,00%	100,00%	13,34%	24,00%	6,36
TOTAL LD	15,75	92,00%	64,00%	100,00%	5,84%	36,00%	6,24
TOTAL RESOURCES	4,84	96,00%	80,00%	100,00%	19,82%	20,00%	6,72
TOTAL SEARCH	0,39	96,00%	80,00%	100,00%	244,08%	20,00%	6,60
TOTAL COMMUNICATION & SHARING	4,68	92,00%	60,00%	100,00%	19,67%	40,00%	6,40
TOTAL LEARNING INSTRUCTOR	**47,95**	**95,67%**	**77,48%**	**100,00%**	2,00%	**22,52%**	**6,55**
Mean	**5,33**	**0,96**	**0,77**	**1,00**	**0,50**	**0,23**	**6,55**
Std Deviation	4,44	0,02	0,10	0,00	0,76	0,10	0,22
Std error	1,48	0,01	0,03	0,00	0,25	0,03	0,07
Min	0,39	0,92	0,60	1,00	0,06	0,07	6,24
Max	15,75	0,99	0,93	1,00	2,44	0,40	6,87

These results are illustrated in Figure 110 graphs.

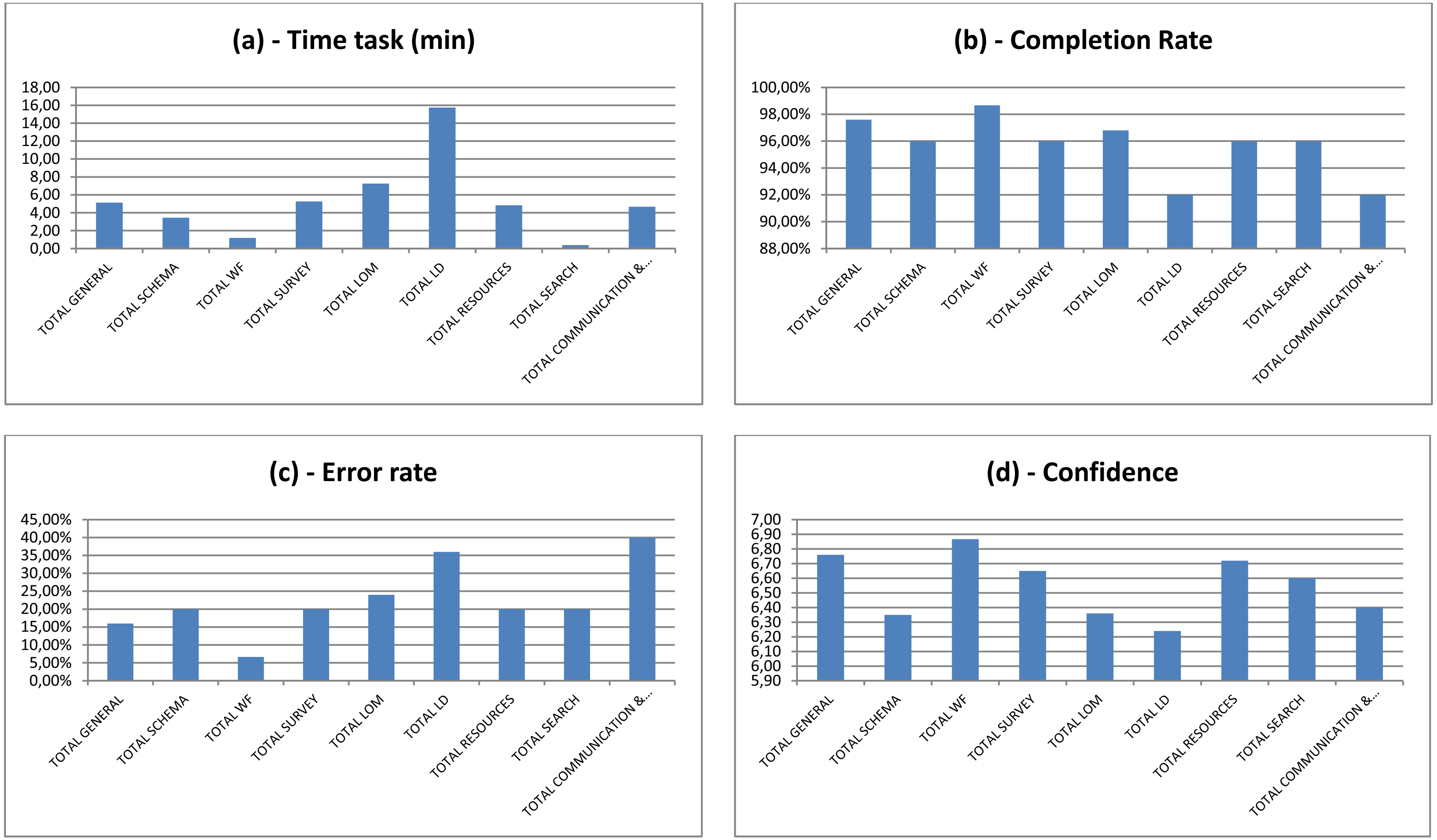


Figure 110. Usability results overall Learning instructor profile per tool – Second phase of testing

As shown in Figure 110(a) Time task graph, Learning designer task takes the highest time to complete the task and at the opposite side it is the search task result.

But in terms of Completion rate, the situation is a litle bit different as shown in Figure 110(b), workflow task has the highest Completion rate (98,67%), followed by general task (97,60%). The worst results are from the LD and Communication & sharing tasks (92,00%).

Also in the Error rate metric the Communication and sharing task as shown in Figure 110(c) has the worst result (40%), followed by the learning design task.

The workflow and general task have the best results in terms of Error rate, scoring specifically 6,67% and 16,00%.

Table 44 gathers the Student profile results per tool.

Table 44. Usability results overall Student profile per tool – Second phase of testing

Student 2ª Phase							
TOOL	**Time task (min)**	**Completion Rate**	**Error-free rate**	**Completion Success**	**Completion Rate/Task Time**	**Error rate**	**Confidence**
TOTAL GENERAL	12,86	94,67%	73,33%	100,00%	7,36%	26,67%	6,43
TOTAL SURVEY	5,41	94,00%	80,00%	100,00%	17,36%	20,00%	6,70
TOTAL RESOURCES	10,97	98,00%	90,00%	100,00%	8,94%	10,00%	6,70
TOTAL COMMUNICATION & SHARING	3,89	96,00%	80,00%	100,00%	24,69%	20,00%	6,40
TOTAL STUDENT	**33,13**	**95,67%**	**80,83%**	**100,00%**	2,89%	**19,17%**	**6,56**
Mean	**8,28**	**0,96**	**0,81**	**1,00**	**0,15**	**0,19**	**6,56**
Std Deviation	4,31	0,02	0,07	0,00	0,08	0,07	0,16
Std error	2,15	0,01	0,03	0,00	0,04	0,03	0,08
Min	3,89	0,94	0,73	1,00	0,07	0,10	6,40
Max	12,86	0,98	0,90	1,00	0,25	0,27	6,70

For, the Time on task metric the results give a total of 33,13 minutes.

The average Completion rate is high, 95,67% and the Error rate is better than the average with 19,17%.

The Confidence mantains the results with an average value of 6,56.

These results are illustrated in Figure 111 graphs, regarding Time on task Completion and Error rate, and also Confidence.

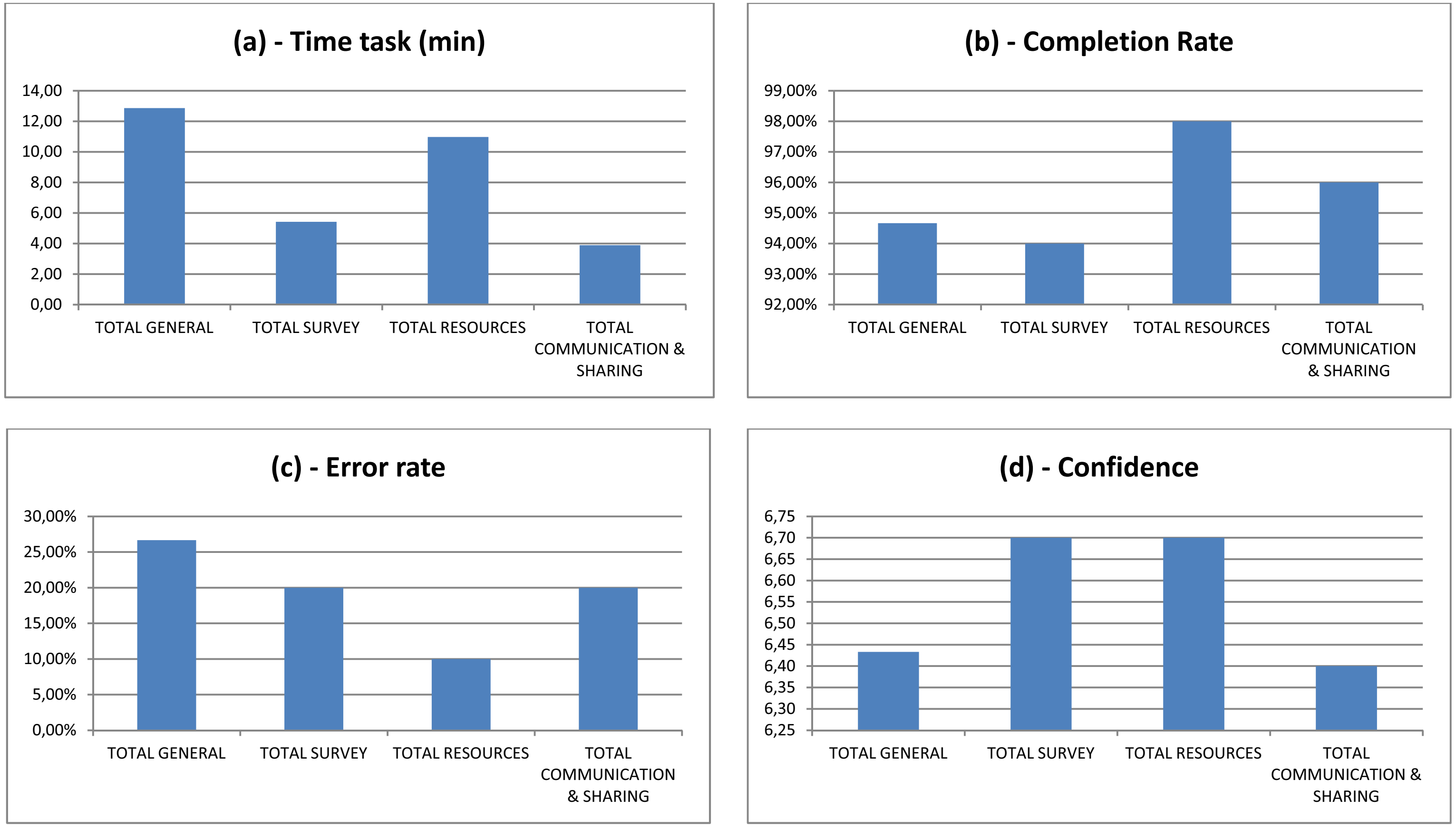


Figure 111. Usability results overall Student profile per tool – Second phase of testing

As shown in Figure 111(a), the General task takes the highest time to complete the task and at the opposite side it is the Communication and sharing task result.

So, in Figure 111(b) the resources task has the highest Completion rate (98,00%).

The worst result is from the the survey task (94,00%).

In the Error rate metric the general task as shown in Figure 111(c) has the worst result (26,67%).

The resources task has the better result in terms of Error rate, scoring a value of specifically 10,00%.

Table 45 collects results from the Technical profile.

Table 45. Usability results overall Technical profile per tool – Second phase of testing

Technical 2ª Phase							
TOOL	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence
TOTAL ADMINISTRATION	10,85	97,33%	86,67%	100,00%	8,97%	13,33%	6,87
TOTAL GENERAL	14,51	98,00%	90,00%	100,00%	6,76%	10,00%	6,80
TOTAL TECHNICAL	**25,35**	**97,67%**	**88,33%**	**100,00%**	3,85%	**11,67%**	**6,83**
Mean	**12,68**	**0,98**	**0,88**	**1,00**	**0,08**	**0,12**	**6,83**
Std Deviation	2,59	0,00	0,02	0,00	0,02	0,02	0,05
Std error	1,83	0,00	0,02	0,00	0,01	0,02	0,03
Min	10,85	0,97	0,87	1,00	0,07	0,10	6,80
Max	14,51	0,98	0,90	1,00	0,09	0,13	6,87

As Table 45 presents, the Completion rate is high, specifically an average of 97,67%.

Contrasting, the Error rate is low, with a value of 11,67%.

Also the Confidence values are high, with an average of 6,83.

Figure 112 graphs illustrate these results.

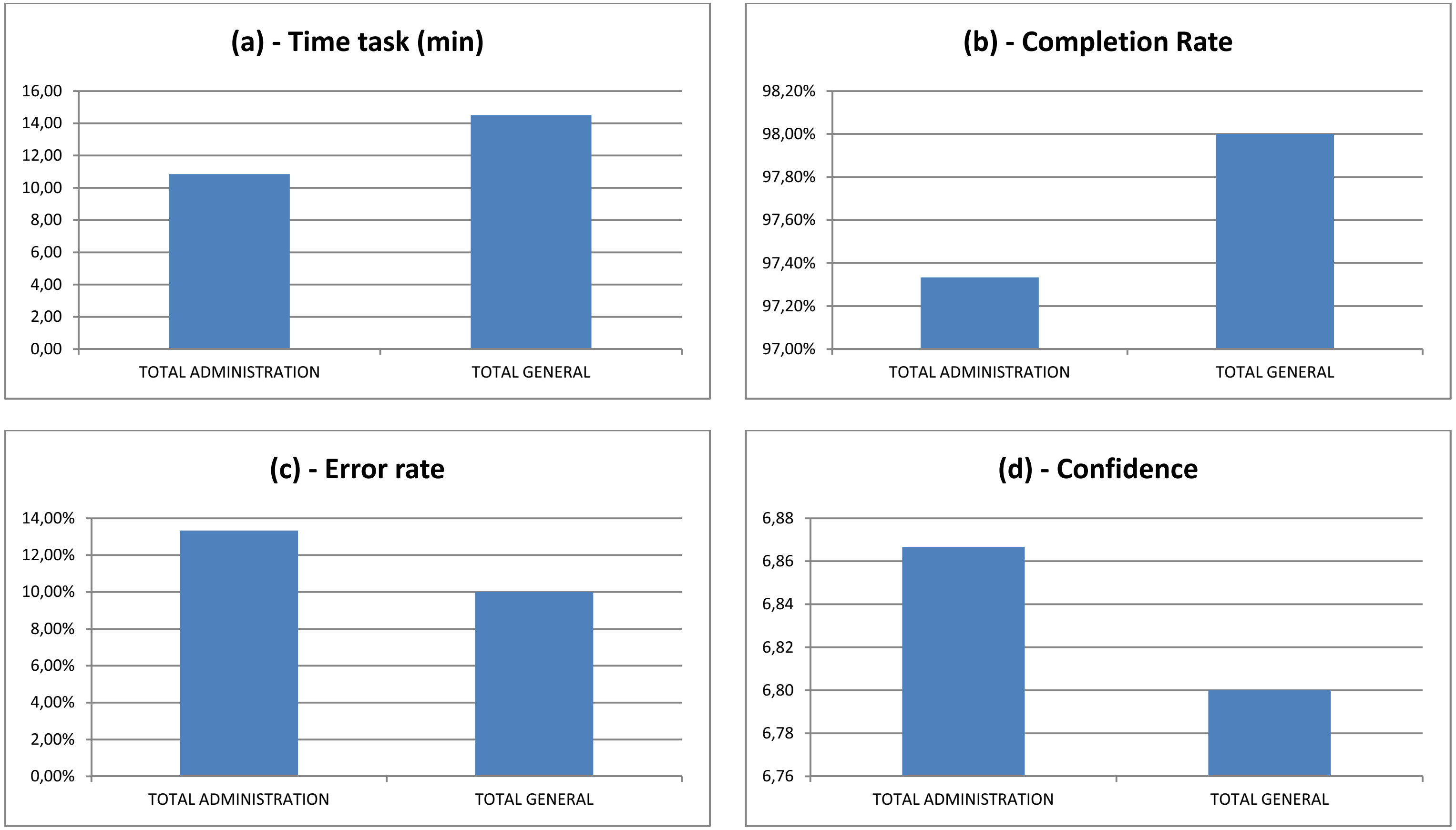


Figure 112. Usability results overall Technical profile per tool – Second phase of testing

As shown in Figure 112(a), the General task takes the highest time to complete the task and at the opposite side it is the Administration task result (10,85 minutes).

But in terms of Completion rate the situation is a litle bit contrasting. So, in Figure 112(b) Completion rate graph the Administration tasks has the highest Completion rate (98,00%). Also, the general task has a high result with 97,33%.

In the Error rate metric, Figure 112(c) shows the Administration task has the worst result in this scenario (13,33%). The General task has the better result in terms of Error rate, scoring 10,00%. Figure 112(d) shows the tendence of high values of Confidence.

4.4.2.2.1.3. Overall results per profile/scenario

Table 46 makes an overall summary per profiles scenarios.

Table 46. Overall results per profile/scenario – Second phase of testing

2ª PHASE							
Profile	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence
Technical	25,35	97,67%	88,33%	100,00%	3,85%	11,67%	6,83
Learning Insctuctor	47,95	96,12%	77,48%	100,00%	2,00%	25,19%	6,55
Learning Designer	42,86	95,80%	71,20%	100,00%	2,24%	19,80%	6,58
Student	33,13	95,67%	80,83%	100,00%	2,89%	19,17%	6,56

Table 46 shows that Completion rates are high, contrasting with the Error rate that has results below the average of 20%. In terms, of the Confidence all the profiles scenarios have satisfactory results.

Table 46 results are illustrated in Figure 113 graphs. Figure 113(a) Time task graph demonstrate that Learning Instructors scenario takes the highest time to complete the tasks and at the opposite side it is the Technical Profile result.

As shown in Figure 113(b), in terms of Completion rate the situation is a litle bit different. So, Tecnical profile had the highest Completion rate (97,67%), followed closely by the Learning Instructor profile (96,42%). The worst result was from the Student (95,67%).

In the Error rate metric the Learning Instructor profile as shown in Figure 113(c) had the worst result (25,19%), followed by Learning Designer profile. Technical profile has the best results in terms of Error rate, scoring 11,67%.

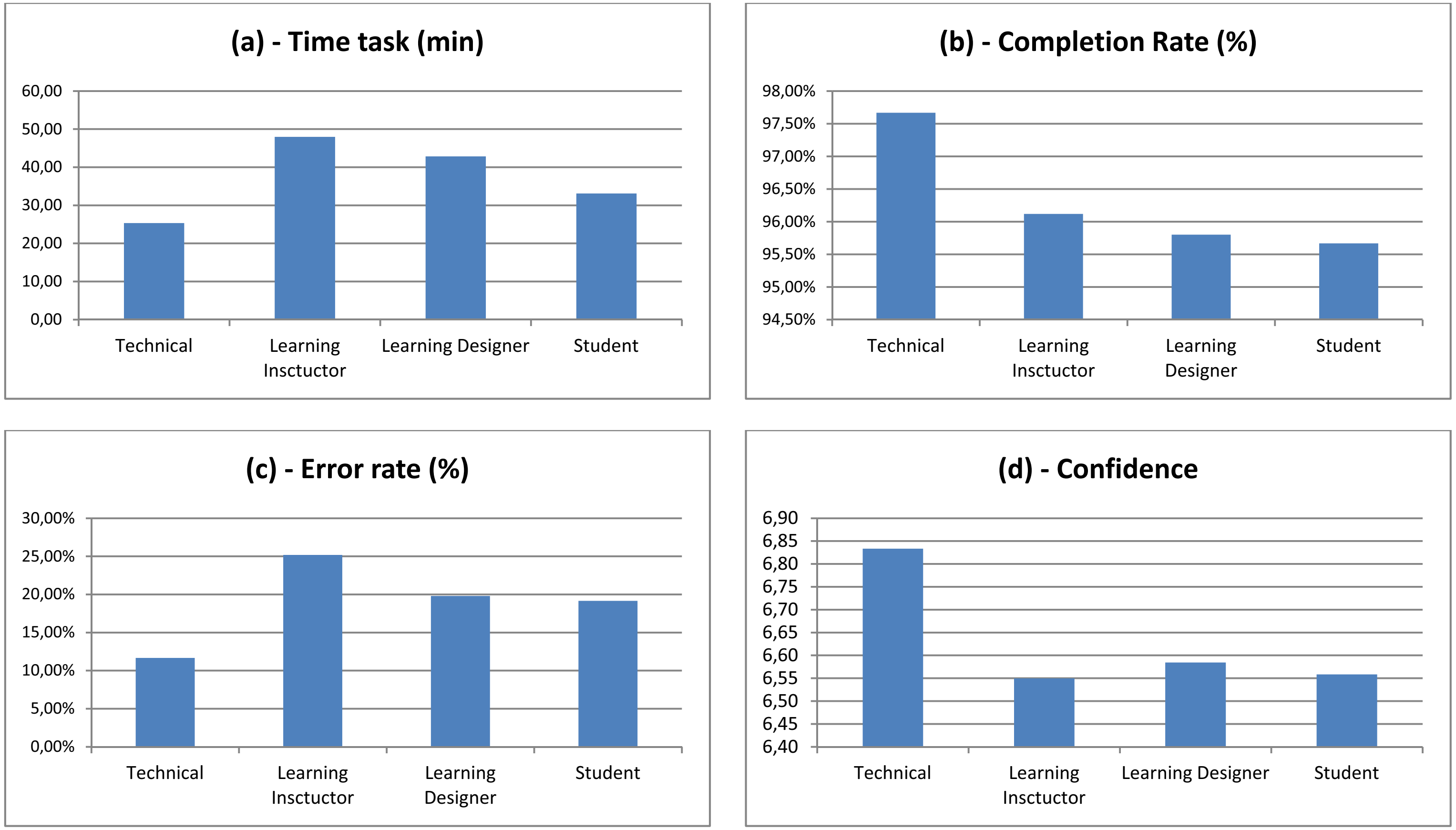


Figure 113. Overall results per profile/scenario – Second phase of testing

As shown in Table 46, there are no average values, since the profiles have different features so they are not directly comparable. Therefore, as well as it happened in the first phase of testing, a mapping by tool is going to be carried out, taking into account more representative profile and participants of certain functionalities.

The criteria of representativeness are:

- Tool that exists only in one profile - Including results from participants of that profile.
- Transversality of tools – Including results from all of the participants.
- Tools with additional features between profiles - Including sample of participants with greater breadth of functionality.

Table 47. Overall results per tool – Second phase of testing

TOOL	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence
TOTAL ADMINISTRATION	10,85	97,33%	86,67%	100,00%	8,97%	13,33%	6,87
TOTAL INTEROPERABLITY	4,73	96,00%	80,00%	100,00%	20,29%	20,00%	6,73
TOTAL QUALITY	1,91	94,00%	70,00%	100,00%	49,20%	30,00%	6,70
TOTAL RECOMMENDATION	1,37	96,00%	80,00%	100,00%	70,02%	20,00%	6,50
TOTAL SURVEY	5,27	96,00%	80,00%	100,00%	18,22%	20,00%	6,65
TOTAL LOM	7,26	96,80%	76,00%	100,00%	13,34%	24,00%	6,36
TOTAL LD	15,75	92,00%	64,00%	100,00%	5,84%	36,00%	6,24
TOTAL GENERAL	9,56	96,97%	83,83%	100,00%	10,14%	16,17%	6,62
TOTAL SCHEMA	10,46	94,40%	72,00%	100,00%	9,03%	28,00%	6,36
TOTAL WF	2,45	96,00%	80,00%	100,00%	39,18%	20,00%	6,55
TOTAL Resources	10,97	98,00%	90,00%	100,00%	8,94%	10,00%	6,70
TOTAL COMMUNICATION & SHARING	4,14	94,67%	73,33%	100,00%	22,84%	26,67%	6,47
TOTAL SEARCH	0,49	98,00%	90,00%	100,00%	199,48%	10,00%	6,70
TOTAL SYSTEM	**85,20**						
Mean	**6,55**	**95,86%**	**78,91%**	**100,00%**	**14,63%**	**21,09%**	**6,57**
Std Deviation	4,65	0,02	0,08	0,00	0,53	0,08	0,18
Std error	1,29	0,00	0,02	0,00	0,15	0,02	0,05
Min	0,49	0,92	0,64	1,00	0,06	0,10	6,24
Max	15,75	0,98	0,90	1,00	1,99	0,36	6,87

Thus, Table 47 gathers the results for tool/task of AHKME system. Therefore, it also becomes easier to establish the mapping with the objectives and the hypothesis assumptions of the study, since they are related to the tools being evaluated in these tests. As Table 47 shows the average Completion rate 95,86% is a high valuable result.

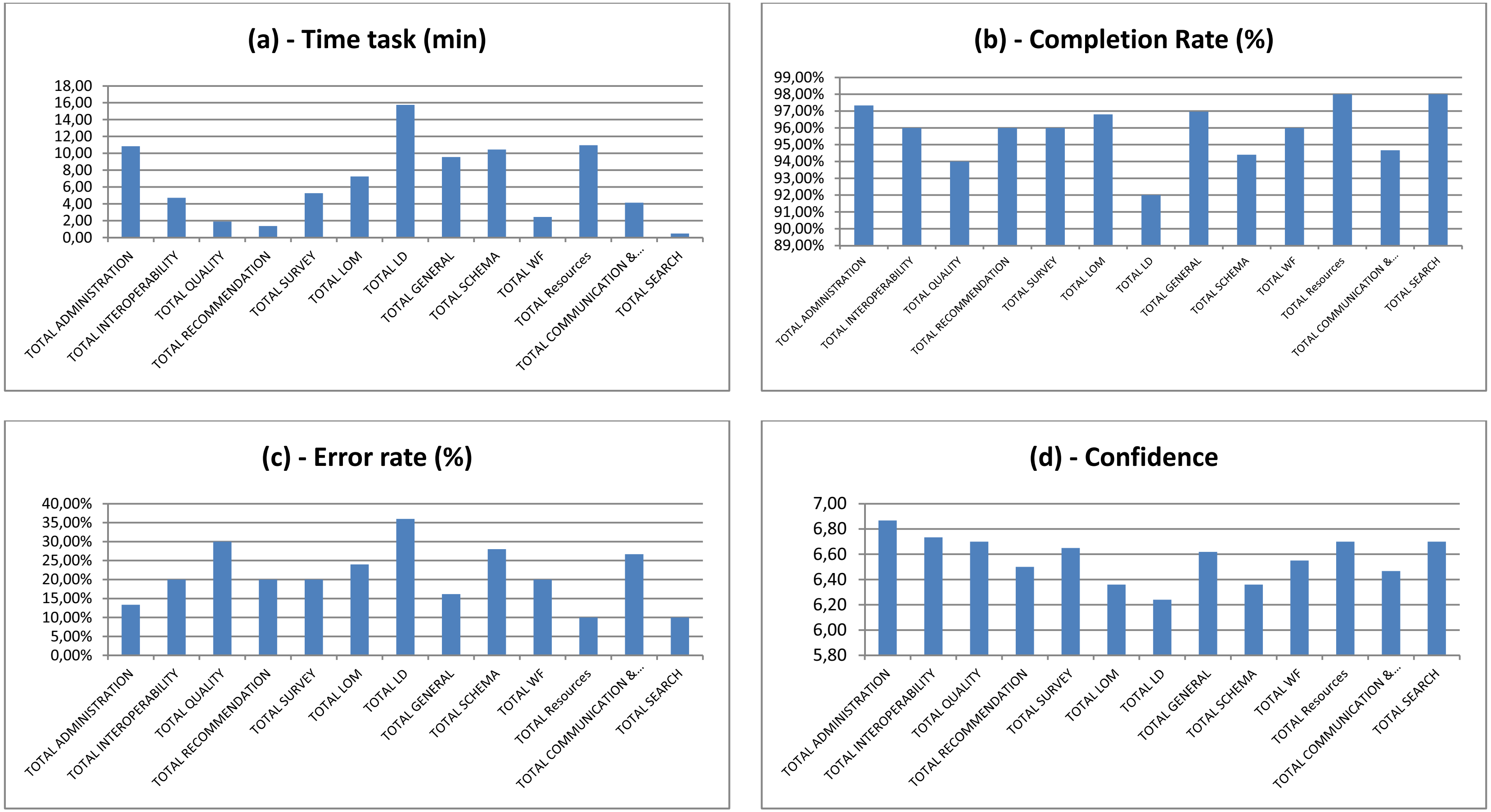


Figure 114. Overall results per tool – Second phase of testing

As Table 47 presents the Error rate is better with 21,09% and also the Confidence metric.

Figure 114 above presents the graphs ilustrating Table 47 results

About the Time task graph of Figure 114(a), the learning design tool presents the worst result, followed by the resources tool.

The search and recommendation/adaptation tools have the best Time on task results.

In terms of Completion rate graph the resources and search tools have the best results, at the opposite side it is the learning design tool.

The learning design tool/task has the worst Error rate as shown in Figure 114(c), instead the best results belong to the resources task Error rate.

The Confidence values are still high for all of the tools, as presented in Figure 114(d).

4.4.2.2.2. Satisfaction Results

Table 48 presents the satisfaction results, obtained with SUS post-test questionnaire.

The average SUS Score at the second phase of testing it is a good result with 74,63%, clearly above the scenario goal (70%).

Table 49 presents the SUS histogram results.

As shown in Table 49 histogram, the distribution of experimental data in terms of frequency gives results that participants concentrated mainly theirs answers in positive results for the system.

Table 48. Tabular satisfaction results – Second phase of testing

SUS																					
Question	**Pilot1**	**Pilot2**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**	**P17**	**P18**	**Avg SUS**
1	4	2	4	4	2	4	2	3	3	2	4	2	3	3	1	4	3	4	3	4	
2	3	2	3	4	2	3	3	4	4	3	4	4	4	3	2	4	4	4	2	4	
3	3	2	2	4	2	3	2	2	4	3	3	2	2	4	1	3	4	3	4	4	
4	2	1	3	2	1	4	3	4	3	3	4	3	3	3	1	3	3	3	3	3	
5	4	4	4	3	3	4	3	3	4	4	4	3	4	4	2	4	3	3	4	3	
6	3	4	4	3	4	3	4	4	3	4	3	3	3	4	4	4	4	3	3	3	
7	2	2	4	3	2	2	2	1	3	1	4	2	3	1	1	2	1	2	2	1	
8	3	3	3	2	4	4	4	4	3	3	4	4	3	4	4	4	4	3	4	4	
9	4	3	3	4	1	3	2	2	3	2	4	2	2	2	1	3	3	3	3	3	
10	3	2	2	3	3	3	2	3	3	3	3	2	3	3	1	3	3	2	3	3	
SUS	77,5	62,5	80	80	60	82,5	67,5	75	82,5	70	92,5	67,5	75	77,5	45	85	80	75	77,5	80	**74,63**

74,63	**% SUS Score**

Table 49. SUS Histogram – Second phase of testing

	System Usability Scale Histogram	Strongly Disagree 1	2	3	4	Strongly Agree 5
1	I think I would like to use this software product frequently.					
2	I find the product unnecessarily complex.					
3	I think the product was easy to use.					
4	I think I would need Tech Support to be able to use this product.					
5	I find the various functions in this product are well integrated.					
6	I think there is too much inconsistency in this product.					
7	I imagine that most people would learn to use this product very q ickly.					
8	I find the product very cumbersome to use.					
9	I feel very confident using this product.					
10	I need to learn a lot about this product before I could effectively use it					

SUS Hi to ram Tally

Item#	1	2		4	5	N
1	0	1	5	6	8	0
2	10	6	4	0	0	20
3	0	1	7	6	6	20
4	3	12	2	3	0	20
5	0	0	1	8	11	0
		10	0	0	0	20
7	0	6	9	3	2	0
8	12	7	1	0	0	2
9			6	9	3	0
10	0	4	5	1	0	20

4.4.2.2.3. Web Performance Results

Also it has been measured some performance results, regarding response and downloading times.

The table presents the results of response and download time in terms of mili-seconds and seconds.

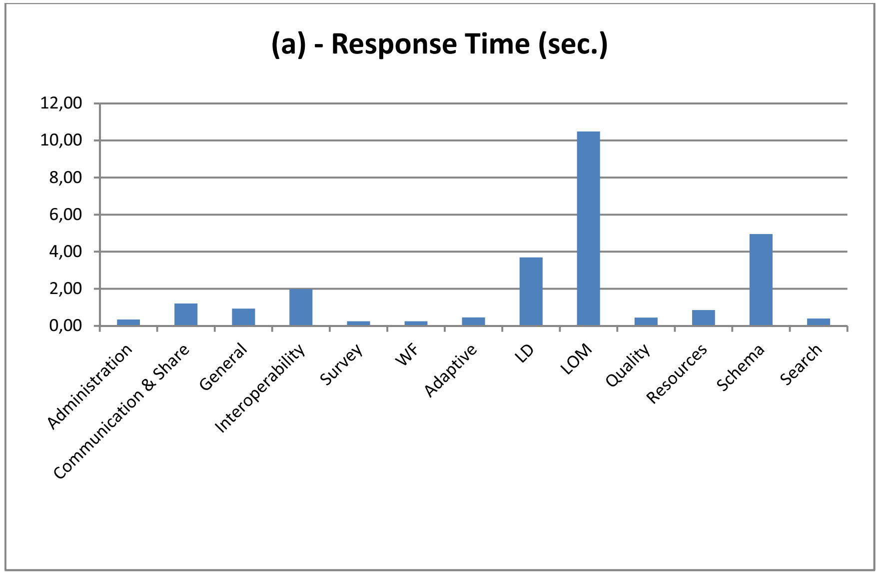
Table 50. Performance results – Second phase of testing

PERFORMANCE				
Tool	**Response Time (ms)**	**Response Time (sec.)**	**Download Time (ms)**	**Download Time (sec.)**
Administration	342	0,34	98	0,10
Communication & Share	1202	1,20	297	0,30
General	931	0,93	144	0,14
Interoperability	1984	1,98	1711	1,71
Survey	244	0,24	44	0,04
WF	248	0,25	41	0,04
Adaptive	457	0,46	54	0,05
LD	3690	3,69	1303	1,30
LOM	10489	10,49	8553	8,55
Quality	444	0,44	62	0,06
Resources	854	0,85	9	0,01
Schema	4951	4,95	4419	4,42
Search	394	0,39	126	0,13
Mean	**2018**	**2,02**	**1297**	**1,30**

Table 50 shows that all tools have good results in terms of Response and Download time, with LOM and Schema tools with the highest values.

Figure 115 graphs illustrate the results per tool.

In these graphs express that LOM and Schema tools have high results in terms of download and Response time.



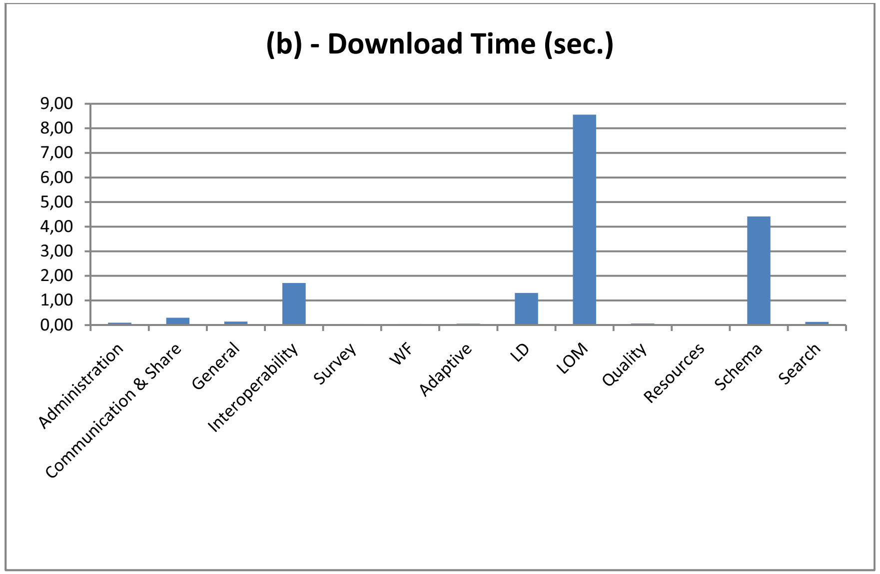


Figure 115. Performance results – Second phase of testing

4.4.2.2.4. Overall Second phase of testing

At this point is presented the Table 51 with the overall results of the second phase of testing, in terms of usability, satisfaction and performance.

Table 51. Overall results – Second phase of testing

Phase	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence	SUS	RESPONSE TIME (sec)	DOWNLOAD TIME (sec)
2	85,20	95,86%	78,91%	100,00%	1,13%	21,09%	6,57	74,63%	2,02	1,30

Table 52 makes a comparison between the results of usability, satisfaction and performance for the second phase of the testing process.

Analysing Table 52 data, it shows that the Time on task is very near to the scenario value, only 3 minutes separating each.

The Completion rate results are much better 95,86%, with a value above the scenario goal.

This can be seen in the Figure 116 graphs.

Table 52. Overall Goals limits comparison – Second phase of testing

Phase	Time task (min)	Scenarios Time task (min)	Completion Rate	Scenario completion rate	Completion Rate/Task Time	Error rate	Scenario Error rate	SUS	Scenario SUS	RESPONSE TIME (sec)	Scenario RESPONSE TIME (sec)	DOWNLOAD TIME (sec)	Scenario DOWNLOAD TIME (sec)
2	85,20	82,75	95,86%	90,00%	1,13%	21,09%	20,00%	74,63%	70,00%	2,02	1,00	1,30	10,00

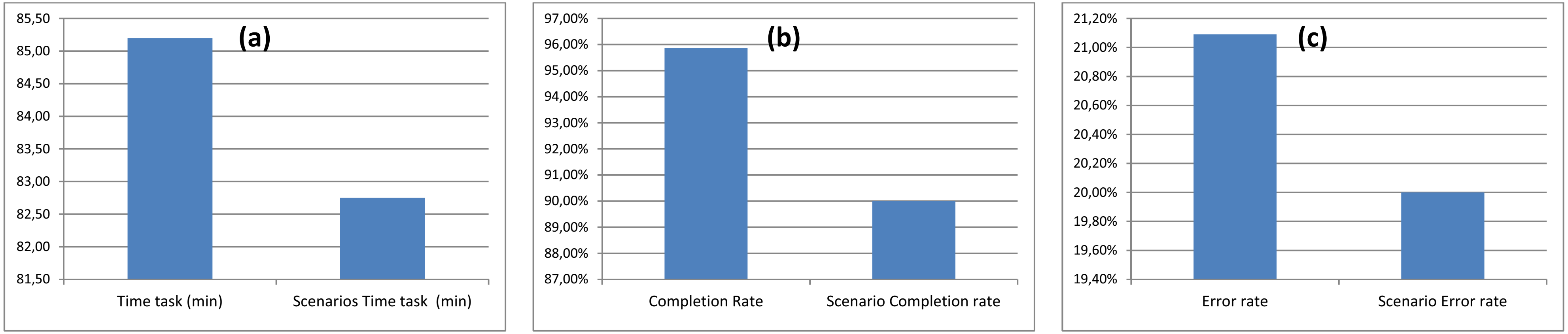


Figure 116. Overall usbility results, Time task, Completion and Error rate comparison to scenario limits – Second phase of testing

As shown in Figure 116 graphs, all ot the metrics are above the scenario goals, with the Error rate very near the scenario goal limit 20%, with the an average of 21,00%.

For the satisfaction results, 74,63% are above the scenario goal of 70%, as it is illustrated in Figure 117.

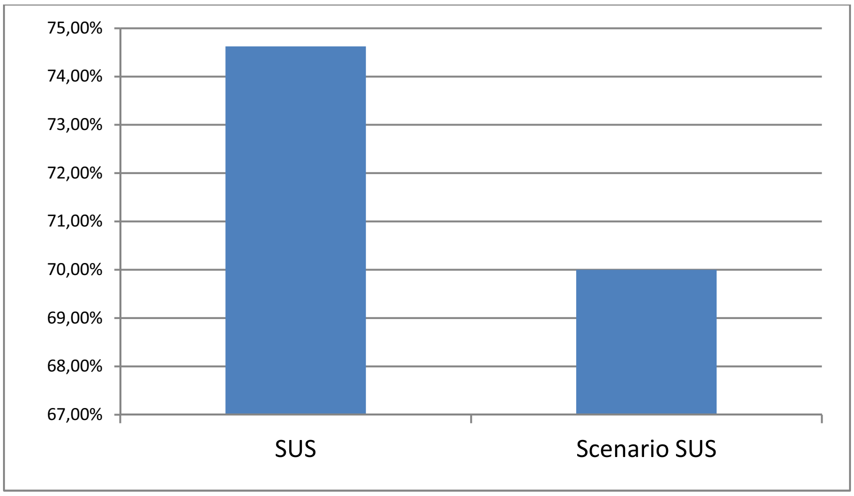


Figure 117. Overall SUS results – Second phase of testing

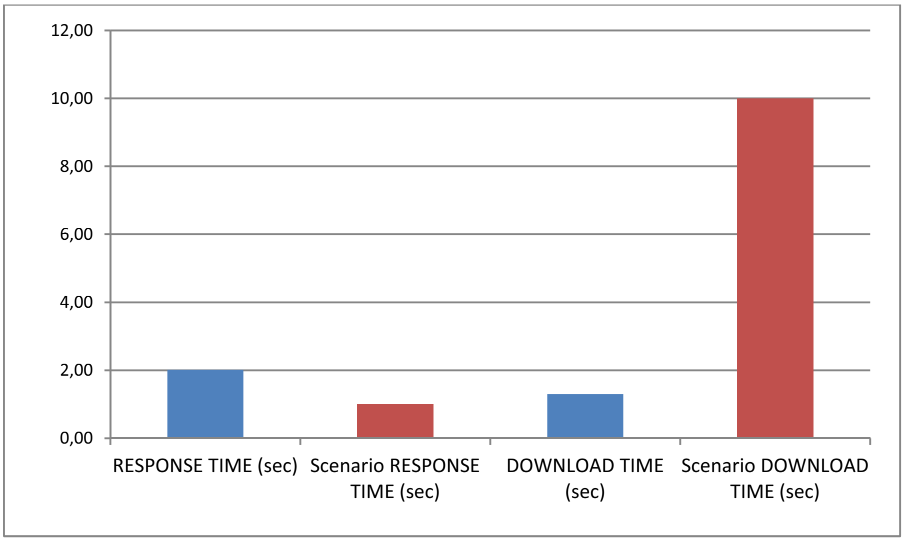


Figure 118. Overall Performance results – Second phase of testing

The performance results, are a little contrasting, so the Response time is still a little above the limit, with 2,02 seconds, on the other hand the Download time is below the scenario limit, 10 seconds. This situation it is presented more clearly in Figure 118.

So, the tasks have been completed more quickly, and with fewer errors. Also, the users are more satisfied with the system. About the performance, the system responds more quickly.

4.4.2.3. OVERALL: TWO PHASES OF TESTING

Table 53 presents the overall results in terms of usability, comparing the two phases of the testing process.

As shown in Table 53, in the second test phase, almost all of the metrics present an improvement.

In Figure 119, Figure 120 and Figure 121 it can be seen the difference between phases.

In terms of average Time on task, it decreases 17 minutes from phase one to phase 2, as presented in Figure 119(a).

In the Completion rate, the results are contrasting with this, as shown in graph (b) of Figure 119 it increases about 3% in the second phase.

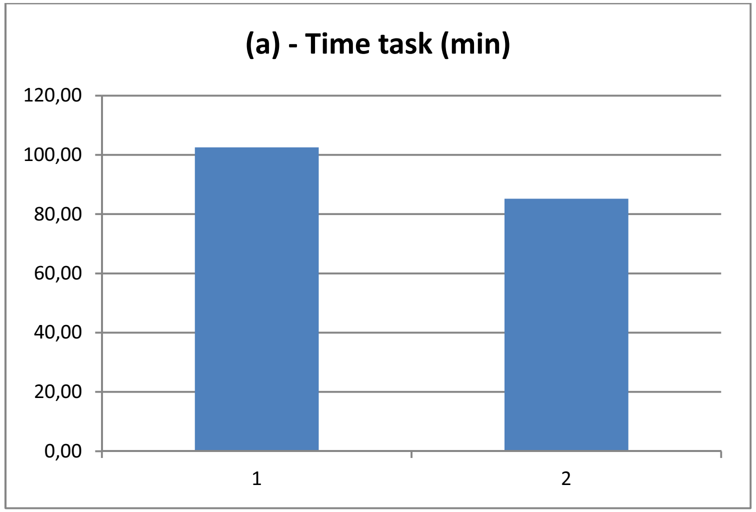
The Error rate decreases about 15% from phase one to phase two, as shown in Figure 119 (b).

In terms of satisfaction, SUS test results increase 8,5% in the second test phase, as shown in Figure 120.

In terms of performance results, both Response and Download time decrease from phase one to phase two (see Figure 121).

Table 53. Overall comparison usability results - two phases of testing

Phase	Time task (min)	Completion Rate	Error-free rate	Completion Success	Completion Rate/Task Time	Error rate	Confidence	SUS	RESPONSE TIME (sec)	DOWNLOAD TIME (sec)
1	102,53	92,65%	63,62%	100,00%	0,90%	36,38%	6,40	66,13%	2,75	1,86
2	85,20	95,86%	78,91%	100,00%	1,13%	21,09%	6,57	74,63%	2,02	1,30
% Improvement rate	**16,90%**	**3,46%**	**24,03%**	**0,00%**	**24,51%**	**42,03%**	**2,70%**	**12,85%**	**26,58%**	**30,39%**
Difference value	**-17,33**	**3,21**	**15,29**	**0,00**	**0,22**	**-15,29**	**0,17**	**8,50**	**-0,79**	**-0,61**



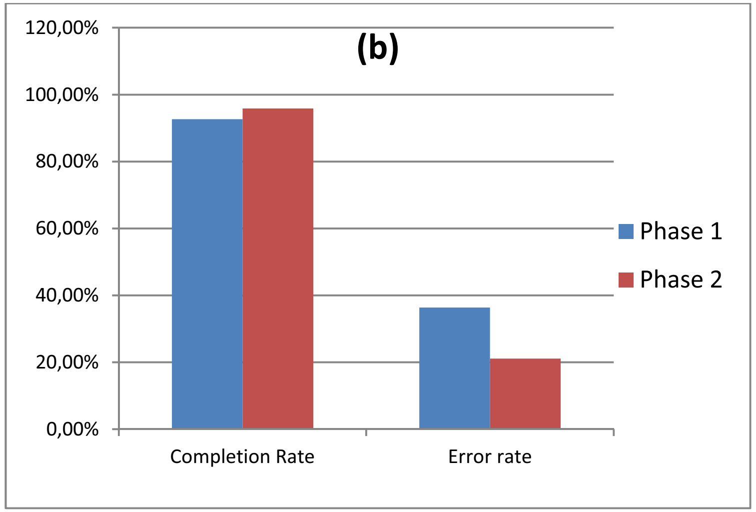


Figure 119. Overall usability results - two phases of testing

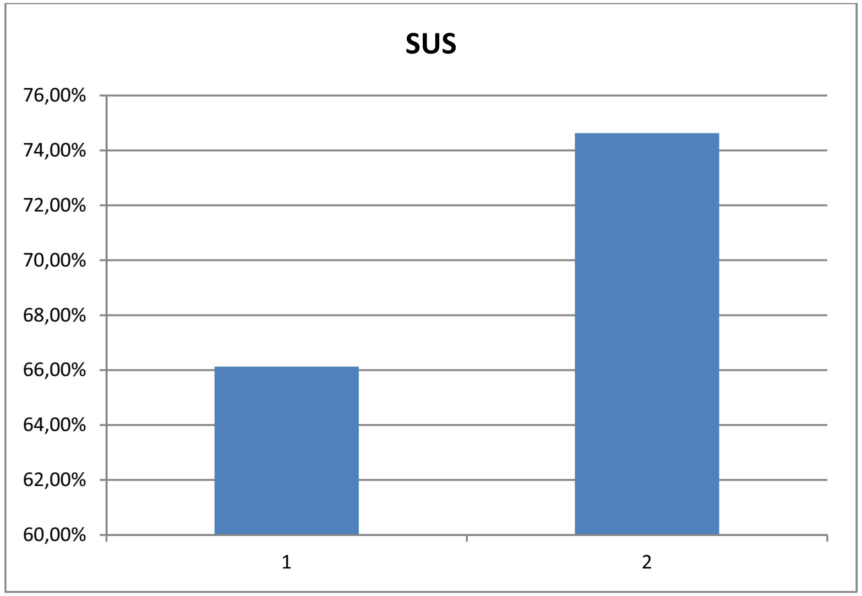


Figure 120. Overall SUS results – Two phases of testing

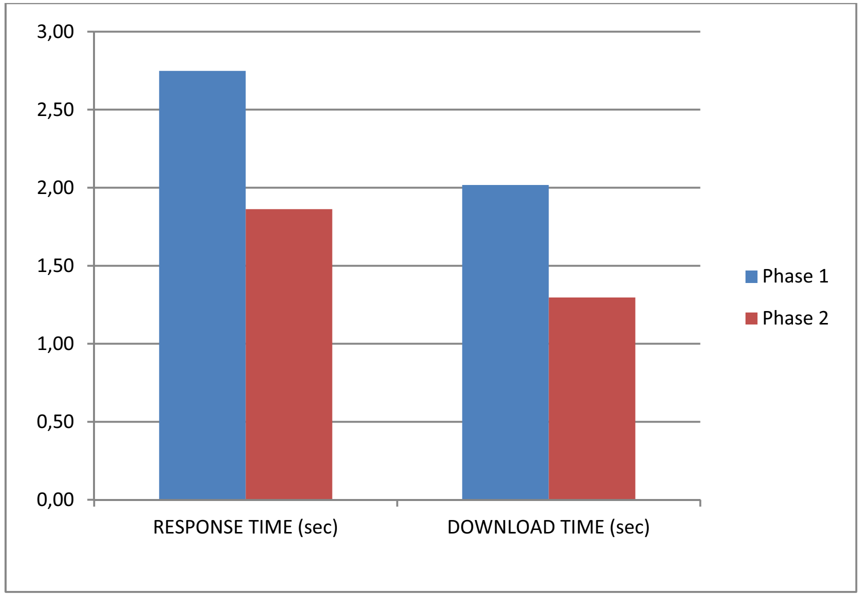


Figure 121. Overall Performance results – Two phases of testing

Figure 122 illustrates the Improvement rate for the different testing metrics.

As shown in Figure 122, all registered metrics present an improvement rate of more than 10%, with the exception of Completion rate that is already high in the first test phase.

Table 54 presents a comparison of the overall results in the the two phases, against the test scenarios metric goals.

As shown in Table 54, in the second phase all of the test metrics have achieved good results comparing to the scenario expectations.

Figure 123 graphs illustrate this situation. As shown in Figure 123 graphs, the Completion rate, SUS and Download time exceeded the expectations in terms of scenario goals.

The Time on task, Error rate and Response time are very near to the scenarios values.

Table 55 does a comparison by tool and subsystem of AHKME, with the scenarios metric goals.

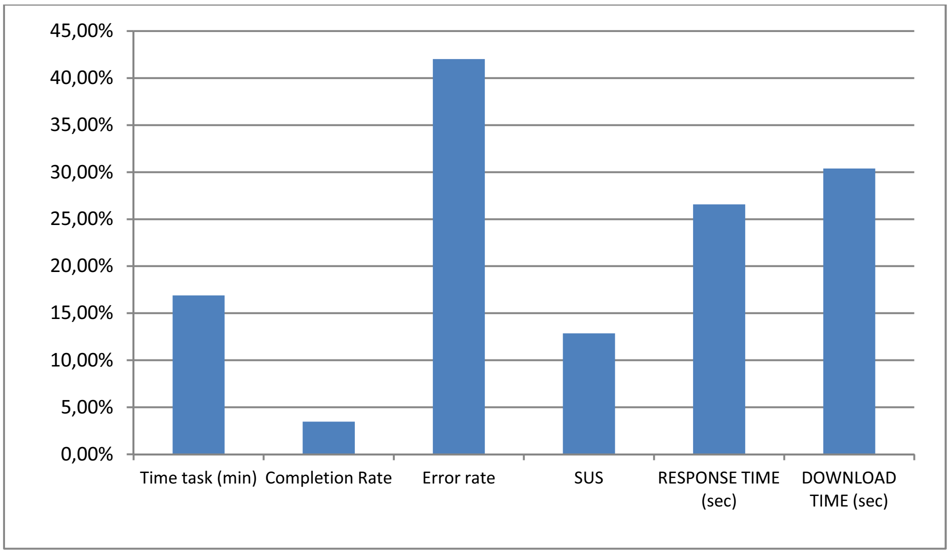
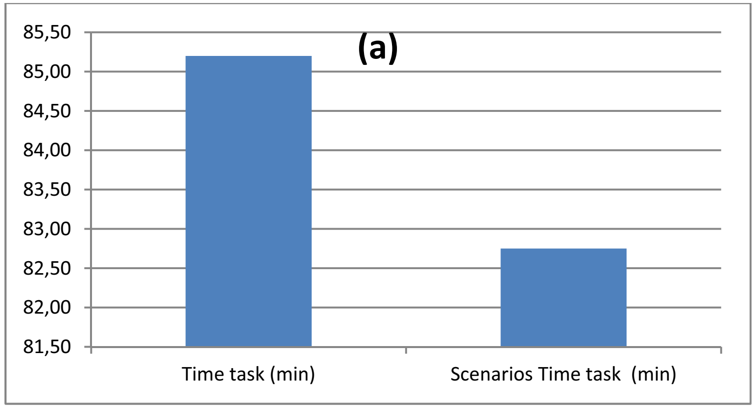
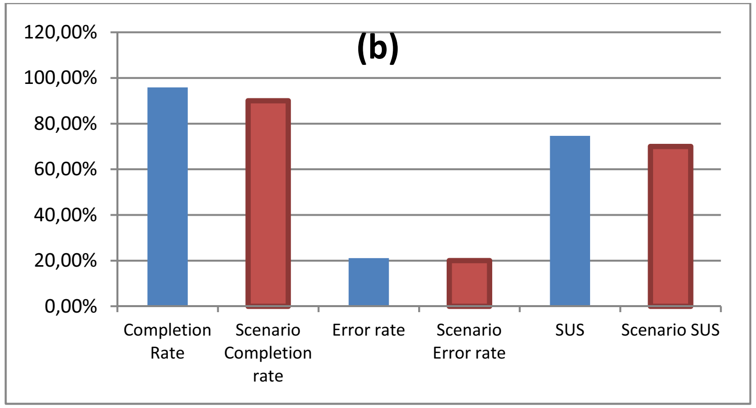


Figure 122. Overall Improvement rate – Two phases of testing

Table 54. Overall two phases of testing results comparison with scenario goals

Phase	Time task (min)	Scenarios Time task (min)	Completion Rate	Scenario Completion rate	Error rate	Scenario Error rate	SUS	Scenario SUS	RESPONSE TIME (sec)	Scenario RESPONSE TIME (sec)	DOWNLOAD TIME (sec)	Scenario DOWNLOAD TIME (sec)
1	102,53	82,75	92,65%	90,00%	36,38%	20,00%	66,13%	70,00%	2,75	1,00	1,86	10,00
2	85,20	82,75	95,86%	90,00%	21,09%	20,00%	74,63%	70,00%	2,02	1,00	1,30	10,00
% Improvement rate	**16,90%**		**3,46%**		**42,03%**		**12,85%**		**26,58%**		**30,39%**	
Difference value	**-17,33**		**3,21**		**-15,29**		**8,50**		**-0,79**		**-0,61**	**0,00**





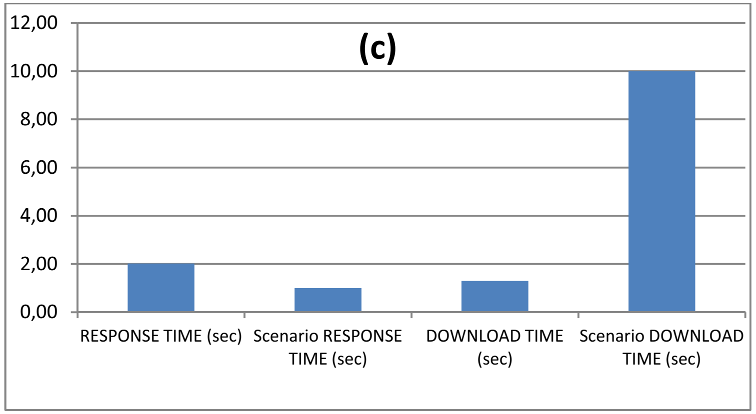


Figure 123. Overall two phases of testing results comparison with scenario goals – Usability, Satisfaction and Performance

Table 55. Overall results per tool/subsystem comparison with the scenario goals

Overall Results comparison per Tool - Scenario Metric													
TOOL	**Subsystem**	**Results Time task (min)**	**Scenarios Time task (min)**	**Completion rate**	**Scenario Completion rate**	**Error rate**	**Scenario Error rate**	**SUS**	**Scenario SUS**	**Response Time**	**Scenario Response Time**	**Download Time**	**Scenario Download Time**
TOTAL ADMINISTRATION	Presentation	12,15	13,00	96,00%	90,00%	20,00%	20,00%	70,38%	70,00%	0,36	1,00	0,10	10,00
TOTAL INTEROPERABILITY	LOM and LD	4,94	4,00	95,33%	90,00%	23,33%	20,00%			2,13	1,00	1,83	10,00
TOTAL QUALITY	Knowledge Management	2,00	3,00	92,00%	90,00%	40,00%	20,00%			0,44	1,00	0,06	10,00
TOTAL RECOMMENDATION	Adaptation	1,40	3,00	93,00%	90,00%	35,00%	20,00%			0,45	1,00	0,05	10,00
TOTAL SURVEY	Feedback	5,48	4,00	95,50%	90,00%	22,50%	20,00%			0,25	1,00	0,05	10,00
TOTAL LOM	LOM and LD	8,03	8,00	94,00%	90,00%	34,00%	20,00%			14,15	1,00	11,54	10,00
TOTAL LD	LOM and LD	18,12	13,00	90,40%	90,00%	44,00%	20,00%			4,12	1,00	1,45	10,00
TOTAL GENERAL	Presentation	10,50	7,75	95,24%	90,00%	22,54%	20,00%			0,93	1,00	0,14	10,00
TOTAL SCHEMA	LOM and LD	11,64	8,00	92,00%	90,00%	38,00%	20,00%			5,40	1,00	4,82	10,00
TOTAL WF	Adaptation	2,77	4,00	95,50%	90,00%	22,50%	20,00%			0,25	1,00	0,04	10,00
TOTAL RESOURCES	Presentation	12,00	10,00	98,00%	90,00%	10,00%	20,00%			0,86	1,00	0,01	10,00
TOTAL COMMUNICATION & SHARING	Presentation	4,34	5,00	93,33%	90,00%	36,67%	20,00%			1,22	1,00	0,30	10,00
TOTAL SEARCH	LOM and LD	0,51	2,00	95,00%	90,00%	25,00%	20,00%			0,42	1,00	0,14	10,00
TOTAL SYSTEM		**93,86**	**82,75**	**94,25%**	**90,00%**	**28,73%**	**20,00%**	**70,38%**	**70,00%**	**2,38**	**1,00**	**1,58**	**10,00**

At this point it is important to make a mapping between the results and the study goals, in order to check the validaty of the study objectives and the hypothesis assumptions.

Thus, to do so the metrics of the objectives are mapped to the test metrics and classified according to the scale of values defined in Table 56.

Table 56. Metrics Scale

Scale											
Error rate		Completion rate		Time task		SUS		Response time		Download time	
<=20%	1,00	>= 90%	1	<= Scenario task time	1	>=70%	1	< 1 sec.	1	<=10 sec.	1
>=20% and <40$	0,5	>= 66% and < 90%	0.5	<=2*Scenario task time	0,5	>=65% and <70%	0,5	> 1 sec and <= 10 sec.	0,5	> 10 and <= 15 sec	0
>40%	0	< 66%	0	>2*Scenario task time	0	<65%	0	> 10 sec.	0	> 15 sec	0

Table 57 shows the description of the metric classification defined in Table 56, and also the objective measurement indicator defined in Chapter 1.

Table 57. Metric classification and Objective measurement indicator

Metric Classification		Objective Measurement Indicator	
Value	Description	Value	Description
1	Exceeded	>= 83%	Exceeded
0,5	Fulfilled	>= 50%	Fulfilled
0	Not Fulfilled	< 50%	Not Fulfilled

If the average of all the metrics gives a value according to the measurement indicator of the objective (Chapter 1), then the objective reaches the defined goal.

Table 58. Mapping between Study Objectives and Goal Achievemtn

Objectives of Study - Goals Achievement											
TOOL	**Subsystem**	**Time task (min)**	**Completion rate**	**Error rate**	**SUS**	**Response Time**	**Download Time**	**Average metrics**	**Objectives/ Hypothesis assumptions No**	**Objectives of the Study**	**Goal Achievement**
TOTAL ADMINISTRATION	Presentation	1,00	1,00	1,00	1,00	1,00	1,00	100,00%	5		Exceeded
TOTAL INTEROPERABILITY	LOM and LD	0,50	1,00	0,50		0,00	1,00	60,00%	1;5;10	Interoperability	Fulfilled
TOTAL QUALITY	Knowledge Management	1,00	1,00	0,50		1,00	1,00	90,00%	1	Quality	Exceeded
TOTAL RECOMMENDATION	Adaptation	1,00	1,00	0,50		1,00	1,00	90,00%	7;1;H10;H11	Adaptation	Exceeded
TOTAL SURVEY	Feedback	0,50	1,00	0,50		1,00	1,00	80,00%	12;H1-5;H12-19	Adaptation	Fulfilled
TOTAL LOM	LOM and LD	0,50	1,00	0,50		0,00	0,50	50,00%	4;1;H7;H11	Learning domain Independence/Reusability	Fulfilled
TOTAL LD	LOM and LD	0,50	1,00	0,00		0,00	1,00	50,00%	6;1;H7;H11	Learning domain independence/Reusability	Fulfilled
TOTAL GENERAL	Presentation	0,50	1,00	0,50		1,00	1,00	80,00%	2;3		Fulfilled
TOTAL SCHEMA	LOM and LD	0,50	1,00	0,50		0,00	1,00	60,00%	9;1;H8;H11	Learning domain independence	Fulfilled
TOTAL WF	Adaptation	1,00	1,00	0,50		1,00	1,00	90,00%	8;H9	Adaptation	Exceeded
TOTAL RESOURCES	Presentation	0,50	1,00	0,50		1,00	1,00	80,00%	11;1	Learning domain independence/Reusability	Fulfilled
TOTAL COMMUNICATION & SHARING	Presentation	1,00	1,00	0,50		0,50	1,00	80,00%	11	Learning domain independence/Reusability	Fulfilled
TOTAL SEARCH	LOM and LD	1,00	1,00	0,50		1,00	1,00	90,00%	1;H6	Reusability	Exceeded
TOTAL SYSTEM		**73,08%**	**100,00%**	**50,00%**	**100,00%**	**65,38%**	**96,15%**	**76,92%**			**FULFILLED**

As shown in Table 58, the objectives of the study, in a generic view fulfill the expectations, according to the measurement indicators of the objectives.

Figure 124 illustrates the mapping this in terms of AHKME tools.

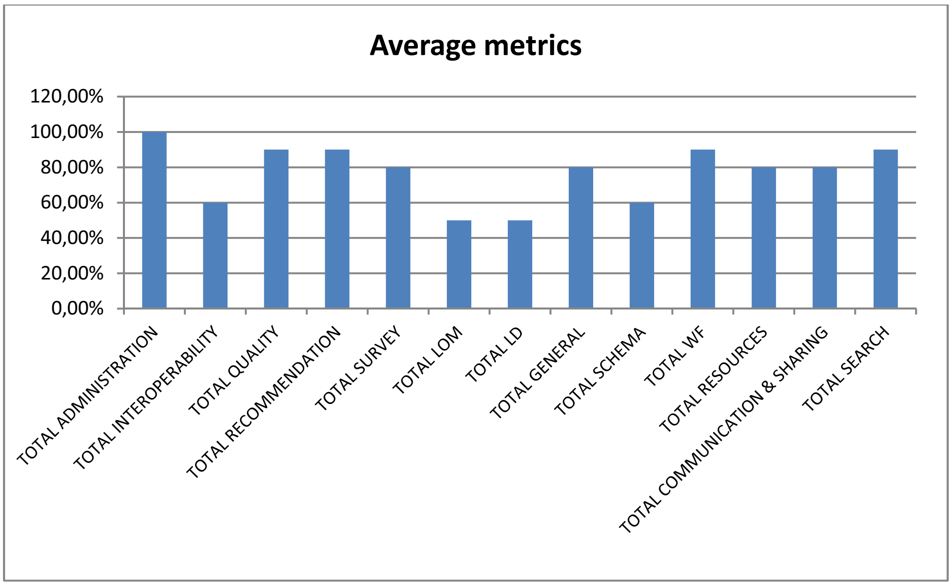


Figure 124. Average Metrics results

Table 59 shows an agreggate of the average metric and the subsytems to find the results in terms of goal achievement.

Table 59. Objectives of study – Goal Achievement by Subsystem

Objectives of Study - Goals Achievement by Subsystem	
Subsystem	**Average metrics agreggate**
Presentation	100,00%
LOM and LD	62,00%
Knowledge Management	90,00%
Adaptation	90,00%
Feedback	80,00%

As shown in Table 59, all of AHKME subsystems obtain satisfactory results.

This fact is illustrated in Figure 125.

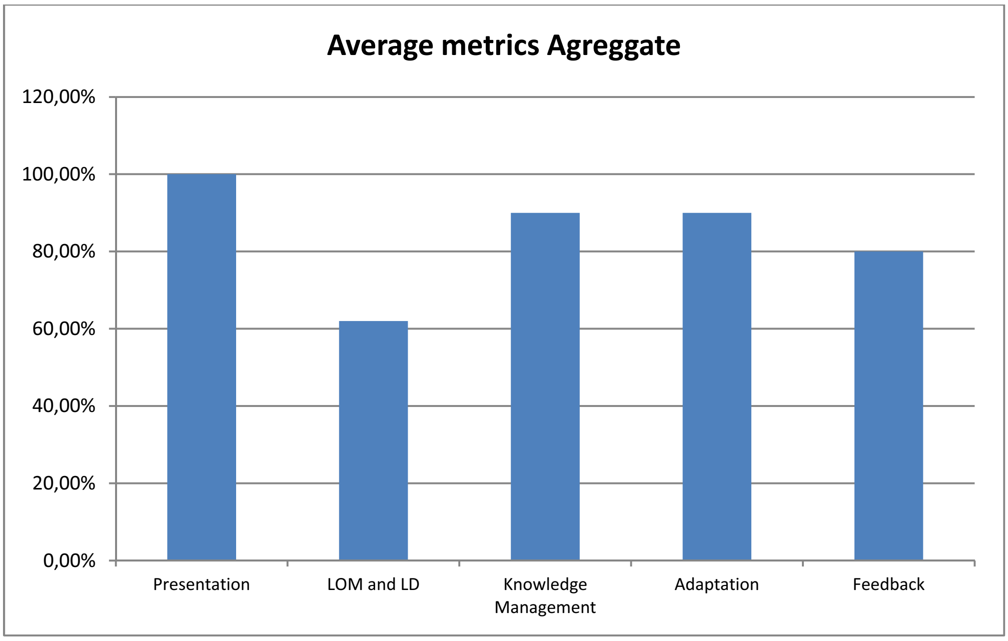


Figure 125. Average metrics aggregated by subsystem

Thus, the test results confirm the study objectives and hypothesis, regarding usability, satisfaction and system performance concerns.

Besides the results, from post-test and post-task questionnaire a set of recommendations is extracted in Table 60 to future AHKME developments (HotmailUsability, 1999).

As shown in Table 60, the severity of the problems has decreased regarding the first test phase.

Table 60. Recommendations

RECOMMENDATIONS					
No	**Tool/Task**	**Usability Problems**	**No of Test Partcipants affected**	**Severity level**	**Scope**
1	General :: Tool finding	Can be more straighforwarding or grouped	4	4	Global
2	General :: Help	Can have tutorials of same features, Still need search mechanism	5	2	Global
3	Schema :: import	Needs to be quicker	2	3	Local
4	Schema :: generate/personalized	Needs to be quicker	2	4	Local
5	Schema :: create	Needs a more simpler functionality and to include semantic features	4	3	Local
6	Schema :: list	Still needs a better search mechanism	2	3	Local
7	Schema :: edit	Needs a more simpler functionality	4	2	Global
8	Wf :: history	Needs a search mechanism	1	4	Global
9	General :: Profile	Can be more strighforwarding and simpler	2	4	Global
10	General :: Student Feedback	Perhaps it can have an upload file field	1	4	Local
11	Surveys :: create	It seems a very powerfull tool but a little bit complex. Can be more user-friendly.	3	3	Local
12	Surveys :: edit	As in the creation case it is a little bit complex. Can be more user-friendly	3	3	Local
13	Surveys :: list	It can be useful to have a search mechanism	2	3	Local
14	Recommendation :: view attribute importance	Needs more contextualized information.	3	3	Local
15	Recommendation :: view decision tree	Representation can be improved.	3	2	Local
16	Quality :: view attribute importance	Needs more contextualized information.	3	3	Local
17	Quality :: view decision tree	Needs a mora graphical view	3	2	Local
18	LOM :: Edit	Needs to be faster	2	4	Local
19	LOM :: list	Needs a search mechanism with more semantic features	1	3	Local
20	LD :: Edit	Needs to be faster.	2	3	Local
21	LD :: use	Needs interface enhancement.	3	3	Local
22	LD :: list	Needs a search mechanism with more semantic features	2	3	Local
23	Resources :: search	Needs more advanced search mechanisms	1	4	Local
24	Search	Needs to improve the semantic relation of the search result	2	3	Local
25	Interoperability :: Create/Export Package	Can explicit give confirmation information about packege creation	2	4	Local
26	Administration :: Users & Tools Access	It can have tools to integrate with Active Directory or other kinds of users' Directories.	2	3	Local
27	Administration :: Templates	Can have a preview of the templates	1	4	Local

4.5. OTHER TESTS

In addition to the assessments described in previous sections, the LD has been used in the case study to perform additional experiments to verify their interoperability and the reusability of elements in other LD.

4.5.1. EXTERNAL TOOLS

To verify the interoperability of the LD, CopperCore LD player is used because from the existing ones, it is the most used and has a more robust implementation. The test is regarding to import in this tool the package containing the LD defined for the case study and play it to check if it scored an error. The test results reveal that CoperCore has not problem to open a generated AHKME-LD package, its elements are properly deployed and the elements can be played and saved without any problem (see Figure 126).

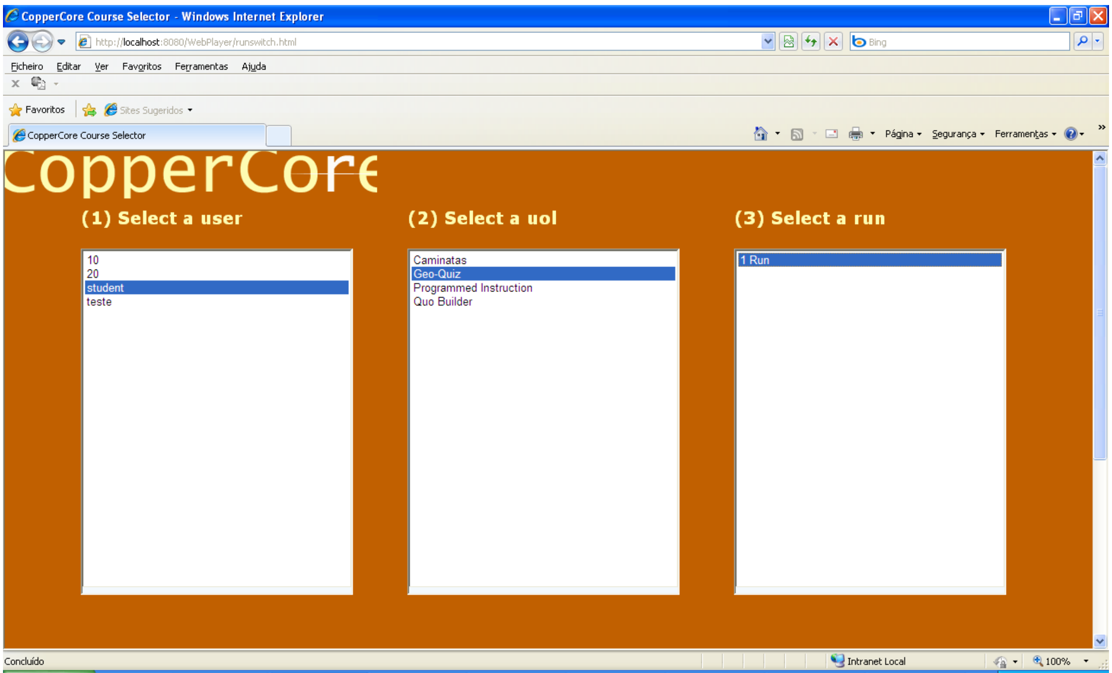


Figure 126. CopperCore main screen

By choosing the specific learning unit and run, it plays it on CopperCore without errors as shown in Figure 127.

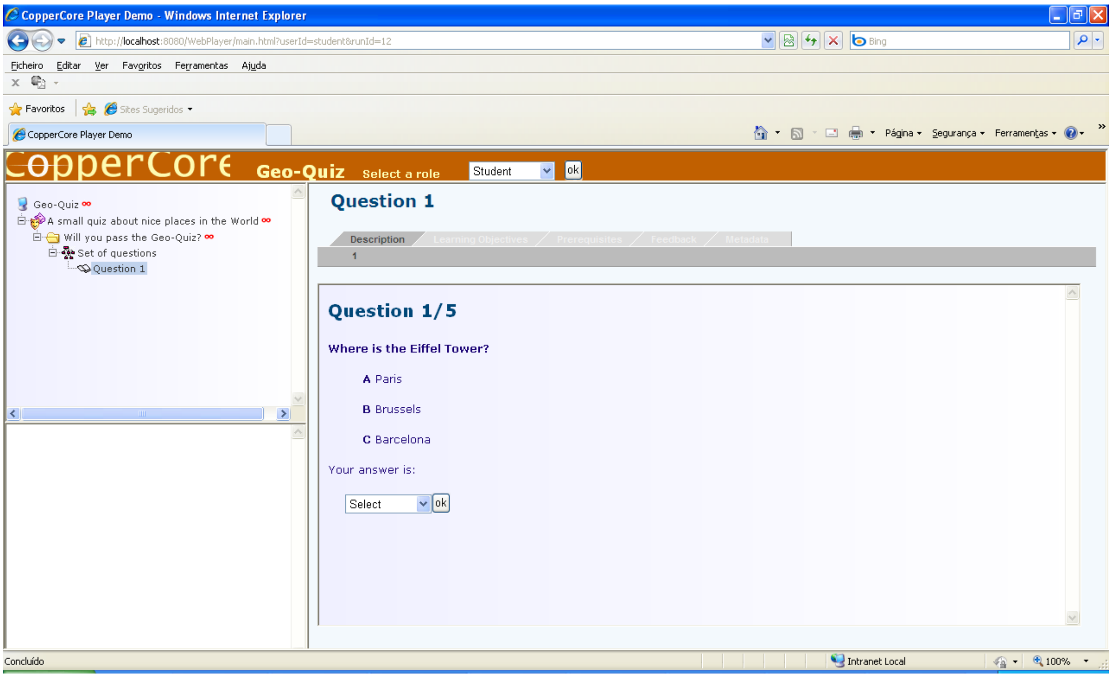


Figure 127. CopperCore learning unit player

By this means, it confirms the interoperabiltity goal of the study, because the package has been changed with AHKME LD and now it plays correctly in an external tool.

To check whether the elements of the designed LD in the case study are suitable capable of being reused in other ones, it is created a new LD based on the original. The LD included learning activities, and events of the original sequences but instead of using a single play, has two plays by type of student (i.e. Computer Sciences, Other).

In addition, it incorporates a new rule to adapt the expert type, depending on the type of student, shows an additional learning activity at the end of the lesson. These elements are integrated into a new method, and thus a new LD, which is validated and runs without problems in AHKME-LD.

This test verifies that the previously defined elements may be included in new LD, optimizing their design process and reducing time and cost spent in design.

4.5.2. SIMILAR TOOLS

This section is devoted to present some tests made to compare AHKME tools, specifically LOM and LD tools, with other similar tools.

These tests are made to proof the interoperability and reusability study goals.

The results of the LOM-based tests are presented in Table 61.

By confronting the metrics, it is possible to see that AHKME LOM has very relevant results comparing to the other tools.

This difference is shown by the Completion rate/task on time ratio, where AHKME LOM obtains the highest value, 13,34%/minutes, which means that is the tool that completes more correctly the tasks by minute.

This happens also by confronting the LD tools, as shown in Table 62.

The only difference here is that the Reload Editor also obtains good results, which gives more relevance to the AHKME-LD results.

Figure 128 and Figure 129 ilustrate these situations, both with AHKME LOM and LD.

These results confirm the study goals, including interoperabilty and reusability.

Table 61. LOM tools comparison

LOM Tools										
Tool	Time task (min)	Completion Rate (%)	Completion Rate/Task Time	Error rate (%)	Confidence	SUS	RESPONSE TIME	RESPONSE TIME (sec)	DOWNLOAD TIME	DOWNLOAD TIME (sec)
Reggie	22,56	68,53%	3,04%	49,83%	4,10	56,65%	15040	15,04	12116	12,12
ADL SCORM	20,54	74,00%	3,60%	43,85%	4,80	58,10%	14250	14,25	11434	11,43
EUN	14,38	77,25%	5,37%	41,77%	5,20	64,64%	13823	13,82	10998	11,00
LOM Editor	12,62	85,11%	6,74%	32,67%	5,70	68,99%	13002	13,00	10125	10,13
AHKME LOM	7,26	96,80%	13,34%	24,00%	6,36	72,63%	10489	10,49	8553	8,55

Table 62. LD tools comparison

LD Tools										
Tool	Time task (min)	Completion Rate (%)	Completion Rate/Task Time	Error rate (%)	Confidence	SUS	RESPONSE TIME	RESPONSE TIME (sec)	DOWNLOAD TIME	DOWNLOAD TIME (sec)
Reload LD	17,32	89,26%	5,15%	27,89%	5,90	70,89%	4110	4,11	1759	1,76
Alfanet Editor	25,20	78,14%	3,10%	38,15%	5,30	61,94%	4698	4,70	2514	2,51
CopperAuthor	22,05	81,89%	3,71%	35,80%	5,10	66,42%	4912	4,91	2845	2,85
ASK-LDT	20,31	86,67%	4,27%	31,29%	4,90	68,66%	5123	5,12	3101	3,10
MOT+	26,77	77,48%	2,89%	37,67%	5,2	59,70%	4803	4,80	2451	2,45
eLive LD Suite	33,07	72,29%	2,19%	43,19%	4,4	52,24%	5890	5,89	3633	3,63
AHKME LD	15,75	92,00%	5,84%	36,00%	6,24	74,63%	3690	3,69	1303	1,30

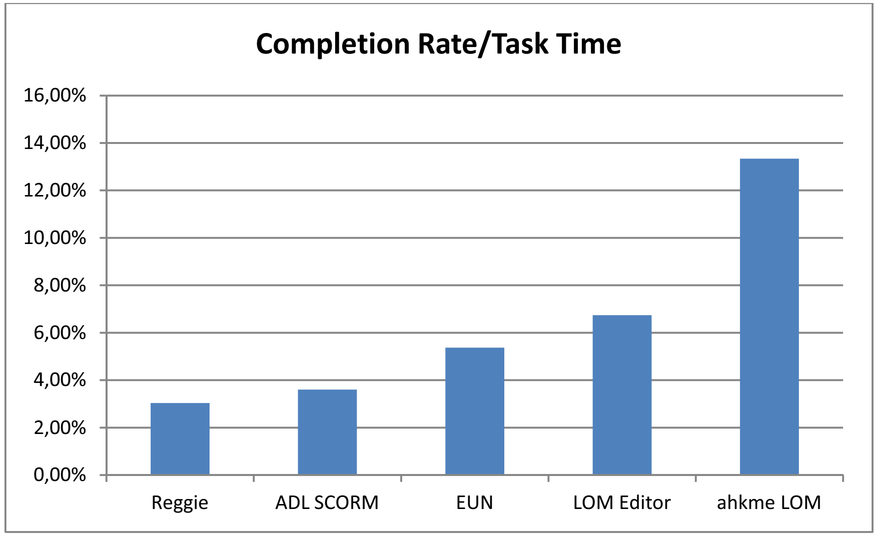


Figure 128. LOM tools comparison for Completion rate/Task time ratio

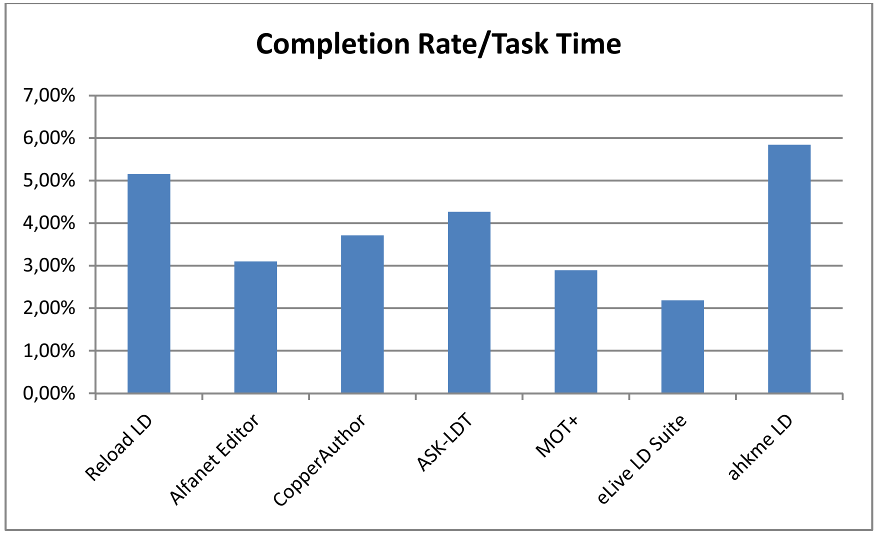


Figure 129. LD tools comparison for Completion rate/Task time ratio

4.6. CONCLUSIONS

This chapter has presented the test scenarios and the developed work to evaluate the study proposal.

After completion of two phases of testing can denote a change in the results.

From Table 54 is possible to see this evolution that is reflected in general by all metrics, but with greater relevance in terms of Error rate with an improvement of 42,03%.

Although the Error rate is not below 20%, usually referenced as acceptable values, is already an approximate value of 21,09%. On the other hand taken into account the trend between the two phases of testing, with improvements in the tools, and most familiriaty with the functionality of the system in the second phase of tests, a trend that translates to the sequence of changing versions of system and its use, the Error rate will fall below this reference value.

The Completion rate has a value above the average with 92%.

The mean Task time also has been an improvement of 16,90%, to stand below the goals set for usability testing scenario.

The improvement in these metrics also is justified by the better user's familiarity with the system, especially in the mean Task time with the acquisition of some routines, but mainly in the Completion rate with the evolution of the system according to the findings and recommendations of the first phase of testing.

This trend of improvement is reflected in general obtained values in the different profiles of the system.

From the standpoint of satisfaction results in terms of SUS scale already have had above-average results, and now registered a slight improvement. The justification, according to comments from users, is because of they have seen their needs reflected in the evolution of the functionality of the system.

In terms of performance results, the Download time has exceeded the expectations in terms of scenario goals. The Response time is very near to the scenarios goals, registering a relevant improvement of 26,58%. This was mainly due to source code optimization.

Also, the results from other tests like running a learning unit in CopperCore and comparing several LOM and LD Tools to AHKME LOM and LD tools have confirmed the study goals in terms of reusability and interoperability.

Thus, the execution of these testing processes and the obtained results stand out with big relevance to confirm the study objectives as well as the hypothesis.

Besides the user satisfaction, still, the second test phase also has manifested the users' comments in the post-questionnaires and post-test tasks, which will be seen as recommendations and opportunities for improvement the system.

5. CONCLUSIONS

This chapter synthesizes the proposal raised in this thesis and exposes its main contributions. Subsequently it details the lines of research that can be further developed from the work done.

Finally, the chapter lists the publications to endorse its development and show its evolution.

5.1. SUMMARY

The Web has made an evolution from its early days of worldwide spread, to nowadays Web 2.0, with social networking, and with the emergence of new concept of a so called Web 3.0. In parallel, the web and eLearning systems have also evolved.

The analysis of state-of-the-art approaches in eLearning systems, standards and AEHS has denoted problems with interoperability, reusability of resources and adaptation. Besides, Web 3.0 has difficulty for implantation, because it requires specialized technical knowledge and the exigence of restructuring of the system and webpages. The eLearning systems do not escape this situation. By this mean, it was needed to adapt eLearning systems to this transition and prepare them for this new concept.

This thesis has exposed an alternative to design the learning process in the eLearning systems through components called Learning Objects/units. These components allow and provide every student in a custom flow of learning under conditions previously defined by the Learning designer. The definition of the LD is focused both on the use of a specification to shape the learning process as in the separation of the elements that make the learning design.

Thus, as proposal a prototype of an eLearning system - AHKME - has been developed. AHKME combines different technologies in order to facilitate the use of instructional design for teachers.

The evaluation of this proposal has been driven through a testing process. First, the prototype passed to heuristic analysis from specialists. Second, the system was subjected to a usability testing process divided in two separate testing phases.

From the results it is important to highlight the results of the satisfaction of users with 70.38%, which reflects the evolution of the system through the feedback collected.

Of the remaining results highlight the LOM and LD tools with a Completion rate above 90% and resources tool with an Error rate of 10%, values that exceed the targets and function as indicators of the high perception of these features by users.

In terms of performance there is the workflow engine with a value of 0.25 for Response time and a value of 0.04 for Download time, well below the limits, with results at the level of entry into the production phase.

At the subsystem level, all the objectives met and even exceeded the indicators of the objectives.

From these results and taking into account the satisfaction of users it can be concluded that the versatility introduced into the system to create more interaction, as well as betting on feature to help in the process of instructional design, help to obtain the levels achieved and to confirm the relevance of the proposed application and/or further research.

As shown in Table 63, the objectives of the study, in a generic view fulfill the expectations, according to the value of the measurement indicators of the objectives (see Chapter 1) they reached the defined goals.

Table 63. Objectives of study - Goals achievement

Objectives of Study - Goals Achievement				
Operational Objective No	**General Objectives of the Study**	**Goal**	**Average metrics**	**Goal Achievement**
1	learning domain independence/reusability/interoperability	Fullfilled: Average value of the objective metric >= 50%. Exceeded: Average value of the objective metric >= 83%.	71,25%	Fulfilled
2	learning domain independence/reusability/interoperability		80,00%	Fulfilled
3	learning domain independence/reusability		80,00%	Fulfilled
4	learning domain independence/reusability		50,00%	Fulfilled
5	Interoperability		80,00%	Fulfilled
6	learning domain independence/reusability		50,00%	Fulfilled
7	Adaptation		90,00%	Exceeded
8	Adaptation		90,00%	Exceeded
9	learning domain independence		60,00%	Fulfilled
10	learning domain independence/reusability/interoperability		60,00%	Fulfilled
11	learning domain independence/reusability		80,00%	Fulfilled
12	Adaptation/Quality		80,00%	Fulfilled
	TOTAL SYSTEM		**72,60%**	**FULFILLED**

Finally, the test results confirm the study objectives and hypothesis, regarding usability, satisfaction and system performance concerns. Thus, the obtained results allow concluding that the system has achieved the objectives. By this mean, the proposal has contributed to improve reusability, and interoperability of learning objects, as well as collaborate to apply the new concepts regarding the Web and the research of eLearning systems.

5.2. MAIN CONTRIBUTIONS

The proposal claimed to create a prototype of a web information system – AHKME - that must act as a learning design back-office, introducing management skills of standardized packages of learning resources for interoperability among systems. It also seeks to include a search capability for reuse of resources through metadata and the ability to adapt to the user profiles.

Creating this system seeks to add the ability to integrate with other systems such as LMS and social networks by providing them with these features.

Beyond that, AHKME also enters the ability to prepare in practice the Semantic Web, with tools for creating/customizing specifications and ontologies to convey meaning as well as mechanisms for automatic search by context and adaptive recommendation. The features used by in collaboration and the social tools helps to implement the concept of Semantic Web and more specifically reinforces the role of the Social Semantic Web.

This PhD thesis intends to implement a new system of learning technology mainly developed on software and freeware support, in which the teacher/tutor or trainer participates in the process of designing and structuring of content and learning information. The system outcomes are presented to the student, which in turn will be the true evaluator of the system quality, both in terms of usability, and quality of learning units or courses.

Finally, the overall software development has intended demonstrating a new approach to software process in the development of Web information systems for eLearning, with the combination of functionality of different types of information systems in an elearning system. As well as the introduction of concepts related to social semantic web in elearning systems.

5.3. FUTURE RESEARCH LINES

According to test recommendations and to the state of the work, it is worth developing in this thesis new lines of research to improve the functionality of AHKME, autonomy in LD, introduce the concept of collaboration and data mining to AEHS, and the preparation to Web 3.0. Here are these lines of development and future research:

- Introduce intelligent wizards in AHKME to help users to annotate learning objects and in the learning design.
- Upgrade the open source social network to a new release, improving the interface of collaboration and sharing with the users.
- Improve the help feature to include contextualization.
- Improve the presentation front-end specifically in LD player, customizing the interface to be more user-firendly.
- Improve the search tool, to more advanced search and furthermore to semantic search.
- Implement the level A, AA and AAA of conformance according to the Accessibility WCAG.
- Introduce AHKME to mobile platforms and techonology:
    - Developing applications from AHKME tools that work standalone for mobile platforms and Operating Systems (OS).
    - Explore more in detail the cross-platform technologies like Airplay (2010) or Qt (2010).
- Implement Semantic technologies, regarding ontologies languages like OWL (2009) and RDF (2004).

In addition to these improvements and because so far there is not much implementations of eLearning system regarding the new paradigm of web and technologies, like mobile platforms and ontologies, the main research line continues with development of mobile applications to deploy in mobile marketplaces through cross-platform technologies and the introduction of RDF and ontologies languages in AHKME.

By this mean, next it will be described some of the concepts already explored and presented some future ideas regarding mobile technology applied to elearning.

Learning 3.0 and mobile

Learning 3.0 will be about harnessing the ubiquity of the mobile phone/handheld device and using it as an educational tool. Given the fact that many people in the education ecosystem are finding the Learning 2.0 pill hard to swallow.

Another key indicator that the Internet is trending towards a mobile experience is the move by media giants such as Yahoo!, Google, Facebook, Disney Internet Group, Apple Computer, and Sony to provide more and more of their content on mobile devices.

The convergence of mobile and social technologies, on-demand content delivery, and early adoption of portable media devices by students provides academia with an opportunity to leverage these tools into learning environments that seem authentic to the digital natives filling the 21st Century classroom.

Clearly, the spread of web-based technology into both the cognitive and social spheres requires educators to reexamine and redefine our teaching and learning methods.

Already in 2007 Derek Baird (2007) identified a few quick facts on mobile technology, Generation Y and education, many of them confirmed today:

- ❖ A 2005 study conducted by the USA-based Kaiser Family Foundation found that, although 90% of teen online access occurs in the home**,** most students also have web access via mobile devices such as a mobile phone (39%), portable game (55%), or other web-enabled handheld device (13%).
- ❖ 64 million votes were cast for American Idol contestants using cell phones, more votes than have been cast for any U.S. president. Kudos to News Corp/Fox Interactive Media for recognizing this trend and tapping into the love affair between Gen Y and their mobile technology.
- ❖ One reason that iPhone has been so successful is that Apple recognized Gen Y's love affair with mobile technology, and built Mobile Social Software (MoSoSo) opportunities into their community.

- ❖ Palm estimates that mobile and handheld devices for public schools will be a 300 million dollar market. A few progressive school districts in the USA have already started using mobile devices in the classroom.
- ❖ There are also the IPad from Apple and tablets of gender as mobile emerging platforms.
- ❖ Australia is emerging as a leader in mobile learning (mlearning).
- ❖ The National College of Ireland, University of Scotland and other European universities have already started experimenting and integrating mobile technologies into their classes.
- ❖ A recent study by the Irish National Teachers Organization (INTO) found that students are using their mobile phones for just about everything, except making phone calls.
- ❖ There are a myriad of new MoSoSo applications being developed, and the number is poised to explode.
- ❖ Some developing countries, like Kenya, are bypassing the use of desktop computers all together and using handheld WI-FI devices and open source software to reduce the cost of education in rural areas.
- ❖ Mobile School is a Belgian non-profit organization that is using mobile technology to provide educational opportunities for homeless children.
- ❖ Mobile phones are in the early phases of being used for student testing and assessment.
- ❖ Facebook launched a mobile version of their popular social networking service. The Kansas City Star notes that Facebook's mobile services will be available to more than 2,000 universities. Also, there is the emergence of Google+.
- ❖ SparkNotes are available for download on both the iPod (text and audio format) or via SparkMobile, a SMS version for mobile phones.

In the 2011 Horizon report (Johnson, Smith, Willis, Levine, & Haywood, 2011) and also in 2010 it has been announced the following areas of emerging technologies that will have significant impact on education, as well as a preview of the time to adoption:

- Time to adoption: One Year or Less.
    - Electronic Books.
    - Mobiles.
- Time to adoption: Two to Three Years.
    - Augmented Reality.
    - Game-based Learning.
- Time to adoption: Four to Five Years.
    - Gesture-based Computing.
    - Learning Analytics.

The combination of social interaction with opportunities for peer support and collaboration creates an interesting, engaging, stimulating, and intuitive learning environment for students. Effective course design will need to blend traditional pedagogy with the reality of the media hungry and mobile Gen Y learner.

Even more astounding is how mobile devices are increasingly being used as the primary way in which people connect to the Internet. In fact, is relevant to consider that a percentage of the Internet users will most likely never use a personal computer to connect to the Internet. Rather, they will access information, community, and create content on the Internet via a mobile device.

In order to create a better learning environments designed for the digital learning styles of Generation Y, there is a need to use strategies and methods that support and foster motivation, collaboration, and interaction.

The use of mobile devices is directly connected with the personal experiences and authentic use of technology students bring to the classroom.

The use of mobile technologies is growing and represents the next great frontier for learning. Increasingly it will continue the academic and corporate research invest, design and launch new mobile applications, many of which can be used in a learning context.

Thus, the main future lines of research include mobile learning, by developing a mobile version of AHKME, but also the continuation of the development of AHKME, specifically in the areas of social and semantic web, exploring RDF language and semantic technologies and with the advance in features of social network and collaboration.

5.4. CONTRAST OF RESULTS

As set out in the first chapter, an important part of the working method used to develop this thesis has been to expose the course of the investigation and its proposals to the scientific community that works on these issues.

In this way was obtained feedback, and met the last contributions to the state of art, which helped refine our work. The process and the partial obtained results have been presented in different forums which led to the next set of publications.

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6. APPENDICES

A. ANALYSIS OF ELEARNING CURRENT APPROACHES

This appendix explains the process of analysis of current elearning systems. For this, it describes systems appointing their characteristics and features, both in comercial and open source world.

It also presents the main features regarding core aspects in software analysis, usability and accessibility.

For illustrating the evolution of this kind of systems, the analysis has been made with the latest versions of these systems.

1. INTRODUCTION

Nowadays several eLearning platforms and tools appeared, some commercial and others open source, so it is very difficult for an institution/enterprise to choose the best solution that fits their needs.

Costumers deal with several problems to make their choices. If anyone wants to buy a platform, it has to deal with the cost of licensing, installation, maintenance and with the problem of extensibility of the platform. On the other hand, if the choice is an open source and freeware solution, it has to deal with problems like lack of documentation, support and maintenance.

One of the things that also interferes with the choice and should be considered is the know-how of the future users of these tools, so it must be considered the main target of these tools, their previous knowledge and their IT skills.

Also, it must be taken into account if the persons that are on the process of selecting a platform do not know much about eLearning, that it maybe be better try to find an already known platform, in contrast with some freeware solutions. These persons should look for a platform that has a very good support tool. On the other hand, if there are persons that know about eLearning processes, a platform that best fits the needs should be looked for, taking into account the functionalities of the platform and its evolution capabilities.

In order to clarify how to make an analysis of eLearning systems, it is presented how it can be done, taking into account factors like standards compliance, accessibility, usability tests that should be done and the language support.

First, some current approaches to eLearning platforms, both freeware/open source and commercial and also some authoring & packaging tools, are going to be explored. Then, a proposed eLearning framework is introduced, entering in the process of analysing a platform seeing the factors and criteria to be used to evaluate them.

Finally, see some analysis examples of eLearning platforms and tools are discussed.

2. CURRENT APPROACHES

Nowadays, there are several solutions to support eLearning, where some are more content-centered and others more students centered. There are typical course management systems like the Learning Management Systems (LMS) and the Learning Content Management Systems (LCMS) more focuses on content management. There exist also tools to make the authoring of content and packaging, tools to associate metadata to the Learning Object (LO).

Now, some of these tools are going to be analyzed.

2.1. LMS AND LCMS

Generally, typical LMS and LCMS support the following tools:

- Communication – Tools that permit the communication among the users of the platform. Ex: chat, forum.
- Administration – Permits, the user profile management, reports and statistics management.
- Resources Management - Regarding management the resources like creation, editing and authoring.
- Course management – Defines units of learning, activities and their sequence.
- Evaluation – Management of the assessment, types of tests and allowed questionnaires.
- Adaptation - Regarding user personalization, adaptation and customization.

Thus, there are several types of platforms in the market, commercial like Blackboard (2010), Desire2Learn (2010), IntraLearn (2010), Angel (2010) and freeware/open-source like Atutor (2010), Moodle (2010), Sakai (2010) and dotLRN (2010).

In Table 64 and Table 65 it can be seen some of the current commercial and open source eLearning platforms.

Table 64. Commercial LMS & LCMS

LMS/CMS Analysis	
Product Name	**The Blackboard Learning System (Release 7) - Enterprise License (Bb, 2010; Edutools, 2009)**
Developer Name	**BlackBoard**
Communication Tools	
Discussion Forum	A spell-checker is available for student and instructor responses.
	Discussions can be viewed by date, thread, or poster. Discussion threads are expandable and collapsible to view an entire conversation on one screen. Discussion threads can be searched. Posts can contain URLs, file attachments and may contain HTML. The discussion software includes a formatting text editor which can create mathematic equations.
Discussion Management	Instructors can allow students to create discussion groups. Instructors can set up moderated discussions where all posts are screened.
	Posts may be peer reviewed by other students.
	Instructors can view statistical summaries of discussions displaying participation which can be used to generate grades.
	Instructors can associate a discussion with any course content. Instructors can enable or disable anonymous posting, and determine whether student posts are re-editable. Instructors can determine if threads are graded or ungraded. Instructors can enable peer rating, which uses a 5-star scale. Instructors can determine if threads are moderated – if so, control over moderation can be delegated to any user. Instructors can view posting statistics to evaluate student participation. Instructors may create separate discussion environments for small groups of students and teaching assistants.
File Exchange	Students can submit assignments using drop boxes.Students can share the contents of their personal folders with other students.
	Students have a private folder into which they can upload and download files. Students can upload files to a shared group folder. Students can submit assignments using drop boxes. Instructors can upload files to the personal folder of a student.
Internal Email	Students can use the built-in email functionality to email individuals or groups.Students can use a searchable address book. Students can use Blackboard Messages (internal email) to email individuals, groups, or all users with a specific role in their courses. Students can attach files to emails, and emails can contain URLs, file attachments and may contain HTML.
	Instructors can email the entire class at once at a single address or alias.
Online Journal/Notes	Students can make private notes about their course.
Real-time Chat	The chat tool supports unlimited simultaneous group discussions
	Students can create new rooms.
	The Java-based chat tool supports unlimited simultaneous group discussions and private messages. Instructors may moderate chats and suspend students from the chat rooms. The system creates archive logs for all chat rooms. Instructors can view chat logs and share these with students. The virtual classroom tool supports a structured way for students to ask questions and instructors to provide answers.
Whiteboard	The whiteboard supports image and PowerPoint uploading.The whiteboard supports mathematical symbols.
	The software can archive a recording of whiteboard sessions for future viewing.
	The software supports a whiteboard that can have multiple instances in the same course. The whiteboard supports mathematical symbols, and image and PowerPoint uploading. The software supports group web browsing. The software can archive a recording of whiteboard sessions for future viewing.
Productivity Tools	
Calendar/Progress Review	Students have a personal home page that lists all courses in which the student is enrolled, new email and all course and system-wide events from their personal calendar.
	Students can view their grades on completed assignments, total points, course grade, and compare grades against the class performance.
	Instructors can post course-related events and announcements in the course calendar or to the course homepage. The instructor can assign tasks by using the calendar and the instructor can enable an option so that the student can check their status at any point in a course. Students can check their grades on submitted assignments as well as compare their grades against the overall class performance.
Searching Within Course	Students can search all discussion threads. Students can search chat or virtual classroom session recordings.
	Students can search all Discussion Boards, as well as chat or virtual classroom session recordings by name or dates.
Work Offline/Synchronize	Students can compile and download the content for an entire course into a format that can be printed or stored locally.
	Students can download course content and discussion group content with a PDA.
	Instructors can publish course content on a CD-ROM that can be linked to dynamically from within the online course or viewed offline. Students can download course content into a format that can be accessed on a mobile device and synchronize calendar events with a PDA.
Orientation/Help	The system includes online tutorials for students that help students learn how to use the system.
Student Involvement Tools	
Groupwork	Each group can have its own discussion forum. Each group can have its own chat or whiteboard.
	The software supports assigning students into groups by the instructor. Each group can have its own shared file exchange, private group discussion forum, synchronous tools, and group email list.
Community Networking	Students can create online clubs, interest, and study groups at the system level.
	Students from different courses can interact in system-wide chat rooms or discussion forums.
Student Portfolios	Students can create a personal home page. Personal home pages may include a photo, personal information, and links to important websites
Administration Tools	
Authentication	Administrators can allow guest access to all courses.
	Administrators can set courses to be publicly accessible or protect access to individual courses with a username and password. The system can also authenticate against an external LDAP server, Active Directory, Microsoft's .NET Passport Web Service, or using other protocols (Kerberos, CAS and Shibboleth have been implemented). SIF is compatible. User sessions can be encrypted with SSL. Administrators can set up fail-through authentication against multiple sources in the event that the primary source fails. Passwords stored in the system database are encoded.

LMS/CMS Analysis	
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools. Instructors or students may be assigned different roles in different courses. Administrators and Instructors can assign different levels of access to the system or to specific courses based on pre-defined roles. The system can access authorization information stored in an LDAP directory.
Registration Integration	Administrators and Instructors can batch add students to a course using a delimited text file or students can self-register. Administrators can batch create courses, users, and enrollments in the system. The software supports integration with student information systems through an event-driven API or through their tool which is based on scheduled system extracts. Administrators can transfer student information bi-directionally between the system and an SIS in batch or in real time. The system supports the use of SOAP-based data integration. Integration with Student Information Systems is available through existing plug-ins. The service provider will assist, as a services engagement, in transferring student registration information between the CMS and the institutional SIS. The software is compliant with the IMS Enterprise specification for student data.
Hosted Services	The product provider offers a hosted system that includes 99.75% Service Level Agreements with guaranteed system availability and performance on a network of high-performance, fault-tolerant servers with fail-over capability including load balancing and clustering, managed software installation, redundant Internet connections, redundant and conditioned power, redundant hosting platforms, 24x7x365 monitoring, 10GB – 20GB storage space to start, managed bandwidth usage, redundant T3 connections, daily data backups and weekly tape backups, and a secure facility with environmental control and a modern alarm/security system.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Matching, Ordering, Jumbled sentence, Calculated,Fill-in the blank,Short answer,Survey questions,Essay. Questions can contain other media elements (images, videos, audio)
Automated Testing Management	The students are allowed to review past attempts of a quiz. Instructors can specify whether correct results are shown as feedback. Instructors can create self-assessments.Instructors can set a time limit on a test.
	Instructors can create different levels of feedback messages. Instructors can import questions from existing test banks. Instructors can set dates and times for when students must access tests. Instructors can use passwords to restrict access to tests. Instructors can use the MathML and WebEQ equation editors to enable students to enter and edit mathematical notations. Instructors can create unit-specific tests or course-level tests.
Automated Testing Support	Instructors can create personal test banks. Instructors can create system wide test banks.
	Instructors can create question pools, an export and import those pools. The system provides analysis data for surveys and test item results can be exported for analysis.
Online Marking Tools	Instructors, and teaching assistants can mark paragraph questions, and mark and return assignments turned in through the assignment dropbox. Instructors can provide feedback on all assignments through annotations. Instructors can publish student submissions as examples for other students to see.
Online Gradebook	Instructors can add the grades for offline assignments to the online gradebook. Instructors can sort and view grades in the gradebook by assignment, by student, by category and for all students on all assignments. Instructors can import and export a comma-delimited version of the gradebook from/to an external spreadsheet program. Instructors can search the gradebook to find all students who meet a specific performance criteria, mark, or status such as exam completion.
Course Management	Instructors can selectively release assessments, announcements and other materials based on previous course activity, previous grade, or specific start and end dates. Instructors can specify start and stop dates for the entire course or for specific materials. Instructors can personalize access to specific course materials based on previous course activity, on student performance, on group membership.
Student Tracking	The Performance Dashboard contains at-a-glance statistics about student access, grades, and Discussion Board participation. The Early Warning System allows instructors to set rules for acceptable performance, and track students based on those rules. Students who appear to be at risk can be notified within the system, and notifications are tracke. Instructors can get reports showing the number of times and date on which each student accessed course content, discussion forums and assignments.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act, WAI WCAG 1.0 Level A guidelines and WAI WCAG 1.0 AA guidelines.
Content Sharing/Reuse	
Course Templates	Instructors can use templates to create course content. The templates include a rich text content editor. Instructors can categorize course content as announcements, calendar entries, course units, discussion forums, handouts, instructor biography, lecture notes, links, syllabus and course descriptions, tips, FAQs and resources. Instructors can create new content templates. A Course Creation Wizard enables instructors to easily set up a course using templates.
	The system allows administrators to use an existing course or a pre-defined template as a basis for a new course.
Customized Look and Feel	The system provides default course look and feel templates. Institutions can apply their own institutional images, headers and footers across all courses. Instructors can change the navigation icons and color schemes and the order, name, and function of menu items for a course.
Instructional Standards Compliance	The software has been issued a certificate of compliance with SCORM 1.2 level LMS-RTE3. The software has been self tested to support SCORM 2004 (aka SCORM 1.3) and is undergoing independent SCORM 2004 certification. The system supports the following standards: IMS Metadata vocabulary v1.2.1, IMS Content Packaging 1.1.2, , IMS Enterprise Specification 1.01. The system includes tools to facilitate the migration of course content between different versions of the software.
Hardware/Software	
Client Browser Required	For the Windows 2000 operating system, the following browsers are compatible: IE 6.0, Netscape 7.1 and 8.0, and Firefox 1.0. For Windows XP, the following browsers are compatible: IE 6.0 and 7.0, Netscape 7.1 and 8.0, and Firefox 1.0. For Mac OS 10.2, 10.3, and 10.4, compatible browsers include: IE 5.2, Netscape 7.1, Firefox 1.0, Safari 1.1, 1.2 and 1.3. A full browser matrix is available.
Database Requirements	The system supports Oracle and MS SQL Server..
UNIX Server	A Unix version is available.
Windows Server	A Windows version is available.

LMS/CMS Analysis	
Company Details/Licensing	
Company Profile	Founded in 1997, Blackboard is a public company (NasdaqNM:BBBB) that has over the years acquired CourseInfo, Web-Course-in-a-Box, Prometheus, and WebCT course management systems. The Company's product line consists of the Blackboard Academic Suite (including the Blackboard Learning System, Blackboard Community System , and Blackboard Content System) and the Blackboard Commerce Suite. Blackboard is headquartered in Washington, D.C.
Costs / Licensing	The annual license fee is based on FTE students in an institution (or school within an institution) or consortium. In some markets, the annual license fee is determined on a per-user basis.

Product Name	**Desire2Learn Learning Environment 8.4.2 (Desire2Learn, 2010; Edutools, 2009)**
Developer Name	**Desire2Learn Inc.**
Communication Tools	
Discussion Forum	Discussions can be viewed by date, by thread, by title or by author. Users may create separate discussion environments for small groups. Discussion threads are expandable and collapsible to view an entire conversation on one screen. Posts can include media, equations, attachments or URL addresses. Posts can be either plain text or html. Administrators can enable or disable anonymous postings. The entire discussion can be saved or printed for off-line reading. Discussions can be shared across courses, departments, or any organizational unit. Users can associate a discussion with any course content. Users can limit discussions to specific time periods and for specific groups.
Discussion Management	Instructors can allow students to create discussion groups. Instructors can view statistical summaries of discussions displaying participation which can be used to generate grades. Instructors can set up moderated discussions where all posts are screened. Discussions can be shared across courses, departments, or any institutional unit.
File Exchange	Students can submit assignments using drop boxes.
	Students can share the contents of their personal folders with other students.
	Administrators can define disk space limitations for each user.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	The Desire2Learn email system can be setup to support multiple modes: full email system, internal course-mail only, forwarded to an external account, IMAP, and other combinations. The email system also supports tracking/filtering correspondence by course, folders, personal address-books, search, and more. Emails can be composed using HTML editor, spell checked, saved as drafts, and can add multiple attachments. Flexible email permissions allow for different email options for each role. For instance, for certain roles, administrator can restrict receiving messages from email address that are not internal. Also, storage quotas can be defined individually for each role in the system.
Online Journal/Notes	Students can attach notes to any page.
	Students can combine their notes with the course content to create a printable study guide.
Real-time Chat	The chat tool supports a limited number of simultaneous rooms, unlimited simultaneous group discussions
	Instructors may moderate chats and suspend students from the chat rooms.
	The chat tool supports a structured way for students to ask questions and instructors to provide answers.
	The system creates archive logs for all chat rooms.
Whiteboard	The whiteboard supports image and PowerPoint uploading.Supports mathematical symbols.The software supports graphing, polling, and instructor moderation.Supports also group web browsing, application desktop sharing and two-way voice chat.
Productivity Tools	
Bookmarks	Students can create bookmarks in a private folder. Students can bookmark any content material in a course.
	Users can create annotated bookmarks, one at a time, for specific courses. Students can bookmark content pages, creating a link that allows them to quickly return to any particular section in the course content. There is also a jump to last topic bookmark.
Calendar/Progress Review	Instructors and students can post events in the online course calendar and post to a course announcement page.
	Students have a personal home page that lists all courses in which the student is enrolled, new email and all course and system-wide events from their personal calendar.
	Students can view their grades on completed assignments, total points possible, course grade, and compare their grades against the class performance.
Searching Within Course	Students can search all course content Students can search all discussion threads.
Work Offline/Synchronize	Students can compile and download the content for an entire course into a format that can be printed or stored locally.
	Instructors can publish course content on a CD-ROM that can be dynamically linked from within the online course or viewed offline. Students can compile and download the content for an entire course into a format that can be printed or stored locally.
Orientation/Help	The system includes online guides and inline help. Users can access context sensitive help for each of the major tools. Help items are further customizable by the institution. Users can use keywords to search a guide and other help documentation made available by the organization. Institutions can also create FAQs and help files, as well as custom widgets to organize access to orientation information.
	The system includes online tutorials for students that help students learn how to use the system.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	The system can randomly create groups of a certain size or a set number of groups.
	Students can self-select groups. Each group can have its own discussion forum. Can have its own chat or whiteboard.
	Groups may be private or instructors can monitor groups.
Community Networking	Students can create online clubs, interest, and study groups at the system level.
	Students from different courses can interact in system-wide chat rooms or discussion forums.
Student Portfolios	Students can create a personal home page in each course and can use their personal home page to selectively display their course work. Students can export their personal home page.
Administration Tools	

LMS/CMS Analysis	
Authentication	Administrators can allow guest access to all courses.
	The system can authenticate against an external LDAP server and using the Kerberos protocol. Also supports Shibboleth. The system can authenticate against IMAP, POP3 or secure NNTP.
	The system supports the Central Authentication Service (CAS).
	The system can support multiple organizational units and virtual hosts within a server configuration.
	The system has a password reminder option and students can maintain their own passwords. Administrators can set password length restrictions and require password changes after the initial logon and after a specified period of time. Single Sign On option is also supported. User logins can be encrypted with the Secure Sockets Layer protocol.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools.
	Administrators can distribute the permissions and roles across multiple institutions or departments hosted in the server environment.
	Instructors or students may be assigned different roles in different courses.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Administrators can transfer student information bidirectionally between the system and an SIS using delimited text files, using IMS Enterprise Specification v1.1 XML files via web services.
	The software supports data interchange with student information systems through an event-driven API.
	The software supports integration with SCT Banner, SCT Luminis, Datatel, PeopleSoft 8 or customized integration with other SIS or portal systems. The software is compliant with the IMS Enterprise Specification for Student Data.
Hosted Services	The product provider offers a hosted system that includes 24x7x365 monitoring, redundant hosting platforms, intrusion detection, nightly backups, options for geographical disaster recovery, and service level agreements on a network of high-performance, fault-tolerant servers with fail-over capability with redundant Tier 1 network connections.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Matching, Ordering, Calculated, Fill-in the blank, Short answer, Survey questions, Essay
	Questions can contain other media elements (images, videos, audio). Custom question types can be defined.
Automated Testing Management	The system can randomize the questions and answers.
	Instructors can create self-assessments. Can set a time limit on a test. Can permit multiple attempts.
	The students are allowed to review past attempts of a quiz.
	The system supports a MathML editor for the inclusion of mathematical formulas in both questions and answers.
	Instructors can specify whether correct results are shown as feedback
Automated Testing Support	Instructors can create personal test banks. Can create system wide test banks.
	Questions can be imported from external test banks that support QTI.
	There is a consolidated question library for quizzes, surveys and self assessments. Test questions can incorporate images, sound, video and other media types. Questions can be built with the tool or instructors can import and export questions from external test banks in the IMS QTI specification format or custom CSV format. Questions can be randomized to provide different questions for different users/attempts. Random values can be generated for variables to provide different questions to different students. Users can also use HTML editor and Spell Check feature to respond to questions. You can set a time limit on a test and give special access for individual students. Assessments can be restricted by IP address or a password.
Online Marking Tools	Instructors can choose to mark each student on all questions or to mark each question on all students.
	Instructors can choose to evaluate student responses anonymously and enable students to rate/comment on submissions of other students
Online Gradebook	When an instructor adds an assignment to the course, the software automatically adds it to the gradebook.
	Instructors can add grades for offline assignments. Can add details to the gradebook in custom columns.
	Instructors can export the scores in the gradebook to an external spreadsheet.
Course Management	Instructors can selectively release assignments, assessments, and announcements based on specific start and stop dates.
	Instructors can release materials based on a single criteria (date, grade, etc.) or instructors can use Boolean expressions to identify multiple selective release criteria.
	Instructors can link discussions to specific dates or course events.
	Instructors can personalize access to specific course materials based on group membership, based on previous course activity and based on student performance.
	Supported versions of IMS CP packages can be imported and also exported from any course in the Learning Environment. Users (that have permission to do so) have the ability to choose individual items to copy/import/export. For instance, instructors can choose a single quiz and specific topic to export rather than exporting all quizzes and content.
Student Tracking	Instructors can get reports showing the number of times, time, date, frequency and IP address of each student who accessed course content, discussion forums, course assessments, and assignments.
	Instructors can review the navigation record of each student.
	Usage statistics can be aggregated across courses or across the institution.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act.
	The product provider self-reports that the software complies with the WAI WCAG 1.0 Level A guidelines.
Course Templates	The system provides course design wizards that provide step-by-step guides that take faculty and course designers through the completion of common course tasks, such as setting up the course homepage, syllabus, organizer pages, content modules, discussion. Course content may be uploaded through WebDAV.
	Course templates may contain selective release criteria and custom gradebook columns that persist with each new course instance.

LMS/CMS Analysis	
	Course templates containing either layout or content can be created at any level above the specific section level. Instructors can create announcements, calendar entries, discussions, links, syllabus, course descriptions and other course content using templates that include a HTML editor (a.k.a. WYSIWYG content editor), or upload and choose content from the system-wide content library. Instructors can create new content templates. Instructors can incorporate course functions into specific course templates.
Customized Look and Feel	Institutions can create their own look and feel templates across the entire system, including their own institutional logos, headers, footers. Instructors can change the navigation icons and color schemes for a course and can change the order and name of menu items for a course.
	The system can support multiple institutions, departments, schools or other organizational units on a single installation where each unit can apply its own look and feel templates as well as institutional images, headers and footers.
Instructional Standards Compliance	AICC. IMS Content Packaging 1.1.3. IMS Content Packaging 1.1.4. IMS QTI 1.2.1. IMS QTI 2.0. IMS Enterprise 1.1. IMS Metadata 1.2.2. IMS Metadata 1.3. SCORM 1.2. SCORM 1.3
Hardware/Software	
Client Browser Required	Firefox 3.5 (Windows and Mac OS X), Firefox 3.0 (Windows and Mac OS X), Firefox 2 (Windows and Mac OS X),Internet Explorer 8 (Windows). IE 7 (Windows), IE 6 (Windows), Chrome (Investigation),Safari 3.1 (Mac OS X)
Database Requirements	The system supports MS SQL Server. Requires only one database and can coexist with tables from other applications.
Windows Server	A Windows version is available.
Company Details/Licensing	
Company Profile	Located in the US, Canada (3 offices with headquarters in Kitchener-Waterloo), Australia, and the UK. Desire2Learn was founded in 1999. It employs over 185 people and is privately held.
Costs / Licensing	There is an initial startup fee. The license fees are typically based on either an FTE or per user/enrollment depending on the client requirements.

Product Name	IntraLearn SME (Edutools, 2009; Intralearn, 2010)
Developer Name	**IntraLearn**
Communication Tools	
Discussion Forums	Discussions can be viewed by date and by thread. The threaded discussion software includes a formatting text editor. Posts can include attachments and URLs.
File Exchange	Students can upload files to a shared course or group folder.
Internal Email	Students can use the Internal email feature to email individuals and groups.
Online Journal/Notes	Students can make notes for all their courses in one private journal.
Real-time Chat	There is a basic CGI-based chat tool.
Productivity Tools	
Bookmarks	Students can create and share bookmarks in a course folder.
Searching Within Course	Students can search all discussion threads, documents, images, and page content in their course.
Calendar/Progress Review	Students can view their grades.
Work Offline/Synchronize	Upon re-entering a course, students have the option of resuming at the last page viewed.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups. Each group can have its own discussion forum, chat room, and group homepage.
Self-assessment	Instructors can create self-assessments. The system automatically scores multiple choice, true/false, and multiple answer type questions and can display instructor-created feedback and links to relevant course material.
Student Portfolios	Students can create a personal homepage.
Administration Tools	
Authentication	Administrators can protect access to individual courses with a username and password. The system has a password reminder option.
Course Authorization	Administrators can assign different levels of access to the system based on the following pre-defined roles: instructors, registrars, managers, proctors, and administrators. Instructors can assign different levels of access to their course.
Registration Integration	Instructors can batch add students to a course using a delimited text file. Administrators can transfer student information bi-directionally between the system and an SIS either in batch or in real time.
Hosted Services	The product provider offers a hosted system from Vobix, a company partner, for a monthly subscription fee. Hosting is also available from Embanet, which provides daily and offsite tape backups, system clustering, managed bandwidth usage, and multiple Internet service providers to provide redundant fail-over capabilities.
Course Delivery Tools	
Course Management	Instructors can personalize access to specific course materials based on student performance.
Student Tracking	Instructors can get reports showing the number of times each student accessed specific course units. Instructors can get a report showing the duration of time each student spent on specific course units.
Automated Testing and Scoring	Instructors can create true/false, multiple choice, multiple answer, fill-in-the-blank, image map (click on the correct part of the image), matching, and short answer/essay questions. Questions can contain images. The system can randomize the questions in a test and the alternatives for multiple choice questions. Instructors can set a time limit on a test. The system supports proctored exams and the proctor can turn off browser controls during the exam.
Curriculum Design	
Accessibility Compliance	To comply with Section 508 of the US Rehabilitation Act, the software implements the following features: an authoring tool that enables course developers to create compliant web-based content.
Course Templates	Instructors can use templates to create course content and learning objectives.

LMS/CMS Analysis	
Curriculum Management	The system supports management of curriculum, competencies, and certification.
Customized Look and Feel	Instructors can change the color schemes and background for a course.
Instructional Standards Compliance	The product provider self-tested the software and reports that it is compliant with IMS metadata specification 1.2.2, and IMS Content Packaging 1.1.3. The software can import course content that is AICC, IMS, or LRN compliant.
Instructional Design Tools	Instructors can use the built-in Wisconsin Instructional Design System (WIDS), which is a performance-based instructional design software product, to develop their courses. Instructors can create sequences organized hierarchically by course, lesson, topic, and chunk.
Hardware/Software	
Client Browser Required	The software supports Internet Explorer 4+ and Netscape 4+.
Database Requirements	The system requires Microsoft SQL Server, as well as Macromedia Cold Fusion Professional and Crystal Reports Developer.
Server Software	The following server software tools are available: automatic backups, system clustering, archiving utilities to backup and purge either course content or student data. The server administration tools can be accessed over the Web. The software requires Microsoft Internet Information Server (IIS) 4.0+.
Windows Server	The software is available for Windows 2000 or Windows NT. Suggested hardware recommendations are 512 MB RAM, 700 Mhz.
Company Profile	IntraLearn Software Corporation was founded in 1994 with headquarters in Northboro, Massachusetts. IntraLearn has entered into an agreement with Microsoft that allows IntraLearn to sell solutions through authorized Microsoft VARs, Microsoft Certified Solutions Providers and System Integrators. IntraLearn Software is a: Microsoft Gold Certified Solution Provider Partner, a Microsoft Partner in Education and a Tier 1 Alpha Development Partner.
Software Version	The current software version number is 3.1.2.

Product Name	ANGEL Learning Management Suite v. 7.3 (ANGEL, 2010; Edutools, 2009)
Developer Name	**ANGEL Learning, Inc**
Communication Tools	
Discussion Forum	ANGEL 7.3 includes an entirely new, high performance discussion engine. New view and navigation filters allow users to quickly view and navigate between messages. Students can filter their message view and navigation by: All Posts, Unread Posts, Read Posts, My Posts, Replies to My Posts, Draft Posts, Flagged Posts, Posts with Attachments and set any view as their default view. Discussion directions are always visible and fully expanded the first time a user enters a Discussion Forum. Message controls allow users to expand or collapse and sort messages.
Discussion Management	Discussion At-a-Glance summaries provide users a quick graphical view of discussion performance and trends. Instructors can grade posts directly in the interface. Clicking on any post opens a grading interface that includes a quick comment option. Instructors can create rubrics that evaluate and create a score based on a student's participation (posts, replies, replies to posts, average peer rating) and the average instructor score. Instructors can review discussion grades and adjust as necessary before posting all to the gradebook.
	Instructors can view statistical summaries of discussions displaying participation which can be used to generate grades.
File Exchange	Students can submit assignments using drop boxes. Students can share the contents of their personal folders with other students. Administrators can define disk space limitations for each user.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	Students can use a searchable address book. Students can elect to forward their mail to an external address.
	Instructors can email the entire class at once at a single address or alias.
Online Journal/Notes	Students can share their notes with other students. They can make notes in a journal and choose to make the notes private or to share them with their instructor or with other students.Students can attach notes to any page.
	Students can combine their notes with the course content to create a printable study guide.
Real-time Chat	The chat tool supports a limited number of simultaneous rooms.
	The chat tool supports a structured way for students to ask questions and instructors to provide answers.
	The system creates archive logs for all chat rooms.
	Chat is one feature of the ANGEL LIVE synchronous toolset included in ANGEL. In addition to chat, ANGEL LIVE includes virtual office hours, desktop sharing, whiteboard and instant messaging to support real-time learning.
	Virtual office hours provide scheduling capabilities and a queue manager to control student access. Students queue in a visual waiting room until their appointment time, with options to sound a notification alert when the instructor is ready. The instructor can review the student queue and invite multiple attendees into the office for shared discussion.
	Instant messenger allows sending and receiving to one person or the entire class and includes ability to block senders.
Whiteboard	The software supports application desktop sharing.
	ANGEL's whiteboard supports image uploading and instructor moderation. Multiple users can interact on a whiteboard. The instructor controls access to the whiteboard. Objects on the whiteboard can be edited. Import content from any resources. Whileboard state is persistent and therefore not limited to one session.
	Desktop sharing activity indicator lights show which users are using slower connections to enable proper presentation pacing.
Productivity Tools	
Bookmarks	Students can share their bookmarks. Students can create bookmarks in a private folder.
	Sort bookmarks by category. Set permissions to optionally allow others to use them.
Calendar/Progress Review	Students have a personal home page that lists all courses in which the student is enrolled, new email and all course and system-wide events from their personal calendar.
	Students can view their grades on completed assignments, total points possible, course grade, and compare their grades against the class performance. Students can subscribe to RSS feeds to be notified of changes to materials.
	Calendars can include personal, course or group or institution-wide events. Customize calendar view as either list or grid to suit individual preferences. Instructors can also post announcements on the course homepage.

LMS/CMS Analysis	
	Instructors and students stay organized with What's New and Tasks presented at login. ANGEL's Activity at a Glance and Grades are also presented at login on the course homepage. A click on any graph takes the user to more detail. Students can compare their individual performance to class performance.
Searching Within Course	Students can search all course content.
	Students can search all discussion threads.
Work Offline/Synchronize	Students can compile and download the content for an entire course into a format that can be printed or stored locally.
	Instructors can publish course content on a CD-ROM that can be linked to dynamically from within the online course or viewed offline.
Orientation/Help	Students can access context sensitive help for any tool.
	The system includes online tutorials for students that help students learn how to use the system.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	Students can self-select groups.
	Each group can have its own discussion forum.
	Each group can have its own chat or whiteboard.
Community Networking	Students from different courses can interact in system-wide chat rooms or discussion forums.
Student Portfolios	Students can use their personal home page to selectively display their course work.
	Students can use their public personal home page in a course to display their work in that course when assigned by the instructor. Students can export their portfolio to an external email address.
Administration Tools	
Authentication	Administrators can allow guest access to all courses.
	The system can authenticate against an external LDAP server. The system can authenticate using the Kerberos protocol. The system supports Shibboleth.
	The system can authenticate against IMAP, POP3 or secure NNTP.
	The system can support multiple organizational units and virtual hosts within a server configuration.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools. Instructors or students may be assigned different roles in different courses.
	Administrators can distribute the permissions and roles across multiple institutions or departments hosted in the server environment.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Administrators can transfer student information bidirectionally between the system and an SIS using delimited text files.
	The software supports data interchange with student information systems through an event-driven API.
	The software supports integration with SCT Banner, SCT Luminis, Datatel, PeopleSoft 8 or customized integration with other SIS or portal systems.
Hosted Services	ANGEL Learning offers hosting services with 24x7x365 comprehensive web environment monitoring that ensures peak performance, fully redundant systems and daily backup with offsite storage. A historically stable 99.8% uptime standard is offered, with additional options available to meet individual institution needs. Provider personnel perform all maintenance and upgrades, but institution retains complete control of teaching and learning functionality and set up.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Matching, Ordering, Fill-in the blank, Short answer, Survey questions, Essay
	Questions can contain other media elements (images, videos, audio). Custom question types can be defined.
Automated Testing Management	The system can randomize the questions and answers.
	Instructors can create self-assessments. Instructors can set a time limit on a test. Instructors can permit multiple attempts.
	The system supports a MathML editor for the inclusion of mathematical formulas in both questions and answers.
	Instructors can specify whether correct results are shown as feedback
	The system supports proctored tests.
Automated Testing Support	Instructors can create personal test banks. Instructors can create system wide test banks.
	Questions can be imported from external test banks that support QTI. The system provides test analysis data.
	True algorithmic questions provide instructors the ability to create formula-based questions that automatically generate replacement values for variables and calculate correct answers for each student who takes an assessment.
	Question Pool items are selected using powerful search tools so they can be configured with exactly the questions instructors want individual pools to contain. Question Pools search results can be fine tuned with any of all of these parameters: question type, question bank location, difficulty level, keywords, associated standards, associated objectives. Selection boxes allow removal of specific results from the results set.
	Instructors can choose to mark each student on all questions or to mark each question on all students.
	Instructors can choose to evaluate student responses anonymously.
Online Marking Tools	Instructors can enable students to rate and comment on submissions of other students.
Online Gradebook	When an instructor adds an assignment to the course, the software automatically adds it to the gradebook.
	Instructors can add grades for offline assignments. Instructors can add details to the gradebook in custom columns.
	Instructors can create a course grading scale that can employ either percents, letter grades, or pass/fail metrics.
Course Management	Instructors can release materials based on a single criteria (date, grade, etc.) or instructors can use Boolean expressions to identify multiple selective release criteria.
	Instructors can link discussions to specific dates or course events.
	Instructors can personalize access to specific course materials based on group membership, on previous course activity, on student performance
	Date Manager helps instructors prepare to teach their courses in a new semester. The manager displays every lesson item in a course and all dates associated with that item in a single tabular view. A calendar pop-up shows an active lesson item and two months of dates with dates the class meets highlighted. Instructors select a date and select the appropriate scheduling buttons: visible or hidden, assigned or due; enabled or disabled.

LMS/CMS Analysis	
Student Tracking	Instructors can track the frequency and duration of student access to individual course components.
	Unified reporting engine distills and delivers extensive course information in one central console. Configure, customize, display and share course reports via a single, easy-to-learn console. Monitor performance and patterns of activity in real-time. Easily pinpoint at-risk behavior. Intervene proactively. Securely share learner performance reports with parents, mentors and other stakeholders.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act.
	Supports ACCLIP. Students or faculty who have defined accessibility needs in other systems can import them directly into their ANGEL profile.
Course Templates	Create and publish content templates complete with directions and the ability to personalize course content. Ability to design content wizards – embedding consistent pedagogy into the wizard steps.
	Course templates may contain selective release criteria and custom gradebook columns that persist with each new course instance.
Customized Look and Feel	The system provides default course look and feel templates.
	Institutions can create their own look and feel templates across the entire system, including their own institutional logos, headers, and footers.
	The system can support multiple institutions, departments, schools or other organizational units on a single installation where each unit can apply its own look and feel templates as well as institutional images, headers and footers.
Instructional Standards Compliance	IMS Content Packaging 1.1.4, IMS Enterprise 1.1, IMS Metadata 1.3
Hardware/Software	
Client Browser Required	With PCs running Windows OS: Internet Explorer and Firefox. With Macs running OS X: Firefox
Database Requirements	The system supports MS SQL Server.
Windows Server	A Windows version is available.
Company Details/Licensing	
Company Profile	Founded in 2000, ANGEL Learning emerged from research and teaching experience at Indiana University-Purdue University Indianapolis. Today ANGEL Learning has grown from a campus-based organization of university researchers and teachers to a profitable firm with global reach.
Costs / Licensing	The standard ANGEL license is based on the number of user accounts required by an institution. A user account is a unique username that is marked as active in the database. A single user may be enrolled in more than one course or group and still counts as one user. The annual license fee includes the right to use, the upgrades during the term, and support for the ANGEL administrator(s). It permits use of the system in production and on staging or development servers.

New capabilities
ANGEL Learning Management Suite 7.4 (ANGEL, 2010)
Mashups that make it easy to **incorporate rich media content** into courses from sources such as the YouTube™ web site and Picasa™ software The ability to **incorporate RSS feeds** into courses **New lesson plans** that promote consistent design across the enterprise **Grading rubrics** that ensure all manually graded submissions are evaluated against the same criteria. A **new gradebook interface** that supports any grading period and provides improved workflow and reporting. **Enhanced surveys** that improve their effectiveness as pre- and post-course assessment tools More **flexible system administration**. More **powerful content management** capabilities.

Table 65. Open-source LMS & LCMS

LMS/CMS Analysis	
Product Name	**Moodle 1.9 (Edutools, 2009; MOODLE, 2010)**
Developer Name	**Moodle**
Communication Tools	
Discussion Forum	Students can enable or disable posts to be sent to their email.
	Students can receive posts by email as daily digests of subject lines or whole posts.
	Students can subscribe to forum RSS feeds.
	A spell-checker is available for student and instructor responses.
	There are many other features and configurations of forums than are listed here.
Discussion Management	Instructors can allow students to create discussion groups.
	Instructors can set up moderated discussions where all posts are screened.
	Posts may be peer reviewed by other students.
	Instructors can view statistical summaries of discussions displaying participation which can be used to generate grades.
	Discussions can be shared across courses, departments, or any institutional unit.

LMS/CMS Analysis	
File Exchange	Students can submit assignments using drop boxes.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	Students can use a searchable address book.
	Students can elect to forward their mail to an external address.
Real-time Chat	The chat tool supports a limited number of simultaneous rooms.
	The chat tool supports unlimited simultaneous group discussions
	Instructors may moderate chats and suspend students from the chat rooms.
	The system creates archive logs for all chat rooms.
Whiteboard	It can supported by adding available 3rd party modules for Dim Dim, Elluminate or other products.
Productivity Tools	
Bookmarks	
Calendar/Progress Review	Instructors and students can post events in the online course calendar.
	Instructors can post announcements to a course announcement page.
	Students can view their grades on completed assignments, total points possible, course grade, and compare their grades against the class performance.
	Students can subscribe to RSS feeds to be notified of changes to materials.
Searching Within Course	Students can search all discussion threads.
	Students can search chat or virtual classroom session recordings.
Orientation/Help	Students can access context sensitive help for any tool.
	The system includes online tutorials for students that help students learn how to use the system.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	The system can randomly create groups of a certain size or a set number of groups.
	Students can self-select groups.
	Each group can have its own discussion forum.
	Each group can have its own chat or whiteboard.
	Each group can be given group-specific assignments or activities.
	Groups may be private or instructors can monitor groups.
Community Networking	Students can create online clubs, interest, and study groups at the system level.
	Students from different courses can interact in system-wide chat rooms or discussion forums.
Student Portfolios	
Administration Tools	
Authentication	Administrators can allow guest access to all courses.
	The system can authenticate against an external LDAP server.The system can authenticate using the Kerberos protocol. The system supports Shibboleth.
	The system supports the Central Authentication Service (CAS).Can authenticate against IMAP, POP3 or secure NNTP.
	The system can support multiple organizational units and virtual hosts within a server configuration.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools.
	Administrators can distribute the permissions and roles across multiple institutions or departments hosted in the server environment.
	Instructors or students may be assigned different roles in different courses.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Administrators can transfer student information bidirectionally between the system and an SIS using delimited text files.
	Administrators can transfer student information bidirectionally between the system and an SIS using IMS Enterprise Specification v1.1 XML files via web services.
	The software supports data interchange with student information systems through an event-driven API.
	The software is compliant with the IMS Enterprise Specification for Student Data.
Hosted Services	Hosting and support services from Commercial Affiliates.
	Moodle itself is FREE to use, but optional hosting services are provided by Moodle Partners.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Matching, Ordering, Jumbled sentence, Calculated, Fill-in the blank, Short answer,Survey questions,Essay
	Questions can contain other media elements (images, videos, audio)
	Custom question types can be defined.
Automated Testing Management	The system can randomize the questions and answers.
	Instructors can create self-assessments.
	Instructors can set a time limit on a test.
	Instructors can permit multiple attempts.
	The students are allowed to review past attempts of a quiz.
	The system supports a MathML editor for the inclusion of mathematical formulas in both questions and answers.
	Instructors can specify whether correct results are shown as feedback
	The system supports proctored tests.
Automated Testing Support	Instructors can create personal test banks.
	Instructors can create system wide test banks.
	Questions can be imported from external test banks that support QTI.
	The system provides test analysis data.

LMS/CMS Analysis	
Online Marking Tools	Instructors can choose to mark each student on all questions or to mark each question on all students.
	Instructors can choose to evaluate student responses anonymously.
	Instructors can enable students to rate and comment on submissions of other students.
Online Gradebook	When an instructor adds an assignment to the course, the software automatically adds it to the gradebook.
	Instructors can add grades for offline assignments.
	Instructors can add details to the gradebook in custom columns.
	Instructors can export the scores in the gradebook to an external spreadsheet.
	Instructors can create a course grading scale that can employ either percents, letter grades, or pass/fail metrics.
Course Management	Instructors can selectively release assignments, assessments, and announcements based on specific start and stop dates.
	Instructors can personalize access to specific course materials based on group membership.
Student Tracking	Instructors can track the frequency and duration of student access to individual course components.
	Instructors can get reports showing the time and date and frequency students as an aggregated group accessed course content.
	Instructors can get reports showing the number of times, time, date, frequency and IP address of each student who accessed course content, discussion forums, course assessments, and assignments.
	Instructors can review the navigation record of each student.
	Usage statistics can be aggregated across courses or across the institution.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act.
	The product provider self-reports that the software complies with the WAI WCAG 1.0 Level A guidelines.
Course Templates	The software provides support for template-based course creation.
	Course content may be uploaded through WebDAV.
	The system allows administrators to use an existing course or a pre-defined template as a basis for a new course.
Customized Look and Feel	The system provides default course look and feel templates.
	Instructors can change the navigation icons and color schemes for a course.
	Instructors can change the order and name of menu items for a course.
	Institutions can create their own look and feel templates across the entire system, including their own institutional logos, headers, and footers.
	The system can support multiple institutions, departments, schools or other organizational units on a single installation where each unit can apply its own look and feel templates as well as institutional images, headers and footers.
Instructional Standards Compliance	AICC, IMS Content Packaging 1.1.3, IMS Content Packaging 1.1.4,IMS QTI 1.2.1, IMS Enterprise 1.1, SCORM 1.2, SCORM 1.3
Hardware/Software	
Database Requirements	The system supports Oracle. The system supports MS SQL Server. The system supports MySQL. The system supports PostGreSQL.
	The application requires only one database and can coexist with tables from other applications.
UNIX Server	A Unix version is available.
Windows Server	A Windows version is available.
Company Details/Licensing	
Company Profile	Moodle Pty Ltd is the company that organises funding and pays for core development, support plus quality assurance, allowing a broad community to help work on any aspect they want to.
Costs / Licensing	Moodle is free and distributed under the GPL license.
Open Source	The software is distributed under one of the OSI-approved licenses.

New capabilities
Moodle 2.0 (MOODLE, 2010)
Major new features
Repository support File management has undergone a major change in both the interface and function. The File picker presents a standard way to access the new File bank repository system. This allows Moodle to integrate with external repositories of content, making it really simple to bring documents and media into Moodle via an AJAX interface that looks like a standard **Open** dialogue in desktop applications. You can also import files from your desktop or by specifying a URL. There are more attributes that can be added to a file, such as license and author.
Portfolio support Modules can now export their data to external systems, particularly useful for portfolios where snapshots of forums, assignments and other things in Moodle are useful to record in a journal or a portfolio of evidence Different formats are supported (currently LEAP2A, HTML, Images and Text, but others like PDF can be added) Initial plugins in 2.0 include: Box.net, Flickr, Google Docs, **Mahara** and Picasa.
Course completion and prerequisites Teachers can now specify a Course completion condition standard for all students. Conditions include activity completion, but could also be by grade, date or a number of other criteria. Teachers can use the above standard as a prerequisite to other courses that allows ordered progression and scaffolding. Teachers and students can see reports that show the progress within a course, or through a series of courses.
Conditional activities Access to activities can be restricted based on certain criteria, such as dates, grade obtained, or the completion of another activity. These can be chained together to enable progressive disclosure of the course content, if that is desired.

New capabilities
Teachers can now specify conditions that define when any activity is seen as completed by a student. For example, when a certain number of posts have been made, or a grade has been reached, or a choice has been made.
Cohorts Also known as "Site-wide groups", these are site-wide collections of users that can be enrolled into courses in one action, either manually or synchronised automatically
Web services support Support for standards-based web services across the entire Moodle code base, allowing the admin to expose particular functions of Moodle for use by: Administrative systems such as HR or SIS applications Mobile clients Framework contains a very high-level of security with a detailed token system and complete control over the range of functions exposed All defined functions are automatically available via: XML-RPC AMF (Flash) REST SOAP (PHP)
New blocks Comments block - like a shoutbox, allows comments to be added to any page. Great for student feedback. My private files block - allows access to a user's private files, which can then be accessed by them anywhere with the File picker. There is quota management available. Community block - keeps track of external courses one is interested in Course completion status block - reports on the completion status of your courses
Plagiarism prevention Moodle supports integration with plagiarism prevention tools such as Turnitin
Major improvements to existing core features
Backup and restore Completely rewritten Backup/Restore framework, no longer bound by memory (can work with **any size course**). Completely new backup format. Improved interface. Backup can be made of whole courses, but also specific sections or activities.
Blocks Blocks are now consistently implemented on every page in Moodle No longer any limit to placing blocks in only the left and right column regions but also at the top, center or bottom of areas of pages) Any block can be forced to appear in all the page contexts below it (for example, in every course or throughout a course). Blocks can placed in the Dock area on the side of the screen (if the theme supports it)
Blogs Support for comments on each blog entry Removal of group-level and course-level blogs (these are converted into forums on upgrade) Support for external blog feeds (synchronised to Moodle blog)
Comments User comments (Glossaries, Databases, Blogs, etc) are now all consistently handled and displayed throughout Moodle, using AJAX if available
Enrolment plugins Major improvements in the handling of guests and guest accounts Support for multiple forms of enrolment at the same time More detailed control over enrolment in courses
Filters 2.0 In the past, you had to use the same filters everywhere in your Moodle site, and this could only be changed by admins. Now, you can have different filters in different courses, activities or categories. For example, you could turn on the LaTeX filter just for courses in the Maths and Physics categories. Or you could turn off glossary linking in the end of course exam.
HTML editor New editor based on TinyMCE Works on more browsers Resizable editing area Cleaner XHTML output Full integration with configured external repositories to import and embed media into text
Messaging All email sent by Moodle is now treated as a message A message overview panel allows users to control how messages are sent to them Initial message output plugins in Moodle 2.0 include: Email, Jabber and Popups
My Moodle page More customisable My Moodle page with new blocks for showing relevant information Admin can design (and optionally force) site-wide layouts for My Moodle My Moodle page given more prominence as the main "home page" for users
Navigation Standard "Navigation" block on every page showing contextual links, while allowing you to jump elsewhere quickly Standard "Settings" blocks on every page shows contextual settings as well as settings for anything else you have permissions for
Ratings User ratings (Glossaries, Databases, Forums, etc) are now all consistently handled and displayed throughout Moodle, using AJAX if available Aggregation of using ratings into activity grades is now standardised in all activities

LMS/CMS Analysis
Roles and permissions Simplified permission evaluation logic Improved and simplified AJAX interfaces for defining and assigning roles Improved and simplified interfaces for tweaking permissions in any given context New "Archetypes" concept replacing the "Legacy roles" concept. New archetype "manager" to define the role of most people with system-wide editing rights, separate from "admin" role. Permission of "Administrator" superusers can not be modified
RSS feeds All RSS feeds are now secured using a random per-user token in the URL Tokens can be updated by the user at any time (if they suspect a feed URL has been compromised) RSS feeds are now more accurate (eg they support forums with separate groups), and are generated efficiently whenever required
Themes Many new themes in the core distribution - see Theme credits for a list All HTML and JS ouput is now far more efficient (server-side caching) and consistent (tableless layout, new CSS, YUI Framework) Themes can change the HTML of the page if they wish Core support for custom menus in all themes (for example at the top of the page)
Translation system New web portal to make it easer for groups to collaborate on translating Moodle, and to keep their translations up-to-date. More efficient storage format for language strings should slightly improve performance.
User profile pages Site-wide user profile page can be customised by users with blocks, news, feeds and so on Course-specific user profile pages show course blocks and standard profile information, plus information for teachers of that course

Product Name	**Sakai 2.3 (Edutools, 2009; SAKAI, 2010)**
Developer Name	**Sakai**
Communication Tools	
Discussion Forum	Students can enable or disable posts to be sent to their email.
	Students can receive posts by email as daily digests of subject lines or whole posts.
	A spell-checker is available for student and instructor responses.
	There are three discussion forum tools that adopters of Sakai can choose to deploy:
	1. Discussion (U of Michigan);
	2. JForum Discussion & Private Messaging (Foothill College); or,
	3. Message Center (Indiana University)
Discussion Management	Instructors can set up moderated discussions where all posts are screened.
	JForum Discussion and Private Messaging:
	Development Led by Foothill College
	Forums and categories can be sorted. Unlimited forums and categories.
	Supports sticky and announcement topics.
	Users control email notification and profile options. Enable Bookmarks. Enable Attachments. Allow Download of existing attachments. Supports 12 foreign languages.
	Message Center
File Exchange	Students can submit assignments (inline or attachments) using the Assignments tool. Two versions of this tool are available - with grading or no grading capabilities, based on the needs of the adopting institution.
	Students can submit assignments in the JForum Discussion & Private Messages tool, including attachments and media. This allows for peer reviews of the submitted work.
	Students can submit materials in the Resources tool, if permissions for adding new resources is enabled by the instructor, allowing students to gather and share resources on a topic in a common location of the course site.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	Instructors can email the entire class at once at a single address or alias.
	There are a number of tools that support internal email:
	Private Messaging in JForum. Message Center. MailTool
Online Journal/Notes	Students can create a private "Notes" folder (and sub-folders) for their classes in the Resources tool of their MyWorkspace and attach documents or create and publish notes.
Real-time Chat	The chat tool supports a limited number of simultaneous rooms.
	The system creates archive logs for all chat rooms.
	Users Present is a feature of Sakai, that, if enabled, displays who is
Whiteboard	Several organizations have integrated Elluminate, Breeze, and other commercial products in their Sakai implementations.
Productivity Tools	
Bookmarks	Bookmark functionality is available in the JForum Discussion & Private Messaging tool.
	The WebContent tool can be used to add bookmarks as tool buttons to any course site.
	The Resource tool allows bookmarks to be placed as resources.
Calendar/Progress Review	Instructors and students can post events in the online course calendar.
	Instructors can post announcements to a course announcement page.
	Students can subscribe to RSS feeds to be notified of changes to materials.

LMS/CMS Analysis	
Searching Within Course	**Search Tool** - A powerful tool that allows a Google like search all content in a Sakai instance. Anything that is a Sakai entity can be indexed and searched. This includes all Content placed in ContentHostingService which includes content in Resources, Attachments, OSP, Wiki, and all messages in Chat, Email, Announcements, UM Discussion tool. The search tool reads all Office types, PDF's, and extracts the first 2M of text from types that appear to be text based.
	The Help Tool includes search functionality.
Work Offline/Synchronize	Instructors can download the content of lessons (Melete Lesson Builder) into a format that can be printed, stored, or edited locally using a web publishing tool.
	Instructors can download assignments with attachments in one simple click for off-line grading. A folder is created on the instructor's desktop with sub-folders for each student and their attachment submissions.
Orientation/Help	The system includes online tutorials for students that help students learn how to use the system.
	The Help Tool includes context sensitive help the core tools of the Sakai bundle. Help is accessible by all users (students, instructors, Teaching Assistants, etc.) of the system via a question mark at the right corner of each tool's container.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	Each group can be given group-specific assignments or activities.
	Groups are also supported in the JForum Discussion tool, though its functionality is managed from Jforum rather than Sakai groups.
Community Networking	Students can create online clubs, interest, and study groups at the system level.
	Sakai Wiki Tool: Enables users of Sakai to create, share, and manage content in a Wiki Environment. It uses simular markup and shared concepts with other open source Wikis (eg Wikipedia, TWiki, phpWiki etc). Sakai Wiki is now part of the Sakai 2.3 bundle.
	News/RSS - for viewing content from online sources (RSS feeds)
Student Portfolios	OSP (Open Source Portfolio), a provisional tool in Sakai 2.2, offers rich portfolio functionality.
Administration Tools	
Authentication	Administrators can allow guest access to all courses.
	The system can authenticate against an external LDAP server. Can support the Central Authentication Service (CAS).
	The system can authenticate using the Kerberos protocol. The system supports Shibboleth.
	-- Although these have never been done, the system can authenticate against IMAP, POP3 or secure NNTP.
	-- The system can support multiple organizational units and virtual hosts within a server configuration. Typically, institutions run Sakai on multiple boxes; however, multiple Sakai instances can be run on a single box.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools.
	Instructors or students may be assigned different roles in different courses.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Roster Tool: Provides a list of all users in the site, a link to an individual user's profile, a picture the user has made available to all users and an official photo ID for use by the administrative users of the site. The Roster tool now uses a new API to manage privacy.
	Profile Tool: The profile tool is a place (listed under MyWorkspace) where a user can enter or choose to display public and personal information, including a university ID picture if available. The profile tool can have university provided or individually provided information about any user in the system. It can be edited, restricted/opened and include personal images or institutionally provided images.
Hosted Services	Hosting and support services for Sakai are provided from Sakai Commercial Affiliates and other organizations.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Matching, Calculated, Fill-in the blank, Short answer, Survey questions, Essay
	Questions can contain other media elements (images, videos, audio)
Automated Testing Management	The system can randomize the questions and answers. The system supports proctored tests.
	Instructors can create self-assessments. Instructors can set a time limit on a test.
Automated Testing Support	Instructors can create personal test banks.Can import an assessment as a test or as a question pool.
	Questions can be imported from external test banks that support QTI.
	The system provides test analysis data.
Online Marking Tools	Instructors can choose to mark each student on all questions or to mark each question on all students.
	Instructors can choose to evaluate student responses anonymously.
Online Gradebook	When an instructor adds an assignment to the course, the software automatically adds it to the gradebook. Instructors can add grades for offline assignments.
	Instructors can export the scores in the gradebook to an external spreadsheet.
Course Management	Instructors can selectively release assignments, assessments, and announcements based on specific start and stop dates.
	Instructors can personalize access to specific course materials based on group membership.
	Instructors can release learning sequences or materials based on start dates (Melete Lesson Builder AND Resources tool).

LMS/CMS Analysis	
Student Tracking	A **Site Statistics** tool is being developed **for Sakai by Universidade Fernando Pessoa (UFP), Portugal.** It is currently in pilot at several universities. The Site Statistics tool collects and displays statistical data about the class as a whole or on each student - where they've gone and what they've accessed.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act and WAI WCAG 1.0 Level A guidelines.
Content Sharing/Reuse	Materials can be imported or copied from one course site to another. Each user has n area called "My WorkSpace" which can contain materials that are global across the entire system. The materials from My Workspace can be imported into any course site. This allows each instructor and student to maintain their own local space which is only readible to themselves which can be copied into various project and course sites as needed.
Course Templates	The software provides support for template-based course creation.
	The system allows administrators to use an existing course or a pre-defined template as a basis for a new course. Course content may be uploaded through WebDAV.
Customized Look and Feel	Institutions can create their own look and feel templates across the entire system, including their own institutional logos, headers, and footers.
	-- **Users** (instructors and students) can change the order courses are listed, including hiding old term sites from their active list.
	-- **Instructors** can change the skin and color schemes for a course, provided that more skins have been installed in the system. Many custom course skins have been developed by the Sakai community and are available as a free download.
Instructional Standards Compliance	Sakai supports SCORM 1.2 using a SCORM loader and SCORM player from the contributed library. (UC Davis)
	The Tests & Quizzes tool supports IMS QTI.
Hardware/Software	
Client Browser Required	The software supports Internet Explorer 5.5+, Netscape 7.1+, and Mozilla Firefox for Windows, and Netscape 7.1+ or Mozilla Firefox on the Apple OS. Some functions in Sakai will not work well or will not work at all in Safari or Internet Explorer for the Mac. Javascript must be enabled.
Database Requirements	The system supports Oracle. The system supports MySQL.
	The application requires only one database and can coexist with tables from other applications.
UNIX Server	A Unix version is available.
Windows Server	A Windows version is available.
Company Details/Licensing	
Company Profile	The Sakai Foundation is a non-profit organization that is dedicated to coordinating activities around Sakai and the Sakai community to insure Sakai's long-term viability.
	The Sakai Foundation is supported by voluntary partner contributions. The Sakai Partners elect the Sakai Foundation Board of Directors, which provide the strategic leadership for the Sakai Foundation.
Costs / Licensing	The Sakai Project Software is FREE. It is licensed under the Educational Community License.
	Educational Community License
Open Source	The software is distributed under one of the OSI-approved licenses.

New capabilities	
Product Name	**Sakai 2.6 (SAKAI, 2010)**
Tool/Service	**Notes**
Assignments	Support for multiple submissions of an assignment on an assignment-wide basis.
	Support of custom fields, with timing and role control over who/when can see them-
	Improved integration with Schedule and Announcement; when an assignment opens, expose link to the assignment from schedule and announcement items.
Blog	Improved performance of db layer.
Calendar Summary	Added indicator with number of events to each calendar day.
	Event description is now formatted as HTML.
	Improved performance, so tool loads faster.
Citations Helper	New configuration option for maximum number of databases to search simultaneously.
	Support for populating direct vendor URLs from Search Library Resources and RIS import.
	User interface improvements.
Config	New module that includes configuration files (e.g., sakai.properties) and localization files.
Email Archive	Performance improvements for handling a large number of messages in the archive.
Forums	Improved reporting.
Gateway	Improved performance when there is a significant number of sites.
Gradebook	Ability to add multiple items at the same time.
Messages	Ability to reply all.
	Option to turn off 'send to email' option in message composition for a site.
OSP	UX improvements.
	Ability to edit and delete feedback and evaluations.
	Aggregation of Evaluations across sites via My Workspace.
	Better group awareness and filtering in Wizards tool.
	Ability to apply an OSP Style to more screens of a Matrix.

New capabilities	
	Ability to control allowed general and item-specific feedback (0, 1, many) in Matrices and Wizards.
Polls	Add entity support to Polls tool.
Portal	Enhance support for displaying site hierarchies.
Preferences	Customize Tabs is now the default initial page; pages can be re-ordered.
	Improved functionality for re-ordering tabs.
	User configurable number of tabs.
Resources	Notification of items with release dates should be at release time.
Schedule	iCal External Subscription support in Schedule Tool.
Tests & Quizzes	Allow the ability to edit published assessments and re-grade submissions.
	UCT contributed improvements:1) Group scoped tests 2) Improvements to statistics reporting 3)Include part scores in spreadsheet export.
	Missing confirm screen after Submit for Grading. (Based on contributed code from Rutgers).
	Auto-submit at due date in Tests & Quizzes/Samigo.
	Enhancements to Audio Recording Applet.
	Show the anonymous users their test results immediately after they submit the assessment. Contributed by ASU.
	Ability to share question pools with site members. Contributed by UPV.
	Negative point value for incorrect answer selection. Contributed by UPV.
	Samigo published assessments should be registered as Entities in the Entity Broker and available through the direct servlet. Contributed by ASU.
	Improvements to UX and Performance.
User Membership	Include the created and last modified date on the screen and in the CSV export.
	Filtering the searching and viewing of users to only those users with the same named usertype(s).
Worksite Setup/Site Info	Add option to import and replace content from another site.
	Create sites from templates.
	Support for optional survey questions during site setup.
	More configurable control over adding tools (e.g., Chat) multiple times to a site.
	Deep delete of site data before importing content from other sites.
	Enhanced group creation; ability to add a role or a provider id to a group.
WYSIWYG Widget (FCKeditor)	FCKeditor upgrade which brings in bug fixes and better Safari support.
	FCKeditor plug-in to allow users to embed entities.

Product Name	**ATutor 1.6.3 (ATUTOR, 2010; Edutools, 2009)**
Developer Name	**Adaptive Technology Resource Centre University of Toronto**
Communication Tools	
Discussion Forum	Students can enable or disable posts to be sent to their email.
	Discussions can be viewed by thread. Posts can include URLs, and can be either plain text or formatted text. Discussion threads are expandable and collapsible to view a list of topics or view an entire conversation on one screen. Threads can be sorted by author, topic, post date, and activity level. Students can enable or disable notification of new posts sent to their email.
Discussion Management	Discussions can be shared across courses, departments, or any institutional unit.
File Exchange	Students can submit assignments using drop boxes. Students can share the contents of their personal folders with other students. Student and instructors can upload files in most document formats to a shared course library, or to a shared group library. Students can share content from their personal folder with other students, and with an instructor or teaching assistants. Students can submit assignments into a drop box.
	Administrators can define disk space limitations for each user.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	Instructors can email the entire class at once at a single address or alias.
	Students can elect to forward their mail to an external address.
	Students can use the internal email feature or instant messaging tool to communicate with other enrolled students
Online Journal/Notes	Students can keep private or shared notes, associate notes with private or shared files, and print out compiled notes from within their personal work area. Students can make notes in a journal and can select to make them private or to share them with their instructor or with other students.
Real-time Chat	The chat tool supports unlimited simultaneous group discussions. The system creates archive logs for all chat rooms.
	There is a PHP-based chat tool for course or group level messaging. Students can see who else is online within their course, or group. Instructors may monitor chats. The system creates archive logs for all chat rooms. Instructors can schedule chats using the groups calendar. The chat tool supports multiple simultaneous group discussions.
Whiteboard	Available as a third party addon. Open Meeting.
Productivity Tools	
Bookmarks	
Calendar/Progress Review	Available as a third party addon. Google Calendar
Searching Within Course	Students can search all course content. Students can search all discussion threads.
	Students can use keywords to search a single course, all of their courses, or all available courses.
Work Offline/Synchronize	Students can compile and download the content for an entire course into a format that can be printed or stored locally. Students can download course content and discussion group content with a PDA.

LMS/CMS Analysis	
	Students can compile selected course content, or an entire course, into a downloadable content package for viewing offline in an accompanying content viewer. Upon re-entering a course, students have the option of resuming at the last page viewed. Instructors can record synchronous sessions so that students can review them asynchronously at a later time.
Orientation/Help	Students can access context sensitive help for any tool.
	Most documentation is available in the ATutor Handbooks, included with each distribution. Various multimedia documentation can be found on the developers documentation site or wiki.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	The system can randomly create groups of a certain size or a set number of groups.
	Each group can have its own discussion forum.
	Each group can be given group-specific assignments or activities.
	Groups may be private or instructors can monitor groups.
Community Networking	Students from different courses can interact in system-wide chat rooms or discussion forums.
	Students can gather contacts, create and manage their own groups, create a profile, and customize their network with Google Open Social conformant gadgets.
Student Portfolios	Available as a third part addon. Mahara
Administration Tools	
Authentication	Administrators can allow guest access to all courses. The system can authenticate against an external LDAP server.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools.
	Administrators can distribute the permissions and roles across multiple institutions or departments hosted in the server environment.
	Instructors or students may be assigned different roles in different courses.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Students can self-register. Administrators or instructors can batch add students to a course using a delimited text file, and send a system generated email message to students inviting them to join courses. Student registration can be authenticated against a master list generated from a student information system or other directory system.
Hosted Services	Hosting and support services from Commercial Affiliates.The product provider offers: a free hosted systems for a small number of courses: hosting contracts vary from a set fee per course, to school, or board level and offer: a secure facility with environmental control, a direct T3 connection, with load balancing across all systems, 24x7x365 monitoring, and nightly backups.
Course Delivery Tools	
Test Types	Multiple choice,Multiple answer, Matching, Ordering, Fill-in the blank, Short answer, Survey questions, Essay
	Questions can contain other media elements (images, videos, audio)
Automated Testing Management	The system can randomize the questions and answers.
	Instructors can create self-assessments. Instructors can set a time limit on a test. Instructors can permit multiple attempts.
	Instructors can specify whether correct results are shown as feedback
	Instructors can create automatically scored true/false and multiple choice questions, and randomize questions from a larger pool, with optional required questions that appear on all randomized tests. Instructors can set dates and times during which students can access tests. Instructors can provide individual feedback, override automated scoring, and create individual, unit specific, or course level tests. Instructors can also create survey questions. The system provides test analysis data for individual test items, for individual tests, and for surveys. Instructors can differentially weight tests. LaTeX formatting can be used to create math equations.
Automated Testing Support	Instructors can create personal test banks.
	Questions can be imported from external test banks that support QTI.
	The system provides test analysis data.
Online Marking Tools	Instructors can assign partial credit for certain answers. Instructors can view grades, by student, and for all students on all tests. Instructors can delegate the responsibility for grading assignments and tests. Instructors can manually edit all grades. Instructors can create a comma-delimited version of test scores for export to an external spreadsheet program. Instructors can provide feedback on all assignments through links to the relevant course content, and through annotations.
Online Gradebook	Instructors can add grades for offline assignments.
	Instructors can export the scores in the gradebook to an external spreadsheet.
	Instructors can create a course grading scale that can employ either percents, letter grades, or pass/fail metrics.
Course Management	Instructors can selectively release assignments, assessments, and announcements based on specific start and stop dates.
	Instructors can personalize access to specific course materials based on group membership.
Student Tracking	Instructors can review the navigation record of each student.
	Usage statistics can be aggregated across courses or across the institution.
	Instructors can track the frequency and duration of student access to individual course content.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with Section 508 of the US Rehabilitation Act.
	The product provider self-reports that the software complies with the WAI WCAG 1.0 Level A, AA guidelines.
	Conforms with these Accessibility Standards: WCAG 1.0 AA, WCAG 2.0 AA, Section 508 (U.S), Stanca Act (Italy), BITV (Germany), ATAG 2.0 AA, IMS AccessForAll, ISO FDIS 24751, XHTML 1.0
Course Templates	The software provides support for template-based course creation.

LMS/CMS Analysis	
	The software provides support for template-based content creation. Course content may be uploaded to a file manager, imported from, or exported to, a learning object repository, imported directly from the Web using a URL, or imported from an HTML editor. Instructors can clone and modify the default the templates, or create new templates. Instructors can add to, or remove course functions from course templates.
Customized Look and Feel	The system provides default course look and feel templates.
	The system provides 5 default course look and feel templates, as well as others that can be downloaded and installed. Institutions can create their own look and feel templates. Institutions can apply their own institutional images, headers and footers, across all courses, or across categories of courses. Instructors can change the navigation tabs, tools icons available, and the number and order of menu items for a course.
Instructional Standards Compliance	SCORM 1.2
Hardware/Software	
Client Browser Required	Any browser.
Database Requirements	The system supports MySQL.
UNIX Server	A Unix version is available.
Windows Server	A Windows version is available.
Company Details/Licensing	
Company Profile	The software was originally developed at the Adaptive Technology Resource Centre at the University of Toronto. ATRC is a not-for-profit organization that promotes accessibility through its open source development activities. Support and development services available.
Costs / Licensing	The software is free for most uses.
Open Source	The software is distributed under one of the OSI-approved licenses.

Key New Features
Atutor 2.0 (ATUTOR, 2010)
A Fresh Look & Feel: The focus on classrooms. (Show Us Your Classroom) **AContent**: AContent is a standards conformant repository and authoring tool that integrates with other elearning systems. **Integrated Photo Gallery**: Users can create private albums, share photos across courses. **For Learners**: The Preference wizard lets learners quickly configure ATutor to their particular needs. **For Instructors**: A greatly simplified Content editor to help novice content authors get started quickly, but without loosing any of the advanced authoring capabilities. **For Developers**: Restructured source code, an OAuth API for creating single signons when integrating ATutor with other systems.

Product Name	**dotLRN/OpenACS (dotLRN, 2010; Edutools, 2009)**
Developer Name	**dotLRN**
Communication Tools	
Discussion Forum	Students can enable or disable posts to be sent to their email.
	Students can receive posts by email as daily digests of subject lines or whole posts.
	Students can subscribe to forum RSS feeds.
	A spell-checker is available for student and instructor responses.
Discussion Management	Instructors can set up moderated discussions where all posts are screened.
File Exchange	Students can submit assignments using drop boxes.
	Students can share the contents of their personal folders with other students.
	Administrators can define disk space limitations for each user.
Internal Email	Students can use the built-in email functionality to email individuals or groups.
	Instructors can email the entire class at once at a single address or alias.
	Students can elect to forward their mail to an external address.
Real-time Chat	The chat tool supports unlimited simultaneous group discussions
	The system creates archive logs for all chat rooms.
Productivity Tools	
Bookmarks	This feature is available in OpenACS and could be used in dotLRN with minimal effort
Calendar/Progress Review	Instructors and students can post events in the online course calendar.
	Instructors can post announcements to a course announcement page.
	Students can subscribe to RSS feeds to be notified of changes to materials.
Searching Within Course	Students can search all course content.
	Students can search all discussion threads.
Student Involvement Tools	
Groupwork	Instructors can assign students to groups.
	Students can self-select groups.
	Each group can have its own discussion forum.
	Each group can have its own chat or whiteboard.
	Groups may be private or instructors can monitor groups.

LMS/CMS Analysis	
Community Networking	Students can create online clubs, interest, and study groups at the system level.
	Students from different courses can interact in system-wide chat rooms or discussion forums.
Student Portfolios	The portfolio is site wide. A student creates a personal page that they can use for any materials, not a specific course. See dotfolio.org
Administration Tools	
Authentication	Administrators can allow guest access to all courses.
	The system can authenticate against an external LDAP server.
	The system can support multiple organizational units and virtual hosts within a server configuration.
Course Authorization	The system supports restricting access based on roles and roles can also be customizedby the service provider.
	Administrators can create an unlimited number of custom organizational units and roles with specific access privileges to course content and tools. Administrators can distribute the permissions and roles across multiple institutions or departments hosted in the server environment.
	Instructors or students may be assigned different roles in different courses.
Registration Integration	Instructors can add students to their courses manually or allow students to self-register.
	Administrators can batch add students to the system using a delimited text file.
	Administrators can transfer student information bidirectionally between the system and an SIS using delimited text files.
	Administrators can transfer student information bidirectionally between the system and an SIS using IMS Enterprise Specification v1.1 XML files via web services.
Hosted Services	Hosting and support services from Commercial Affiliates.
Course Delivery Tools	
Test Types	Multiple choice, Multiple answer, Short answer, Survey questions, Essay
	Questions can contain other media elements (images, videos, audio). Custom question types can be defined.
Automated Testing Management	The system can randomize the questions and answers. Instructors can specify whether correct results are shown as feedback.Instructors can create self-assessments.Instructors can set a time limit on a test.Can permit multiple attempts.
Automated Testing Support	Instructors can create system wide test banks.
	Questions can be imported from external test banks that support QTI.
Online Gradebook	Instructors can add grades for offline assignments.
	Instructors can export the scores in the gradebook to an external spreadsheet.
	Instructors can create a course grading scale that can employ either percents, letter grades, or pass/fail metrics.
Course Management	Instructors can personalize access to specific course materials based on group membership.
Student Tracking	Usage statistics can be aggregated across courses or across the institution.
Content Development Tools	
Accessibility Compliance	The product provider self-reports that the software complies with the WAI WCAG 1.0 Level A guidelines.
Course Templates	Course content may be uploaded through WebDAV.
	The system allows administrators to use an existing course or a pre-defined template as a basis for a new course.
Customized Look and Feel	The system provides default course look and feel templates. The system can support multiple institutions, departments, schools or other organizational units on a single installation where each unit can apply its own look and feel templates as well as institutional images, headers and footers.
Instructional Standards Compliance	SCORM 1.2
Hardware/Software	
Database Requirements	The system supports Oracle. The system supports PostGreSQL.
UNIX Server	A Unix version is available.
Windows Server	A Windows version is available.
Company Details/Licensing	
Costs / Licensing	GPL
Open Source	The software is distributed under one of the OSI-approved licenses.

The majority of the eLearning platforms have good administrative and communication tools, compliance with standards like SCORM (2009), AICC (2010) and some of the IMS specifications (IMS, 2011). These platforms have high implementation level and good documentation. On the other hand, it must be noticed that these platforms have also some problems regarding LO management, sharing and reusability and in LO quality evaluation, with exception of HEODAR (Muñoz, Conde, & Peñalvo, 2009) integration with Moodle, a quality evaluation tool developed in the GRIAL research group. They also have some problems related to the adaptation of resources to the student's characteristics among others. From the comparison of commercial and freeware/open-source platforms it is found that commercial ones have more difficulty in integrating with other systems and supporting different kinds of pedagogies and obviously in terms of costs.

So, the LMS and LCMS are the engine and the front-end for the teaching/learning process in elearning, and basing on the current solutions it is very important the choice of these solutions because of the features.

2.2. AUTHORING, PACKAGING AND ANNOTATION TOOLS

Contents and resources creation is a key element in eLearning environments.

In order to facilitate the creation of contents, several commercial and freeware authoring, packaging and annotation tools have been developed, like the Advanced Distributed Learning (ADL) Sharable Content Object Reference Model (SCORM) Metadata Generator (2010), the Reload Editor (2010), a metadata editor from the RELOAD Project managed by the University of Bolton, the resource description tool of EUN (2008), created by Lund University in Sweden, the Authorware tool (2010) from Adobe, that includes a learning object metadata editor, the Reggie metadata editor (Reggie, 2008), the LOM Editor (2008), the Alfanet LMS (2010) that has an authoring tool that is based on the standards of the IMS Global Learning Consortium, and also the standalone metatagging tool LomPad (2010) made by LICEF. These tools help users to create eLearning contents allowing them to include several types of objects, adding descriptive information about that content and packaging those contents in packages. But in order to evaluate the quality of these kinds of tools several factors are considered and they are shown in Table 66.

Table 66. Factors for authoring tools evaluation

Authoring Tools Evaluation	
Factors	
Providers	Identification
Typology	Kind of Application
HW/SW Requirements	Hardware and Software necessary requirements
Description	Short description on the tool
Strong Points	Reference to the positive aspects of the tool
Weaknesses	Reference to the negative aspects of the tool

Evaluation process analyses the typology of the tools, kind of application, (application, and extension), and the hardware/software requirements to run the tools. Also, it includes descriptions of the tools, describing their features, which standard support, including their main features. Finally, this evaluation must clearly identify strong points and weaknesses of each tool in order to choose the one that best fits the user's needs. An example of this analysis is presented on Chapter 2, Section 2.2.2.2.3 "LOM Tools".

3. ELEARNING TOOLS ANALYSIS CRITERIA

The analysis of eLearning systems has to be a methodical evaluation of several aspects.

Firstly, the main target of the eLearning systems are considered, if it is a more an enterprise or educational environment, if it is a training or educational environment, then the pre-knowledge of students and their IT skills must be considered and finally it should find out if there is enough budget to acquire the tools or if it must be chosen a freeware and open source solution.

It is important knowing what kind of resources the organization has in terms of hardware building structures like laboratories, multimedia software and tools and also Technical staff to give the support.

Only after analysing these aspects it is possible to enter into the technical evaluation of the elearning system.

3.1. SELECTION CRITERIA

In the process of selecting an eLearning platform, the criteria to follow must be decided. This criterion is basis of a choice of quality but it is also for limiting the solutions to the requirements.

These criteria have weights for distinguishing the different factors and for deciding the choice in the basis of what is important to implement.

3.1.1. EMPIRICAL SCENARIO

An empirical analysis has been made that is more a kind of a technical analysis of the platforms considering the features, tools and potentialities provided by these systems.

In this type of analysis technical aspects are considered, as it is presented in Table 67.

Table 67. Technical aspects to empirically evaluate elearning systems

Tools/Features	Relevance
Technical Aspects	Takes into account some technical aspects that sould be considered regarding the platforms flexibility.
Interoperability/integration	Interoperability of data and integration with other systems.
Standards and specs 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 Costum. And personalization	Possibility constumize 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, sytem users and profiles.
Database Access mechanisms	Mechanisms retrieve information from databases.
Produce reports	Produce statistical reports about the use of the platform.
Admin. workflows quality & functio.	Mechanisms and functionalities to accelerate Administrative workflows in order to get better and faster responses.
Tracking users	Tracks user actions to check if they're in the right way.
Resources Management	Takes care of issues regarding the management 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 Mng.	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 retrieve of LOs.
File upload/download mechanisms	Mechanisms to import and export resources.
Evaluation of quality of resources	Evaluates 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 down timing the time of development of resources.
Communication	Takes care of the communications tools provided by the platform
Forum	Availabity 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.

3.1.2. REAL SCENARIO

In a real scenario it must be taken into account the environment and the factors regarding the implementation of the eLearning system. So both acquisition of commercial and adoption of open source must be the choice criteria.

To make the evaluation of the platforms the criteria presented in Table 68 are proposed. In the case of choosing a freeware eLearning platform the criterion price should not be considered and the execution team will be Technical staff of the institution.

Table 68. Proposed criteria and weights

Criteria	Weight
Technical Evaluation	55%
Execution Team	20%
Price	20%
Execution Time	5%

In the technical evaluation of a real scenario it must be included the aspects described on the empirical analysis and also additional issues regarding the usability of the platforms, the integration with other software already developed or also being acquired, the licensing price, support and maintenance (that are issues where regarding the provided warranty extension and training), the availability of source code and accessibility.

The technical evaluation factor must be the one that has more weight (more than 50%) because it is the most important since it reflects the platform features and characteristics.

In the case of the execution team factor, it is evaluated the curriculum of the team members that are going to develop or install the platform and also their experience.

For the price factor, it is evaluated the cost of the solution, by doing a linear equation where the most expensive have less classification.

The execution time is evaluated the time the team takes to implement the solution and the task schedule.

Each of these criteria has a final classification that is then multiplied by their weight and summed to get the final classification of a proposal.

Obviously the variation of weight is also directly connected with the factor that is considered critical, for example if the price is important or the execution time.

When an eLearning system is going to be chosen, in the decision between a commercial or a freeware solution, the execution time is very relevant. In the case of a urgent implementation, if a freeware solution is chosen, it is more probable having to deal with problems of lack of documentation and configuration for installation, support for the maintenance of the platform, but there are also advantages in terms of extensibility, and a higher degree of personalization/customization of the platform regarding the user and also obsviouly in terms of the zero cost of the platform.

A commercial solution has the advantage of the initial implementation, installation and configuration of the platform that is more reliable. Usually, it guarantees have an efficient support, maintenance and training on the platform, but obsviouly all of these have costs. This kind of solution usually tends to be a closed solution being difficult to develop new components for platform extension.

So, the choice of the adoption of an eLearning solution depends of the amount of budget, the time for implementation, the execution team but mainly the choice is based on the functionalities and technical aspects that the platform must support.

3.2. STANDARDS AND SPECIFICATIONS COMPLIANCE

Other thing that should be considered is the standards compliance of the platform.

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

Among these standards and specifications there are some more focused on the design and structuring of courses and others that try to enclose, in a general way, all the process of teaching/learning. Among the standards and specifications that first emerged there is *Sharable Content Object Reference Model* (SCORM) (SCORM, 2009), a project from *Advanced Distributed Learning* (ADL), and the specification *Educational Modelling Language* (EML) (Koper, 2003). However these have some problems.

SCORM becomes more a standard integrator than a standard by itself, which makes it dependent of the other standards it integrates; besides it does not consider the evaluation and characterization of students. EML is a specification that becomes obsolete when the IMS (*Instructional Management Systems*) Learning Design (LD) (IMSLD, 2003) 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. Finally, there exist 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 (IEEELOM, 2002) 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 (Bray et al., 2004). The main objective of these specifications is to cover the learning domain as possible, so they can be applied to any process of teaching/learning.

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(s) automaticaly makes everything you make cross systems providing this way common knowledge. The use of a standard helps to achieve more stable systems, reduces the development and maintenance time, allows backward compatilibity and validation, increases search engine success, among many other advantages.

So it is why is important to analyse several aspects of standards and specifications in order to check those that best models the teaching/learning process. Thus, it is possible to choose a platform for the standard compliance criteria, like described on Chapter 3, Section 3.4 "Standards and Schema Proposal".

3.3. USABILITY

Usability is not a single dimensional property of a user interface; usability has multiple components and is associated with the following five usability attributes (Nielsen, 1992a):

- Learnability – The system should be easy to learn so the user can easily and rapidly work with it.
- Efficiency – The system should be efficient to use so that when user learns how to work of the system he can reach a high level of productivity.
- Memorability – The system should be easy to remember so that the casual user can come back to the system after some period not working with it without having to learn everything all over again.

- ❖ Errors – The system should have a low Error rate so that users make few errors during the use of the system and in the case of doing errors they can easily recover from them, further catastrophic errors must not occur.
- ❖ Satisfaction – The system should be pleasant to use so that users are subjectively satisfied when using it.

Only by defining usability using these measurable components is able to arrive to a more precise engineering process where usability is evaluated not just as an abstract concept but as a systematically and objective engineering discipline.

Usability is typically measured by having a number of test users (representative of some scenario) use the system to perform specific task (in a virtual scenario). It can also be measured by testing real users performing tasks while they use the system (production scenario) (Shackel, 1991).

3.3.1. USABILITY HEURISTICS

These are ten general principles for user interface design. They are called "heuristics" because they are more in the nature of rules of thumb than specific usability guidelines (Nielsen, 1992b).

- ❖ Visibility of system status.
    - o The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- ❖ Match between system and the real world.
    - o The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- ❖ User control and freedom.
    - o Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
- ❖ Consistency and standards.

    - Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- Error prevention.
    - Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- Recognition rather than recall.
    - Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- Flexibility and efficiency of use.
    - Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- Aesthetic and minimalist design.
    - Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- Help users recognize, diagnose, and recover from errors.
    - Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- Help and documentation.

Heuristic evaluation is a systematic inspection of the user interface design for usability (Mack & Nielsen, 1993; Nielsen & Molich, 1990). The goal of heuristic evaluation is to find usability problems in a user interface design so that they can be attended to as a part of an interactive design process. Heuristic evaluation evolves having a small set of evaluators examining the interface and judging its compliance with recognized usability principles, the "heuristics".

3.3.2. USABILITY TESTING

User testing with real users is the most fundamental usability method because it provides direct information about how people uses the computers and what are the exact problems when they use the interface being tested. But there are some pitfalls on these method when doing usability tests we have to consider aspects like reliability and validity.

Reliability deals if whether or not get the same result if the test would be repeated, and validity is the question of whether the results reflect the usability issues that are going to be tested (Nielsen, 1993).

Before making the testing process, it is compulsoy to clarify the purpose of the test because it has an impact on the type of testing to be applied.

3.3.2.1. Test Plan & Goals

It is advisable to make a test plan where the following issues must be addressed (Nielsen, 1993):

- The Test goals.
- Date and place of the test.
- Duration of the test.
- Computer support needed (hardware requirements).
- Software needed (software requirements).
- Initial state of the system.
- Define system/network load and response times.
- Type of experimenters.
- Define test users and how to get them.
- Number of test users.
- Test tasks.
- Successful finishing criteria for test tasks.
- Help documentation available.
- Experimenters help to users.
- Data being collected.
- Method to analyse data.

- ❖ Success criteria for the interface.

Other thing worth considering is the test budget that should be included in the test plan.

Typical cost elements of a user test budget are:

- ❖ Usability specialists to plan run and analyse the test (if outside people are hired).
- ❖ Administrative assistance to schedule tests and enter data (if outside people are hired).
- ❖ Software developers to modify the code to allow data collection or other customization (if outside people are hired).
- ❖ Test users time (if outside people are hired).
- ❖ Computers and laboratory use during tests (if outside resources are rented or acquired).
- ❖ Video tapes, CD, DVDs or other type of consumables.

3.3.2.2. Test users and Experimenters

The main rule when choosing test users is that they should reflect and be representative as possible of the intended users of the system, also one thing to be considered is that novice or expert user categories must be chosen (Nielsen & Schaefer, 1993).

Independently of the chosen experiment method, experimenters to run the test must be selected.

The experimenter has to know how to use the test methods and in addition must have extensive knowledge of the application and user interface. System knowledge is necessary for the experimenter to understand what the users are doing when they are performing tasks with the system and to reasonable understand the users' intentions at the various stages of the dialogue (Nielsen, 1992a).

3.3.2.3. Test Phases

A usability test is divided into four stages (Nielsen, 1993):

1. Preparation – The experimenter has to make sure that all of the conditions like the test room, hardware, software and the test materials, instructions and questionnaires are available.(Start state of the test plan).

2. Introduction.
    a. The experimenter gives the purpose of the test (evaluate a software) and informs the users he has no relation to the software being tested and is independent of the system design.
    b. Inform that the test results are going to be used to improve interface, which will influence the final layout software that will be different from the one being tested.
    c. He must give a reminder that the system is confidential and should not be discussed with others and that the results of the test will be kept confidential.
    d. The user must know that the test is voluntary.
    e. It should be pointed out when the user is being video or audio recorded during the test.
    f. It should be explained that the user is welcome to ask questions but the experimenter can not answer because the objective of the test is to see how the user handles the application.
    g. Users should be warned about specific instructions for the kind of experimenting we'll use to avoid mistakes.
    h. The user should be invited to put questions before starting the experiment.
3. The Test.
    a. During the test the experimenter should normally refrain from interacting with the user and should not express personal opinions, the only exception where users could be helped is when they are clearly stuck and are getting unhappy with the situation or when a user encounters a problem that has been observed several times on previous tests.
    b. If there are several people observing the experiment there should be one that is nominated the official experimenter that is the one that provides instructions and speak during experiment so the users do not get confuse.
4. Debriefing.
    a. After the test the user is debriefed and is asked to fill in any subjective satisfaction questionnaires that should be administered before any other

discussion of the system, to avoid bias from comments by the experimenter.

b. The users during debriefing are invited to make some contents and suggestions they may have to improve the system.
c. After the user has left the experimenter should check that all results from the test have been labelled with the test user's number.
d. The experimenter should write up a brief report on the experiment.
e. A full report on the complete sequence of experiments may be written later, but the work of writing such report is lighter by having well-organized notes and the preliminary reports from the individual tests.

3.3.2.4. Performance Measurement

It is important in the usability engineering lifecycle to measure whether the usability goals have been met. User performance is almost always measured by having a group of test users performing a pre-defined set of tests while collecting time and error data. One possible model of usability measure is presented in Figure 130 (Nielsen, 1993).

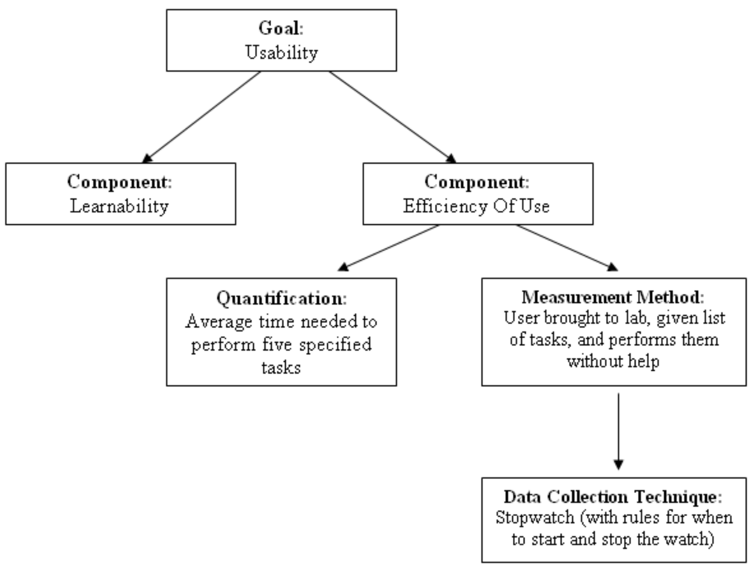


Figure 130. Model of usability measure

The model presented starts presenting clearly the goal of the exercise and assumes that usability as an abstract concept is a goal and then usability is divided in two different attributes (components of the goal) like learnability and efficiency of use. Next step is to quantify the components of the goal as it is shown in Figure 130, efficiency of use can be quantified as average time needed to perform five specified tasks.

Given the quantification, now measurement method of the users' performance is defined, like the example presented in Figure 130. Finally, collect data activities must be introduced, with a clear start and stop points definition.

Some factors that a typical quantifiable usability measurements are the time users take to complete specific tasks, number of tasks that can be completed within a given time limit, number of user errors, number of commands and features that were never used by the user, frequency of time spent with the manuals or help, the number of times the user express clear frustration and the number of times the users workaround an unsolved problem among others.

3.3.3. USABILITY ASSESSMENT METHODS

Even though usability testing forms the cornerstone of most recommended usability engineering practice, there are several other usability methods that can and should be used to gather supplementary data. Table 69 presents a summary of the evaluation usability methods (Nielsen, 1993).

Table 69. Summary of evaluation usability methods

Method	Lifecyle Stage	Users Needed	Main Advantage	Main Disadvantage
Heuristics evaluation	Early design, "inner cycle" of iterative design	None	Finds individual usability problems. Can address expert user issues	Does not involve real users, so does no find "surprises" relating to their needs.
Performance measures	Competitive analysis, final testing	At least 10	Hard numbers. Results easy to compare	Does not find individual usability problems
Thinking aloud	Iterative design, formative evaluation	3-5	Pinpoints user misconceptions. Cheap test.	Unnatural for users. Hard for expert users to verbalize
Observation	Task analysis, follow-up studies	3 or more	Ecological validity; reveals users' real tasks. Suggests functions and features	Appointments hard to set up. No experimenter control
Questionnaires	Task analysis, follow up studies	At least 30	Finds subjective user preferences. Easy to repeat	Pilot work needed (to prevent misunderstandings)
Interviews	Task analysis	5	Flexible, in-depth attitude and experience probing	Time consuming. Hard to analyse and compare.
Focus groups	Task analysis, user involvement	6-9 per group	Spontaneous reactions and group dynamics	Hard to analyze. Low validity.
Logging actual use	Final testing, follow-up studies	At least 20	Finds highly used (or unused) features. Can run continuously.	Analysis programs needed for huge mass of data. Violation of user's privacy
User feedback	Follow-up studies	Hundreds	Tracks changes in user requirements and views	Special organization needed to handle replies.

Methods on Table 69 are intended to supplement each other since they address different part of usability engineering life-cycle. Since their advantages and disadvantages can partially make up for each other, so it is recommended not to use a single of these methods but to combine various methods.

There are two major reasons for alternating between heuristics evaluation and user testing:

- ❖ First heuristic evaluation can eliminate a number of usability problems without the need of "waste users".
- ❖ Second, these two categories of usability assessment methods have been demonstrating to find distinct sets of usability problems, meaning that they supplement each other rather than leading to repetitive findings.

3.4. ACCESSIBILITY

Tim Berners-Lee (2010), states that "The power of Web is in its universality. The access by all taking away incapacity is an essential aspect". So, taking into account users with incapacities the situation is completely different, that why, nowadays, several countries are now integrating into their laws Internet accessibility issues trying to assure that the reading can be done without using vision, precise moves, simultaneous actions or pointing devices like mouse and the search and retrieval of information can be done through auditive, visual and tactile interfaces (MicrosoftAccess, 2005).

The Web Accessibility Initiative (WAI) of W3C has developed a set of accessibility directives of Web contents that are related to web navigation problematic and with one of the most important principles of accessibility, the principle of harmonious transformation. In practice this principle allows a certain text, audio or image elements to be harmoniously transformed in any of the other two formats (e.g. transform text in audio, audio in text, text in image, image in text, etc.) (WAI, 2009).

In the area of digital information access, mainly through computers, the vision, auditive and tactile senses assume a vital importance. Any perception difficulty by one of these senses bring with it a special need, that in case of information represents a transformation need according to the user's capacities. In addition to these difficulties there are others regarding motor character like tetraplegic persons, who are not able to work with the keyboard or mouse (AppleAccess, 2005).

Nowadays, some of these transformations are possible, thanks to user agents used on web access, like, navigators and technical helps.

Today it is possible to transcribe text to audio automatically through a voice synthesizer, text to Braille, make screen amplifications, and modify colour contrast. Meanwhile, there are rules and techniques that web designers have to follow to facilitate the work of user's agents in these tasks of adequacy to the user's needs (SunAccess, 2005).

There are already some advanced solutions regarding the conversion of audio into text (i.e. voice recognition systems), and the conversion of text into image (i.e. avatars for sign language, pictographic language for persons with cognitive deficit), but they are not used very frequently on Web.

This demands an additional work for the creators of web pages in order to reach the so desired harmonious transformation. By providing and audio track it is necessary to have an equivalent textual and sign language description to make the message clear to def persons (MacromediaAccess, 2005).

But it is not only the persons with special needs that benefit from information that include the accessibility directives. When these principles are applied, they make web contents to become accessible to a wide variety of web navigation devices, such as telephones, portable hand assistants, news stand, network applications, etc. (IBMAccess, 2005). By making contents accessible to a wide variety of devices, these contents are also going to be available to persons in a wide diversity of situations.

The technology itself gains "reading capabilities" and "interpretation". For Example, search engines acquire the capacity to make searches in audio tracks and even in elements as images.

Sometimes navigators are able to identify indexes in a huge collection of documents, and can negotiate with the server in which is the preferred language of the user. Technologies like screen readers, for use with blind users, gain a capacity of distinguishing a paragraph from a header.

In order to implement accessibility the WAI of W3C has separated those directives in three different levels of priority (WAI, 2009):

- Priority 1 – Issues that web content creators have to satisfy absolutely. If they do not absolutely satisfy them one or more groups of users will be unable to access the information included in the documents. The satisfaction of these issues is a basic requirement so that determined groups of users can access to information available on the Web.
- Priority 2 – Issues that web content creators must satisfy. If they do not satisfy them one or more groups of users will have difficulties to access the information included in the documents. The satisfaction of these issues is traduced in the removal of significant obstacles to the access to information available on the Web.
- Priority 3 – Issues that web content creators can satisfy. If they do not satisfy them one or more groups of users may face some difficulties on the access to the information included in the documents. The satisfaction of these issues will improve the access to information available on the Web.

The designers and web page creators can make two types of web page tests. A manual evaluation based on some technical help and an automatic evaluation based on software that makes accessibility reports.

To obtain the complete accessibility report it is advisable to use one of the three existing automatic tools:

- Bobby (English) (Bobby, 2005).
- Cynthia Says (English) (Cynthia, 2005).
- Test Accessibilidad à la Web (TAW) (2005).

3.6. LANGUAGE SUPPORT

As a consequence of globalization, the world is becoming a so called global "village", with the evolution of communications and the convergence of cultures and people.

The English language has become the global language in eLearning systems. However this globalization of the English language does not reach all the people in the world and in many cases (mainly in underdeveloped countries and interior regions) is an obstacle to the implementation of eLearning.

This way, it is important that eLearning platforms and tools should support as many languages as possible, but at least they should support the native language of the country where the platform or tool is installed and provide information in foreign languages – preferentially English and optionally French or Spanish.

Table 70. Minimum information to provide in foreign languages

Provided information in foreign languages
Institution Identification
Courses identification and description
Menus
Contacts

In Table 70 is suggested the minimum amount of information that any enterprise/institution should have in foreign languages.

4. ANALYSIS EXAMPLES

At this point, it is shown examples of the two kind of analysis presented before. First, the empirical analysis and after the example of a calculus grid for an analysis of eLearning platforms on a real selection scenario, are going to be introduced.

4.1. Empirical Analysis

Table 71 presents an example of an empirical analysis that has been made to the state of art in eLearning platforms to compare between commercial and open source solutions and to identify strong points and weaknesses in eLearning platforms.

This analysis measures whether the systems support the feature, in terms of technical aspects, adaptation and customization, administration, resource management, communication, evaluation and documentation. In addition, it is still considered compliance with the stardards and level of costs. An example of this analysis is presented in chapter 2, section 2.2.2.2.1 “Current eLearning approaches”.

Table 71. Grid of results of an empirical analysis (2006)

Tools/Features	Platforms							
	Comercial				Open Source			
	BB	WebCT	IntraLearn	Angel	ATutor	Moodle	Sakai	.LRN
Technical Aspects								
Interoperability/integration	✓	✓	✓	✓	✓	✓	✓	✓
Standards and specs compliance	(1) (2) (3)	(6) (1)	(1) (2) (3) (4) (5)	(1) (6)	(1) (2)	(1)	(6)	(6)
Extensibility	x	x	x	x	✓	✓	✓	✓
Adaptation and Personalization								
Interface Costum. and 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 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

4.2. REAL SCENARIO ANALYSIS

Table 73 gathers an example of a calculus grid for an analysis of eLearning platforms on a real selection scenario for implementation on a Higher Educational Institution. The criteria used on this analysis are presented on Table 72.

Table 72. Proposed criteria and weights

Criteria	Weight
Technical Evaluation	55%
Functionality	25%
Usability	25%
Integration	20%
Licensing	15%
Support and Maintenance	10%
Source Code	5%
Execution Team	20%
Price	20%
Execution Time	5%

As Table 72 shows, there is the template used in a real analysis based on four main factors, the technical issues, execution team, price and execution time, but on the technical aspects is also considered sub-factors for the functionality of the system, usability, integration of the system with a student management software the merit of licensing, support and maintenance and finally the availability of the source code. These entire sub factors are also weighted and reflect the weight presented for the Technical evaluation on a scale from 0 to 100% that is then translated to the 55%.

All of the criteria, sub-criteria, factors and sub factors where evaluated in a scale from 0 to 20 and then applied the weights to traduce them into the real values. Table 73 represents the final evaluation grid template of the analysis.

Table 73. Template of a final evaluation report

Platform	Technical Merit (55% - 11)						Execution Team (20% - 4)	Price (20% - 4)	Execution Time (5% - 1)	Totall
	Licensing (15%)	Usability (25%)	Functionalities (25%)	Source Code (5%)	Integrability (20%)	Support & Maintenance (10%)				
Platform 1										
Platform 2										
Platform 3										
Platform ..										
Platform ..										
Platform N										

Table 74 shows a more detailed evaluation grid example with all the factors and sub-factors that has been used as the calculus template for the evaluation of the eLearning platforms for implementation on a Higher Educational Institution.

Table 74. Template used for a real scenario evaluation

Technical Evaluation

Sub-Criteria	**Functionality**																																													**Usability**							
Factors	**Comunication Tools**						**FM**	**LO Management**								**FM**	**Course Manag.**					**FM**	**Evaluation**			**FM**	**Adaptation**				**FM**	**Administration**					**FM**	**Tech Aspects**			**FM**	**sCM**	**sCWM**							**FM**	**sCWM**
Sub-Factors	Forum	Chat	Whiteboard	Email	Colaborative	Audio & Video Streaming		Assessments	Content Authoring and Editing	LOs and other types of content Mng.	Templates to aid on content creation	LO Search and Indexation	File upload/download mechanisms	Evaluation of quality of resources	Learning Objects Sharing/Reuse		Course Administration	Assessments	Course Objects organization	Activities booking and definition			Self Assessments	Tests	Inquiries		Interface Costum. and personalization	Personalization	Extensability			Student Manage. / Monitor. tools	Database Access mechanisms	Produce reports	Admin. workflows quality & functio.	Tracking users		Interoperability/Integration	Standards and specs compliance	Extensibility				User-Friendliness	Support	Documentation	Assistance	Language	Consistency		
Maximum Values																																																			
Platform																																																			

Sub-Criteria		**Integration**					**LIC**		**SUP&MNT**				**S CODE**			**Tech Evaluation**
Factors		**AS**	**Platf.**	**DS**	**FM**	**sCWM**		**sCWM**	**MAN**	**TRAIN**	**FM**	**sCWM**		**FM**	**sCWM**	**Total**
Platform																

sCWM	-	Sub-Factor Weighted Mean
sCM	-	Sub-Factor Mean
FM	-	Factor Mean
AS	-	Aquired Solutions
DS	-	Developed Solutions
MAN	-	Maintenance
FOR	-	Formation

Execution Team

Enterprises																	
References																	
Curriculum																	
	Literary habilities																
	Professional Experience																
	Formation																

Price

Sub-Criteria	**Cost**
Platform	

Execution Time

Sub-Criteria	**Time**
Platform	

5. CONCLUSIONS

The paradigm of analysing an eLearning system involves a whole process and deals with many factors.

First is needed to know what eLearning system and tools should be analyzed, because there are several LMS, LCMS and Authoring and Packaging tools. The choice must be done regarding the architecture of the system to implement.

After choosing the framework an empirical analysis should be done.

In an empirical scenario, to get a real value of this analysis, a specific context or situation must be analyzed, otherwise it is advisable to make an analysis of the state-of-the-art of eLearning systems.

In a real scenario analysis where we want to select an eLearning system should be deployed in an institution, it must be considered aspects like the community target, existent resources, software, hardware and infrastructures (building structures, laboratories) and also the human resources. Then it is important to choose if a platform are going to be acquired dealing with the problems of extensibility and maintenance costs, but with easy implementation being a more secure solution, or if the decision is going to be a freeware, open source system dealing with problems of low support and initial installation, but with the possibility to develop the system according to institution needs.

In this analysis more context and project management factors than on an empirical analysis must be taken into account.

Other factors that also influence an eLearning analysis are the standards compliance, so standard or specifications compliant platforms must be chosen that best model actual teaching/learning process. Another factor is the usability of the system, taking into account where we have to consider aspects like the learnability of the system, its efficiency, memorability (it should be easy to remember), errors rate (it should have a low Error rate) and satisfaction (users should be pleasant when using it). The usability analysis can be done using one or a combination of methods. The user interface design may be analyzed using heuristics or making user tests where users probe a system doing specific tasks. This is a sensible factor and in a real scenario it is recommended performing user testing, because it is important to get feedback from the community where it is going to be implemented.

Another sensible factor that should be considered is the accessibility, thus the system should respect the accessibility directives of web contents (at least level A) regarding users with incapacities. It is important that the system is accessible to everyone.

Finally, the system should support several languages - the native language of the country where the platform or tool is being installed and provide information in foreign languages – preferentially English and optionally French or Spanish.

So, analysing and choosing an eLearning system require planning and knowing very well the variables and factors of the choice.

B. AHKME: DATA ARCHITECTURE

This appendix presents AHKME conceptual, architectural and behavioural model, the packages that breaks down and used data design. This focused on AHKME system analysis.

1. DATA ANALYSIS

This section presents system analysis and data architecture, as well as the features/functional requirements in terms of Front-Office, Templates and Back-Office.

In this section it is also presented some diagrams examples of core system features and back-office functionalities to complement the diagrams in Chapter 3. Furthermore, it is presented a more structured diagram of the system architecture, and also diagrams representing the subsystems. Regarding structure and content it is also presented some Class diagrams related to system key features. Finally, are presented the technologies used in the implementation of the system. The developed system consisted of a prototype of a web information system with the following requirements.

1.1. SYSTEM REQUIREMENTS

The system requirements seek to identify what is needed in terms of system architecture and can be summarized as the following ones:

- Database – To store the system data.
- User profiles – Application profiles of users and permissions.
- Front-Office – Front-end for user interaction.
- Back-Office – Back-end for user interaction.

1.1. FEATURES REQUIREMENTS

Table 75 presents the features requirements.

Table 75. Features requirements

	User - Learning Designer	
No	Requirement	Description
	General	6
1	User Login/Registration	Register yourself and then login
2	User Navigation	Familiarize yoursef with the system
3	User Tool finding	Trie to find the profile specific main tools

No	Requirement	Description
4	User Help	Use the help during the test to see how to do a specific function
5	User Profile	Change your profile data
	Schema	10
6	User import schema	Import the Schema test example to the system
1	User selects schema	Select the imported schema to create a new instance
7	User creates schema	Create a new schema with the template manager
2	User lists schema	See in the schema list the details of the imported schema
8	User edits schema	Edit the imported schema, change the some element values
	Workflow	8
9	User creates workflow	Create a LO Adaptation Workflow using the test users for receivers
10	User process pending	Process the existent pending LD Adaptation workflow by pointing out your observation
11	User queries circulation	See the existent circulation and the details of your created Workflow
12	User queries history	See the history of circulations
	Surveys	10
13	User creates survey	Create a survey based on the template manager, use the survey example
14	User edits survey	Edit the created survey
15	User publish surveys	Publish the created survey
16	User use survey	Participate in created survey
17	User lists survey	See the existent surveys and the details of your created survey
	Adaptation	4
18	User views attribute importance	Choose the technique of classification and evaluate the LO example pointing out the most important attributes to adapt
19	User views decision tree	View the decision tree
	Quality	4
20	User views attribte importance	Choose the technique of classification and evaluate the LO example quality - Point out the most important attributes
21	User views decision tree	View the decision tree
	Resources	8
22	User uploads resource	Upload the exampla resource file
23	User edits resource	Edit the uploaded resource
24	User queries my resource	See your resource list and details
25	User searchs resource	Search for the example resource
26	User lists all resources	See all the list of resources
27	User Searchs	Search for the test subject LO and LD
28	User interact with Communication & Sharing	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste useres
	Interoperability	6
29	User Creates/Exports Package	Create a Package with the LD test example
30	User Lists Pachages	See the list of packages, and the created test package
31	User Imports Package	Import na exmple test package

	User - Instructor	
No	Requirement	Description
	General	
1	User Login/Registration	Registe yourself and then login
2	User Navigation	Familiarize yoursef with the system
3	User Tool finding	Trie to find the profile specific main tools
4	User Help	use the help during the test to see how to do a specific function
5	User Profile	Change your profile data
	Schema	
6	User selects schema	Select the imported schema to create a new instance

No	Requirement	Description
7	User generates/personalizes schema	Customize the test schema, create new element, and change values
8	User lists schema	See in the schema list the details of the imported schema
9	User edits schema	Edit the imported schema, change the some element values
	Workflow	
10	User process pending	Process the existent pending LD Adaptation workflow by pointing out your observation
11	User queries circulation	See the existent circulation and the details of your created Workflow
12	User queries history	See the history of circulations
	Surveys	
13	User edits survey	Edit the created survey
14	User publish survey	Publish the created survey
15	User uses survey	Participate in created survey
16	User lists survey	See the existent surveys and the details of your created survey
	LOM	
17	User Generates LOM	Generate LOM instance
18	User Edits LOM	Edit LO and metadata, change value in elements
19	User publish L;OM	Pubish the LO
20	User uses LOM	Use the LO in a course
21	User lists LOM	See the list of LO and details of LO generated
	LD	
22	User Generates LD	Generate LD instance
23	User Edits LD	Edit Ld and metadata, change value in elements
24	User publish LD	Pubish the LD
25	User uses LD	Use the LD in a course
26	User lists LD	See the list of LD and details of LO generated
	Resources	
27	User uploads resource	Upload the exampla resource file
28	User edits resource	Edit the uploaded resource
29	User queries my resource	See your resource list and details
30	User searchs resource	Search for the example resource
31	User list all resources	See all the list of resources
32	User Search	Search for the test subject LO and LD
33	User interact with Communication & Sharing	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste users

	User - Student	
No	**Requirement**	**Description**
	General	
1	User Login/Registration	Registe yourself and then login
2	User Navigation	Familiarize yourself with the system
3	User Tool finding	Trie to find the profile specific main tools
4	User Help	Use the help during the test to see how to do a specific function
5	User Profile	Change your profile data
6	User give Student Feedback	Give some feedback of your usage experience
	Surveys	
7	User uses survey	Participate in created survey
8	User lists survey	See the existent surveys and the details of your created survey
	Resources	
9	User queries my resource	See your resource list and details
10	User searchs resource	Search for the example resource
11	User interacts with Communication & Sharing	Use the communication tool of the Social Network frotn-end, as well as collaboration tools for sharing test resources with the teste users

	User – Technical	
No	**Requirement**	**Description**
	General	
1	User Login/Registration	Registe yourself and then login
2	User Navigation	Familiarize yoursef with the system
3	User Tool finding	Trie to find the profile specific main tools
4	User Help	Use the help during the test to see how to do a specific function
	Administration	
5	Administrator manages Users & Tools Access	Manage a test user, reset passworg and give permission to Learning Design tools
6	Administrator manages Resources Manager	Manage the test resources, by deleting and changing some resources
7	Administrator managesTemplates	Manage templates, deleting and changing some templates

1.3. BEHAVIOURAL MODELLING

Behaviour diagrams emphasize what must happen in the system being modelled. Since behaviour diagrams illustrate the behavior of a system, they are used to describe the functionality of software systems.

In this section, to model the behavior of the system are presented Use cases examples and diagram, and also sequence diagram examples to shows how objects communicate with each other in terms of a sequence of messages. Also indicates the lifespans of objects relative to those messages.

1.3.1. USE CASES

Use cases that follow intend to describe the different sequences of actions that different actors of the system perform in order to obtain a particular result. Thus, as an example of the complete catalog has been chosen the following Use cases that complement the diagrams in Chapter 3, by representing some core system features, regarding authentication and back-office features like user and template management. Further, it will be presented also diagrams to represent the system architecture.

Name: Authentication request

Main Scenario:
Include use case “Authentication Validation”, “User Validation”. It presents a login screen to the user so that the user enters password.

Alternative Scenario 1: The user did not fill in the fields
Include use case "Authentication Validation" Message is displayed to the user giving feedback of failing to fill in the fields.

Alternative Scenario 2: The user does not exist
Include use case "User Validation". It presents a message to the user to indicate the absence of the user.

Alternative Scenario 3: The user enters the wrong password
Include use case " User Validation". It presents a message to the user that the password was entered incorrectly

Name: Create Workflow

Main Scenario:
A screen is displayed to the user to input the data for the workflow process to trigger (choose the type of workflow process to trigger; attach file if necessary, indicate observations; user choose destination).

Alternative Scenario 1: The user did not fill in the fields
Validates workflow fields. Message is displayed to the user giving feedback of failing to fill in the fields.

Alternative Scenario 2: The user does not select the workflow process
It is not presented to the user the possible recipients of the workflow process.

Name: Pending Workflows

Primary Scenario:
A screen is displayed a list of pending cases that require your intervention with the option to view details or process.

Name: Workflow Process

Main Scenario:
Validate fields workflow. A screen is displayed to the user to enter data regarding processing of workflow (choose the state, attach file if necessary; indicate observations; user choose destination).

Alternative Scenario 1: The user does not choose the state or destination
Message is displayed to the user giving feedback of failing to fill in the fields.

Name: Manage User & Tools

Main Scenario:
Include use case "create user", "edit user" and "Remove user". A screen is displayed to the administrator with a list of existing users, as this may create a new user, edit and remove users.

Name: Create User

Main Scenario:
Include use case "User validation", "Validate user and Tools data". A screen is displayed to the administrator for it to enter data for a new user.

Alternative Scenario 1: The manager does not fill the fields
Include use case "validate user and tools data." Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: User already exists
Include use case "User Validation". A message to the manager to indicate the user already exists.

Name: Edit User

Main Scenario:
Include use case "User validation", "Validate user and Tools data". A screen is displayed to the administrator for this to edit the data for the selected user.

Alternative Scenario 1: The administrator leaves fields blank
Include use case "Validate user and Tools data" Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: Changing username to another existing
Include use case "User validation". A message to the manager to indicate there is already a user with that username.

Name: Remove User

Main Scenario:
Include use case "validate user & tools records" A list of users with the symbol "X" in front of you where the administrator must click the user you want to remove.

Alternative Scenario 1: The user to remove the paths is associated with already completed or in progress
It presents a message to the administrator stating that as the user is connected to routes already completed; this will be inactive and not removed.

Name: Managing Groups

Main scenario:
Include use case "Create Group", "edit group" and "remove group." A screen is displayed to the administrator with a list of existing groups, as this may create a new group, edit and remove groups.

Name: Create Group

Main Scenario:
Include use case "validate fields group," "validate the group." A screen is displayed to the administrator for it to enter data for a new group.

Alternative Scenario 1: The administrator does not fill in the fields
Include use case "validate fields group." Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: The administrator already exists
Include use case "validate group." A message to the administrator to indicate the group already exists.

Name: Edit Group

Main Scenario:
Include use case "validate fields group," "validate the group." A screen is displayed to the administrator for this to edit the data for the selected group.

Alternative Scenario 1: The administrator leaves fields blank
Include use case "validate fields group." Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: Change the group name for an existing
Include use case "validation records group." A message to the administrator to specify a group already exists with that name.

Name: Manage Template

Main Scenario:
Include use case "create template", "edit template" and "remove template." A screen is displayed to the administrator with a list of existing templates, since this may create a new template, edit and delete templates.

Name: Create Template

Main Scenario:
Include use case "validate template fields", "validate template." It presents a sequence of screens that the administrator to enter data for a new template, groups, states and associated permissions.

Alternative Scenario 1: The administrator does not fill in the fields
Include use case "validate template fields." Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: A template already exists
Include use case "validate template." You receive a message to the administrator to specify the template already exists.

Name: Edit Template

Main Scenario:
Include case "validate template fields", "validate template." A screen is displayed to the administrator for this to edit the data on the template.

Alternative Scenario 1: You leave fields blank
Include use case "validate template fields." Message is displayed to the administrator realizing the failure to fill the fields.

Alternative Scenario 2: Change of name for an existing template
Include use case "validate template". A message to the administrator to specify a template already exists with that name.

Name: Remove Template

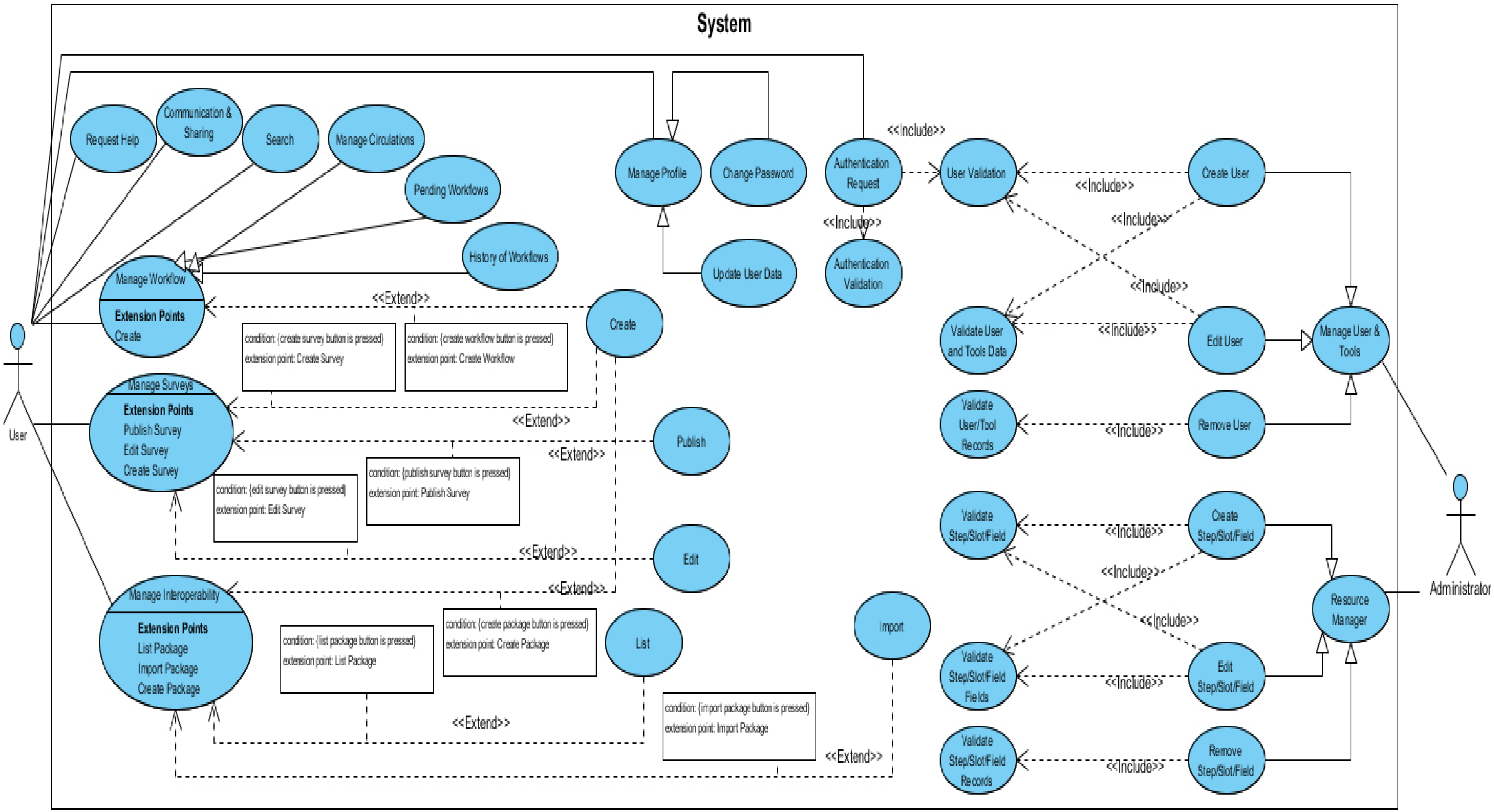
Main Scenario:
Include use case "validate template records." A list of templates under the symbol "X" in front of the user where should click the group you want to remove.

Alternative Scenario 1: A template to remove pathways is associated with already completed or in progress
A message stating that the trustee as the template is associated with courses already completed or under way and this will be inactive and not removed.

1.3.2. USE CASES DIAGRAM

The diagram of use cases presented in Figure 131 seeks to represent use cases described in previous subsection, and the actors and their interrelationships. Thus, this graphical overview of the functionality represents the following actors and use cases:

- Actors: User and Administrator.
- Use cases (goals) User.
  - Authentication Request; Manage Profile; Request Help; Communication & Sharing; Search; Manage Workflow; Manage Surveys; Manage Interoperability; Manage Schemas; Manage LO & LD; Manage Resources; Quality; Adaptation.
- Use cases (goals) Administrator.
  - Manage Users & Tools.
  - Resource manager.
  - Manage Templates.
  - Manage Process.


System
Request Help
Communication & Sharing
Search
Manage Circulations
Pending Workflows
History of Workflows
Manage Workflow
Extension Points
Create
<<Extend>>
Create
condition: {create survey button is pressed}
extension point: Create Survey
condition: {create workflow button is pressed}
extension point: Create Workflow
Manage Surveys
Extension Points
Publish Survey
Edit Survey
Create Survey
<<Extend>>
Publish
<<Extend>>
condition: {publish survey button is pressed}
extension point: Publish Survey
condition: {edit survey button is pressed}
extension point: Edit Survey
<<Extend>>
Edit
<<Extend>>
Manage Interoperability
Extension Points
List Package
Import Package
Create Package
condition: {list package button is pressed}
extension point: List Package
condition: {create package button is pressed}
extension point: Create Package
List
Import
<<Extend>>
condition: {import package button is pressed}
extension point: Import Package
<<Extend>>
User
Manage Profile
Change Password
Update User Data
Authentication Request
<<Include>>
Authentication Validation
<<Include>>
User Validation
<<Include>>
Create User
<<Include>>
<<Include>>
Validate User and Tools Data
<<Include>>
Edit User
Manage User & Tools
Validate User/Tool Records
<<Include>>
Remove User
Validate Step/Slot/Field
<<Include>>
Create Step/Slot/Field
<<Include>>
<<Include>>
Resource Manager
Validate Step/Slot/Field Fields
<<Include>>
Edit Step/Slot/Field
Validate Step/Slot/Field Records
<<Include>>
Remove Step/Slot/Field
Administrator

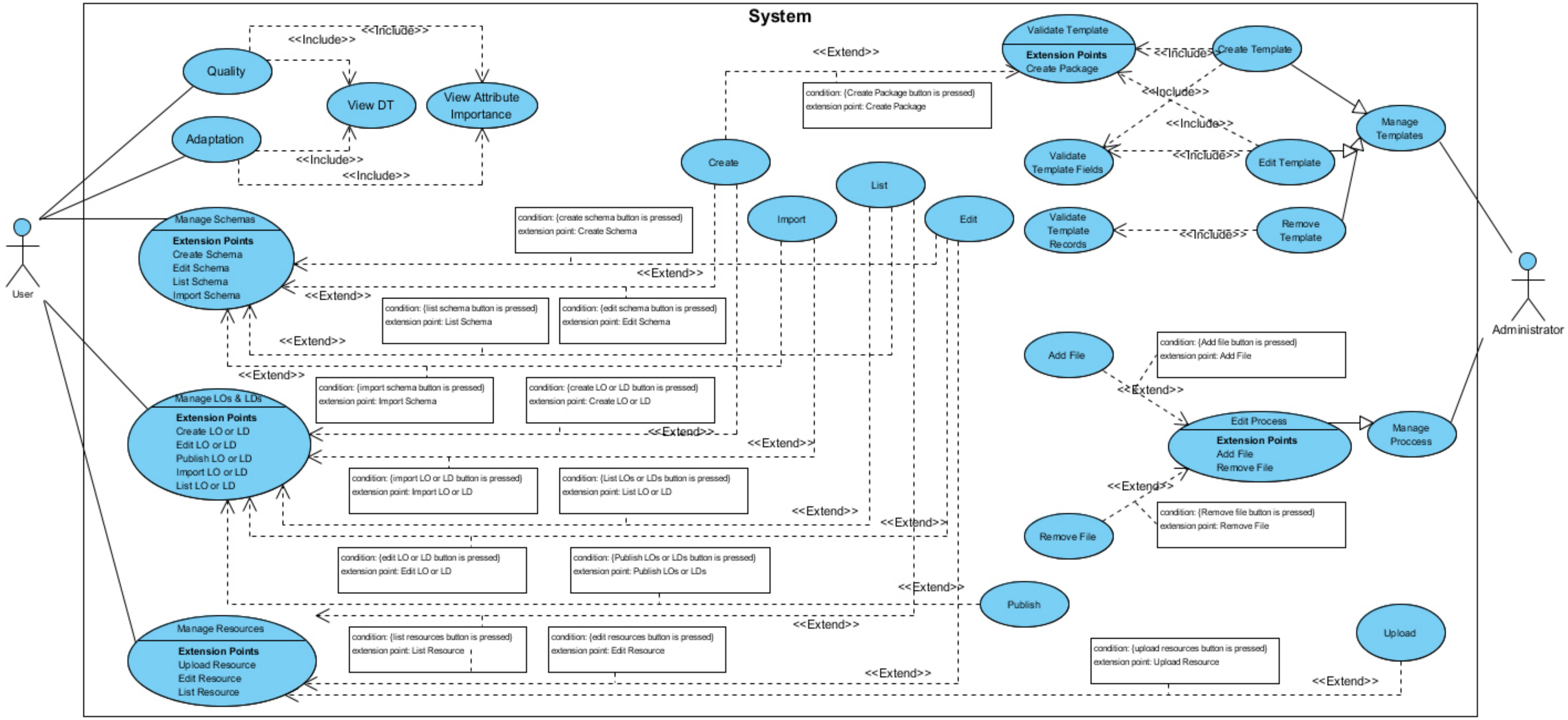


Figure 131. Use case diagram

1.3.3. SEQUENCE DIAGRAM

The following examples of system sequence diagrams presented aims to illustrate the interaction in the system according to a temporal view according to the use cases presented. Thus, following the previously presented Use cases, it is chosen as an example the following sequence diagrams:

- ❖ Authentication request (Figure 132).
- ❖ Create user (Figure 133).
- ❖ Edit user (Figure 134).
- ❖ Remove user (Figure 135).
- ❖ Create template (Figure 136).
- ❖ Edit template (Figure 137).
- ❖ Remove template (Figure 138).

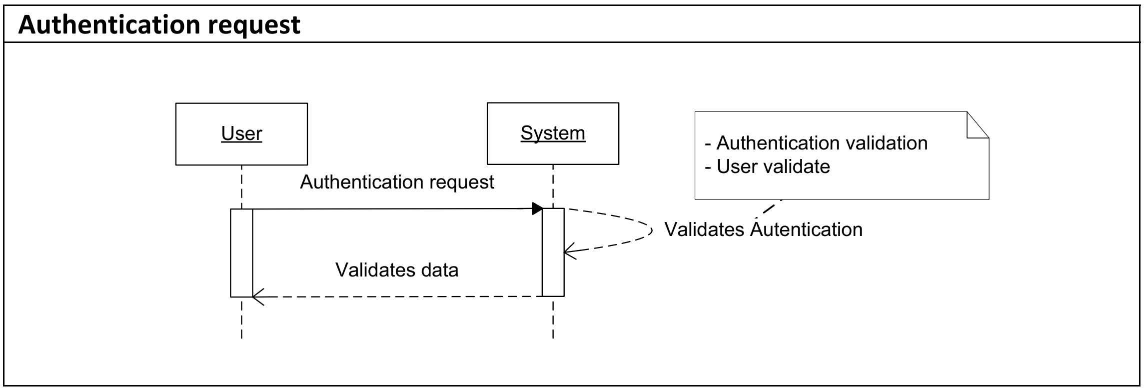


Figure 132. Sequence diagram of the "Authentication request"

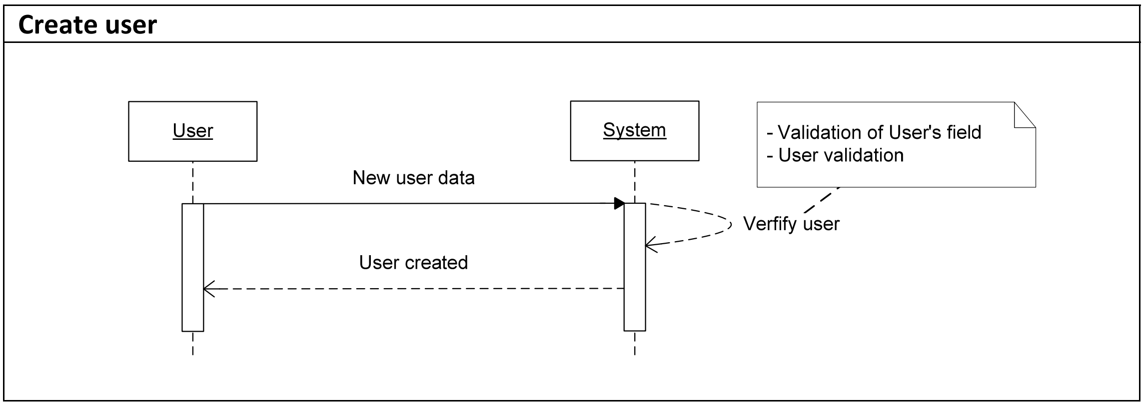


Figure 133. Sequence diagram of the "Create user"

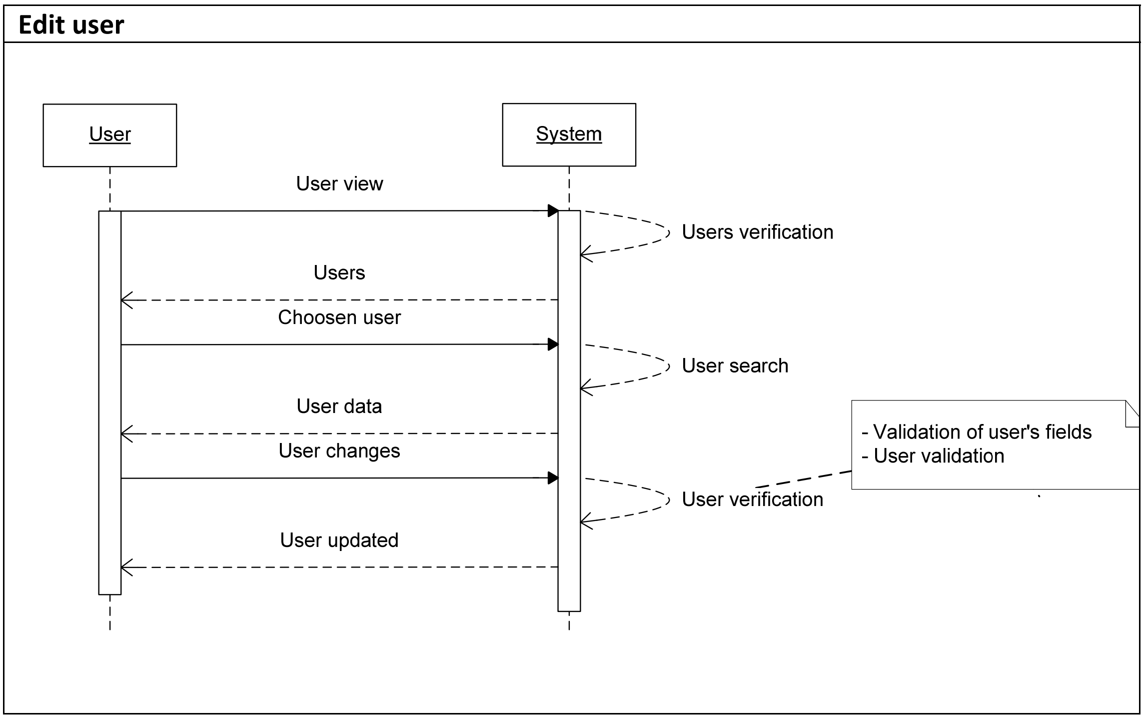


Figure 134. Sequence diagram of the "Edit user"

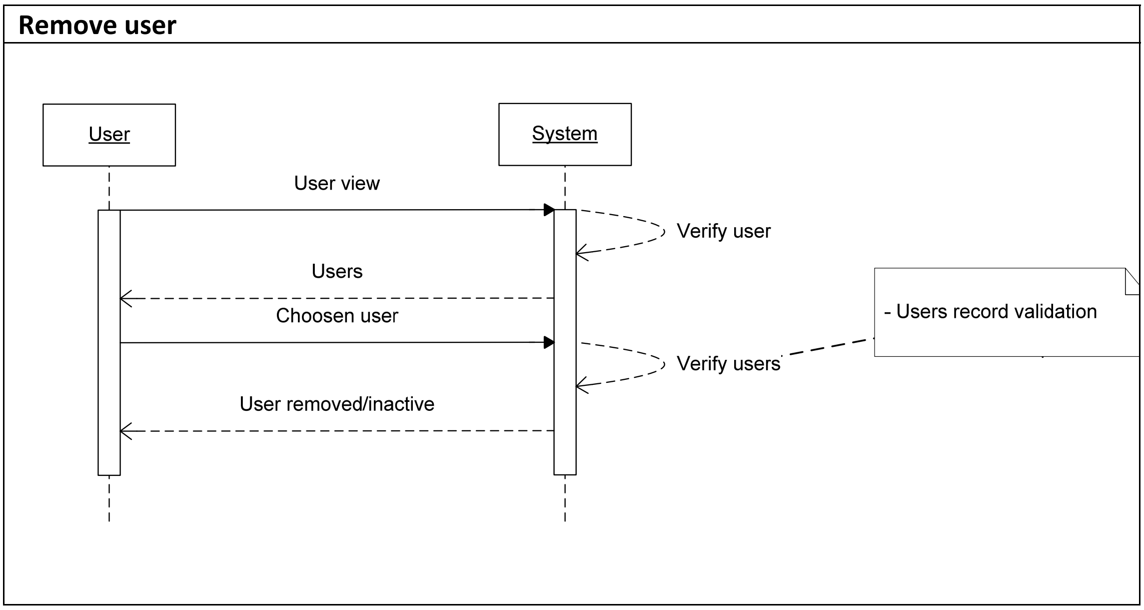


Figure 135. Sequence diagram of the "Remove user"

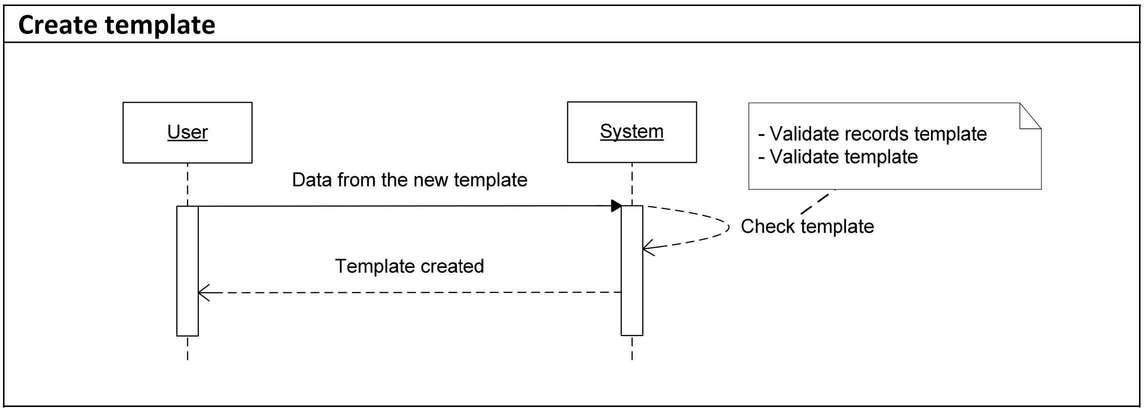


Figure 136. Sequence diagram of the "Create template"

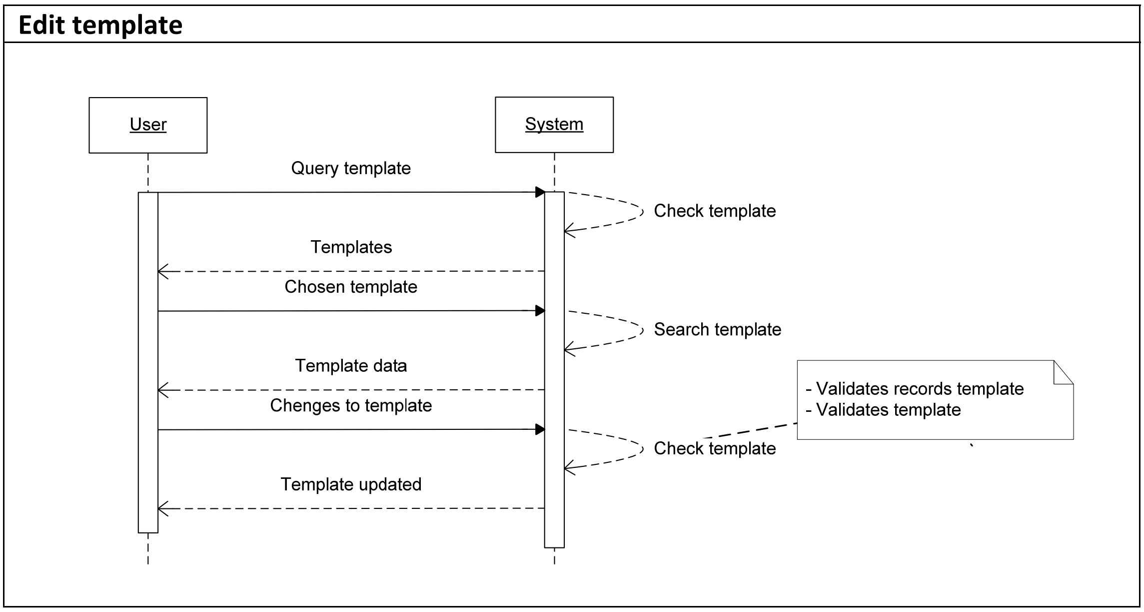


Figure 137. Sequence diagram of the "Edit template"

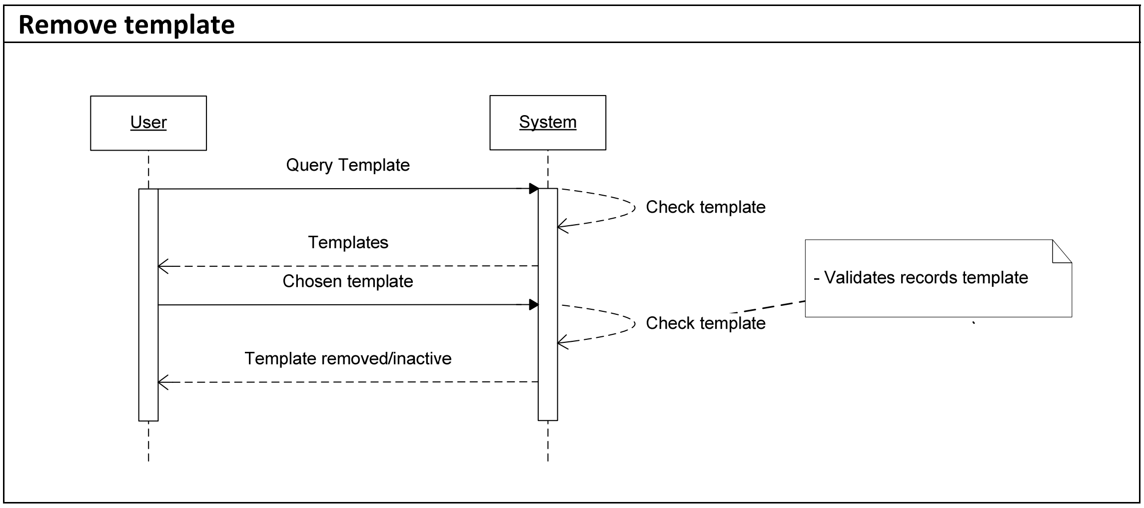


Figure 138. Sequence diagram of the "Remove template"

1.6. ARCHITECTURE MODELLING

In this section are presented structure diagrams that describe in more detail the architecture of the system. Structure diagrams emphasize the things that must be present in the system being modeled.

First is presented diagrams in terms of packages that are UML constructs that enable to organize model elements into groups, making the UML diagrams simpler and easier to understand (Ambler, 2010). When modeling a large scale system, there is a high volume of model elements. They describe a model from different views and different phases, hence are in different types. UML package helps to organize and arrange model elements and diagrams into logical groups, through which it manages a chunk of project data together. It can also be used packages to present different views of the system's architecture. In addition, developers can use package to model the physical package or namespace structure of the application to build (VP, 2011).

Package diagram visualizes packages and depicts the dependency, import, access, generalization, realization and merge relationships between them. It enables to gain a high level understanding of the collaboration among model elements through analyzing the relationships among their parent package (VP, 2011). This also helps explain the system's architecture from a broad view.

Furthermore, is presented in Class diagrams the IMS and Schema Classes structure. A class diagram in UML is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. Class diagrams model class structure and contents using design elements such as classes, packages and objects. These diagrams describe three different perspectives when designing a system, conceptual, specification, and implementation. With detailed modeling, the classes of the conceptual design are often split into a number of subclasses. The class diagram is the main building block in object oriented modelling. It is used both for general conceptual modelling of the systematics of the application, and for detailed modelling translating the models into programming code. It can also be used for data modeling. The classes in a class diagram represent both the main objects and or interactions in the application and the objects to be programmed (Classdiagram, 2011).

In Figure 139 is presented the AHKME architecture divided into three different parts the Fornt-End, Back-End and the Utilities.

In Front-End there is the group of elements related to the user interaction (UI) application stereotype tools. Thus, is indicates that this package contains packages such as Interface and Profile, also the Social Network, Collaboration and Adaptation packages, and finally the Interop package to interact with external systems.

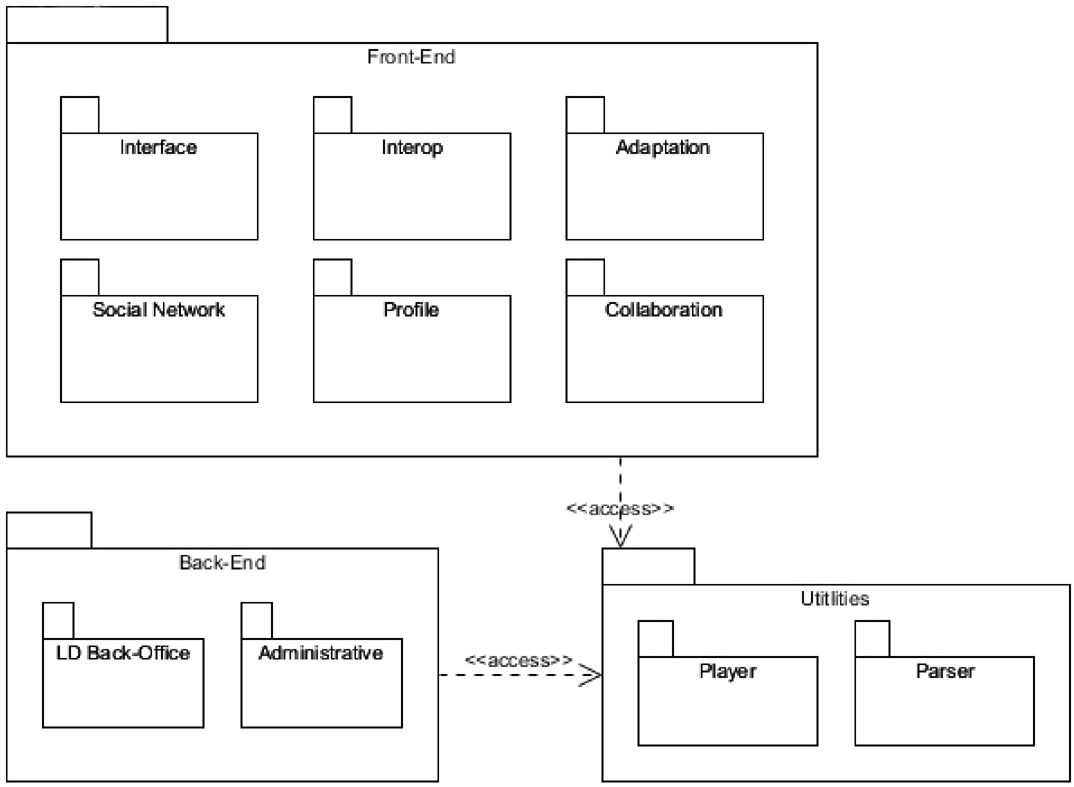


Figure 139. AHKME architecture Package diagram

The Back-End group of elements includes the LD Back-Office and the Administrative tools.

Each package in Figure 139 would lead to a more detailed diagram, perhaps another package diagram for this complicated subsystem or to a UML class diagram

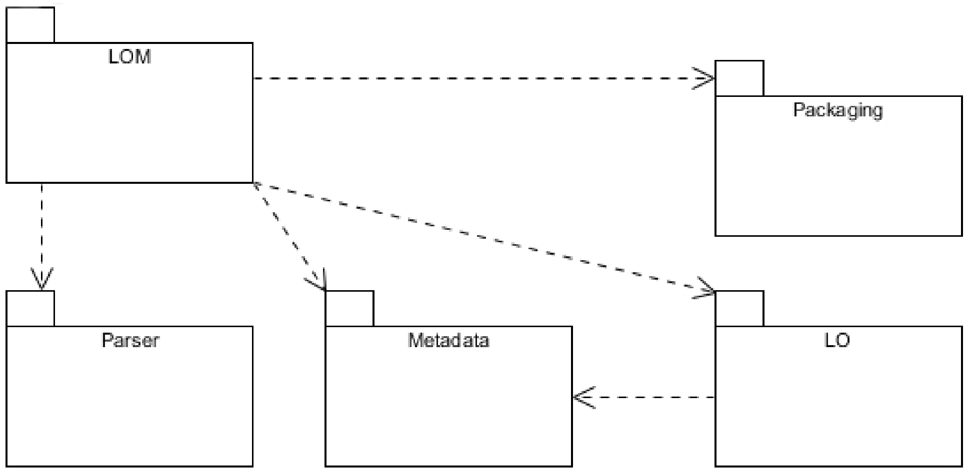


Figure 140. LOM package diagram

The LOM package diagram in Figure 140 presents the architecture of the LOM tool in terms of group of elements or packages.

So, the LOM tool depends of the XML Parser, the Packaging feature, but mainly the LO and the metadata to annotate them.

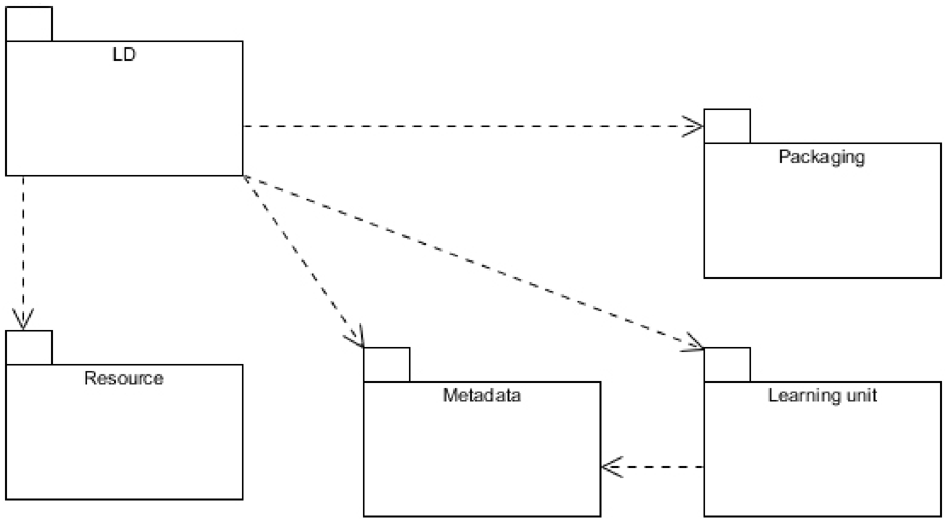


Figure 141. LD package diagram

The LD package diagram in Figure 141 presents the architecture of the LD tool in terms of group of elements or packages.

Thus, the LD tool depends of the XML Parser, the Packaging feature, but mainly the LU and the metadata to annotate them.

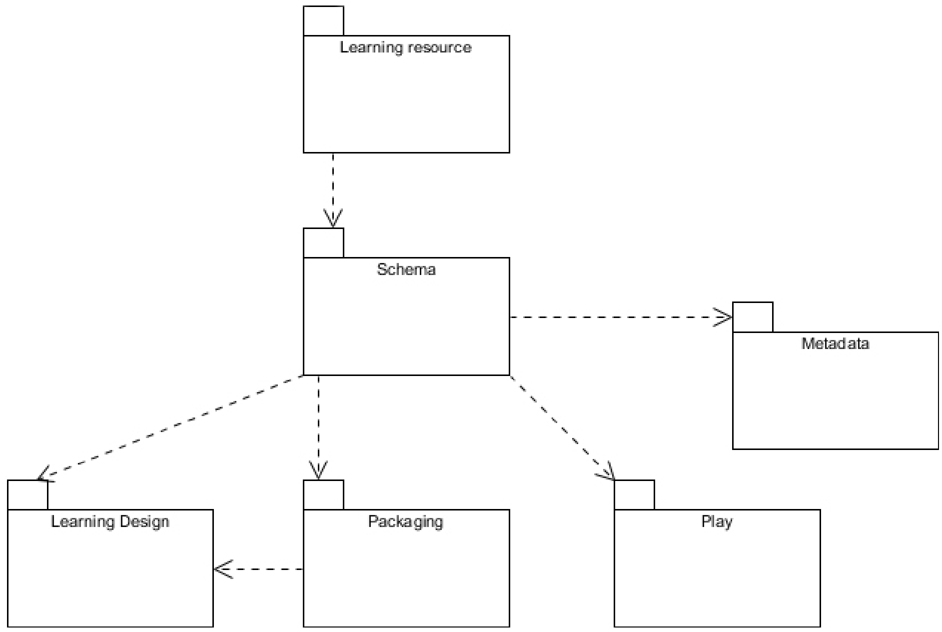


Figure 142. Schema package diaram

In Figure 142 is presented the package diagram illustrating the architecture of the Schema manager tool, with the main group of elements Learning resource depending on the Schema that is associated with the learning design and metadata, but also the Play and Packaging of the resource.

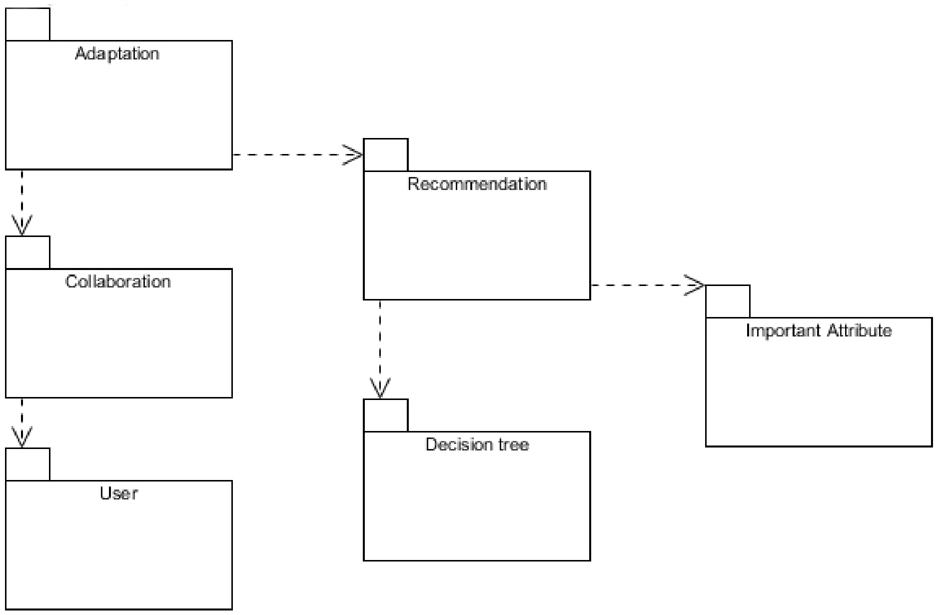


Figure 143. Adaptation package diagram

In Figure 143 is presented the architecture of the Adaptation subsystem with the Recommendation and Collaboration tools. The Recommendation tool depends on the Decision tree and the Attribute Importance calculus. The Collaboration depends mainly on the User.

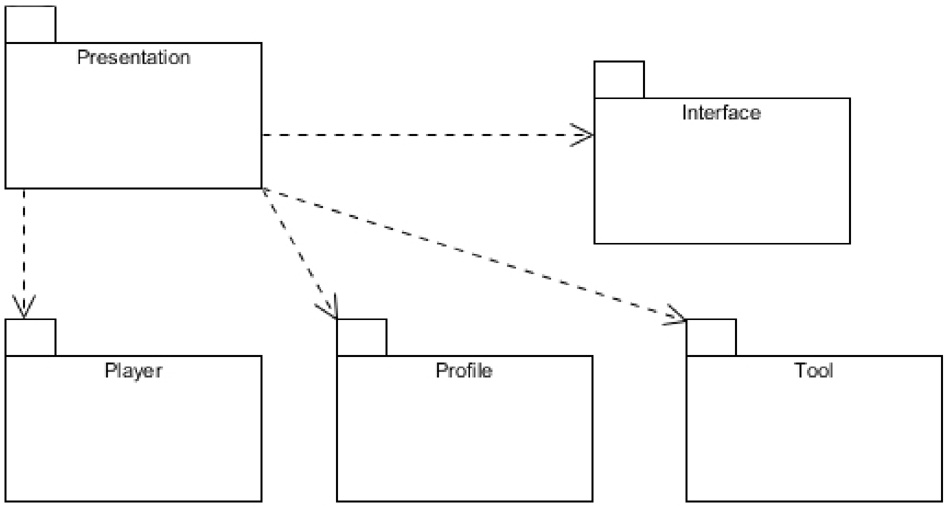


Figure 144. Presentation package diagram

The package diagram in Figure 144 presents the architecture of the Presentation susbsystem that contains the Interface, Profile, Player and Tool Packages.

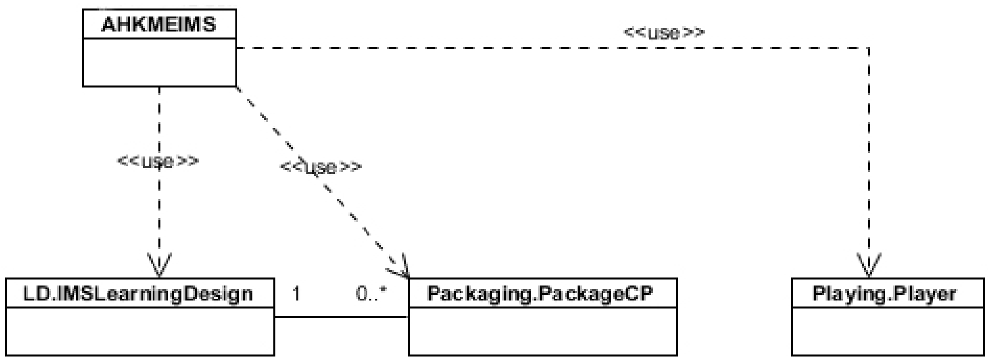


Figure 145. AHKME IMS class diagram

Figure 145 presents the IMS class diagram using the LD.IMSLearningDesign, the Packaging and the Player Classes.

Figure 146 depicts a UML frame which is used to depict the contents of the AHKMESchema Package, in this case a high-level conceptual class diagram. Frames can be used to show the detailed contents of any type of UML model, such as packages, components, classes, or operations.

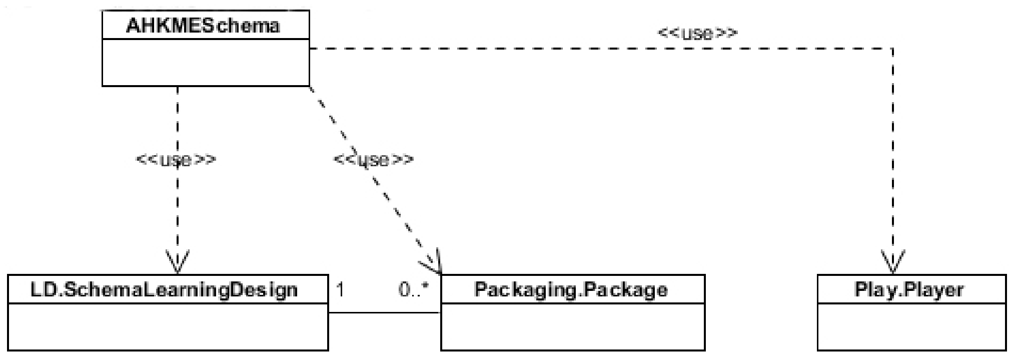


Figure 146. AHKME schema class diagram

Thus, this diagram presents the Schema class using the LD.ShemaLearningDesign, the Packaging and the Player Classes.

2. DESIGN DATA

As mentioned earlier, AHKME stores the information according to IMS LD for instructional design, IMS-CP for packaging and IMS LOM for metadata. Therefore, the instructional design information, its elements and the manifest file, included in every package CP, is stored by the XML schemas that provide each of these specifications.

It is beyond the scope of this appendix include XML schemas using IMS LD to store the instructional design.

Below a representative example explains the structure that this specification provides for storing learning activities (See Figure 147). This structure provides the following tags (IMSLD, 2003):

- learning-activity. Parent tag whose attributes store the identifier of activity, visibility and parameters.
- title: Store the title of the activity.
- learning-objective. Contains learning objectives of the activity.

- prerequisites: Contains the prerequisites of learning activity.
- activity-description: Element type item that stores the description of the activity.
- complete-activity: Store information regarding the completion of the activity. Allowed two alternatives: user-choice (when the user decides) or time-limit (in a set time).
- On-completion: Stores information about the action to take when you end the activity. It allows the creation of a feedback (feedback type label item) or change the value of a property.

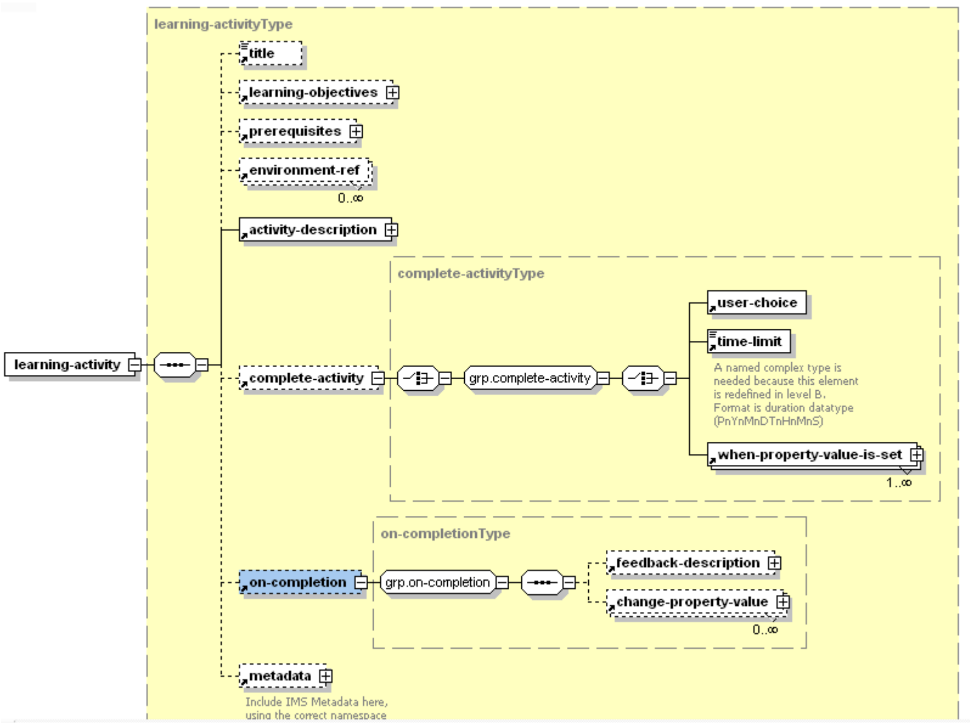


Figure 147. Storage structure for learning activities (IMSLD, 2003)

A sample of how AHKME stores in XML a learning activity is illustrated in the snippet of Figure 148:

```
<?xml version="1.0" encoding="ISO-8859-1" standalone="yes"?>
<learning-activity isvisible="true" parameters="" identifier="LA-1136155140304"
xmlns="http://www.imsglobal.org/xsd/imsld_v1p0">
    <title>Introduction to IMS LD</title>
    <learning-objectives>
        <item identifier="LOB-1" parameters=";;http://www.imsglobal.org" isvisible="true">
            <title>The student will identify the IMS LD elements </title>
```

```
        </item>
    </learning-objectives>
    <activity-description>
        <item parameters=";; file://1.dat" isvisible="true">
            <title>Previous knowledge of LD</title>
        </item>
    </activity-description>
    <complete-activity>
        <time-limit>P0Y0M0DT0H10M0S</time-limit>
    </complete-activity>
    <on-completion>
        <feedback-description>
            <item parameters=";;" isvisible="true">
                <title/>
            </item>
        </feedback-description>
    </on-completion>
</learning-activity>
```

Figure 148. Snippet of a sample of how AHKME stores in XML a learning activity

Note that, following the metaphor of Lego, AHKME allows learning activities assemble different components created before, in this case learning objectives and prerequisites.

3. TOOLS FOR SYSTEM ANALYSIS

The first step in any development project is to conduct planning and system analysis in order to know the information that can generate and circulate. The system analysis has been carried out with the aid of a set of techniques and diagrams, derived from the Unified Modeling Language (UML) (UML, 2005) to help structure the information, based on the study carried out from which resulted the requirements selected for the pilot of this system.

Among these techniques are:

- Functional Requirements - Description of the purpose of the system to implement and indication of the benefits this brings.

- ❖ Use cases - Description of one or more sequences of actions that one or more actors perform a system to achieve a particular result.
- ❖ Use Case Diagram - Diagram representing the use cases, actors and their interrelationships.
- ❖ Sequence Diagram - Diagram illustrating an interaction according to a temporal view.
- ❖ Logic Diagram - Diagram representing the tables and their fields as well as the relationship between them (not used).

4. TECHNOLOGIES USED IN THE SYSTEM

Even if the core of the study is not the technology itself, it works to make possible the application of current study goals.

Thus, the main technologies used in the proposal are:

- ❖ Client-server scripting programming languages – PHP and .NET.
- ❖ Data interchange – XML and XML schemas.
- ❖ Databases – MySQL and MSSQL Server Express.
- ❖ Machine learning and Data Mining.

The main concept is openness by using mainly freeware and open source technologies.

Regarding the programming languages, the choice is PHP, mainly because of the main characteristics involved and Asynchronous JavaScript And XML (AJAX) to create interactive Web applications (AJAX, 2007).

PHP (recursive acronym for “PHP: Hypertext Preprocessor”) is a computer programming language interpreted, freeware and widely used to generate dynamic content on the web enabling the implementation of web applications with access to server-based remote data in several operating systems (Microsoft, Linux) or other platforms, systems or network (Sæther et al., 2003).

XML is used to data interchange in the proposed web information system and XML schema with a dual purpose (Bray et al., 2004; XMLSchema, 2001):

- ❖ XML Validation format.
- ❖ XML schemas for manipulation of educational specifications.

About the databases engines used, MySQL was one of the choices because it is highly compatible with PHP.

MySQL is a management system database, which uses the SQL language (Structured Query Language - Structured Query Language) as the interface. It is now one of the engines most popular databases, with over four million installations worldwide. In an article published in SD Times, MySQL has been identified as the 3rd most commonly used engine in the world (see Figure 149), ahead of DB2, Postgres, Informix or Sybase (MySQL, 2010).

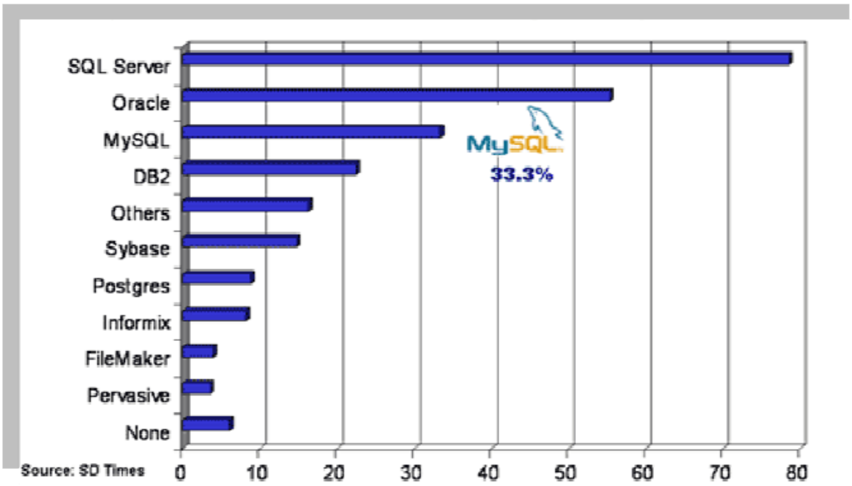


Figure 149. Engines Databases usage (MySQL, 2010)

The MSSQL Server Express who is the freeware version of Microsoft SQL Server is used because of the compatibility with .NET applications.

Some data mining are included for introducing machine learning into eLearning systems.

The data mining techniques is mainly regarding decision tree and classification algorithms for identifying the attribute importance.

Figure 150. web/eLearning 2.5 technologies

Figure 150 shows the combination of the application of these technologies or IT concepts contributes to the development of the web/eLearning 2.5 proposal.

C. SUPPORT DATA FOR TESTING

This appendix contains the support data of the testing process. Thus, it contains data regarding the tests logging, tables of usability and performance data, tools screenshots, post-task and post-test questionnaires.

1. INTRODUCTION

The tests are based on support data in the process design.

It also generates some data that are presented in this appendix in the form of support tables and graphs.

For the data collection is used the Usability Datalogger and QEngine Web performance tool. For the user satisfaction and feedback questionnaires has been used.

2. TEST TOOLS AND SUPPORT DATA

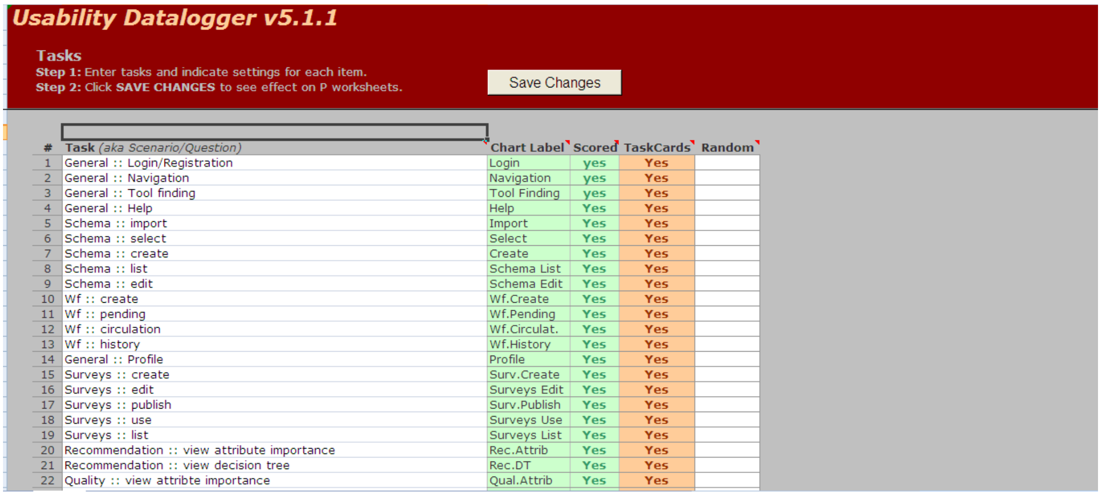
This section presents some screenshots of the test tools.

Thus, it presents screenshots of Usability Datalogger regarding the configuration process of testing but also of the data collection.

Also, some screenshots regarding the QEngine Web performance tool, regarding the measurement of performance, specifically the Response and Download time.

2.1. USABILITY DATALOGGER

Figure 151 shows a screenshot of a Datalogger record example, regarding the first step of the tool process, the Tasks Configuration, in this case the Learning Designer Test Scenario. Thus, in the configuration it is identified the task, the chart label, if is scored, and finally if it has associated task cards for the users.



Usability Datalogger v5.1.1

Tasks

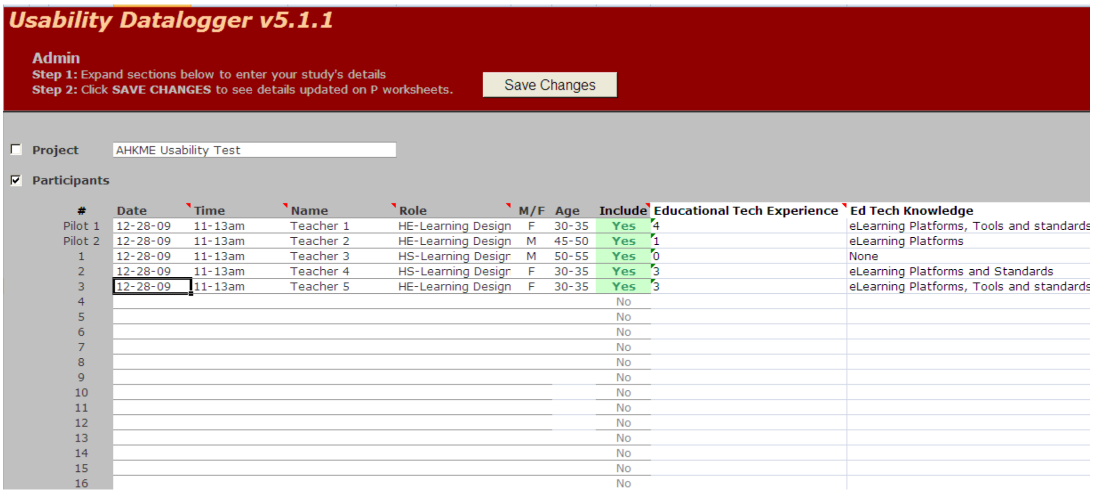
Step 1: Enter tasks and indicate settings for each item.
Step 2: Click **SAVE CHANGES** to see effect on P worksheets.

Save Changes

#	Task *(aka Scenario/Question)*	Chart Label	Scored	TaskCards	Random
1	General :: Login/Registration	Login	yes	Yes	
2	General :: Navigation	Navigation	yes	Yes	
3	General :: Tool finding	Tool Finding	yes	Yes	
4	General :: Help	Help	Yes	Yes	
5	Schema :: import	Import	Yes	Yes	
6	Schema :: select	Select	Yes	Yes	
7	Schema :: create	Create	Yes	Yes	
8	Schema :: list	Schema List	Yes	Yes	
9	Schema :: edit	Schema Edit	Yes	Yes	
10	Wf :: create	Wf.Create	Yes	Yes	
11	Wf :: pending	Wf.Pending	Yes	Yes	
12	Wf :: circulation	Wf.Circulat.	Yes	Yes	
13	Wf :: history	Wf.History	Yes	Yes	
14	General :: Profile	Profile	Yes	Yes	
15	Surveys :: create	Surv.Create	Yes	Yes	
16	Surveys :: edit	Surveys Edit	Yes	Yes	
17	Surveys :: publish	Surv.Publish	Yes	Yes	
18	Surveys :: use	Surveys Use	Yes	Yes	
19	Surveys :: list	Surveys List	Yes	Yes	
20	Recommendation :: view attribute importance	Rec.Attrib	Yes	Yes	
21	Recommendation :: view decision tree	Rec.DT	Yes	Yes	
22	Quality :: view attribte importance	Qual.Attrib	Yes	Yes	

Figure 151. Datalogger Tasks configuration

Figure 152 represents the second step of process, regarding the test participant's configuration. In this tab it is identified the date and time of the test, the name of the participant and role associated, the gender, age, and finally it is indicated the educational technology experience and numbers of years associated.



Usability Datalogger v5.1.1

Admin

Step 1: Expand sections below to enter your study's details
Step 2: Click **SAVE CHANGES** to see details updated on P worksheets.

Save Changes

Project AHKME Usability Test

Participants

#	Date	Time	Name	Role	M/F	Age	Include	Educational Tech Experience	Ed Tech Knowledge
Pilot 1	12-28-09	11-13am	Teacher 1	HE-Learning Design	F	30-35	Yes	4	eLearning Platforms, Tools and standards
Pilot 2	12-28-09	11-13am	Teacher 2	HE-Learning Design	M	45-50	Yes	1	eLearning Platforms
1	12-28-09	11-13am	Teacher 3	HS-Learning Desigr	M	50-55	Yes	0	None
2	12-28-09	11-13am	Teacher 4	HS-Learning Desigr	F	30-35	Yes	3	eLearning Platforms and Standards
3	12-28-09	11-13am	Teacher 5	HE-Learning Design	F	30-35	Yes	3	eLearning Platforms, Tools and standards
4							No		
5							No		
6							No		
7							No		
8							No		
9							No		
10							No		
11							No		
12							No		
13							No		
14							No		
15							No		
16							No		

Figure 152. Datalogger - Participants

The next step is presented in Figure 153 that shows the main feature of the Usability Datalogger, the registration of time measurement per task, the score associated and the Confidence classification. So, it presents a Participant's Record Example.


Usability Datalogger v5.1.1

1
Name Teacher 3
Role HS-Learning Designer 3
Date 28-12-2009
Time 11-13am

Start Timer -:--:-- Clock 0 Total Elapsed (sec)

Task#	Description	Score	Time	Observations	Conf
1	General :: Login/Registration	Easy	98	Fast Login/Registration	7
2	General :: Navigation	Easy	78	No problem navigating	7
3	General :: Tool finding	Medium	110	Some dificculty in finding tools	6
4	General :: Help	Medium	94	Need to have a search mechanism to find more easily a specific word	5
5	Schema :: import	Medium	89	Need to be a litle more quick	6
6	Schema :: select	Easy	72	Lis of schemas	7
7	Schema :: create	Medium	238	Didn't understand very well the feature but it was functional	6
8	Schema :: list	Medium	26	Provides a list of schemas. Needs a search mechanism	5
9	Schema :: edit	Medium	159	Needs to be faster opening the tool	5
10	Wf :: create	Easy	58	Very handy tool allows to create a workflow process	7
11	Wf :: pending	Easy	48	Very easy provides a list of the pending workflows	7
12	Wf :: circulation	Medium	39	Gives the possiblity to see workflows, at firswt sight didn't understant this option, Very similar to pending	5
13	Wf :: history	Easy	43	This one is more necessary because it permits to see the older	6

Figure 153. Datalogger participant record example

Following, it is introduced the charts configuration section. Figure 154 shows the type of charts permitted regarding efectiveness, efficiency and satisfaction.

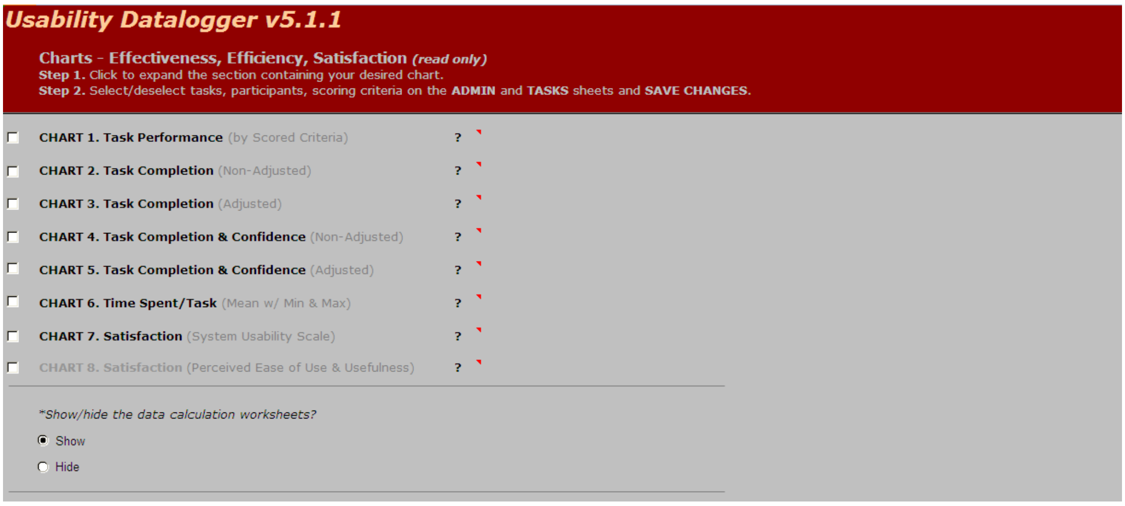


Figure 154. Datalogger charts

Figure 155 presents the registration of Observations, for reviewing participant´s observation on a per-task basis with purpose of analyzing data for common patterns.

Figure 156 is related to “Printing forms” to support the testing process, specifically the Task/Question List for the participants.

Another print form is the Satisfaction Questionnaire to be filled by the participants and that is presented in Figure 157.

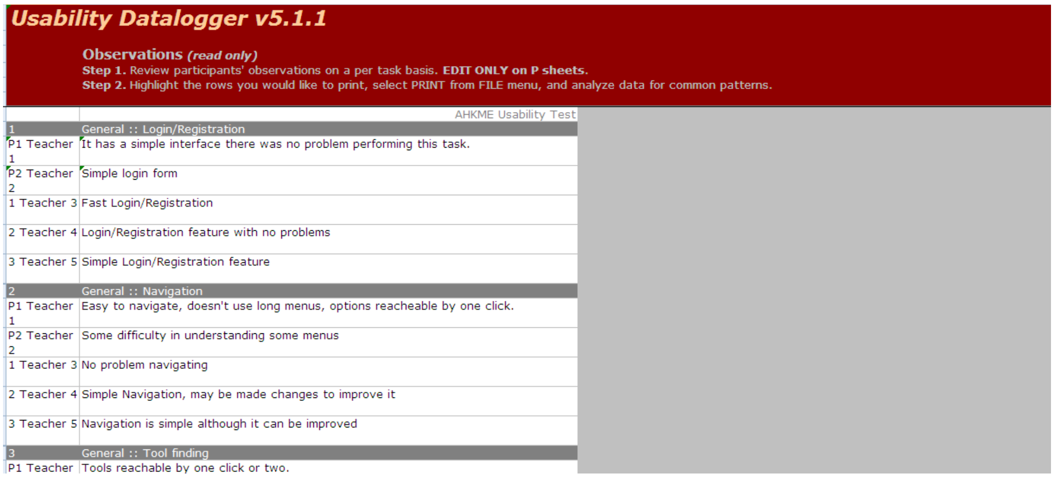


Figure 155. Datalogger observations

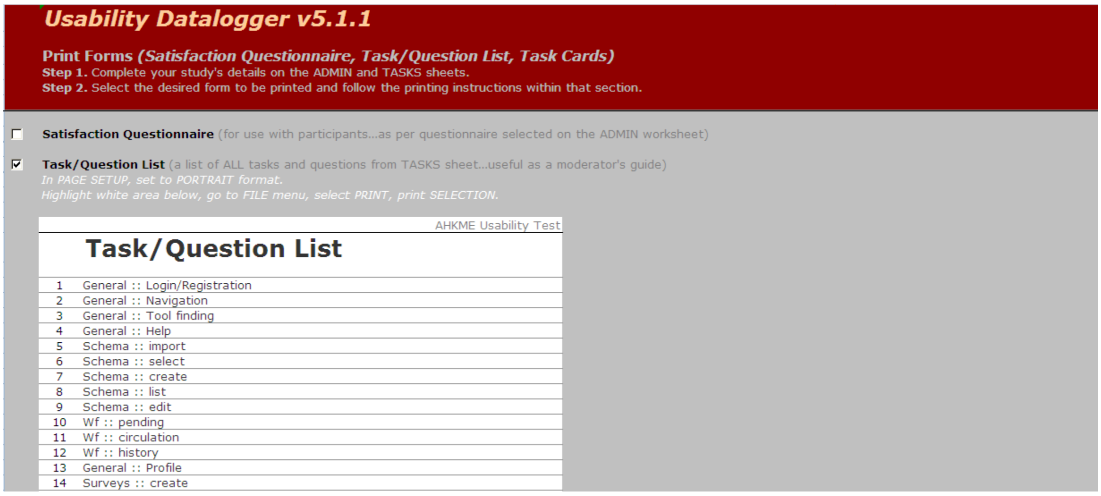


Figure 156. Datalogger task/question list

Figure 157. Datalogger satisfaction questionnaire

Finally, Figure 158 shows Task Cards for helping the test designer and the users.

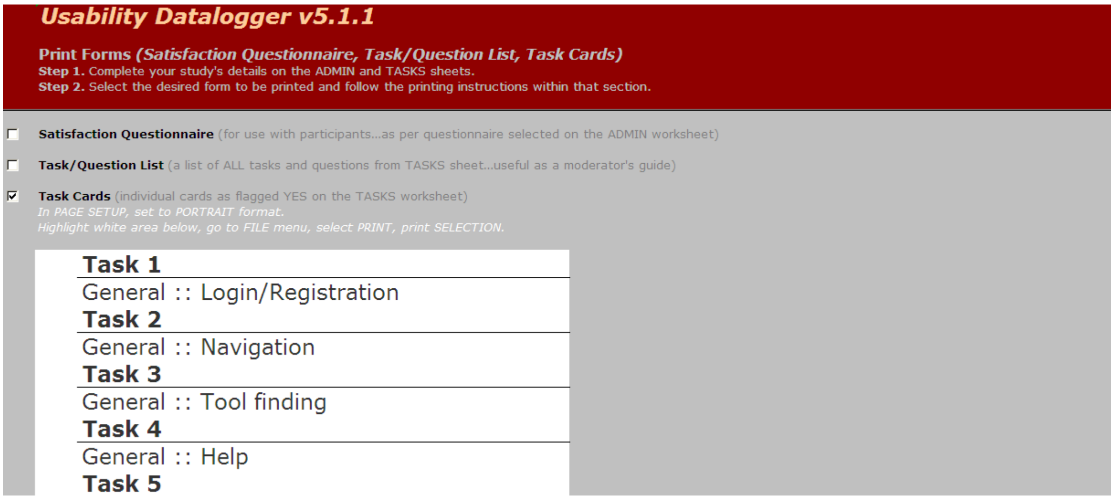


Figure 158. Datalogger tasks cards

2.2. QENGINE WEB PERFORMANCE TOOL

The other test tool is QEngine, a web performance tool. Next some screenshots of this tool are presented. Figure 159 and Figure 160 show the test execution details of AHKME LOM tool for twenty users competitive, such as transaction status, test error details graph, average Response time, user count, page Download time, throughput, etc.

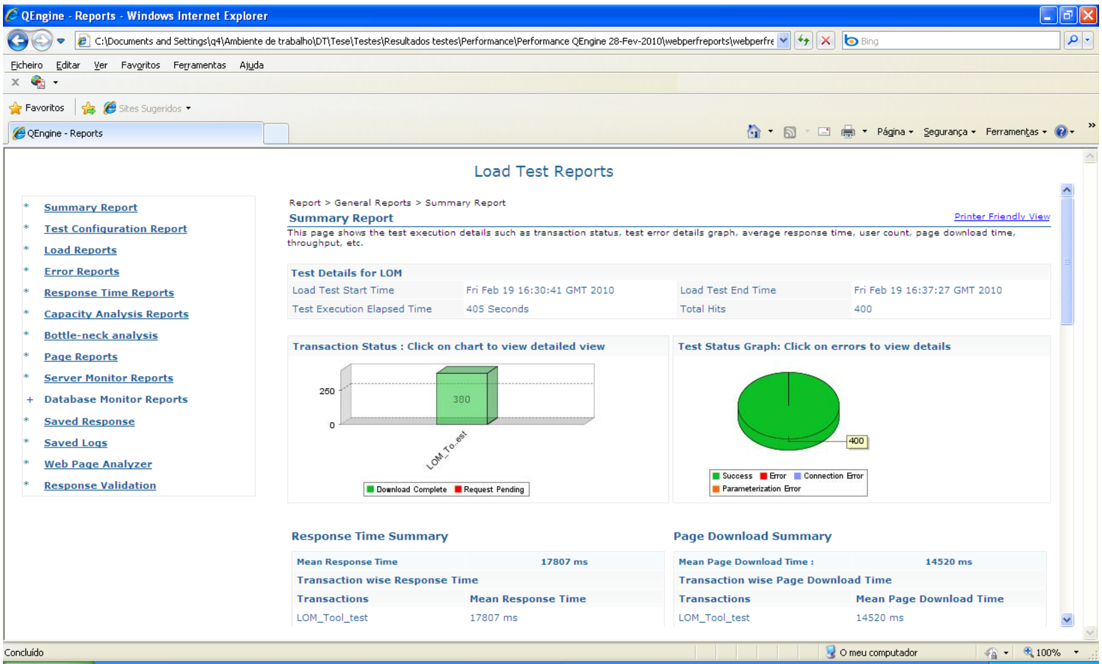


Figure 159. Load Test reports Competitive users

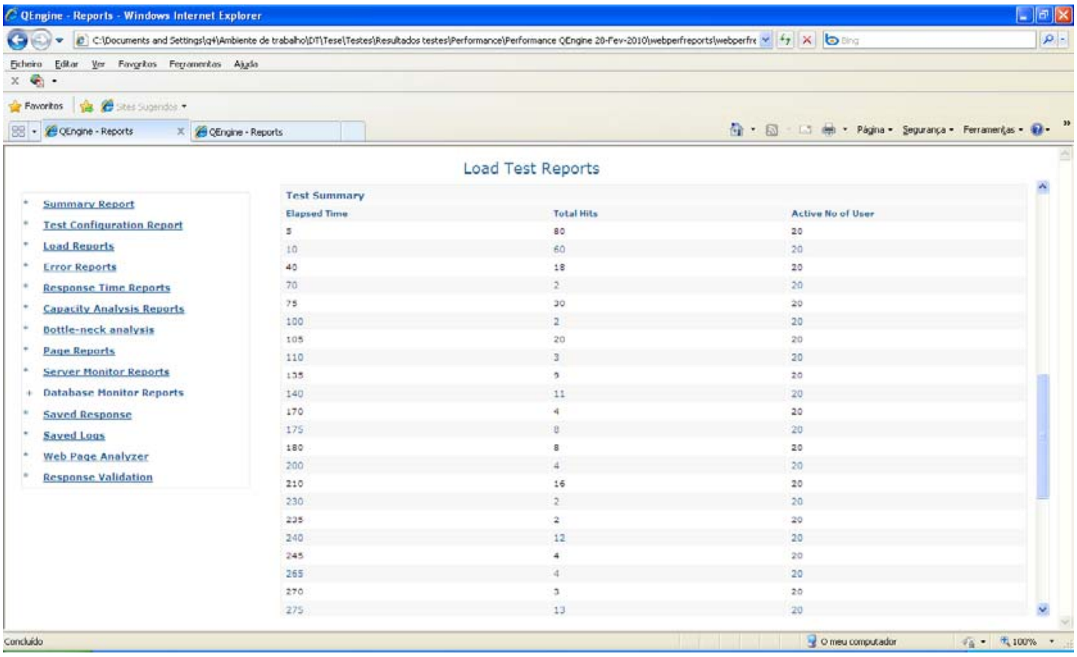


Figure 160. Load test reports – test summary

In the example shown in Figure 159 and Figure 160, the QEngine tool measures the performance results as twenty users simultaneously compete for the same resource.

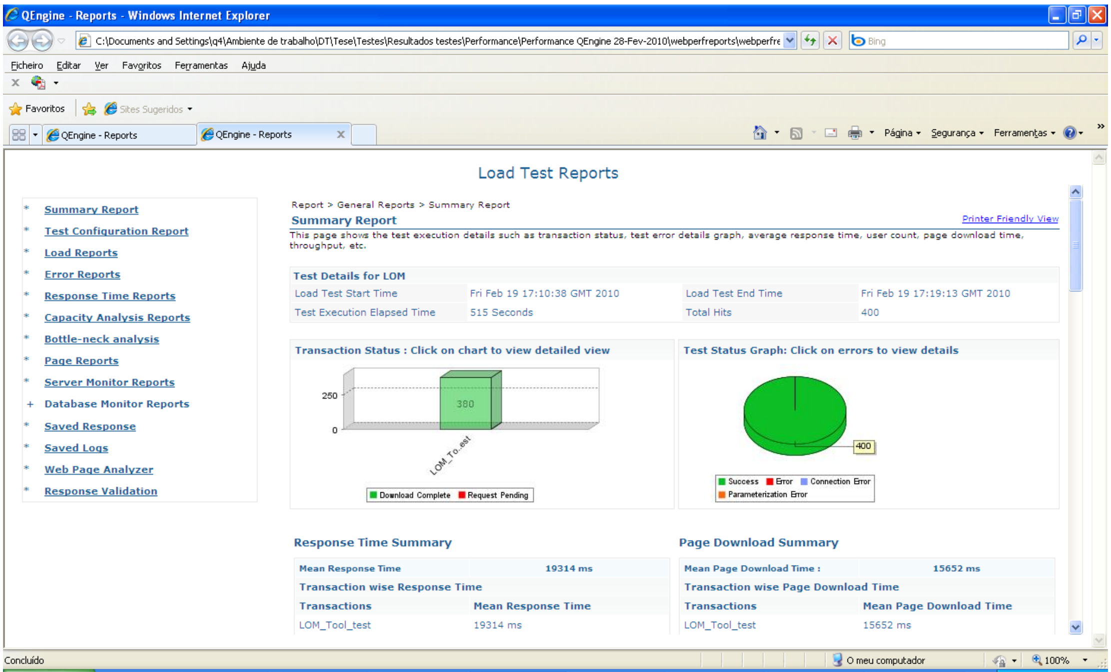


Figure 161. Load test reports Progressive users

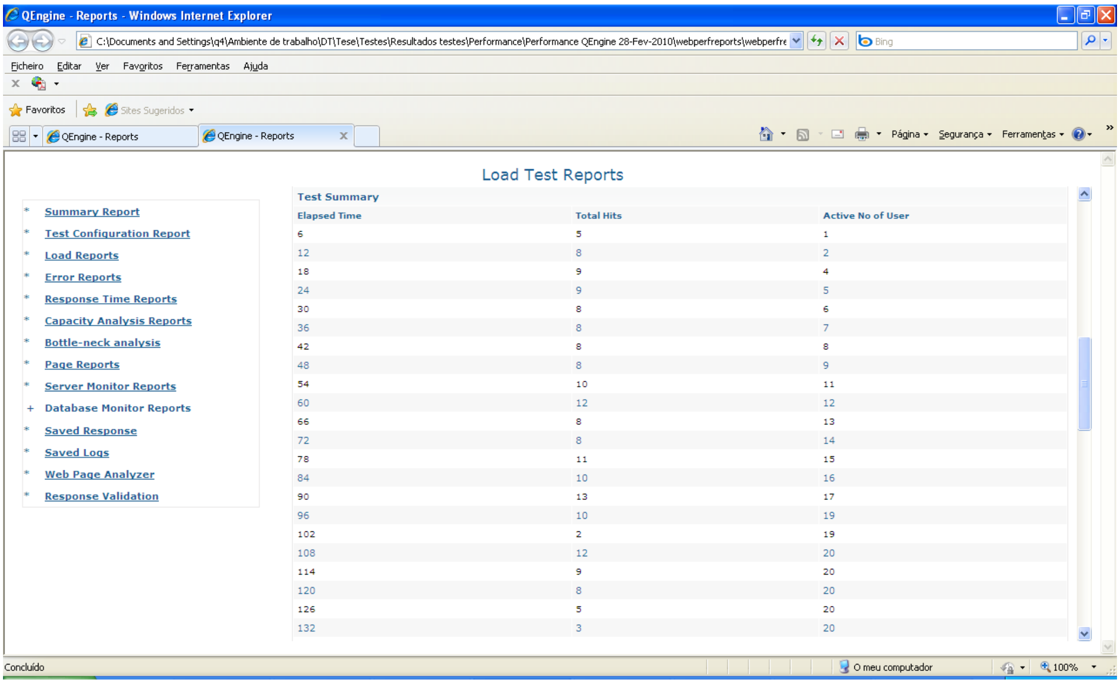


Figure 162. Load test reports test summary

Figure 161 and Figure 162 show the test execution details of AHKME LOM tool for twenty user's progressive, such as transaction status, test error detailsgraph, average Response time, user count, page Download time, throughput, etc.

In this example, the QEngine tool measures the performance results as the number of users increases, up to a limit of twenty.

2.3. EXAMPLE TABLES OF USABILITY DATA

In this point are presented some example tables of data from the usability results that have supported the testing process.

Table 76 presents an example of data table for test results of the Learning designer participants, regarding the usability results per participant and tool, such as Time on task, Error rate, Completion rate, Scoring, Participant error, Completion success, and Confidence, among others.

Table 76. Example of data table for test results of the Learning designer particpants

Learning Designer											
Tool	**General**										
Participant	**Feature**	**Time task (sec)**	**Time task (min)**	**Completion Rate**	**Scoring Datalogger**	**Nº Particip error free**	**Completion Success**	**Nº Particip Complet**	**Completion Rate/Task Time**	**Nº Errors**	**Confidence**
Pilot 1	General :: Help	37,71875	0,628645833	80%	Medium	0	100%	1	127,26%	1	4
P1	General :: Help	49,034375	0,817239583	80%	Medium	0	100%	1	97,89%	1	5
P3	General :: Help	93,578125	1,559635417	80%	Medium	0	100%	1	51,29%	1	5
P4	General :: Help	41,490625	0,691510417	80%	Medium	0	100%	1	115,69%	1	5
P14	General :: Help	56,100987	0,93501645	100%	Easy	1	100%	1	106,95%	0	7
Pilot 1	General :: Login/Registration	88,46582031	1,474430339	100%	Easy	1	100%	1	67,82%	0	7
P1	General :: Login/Registration	79,46582031	1,324430339	100%	Easy	1	100%	1	75,50%	0	7
P3	General :: Login/Registration	98,33300781	1,638883464	100%	Easy	1	100%	1	61,02%	0	7
P4	General :: Login/Registration	90,9890625	1,516484375	100%	Easy	1	100%	1	65,94%	0	7
P14	General :: Login/Registration	96,109454	1,601824233	100%	Easy	1	100%	1	62,43%	0	7
Pilot 1	General :: Navigation	28,171875	0,46953125	100%	Easy	1	100%	1	212,98%	0	7
P1	General :: Navigation	36,6234375	0,610390625	80%	Medium	0	100%	1	131,06%	1	6
P3	General :: Navigation	78,02734375	1,300455729	100%	Easy	1	100%	1	76,90%	0	7
P4	General :: Navigation	30,9890625	0,516484375	100%	Easy	1	100%	1	193,62%	0	6
P14	General :: Navigation	25,366467	0,42277445	100%	Easy	1	100%	1	236,53%	0	7
Pilot 1	General :: Profile	30,68301392	0,511383565	100%	Easy	1	100%	1	195,55%	0	7
P1	General :: Profile	39,88791809	0,664798635	100%	Easy	1	100%	1	150,42%	0	7
P3	General :: Profile	38,215677	0,63692795	100%	Easy	1	100%	1	157,00%	0	7
P4	General :: Profile	33,75131531	0,562521922	100%	Easy	1	100%	1	177,77%	0	7
P14	General :: Profile	39,623576	0,660392933	100%	Easy	1	100%	1	151,43%	0	7
Pilot 1	General :: Tool finding	138,3398438	2,305664063	100%	Easy	1	100%	1	43,37%	0	7
P1	General :: Tool finding	179,8417969	2,997363281	80%	Medium	0	100%	1	26,69%	1	5
P3	General :: Tool finding	110,21875	1,836979167	80%	Medium	0	100%	1	43,55%	1	6
P4	General :: Tool finding	152,1738281	2,536230469	100%	Easy	1	100%	1	39,43%	0	7

Tool	General										
P14	General :: Tool finding	187,54664	3,125777333	100%	Easy	1	100%	1	31,99%	0	7
AGGREGATE											
Pilot 1	General	323,379303	5,38965505	96,00%			100,00%		17,81%	1	6,40
P1	General	384,8533478	6,414222463	88,00%			100,00%		13,72%	3	6,00
P3	General	418,3729036	6,972881726	92,00%			100,00%		13,19%	2	6,40
P4	General	349,3938934	5,823231557	96,00%			100,00%		16,49%	1	6,40
P14	General	404,747124	6,7457854	100,00%			100,00%		14,82%	0	7,00

Tool	Schema										
Participante	**Feature**	**Time task (sec)**	**Time task (min)**	**Completion Rate**	**Scoring Datalogger**	**Nº Particip error free**	**Completion Success**	**Nº Particip Complet**	**Completion Rate/Task Time**	**Nº Errors**	**Confidence**
Pilot 1	Schema :: create	511,21875	8,5203125	100%	Easy	1	100%	1	11,74%	0	6
P1	Schema :: create	664,584375	11,07640625	60%	Hard	0	100%	1	5,42%	1	4
P3	Schema :: create	237,9492188	3,965820313	80%	Medium	0	100%	1	20,17%	1	6
P4	Schema :: create	536,812368	8,9468728	80%	Medium	0	100%	1	8,94%	1	6
P14	Schema :: create	534,643234	8,910720567	80%	Medium	0	100%	1	8,98%	1	6
Pilot 1	Schema :: edit	116,7929688	1,946549479	80%	Medium	0	100%	1	41,10%	1	6
P1	Schema :: edit	151,8308594	2,530514323	80%	Medium	0	100%	1	31,61%	1	5
P3	Schema :: edit	159,1210938	2,652018229	80%	Medium	0	100%	1	30,17%	1	5
P4	Schema :: edit	121,098345	2,01830575	80%	Medium	0	100%	1	39,64%	1	6
P14	Schema :: edit	146,311751	2,438529183	80%	Medium	0	100%	1	32,81%	1	7
Pilot 1	Schema :: import	69,140625	1,15234375	100%	Easy	1	100%	1	86,78%	0	6
P1	Schema :: import	89,8828125	1,498046875	100%	Easy	1	100%	1	66,75%	0	6
P3	Schema :: import	89,0625	1,484375	80%	Medium	0	100%	1	53,89%	1	6
P4	Schema :: import	76,0546875	1,267578125	80%	Medium	0	100%	1	63,11%	1	6
P14	Schema :: import	73,731236	1,228853933	100%	Easy	1	100%	1	81,38%	0	7
Pilot 1	Schema :: list	22,26171875	0,371028646	100%	Easy	1	100%	1	269,52%	0	7
P1	Schema :: list	28,94023438	0,48233724	100%	Easy	1	100%	1	207,32%	0	7
P3	Schema :: list	25,765625	0,429427083	80%	Medium	0	100%	1	186,29%	1	5

Tool	**General**										
P4	Schema :: list	24,48789063	0,40813151	100%	Easy	1	100%	1	245,02%	0	7
P14	Schema :: list	26,93667969	0,448944661	100%	Easy	1	100%	1	222,74%	0	7
Pilot 1	Schema :: select	12,296875	0,204947917	100%	Easy	1	100%	1	487,93%	0	7
P1	Schema :: select	15,9859375	0,266432292	100%	Easy	1	100%	1	375,33%	0	6
P3	Schema :: select	72,07421875	1,201236979	100%	Easy	1	100%	1	83,25%	0	7
P4	Schema :: select	13,5265625	0,225442708	100%	Easy	1	100%	1	443,57%	0	6
P14	Schema :: select	25,37632	0,422938667	100%	Easy	1	100%	1	236,44%	0	7
AGGREGATE											
Pilot 1	Schema	731,7109375	12,19518229	96,00%			100,00%		7,87%	1	6,40
P1	Schema	951,2242188	15,85373698	88,00%			100,00%		5,55%	2	5,60
P3	Schema	583,9726563	9,732877604	84,00%			100,00%		8,63%	4	5,80
P4	Schema	771,9798536	12,86633089	88,00%			100,00%		6,84%	3	6,20
P14	Schema	806,9992207	13,44998701	92,00%			100,00%		6,84%	2	6,80

Similar Tables for the other tools and features…………

Tool	Search										
Participante	**Feature**	**Time task (sec)**	**Time task (min)**	**Completion Rate**	**Scoring Datalogger**	**Nº Particip error free**	**Completion Success**	**Nº Particip Complet**	**Completion Rate/Task Time**	**Nº Errors**	**Confidence**
Pilot 1	Search	28,952806	0,48254677	100%	Easy	1	100%	1	207,23%	0	7
P1	Search	51,557271	0,85928785	80%	Medium	0	100%	1	93,10%	1	6
P3	Search	46,373795	0,772896586	80%	Medium	0	100%	1	103,51%	1	6
P4	Search	30,454611	0,507576848	80%	Medium	0	100%	1	157,61%	1	6
P14	Search	27,452786	0,457546433	100%	Easy	1	100%	1	218,56%	0	6
AGGREGATE											
Pilot 1	Search	28,952806	0,48254677	100%			100,00%		207,23%	1	7
P1	Search	51,557271	0,85928785	80%			100,00%		93,10%	1	6
P3	Search	46,373795	0,772896586	80%			100,00%		103,51%	1	6
P4	Search	30,454611	0,507576848	80%			100,00%		157,61%	1	6
P14	Search	27,452786	0,457546433	100%			100,00%		218,56%	1	6

Table 77. Example of overall data table per profile comparing to metric goal

Overall Comparison Learning Designer per Tool - 1ª Phase

TOOL	Results Time task (min)	Scenarios Time task - Post-task Questionaire (min)	Completion rate	Scenario Completion rate	Error rate	Scenario Error rate	SUS	Scenario SUS	Response time	Scenario Response time	Download time	Scenario Download time
TOTAL INTEROPERABILITY	5,14	4,00	94,40%	90,00%	28,00%	20,00%	71,00%	70,00%	2,27	1,00	1,96	10,00
TOTAL QUALITY	2,08	3,00	89,60%	90,00%	48,00%	20,00%			0,44	1,00	0,07	10,00
TOTAL RECOMMENDATION	1,42	3,00	95,00%	90,00%	25,00%	20,00%			0,45	1,00	0,05	10,00
TOTAL SURVEY	4,05	5,00	90,00%	90,00%	50,00%	20,00%			0,26	1,00	0,05	10,00
TOTAL GENERAL	6,27	4,00	94,67%	90,00%	26,67%	20,00%			0,92	1,00	0,14	10,00
TOTAL SCHEMA	12,82	8,00	90,00%	90,00%	50,00%	20,00%			5,85	1,00	5,22	10,00
TOTAL WF	3,10	4,00	96,00%	90,00%	40,00%	20,00%			0,25	1,00	0,04	10,00
TOTAL RESOURCES	8,34	6,00	91,20%	90,00%	40,00%	20,00%			0,88	1,00	0,01	10,00
TOTAL COMMUNICATION & SHARING	4,26	4,00	88,00%	90,00%	60,00%	20,00%			1,24	1,00	0,31	10,00
TOTAL SEARCH	0,62	2,00	91,20%	90,00%	40,00%	20,00%			0,45	1,00	0,15	10,00
TOTAL SYSTEM	**48,09**	**43,00**	**92,01%**	**90,00%**	**40,77%**	**20,00%**	**71,00%**	**70,00%**	**1,30**	**1,00**	**0,80**	**10,00**

Overall Comparison Learning Instructor per Tool - 1ª Phase

TOOL	Results Time task (min)	Scenarios Time task - Post-task Questionaire (min)	Completion rate	Scenario Completion rate	Error rate	Scenario Error rate	SUS	Scenario SUS	Response time	Scenario Response time	Download time	Scenario Download time
TOTAL SURVEY	5,70	4,00	96,00%	90,00%	16,00%	20,00%	70,50%	70,00%	0,26	1,00	0,05	10,00
TOTAL LOM	8,79	8,00	94,00%	90,00%	30,00%	20,00%			17,81	1,00	14,52	10,00
TOTAL LD	20,48	13,00	98,67%	90,00%	6,67%	20,00%			4,54	1,00	1,60	10,00
TOTAL GENERAL	6,28	4,00	95,00%	90,00%	25,00%	20,00%			0,92	1,00	0,14	10,00
TOTAL SCHEMA	3,53	5,00	91,20%	90,00%	44,00%	20,00%			5,85	1,00	5,22	10,00
TOTAL WF	1,21	3,00	88,80%	90,00%	52,00%	20,00%			0,25	1,00	0,04	10,00
TOTAL RESOURCES	5,33	4,00	95,20%	90,00%	24,00%	20,00%			0,88	1,00	0,01	10,00
TOTAL COMMUNICATION & SHARING	4,73	4,00	88,00%	90,00%	60,00%	20,00%			1,24	1,00	0,31	10,00
TOTAL SEARCH	0,43	2,00	96,00%	90,00%	20,00%	20,00%			0,45	1,00	0,15	10,00
TOTAL SYSTEM	**56,48**	**47,00**	**93,65%**	**90,00%**	**30,85%**	**20,00%**	**70,50%**	**70,00%**	**3,58**	**1,00**	**2,45**	**10,00**

Overall Comparison Student per Tool - 1ª Phase													
TOOL		Results Time task (min)	Scenarios Time task - Post-task Questionaire (min)	Completion rate	Scenario Completion rate	Error rate	Scenario Error rate	SUS	Scenario SUS	Response time	Scenario Response time	Download time	Scenario Download time
TOTAL SURVEY		6,27	6,00	90,67%	90,00%	36,67%	20,00%	54,50%	70,00%	0,26	1,00	0,05	10,00
TOTAL GENERAL		15,87	10,00	94,00%	90,00%	20,00%	20,00%			0,92	1,00	0,14	10,00
TOTAL RESOURCES		13,04	10,00	98,00%	90,00%	10,00%	20,00%			0,88	1,00	0,01	10,00
TOTAL COMMUNICATION & SHARING		4,59	7,00	92,00%	90,00%	40,00%	20,00%			1,24	1,00	0,31	10,00
TOTAL SYSTEM		**39,78**	**33,00**	**93,67%**	**90,00%**	**26,67%**	**20,00%**	**54,50%**	**70,00%**	**0,82**	**1,00**	**0,13**	**10,00**

Overall Comparison Technical per Tool - 1ª Phase													
TOOL		Results Time task (min)	Scenarios Time task - Post-task Questionaire (min)	Completion rate	Scenario Completion rate	Error rate	Scenario Error rate	SUS	Scenario SUS	Response time	Scenario Response time	Download time	Scenario Download time
TOTAL ADMINISTRATION		13,46	13,00	94,67%	90,00%	26,67%	20,00%	68,50%	70,00%	0,37	1,00	0,11	10,00
TOTAL GENERAL		17,32	13,00	93,00%	90,00%	35,00%	20,00%			0,92	1,00	0,14	10,00
TOTAL SYSTEM		**30,77**	**26,00**	**93,83%**	**90,00%**	**30,83%**	**20,00%**	**68,50%**	**70,00%**	**0,65**	**1,00**	**0,13**	**10,00**

Table 77 shows an example of overall data table per profile comparing to the metric/scenario goal. The results are presented per tool, regarding the Time on task, Completion rate, Error rate, SUS, and also performance results for the Response and Download time.

2.4. EXAMPLE GRAPHS OF USABILITY AND PERFORMANCE DATA

This section includes examples of charts regarding usability and performance data.

2.4.1. PHASE 1 GRAPHS

The following graphs will be presented as examples of the usability test results and performance:

- Task Completion success (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted).
- Task Completion rate.
- Task Completion success & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence.
- Completion rate/Time task.
- Satisfaction.
- Web performance.
    - Response time.
    - Download time.

Some of the graphs are presented per profile, including Learning designer, Instructor Student and Technical.

2.4.1.1. Learning designer

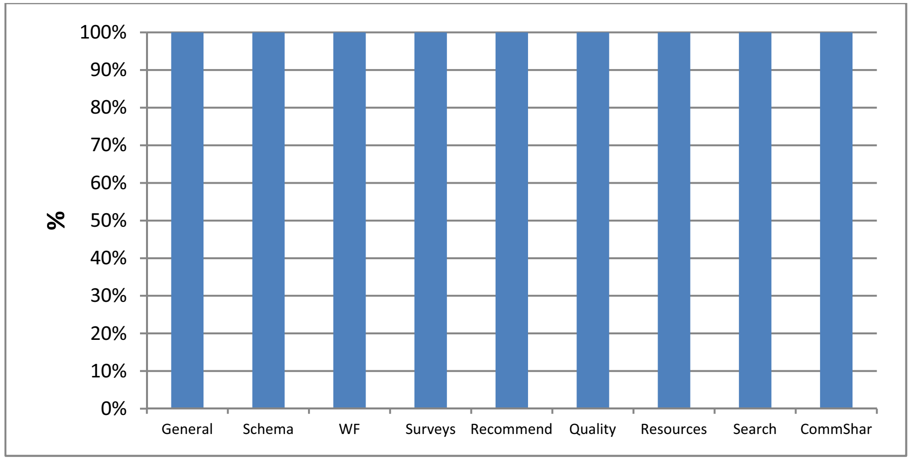


Figure 163. Task Completion success (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted)

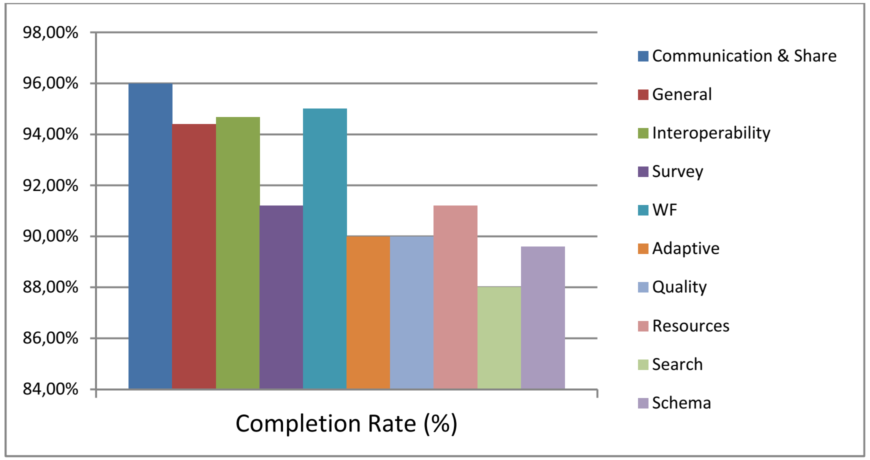


Figure 164. Completion rate

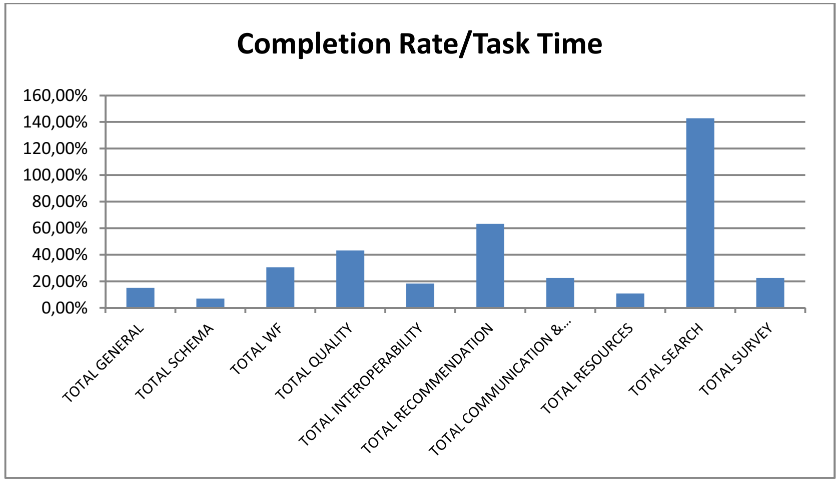


Figure 165. Completion rate/Task time – Learning designer – Phase 1

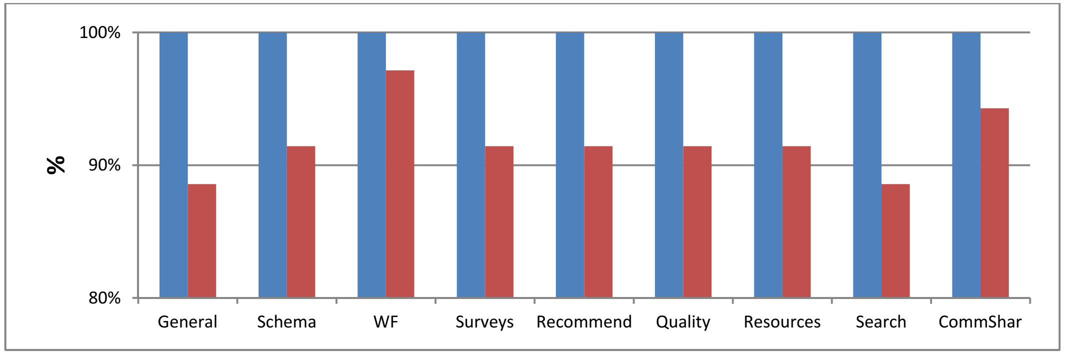


Figure 166. Task Completion success & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence Ratings)

2.4.1.2. Learning Instructor

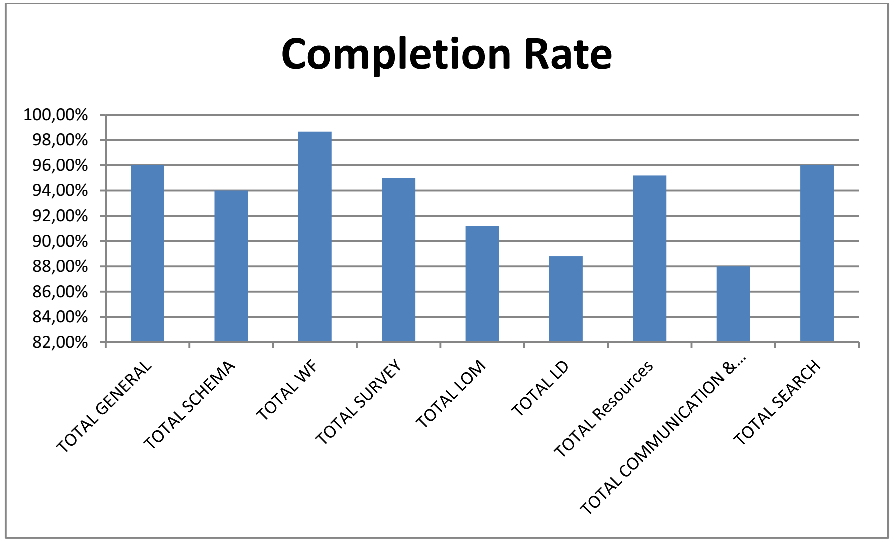


Figure 167. Task completion rate – Learning instructor – Phase 1

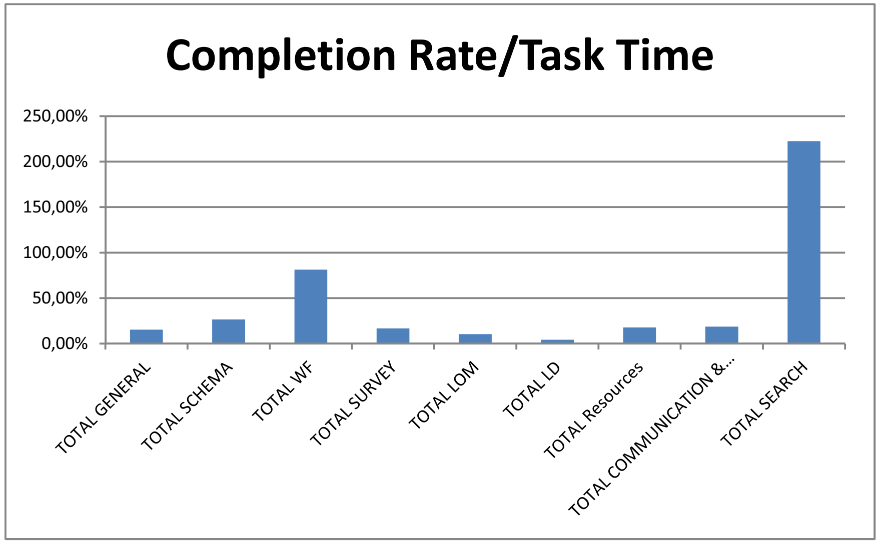


Figure 168. Completion rate/task time – Learning instructor – Phase 1

2.4.1.3. Student

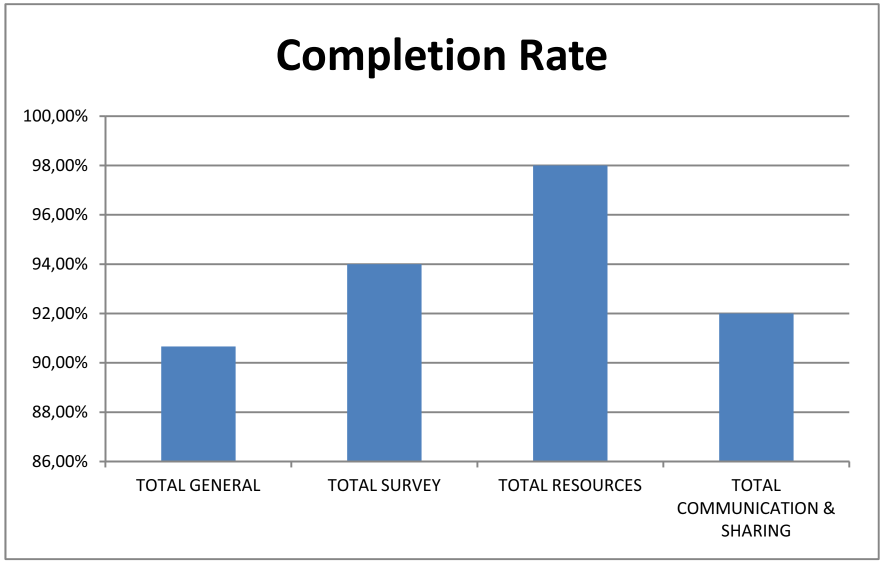


Figure 169. Completion rate – Student – Phase 1

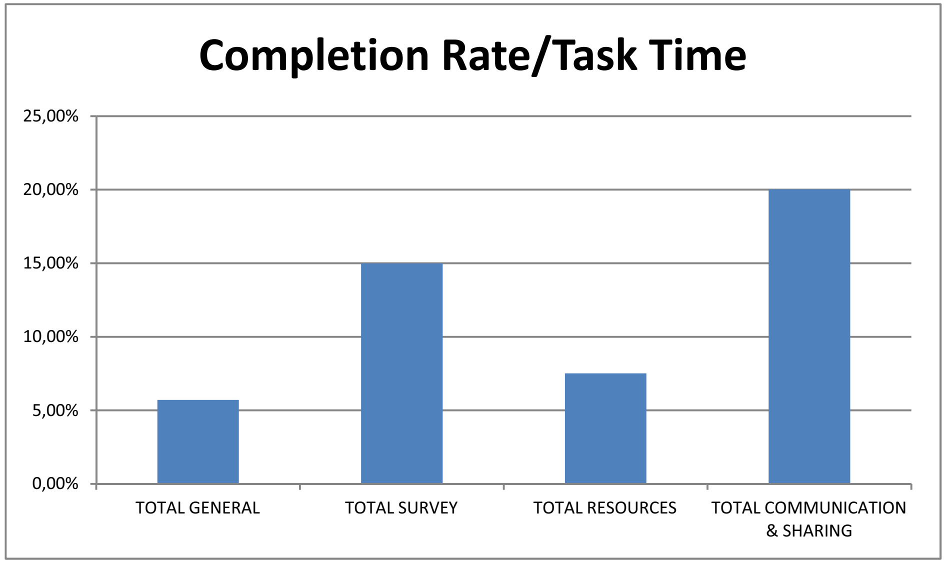


Figure 170. Completion rate/Task time – Student – Phase 1

2.4.1.4. Technical

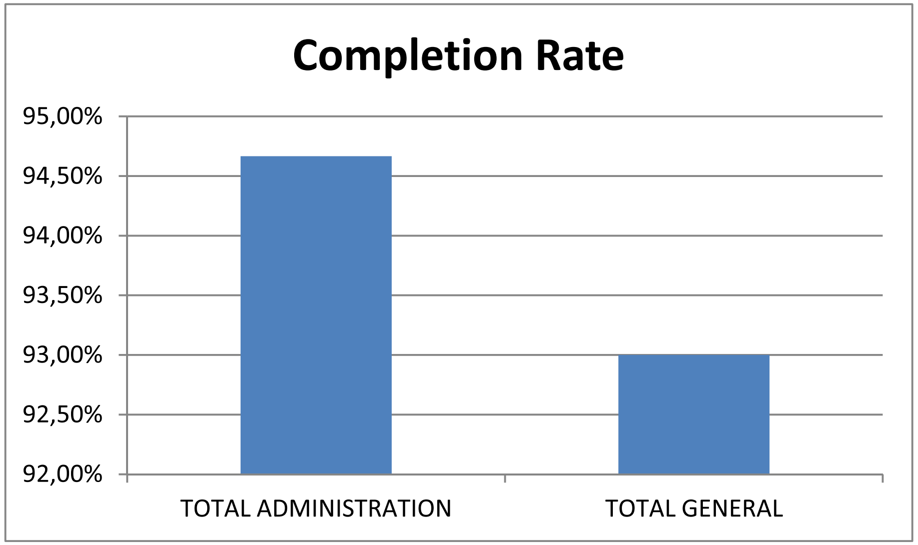


Figure 171. Completion rate -Technical - Phase 1

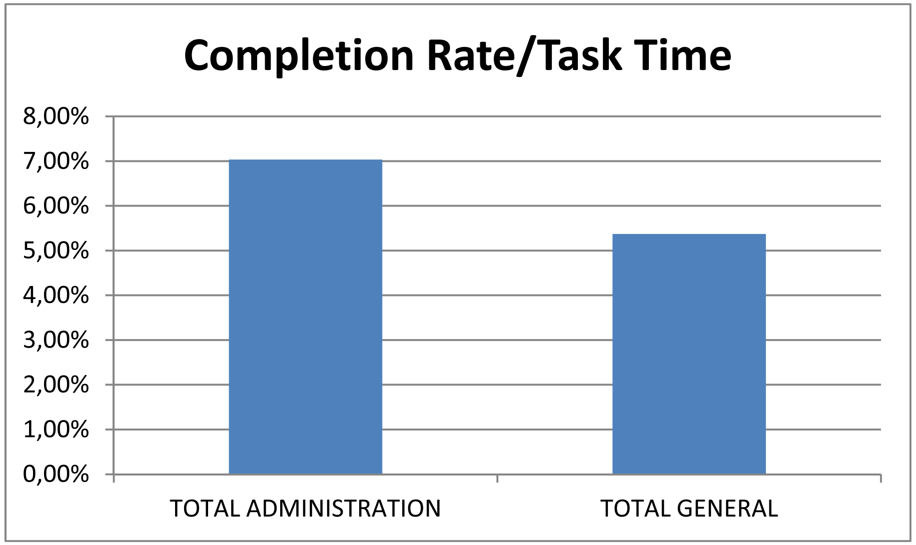


Figure 172. Completion rate/Task time – Technical – Phase 1

2.4.1.5. Overall Graph by System - Tools

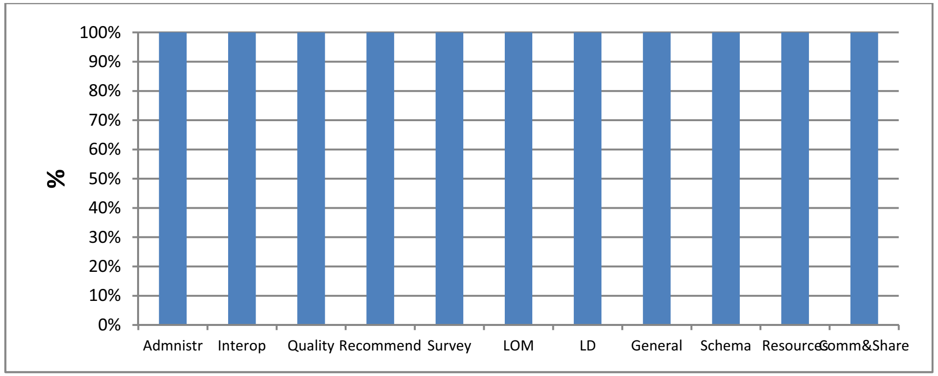


Figure 173. Task Completion (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted)

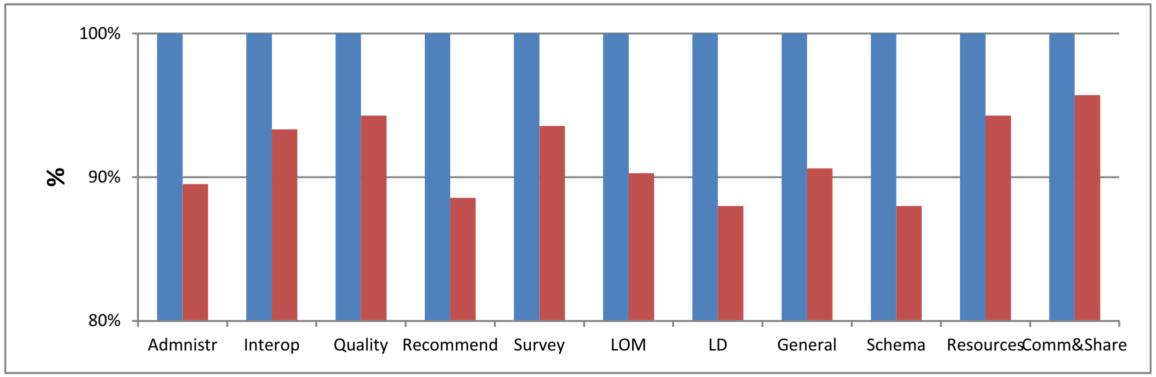


Figure 174. Task Completion & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence Ratings)

2.4.1.6. Satisfaction Graphs

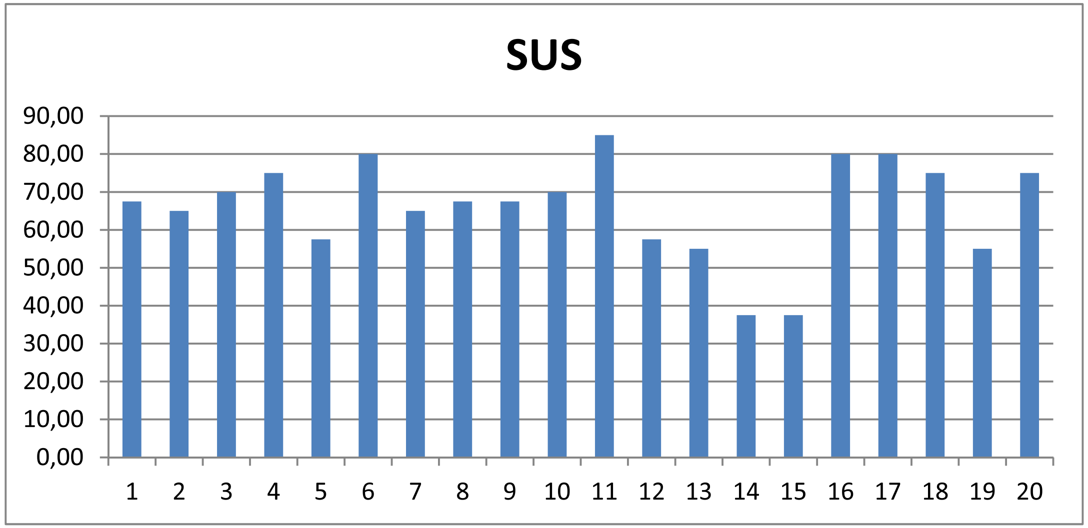
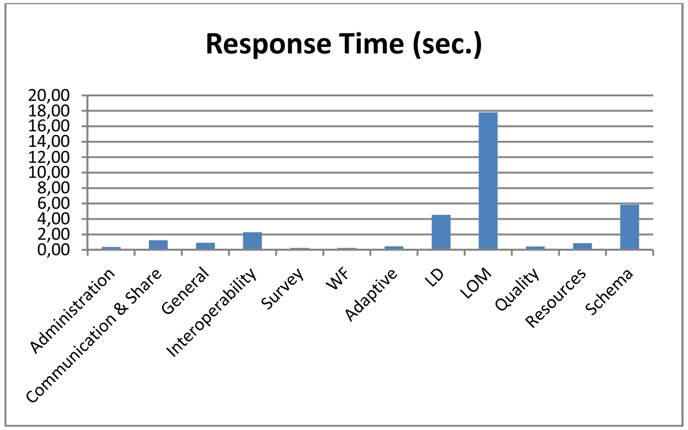
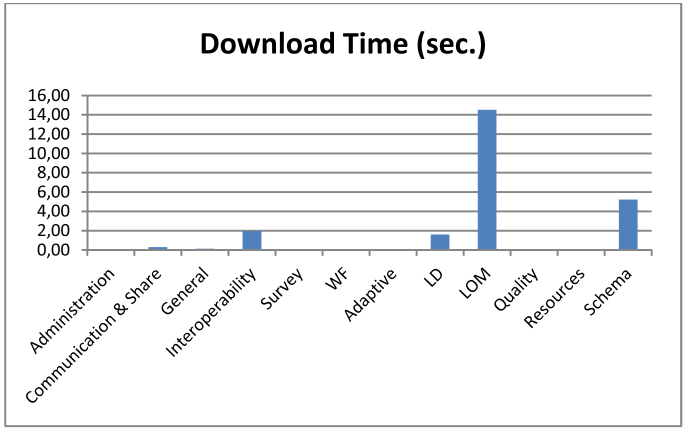


Figure 175. SUS satisfaction graph per Participant

2.4.1.7. Web Performance Graphs





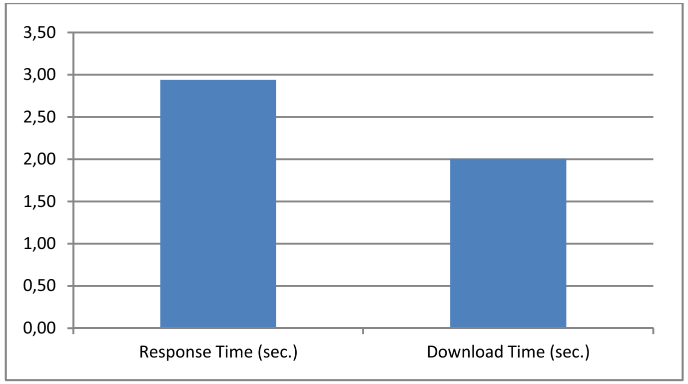


Figure 176. Response and Download time graph, overall performance graph

2.4.2. PHASE 2 GRAPHS

2.4.2.1. Learning designer

Figure 177. Task Completion (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted)

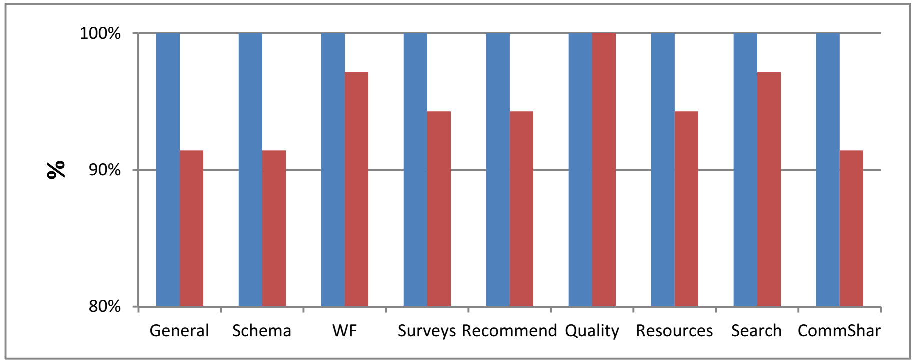


Figure 178. Task Completion & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence Ratings)

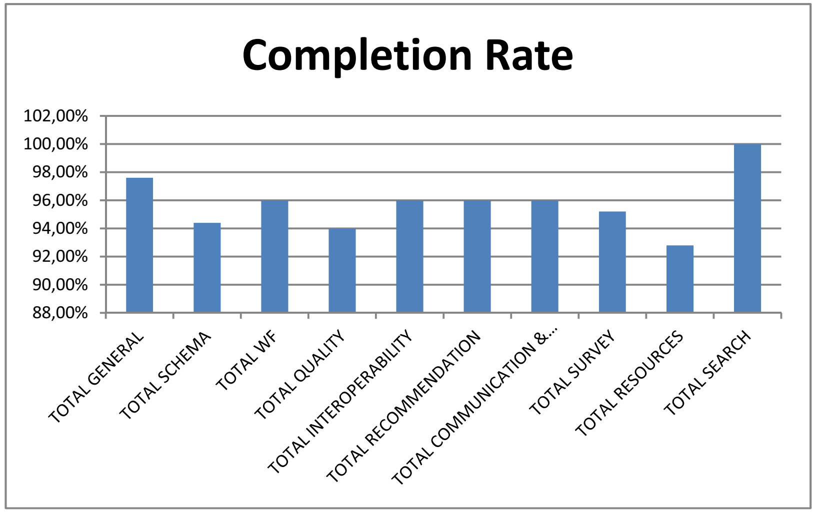


Figure 179. Completion rate – Learning designer – Phase 2

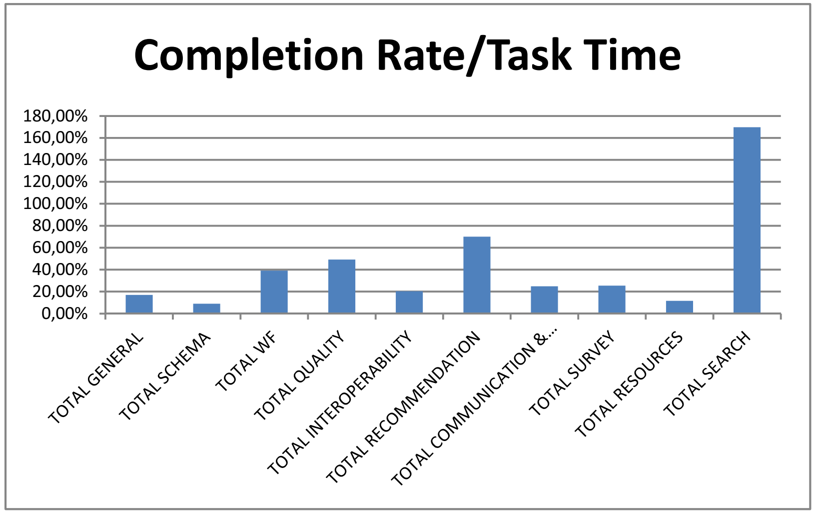


Figure 180. Completion rate/Task time- Learning designer – Phase 2

2.4.2.2. Learning Instructor

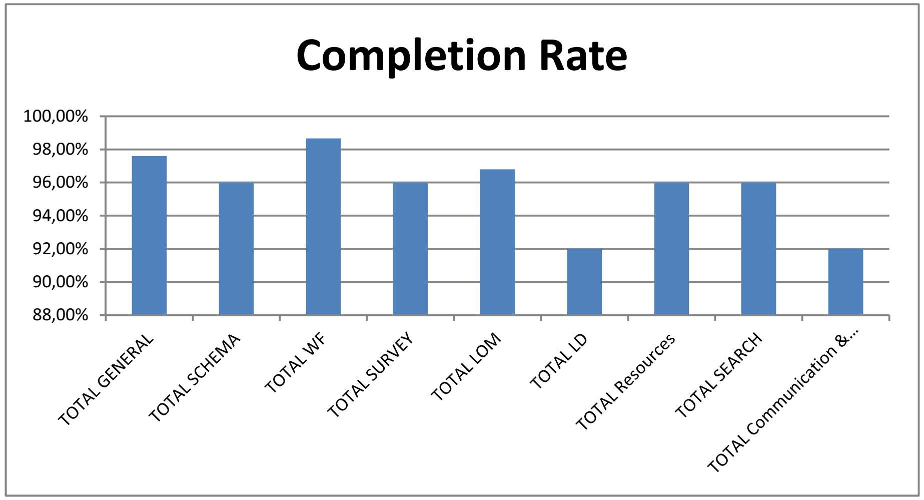


Figure 181. Completion rate – Learning instrcutor – Phase 2

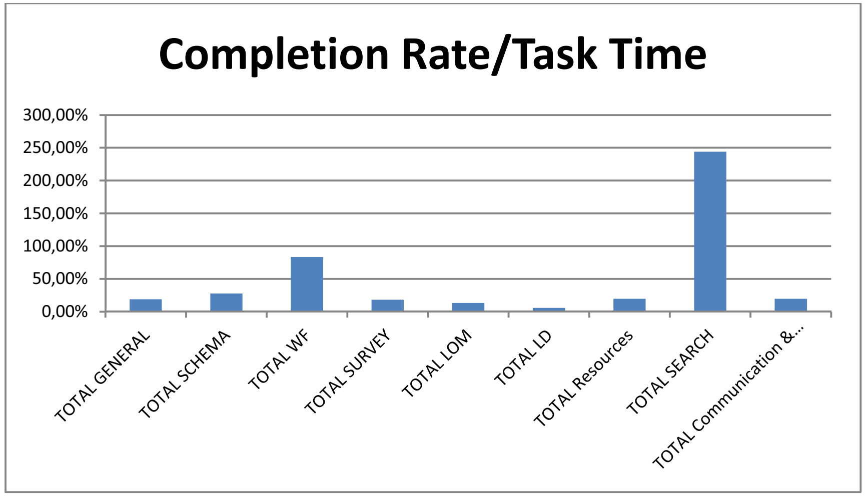


Figure 182. Completion rate/Task time- Learning instructor – Phase 2

2.4.2.3. Student

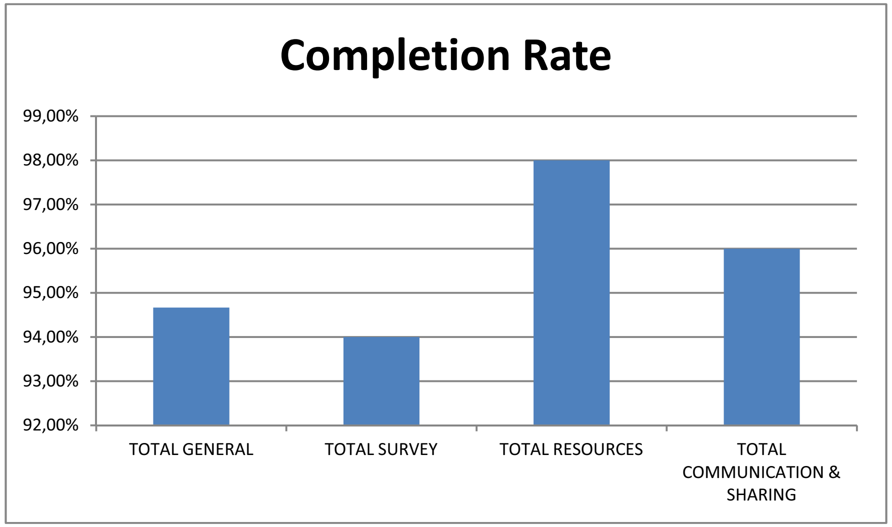


Figure 183. Completion rate – Student – Phase 2

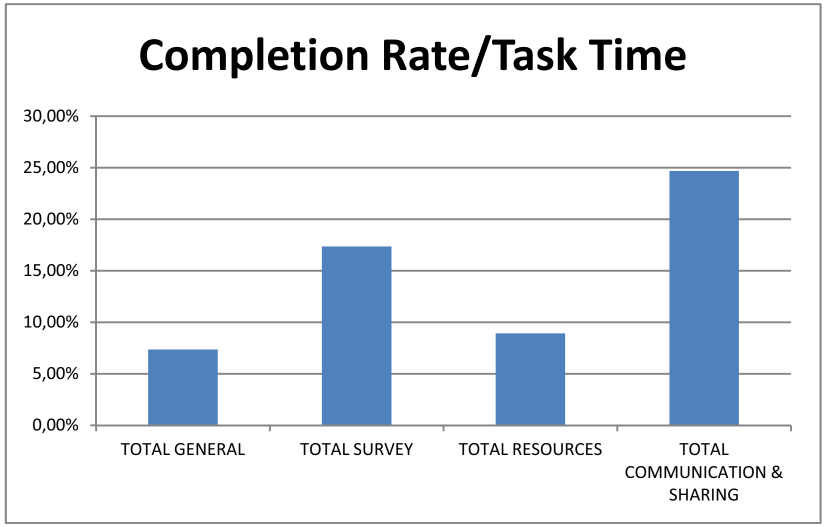


Figure 184. Completion rate/Time task – Student – Phase 2

2.4.2.4. Technical

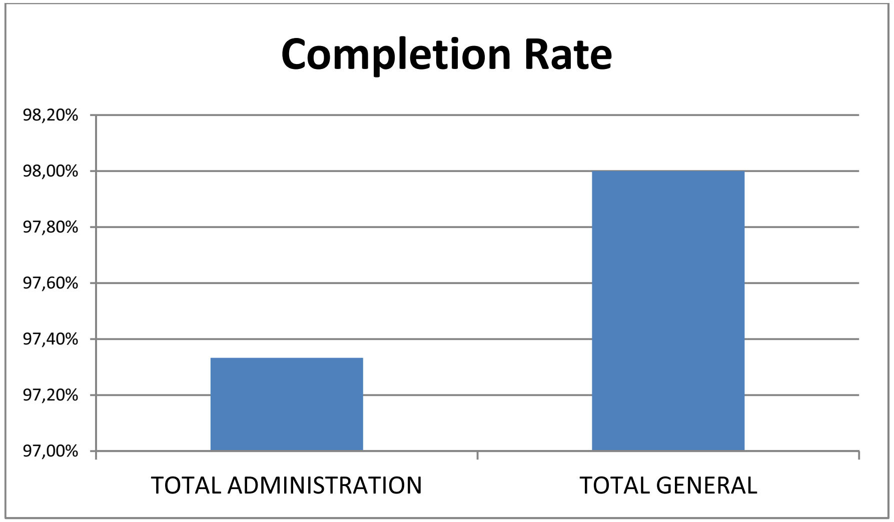


Figure 185. Completion rate – Technical – Phase 2

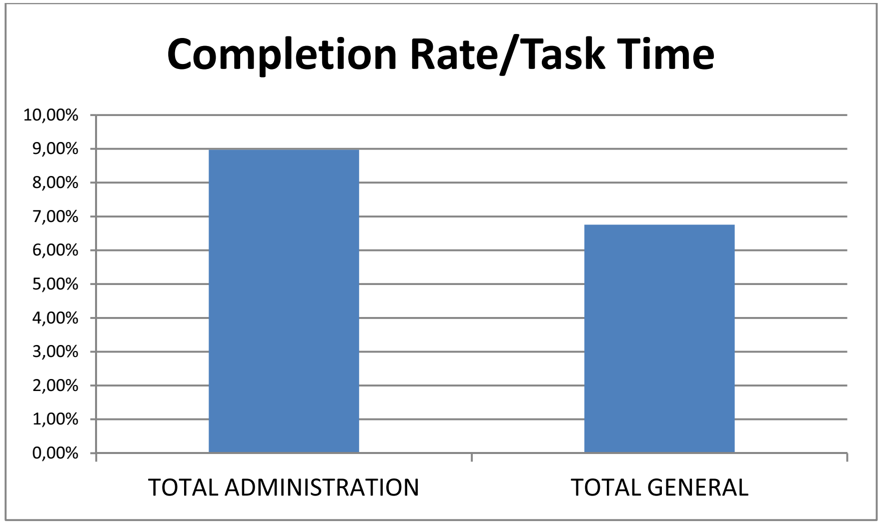


Figure 186. Completion rate/Time task – Technical – Phase 2

2.4.3. Overall Graphs by System – Tools and profile

The following graphs will be presented:

- ❖ Task Completion (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted).
- ❖ Task Completion rate and Completion rate/Time task.
- ❖ Task Completion & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence.
- ❖ Satisfaction and Web Performance.

2.4.3.1. Phase 1

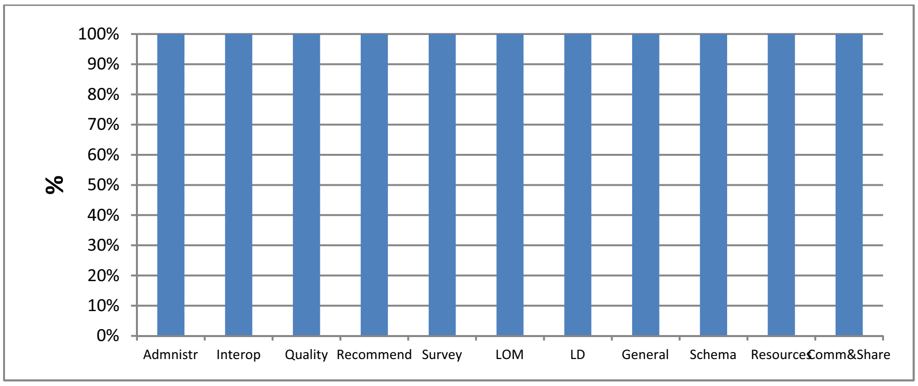


Figure 187. Task Completion (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted)

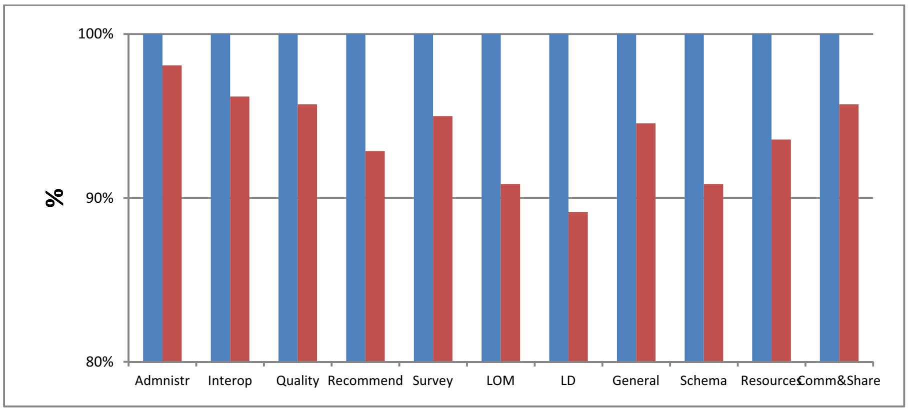
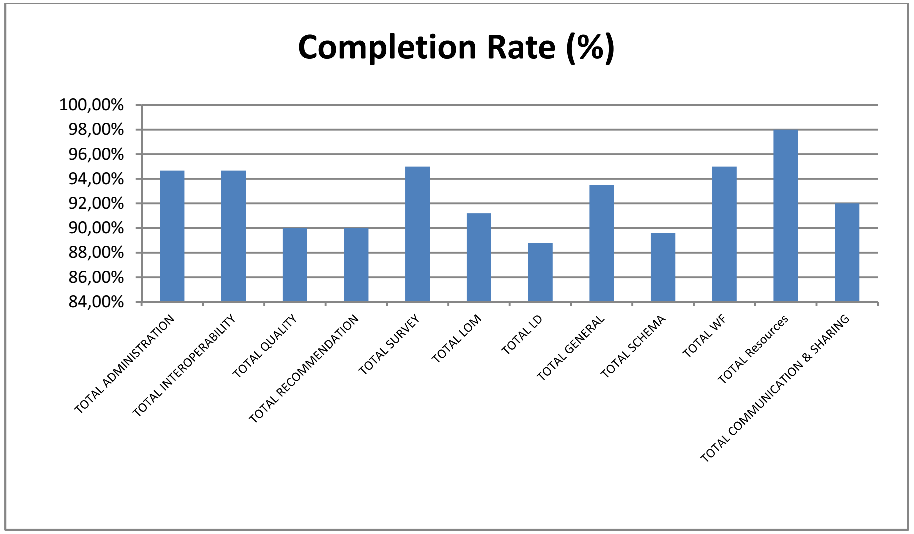


Figure 188. Task Completion & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence Ratings)



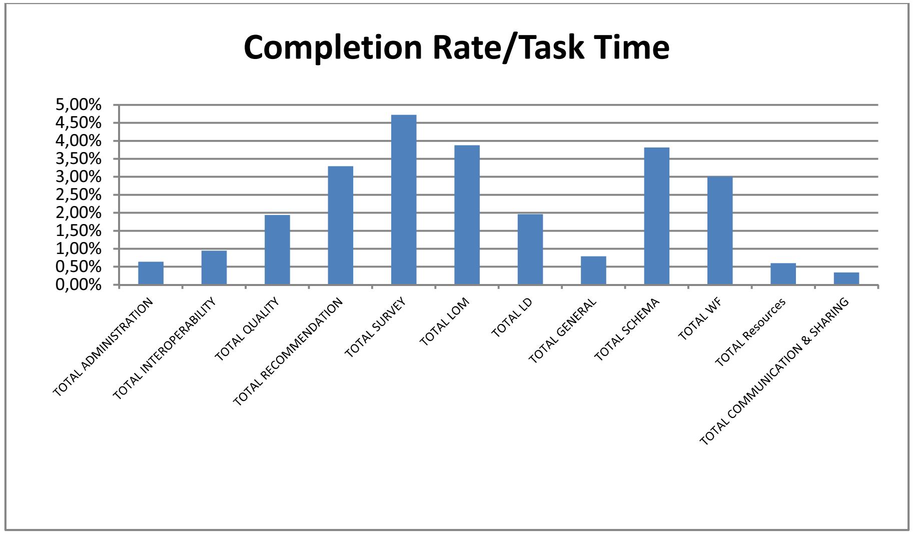


Figure 189. Task Completion rate and Completion/Time task Overall Phase 1 graphs

2.4.3.2. Phase 2

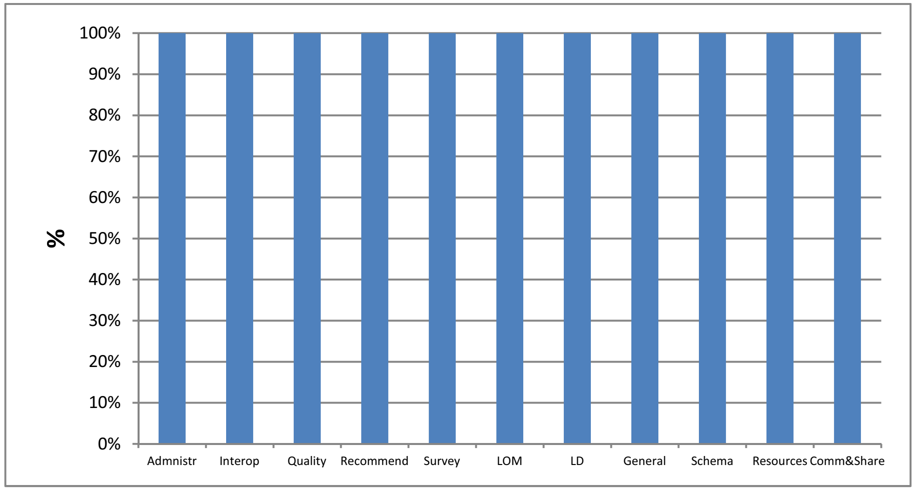


Figure 190. Task Completion (non-adjusted) - Task Completion Rates (% Successful: Pass/Fail Non-Adjusted)

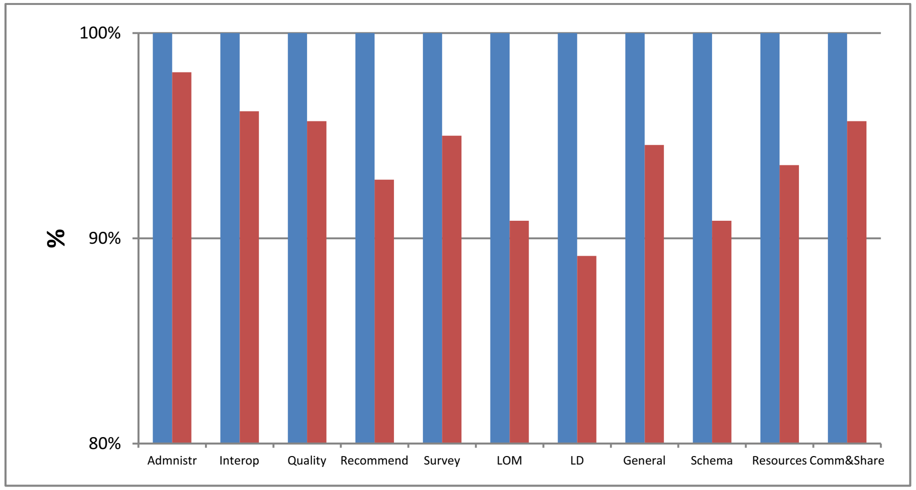
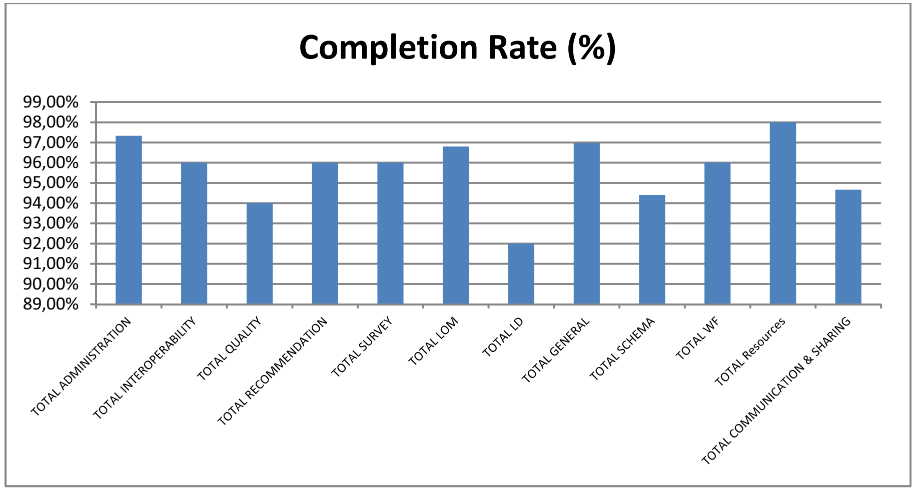


Figure 191. Task Completion & Confidence (non-adjusted) - Task Completion Rates (% Successful: Non-Adjusted w/ Users' Self-Reported Confidence Ratings)



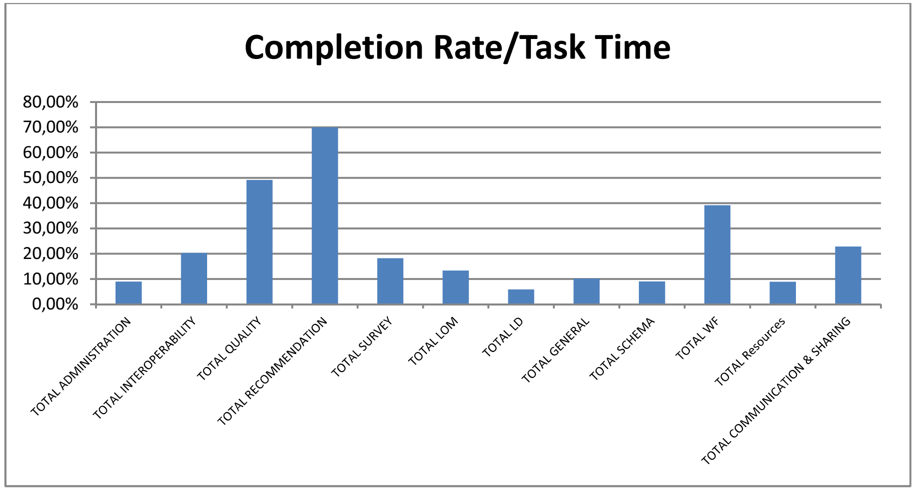


Figure 192. Completion rate and Completion rate/Task time Overall Phase 2

2.4.3.3. Overall Phase 1 per profile

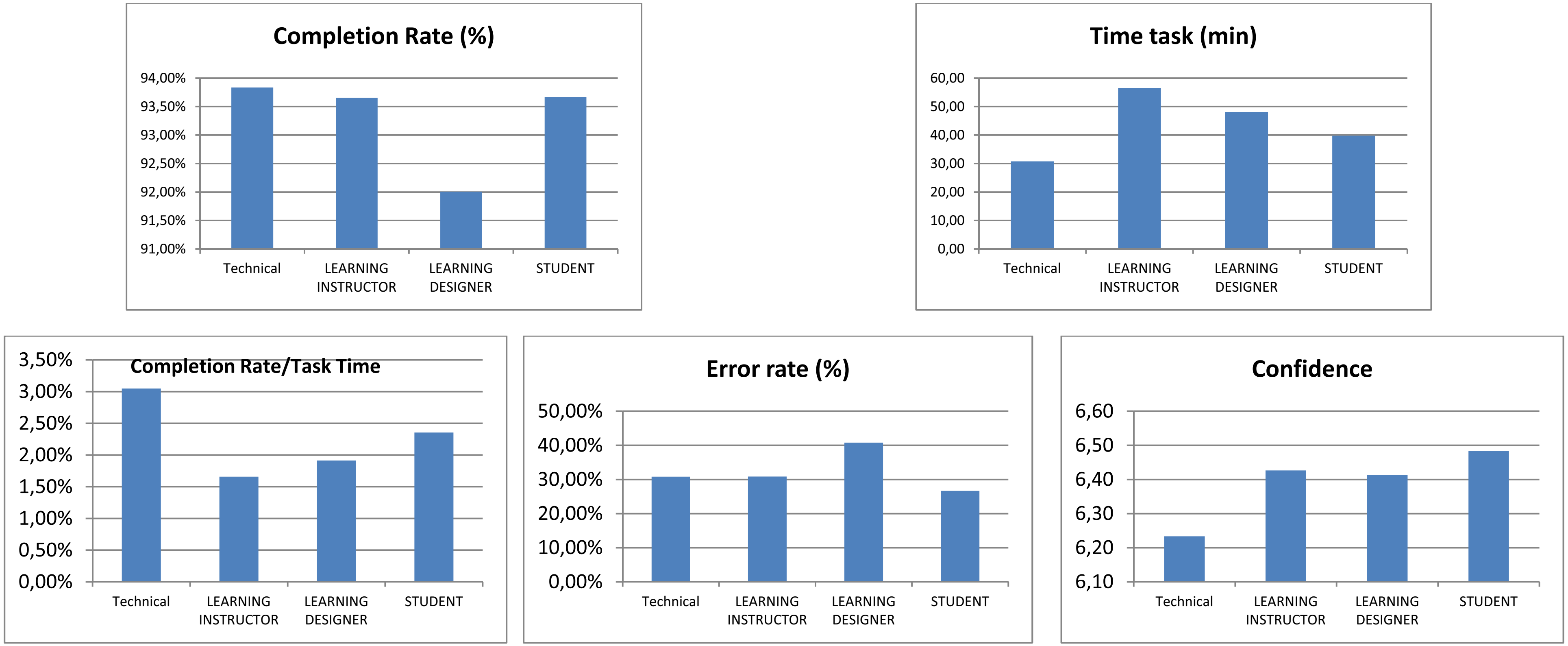


Figure 193. Completion rate, Time task (min), Completion rate/Time task, Error-rate and Confidence graphs

2.4.3.4. Overall Phase 2 per profile

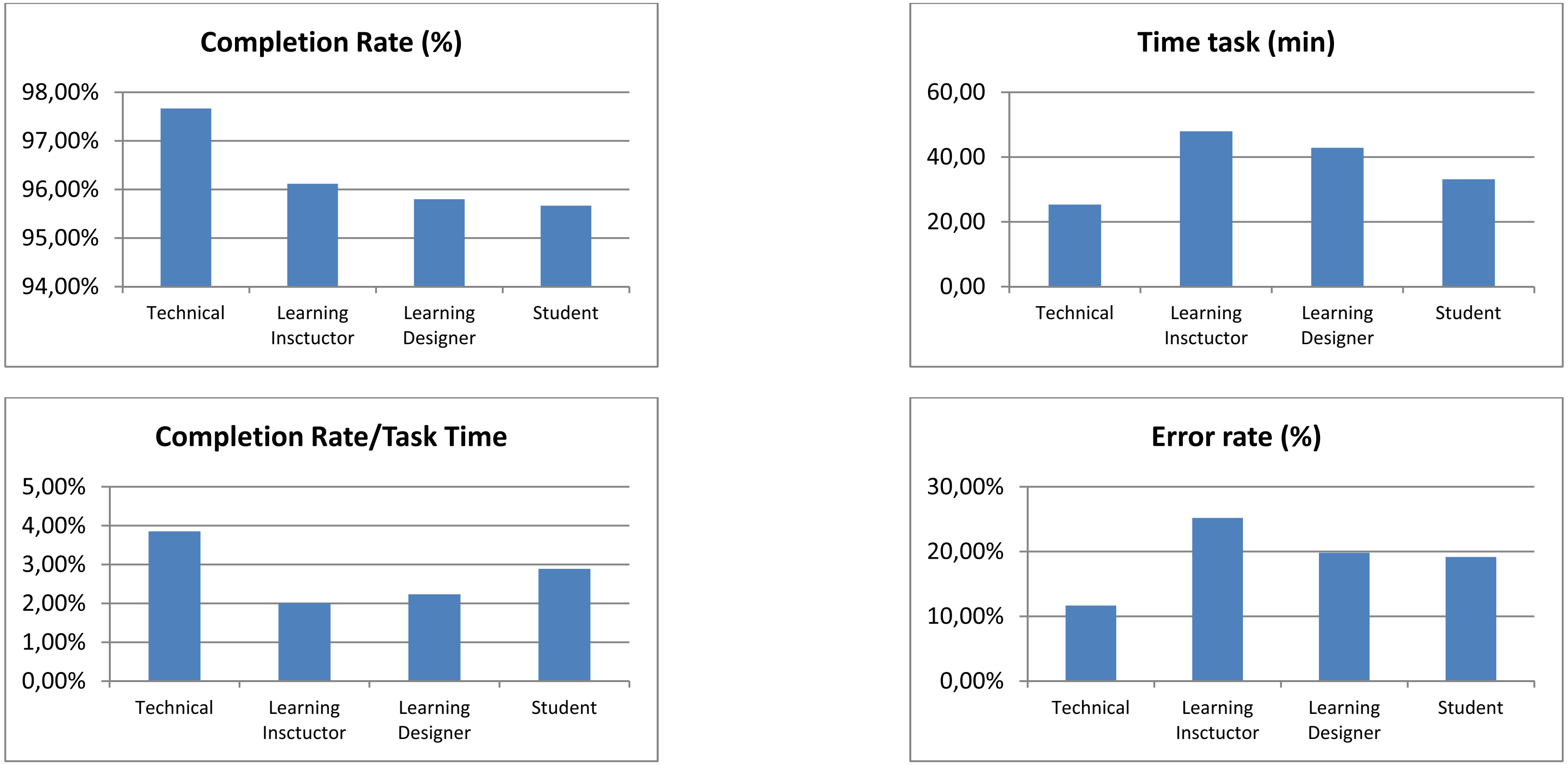
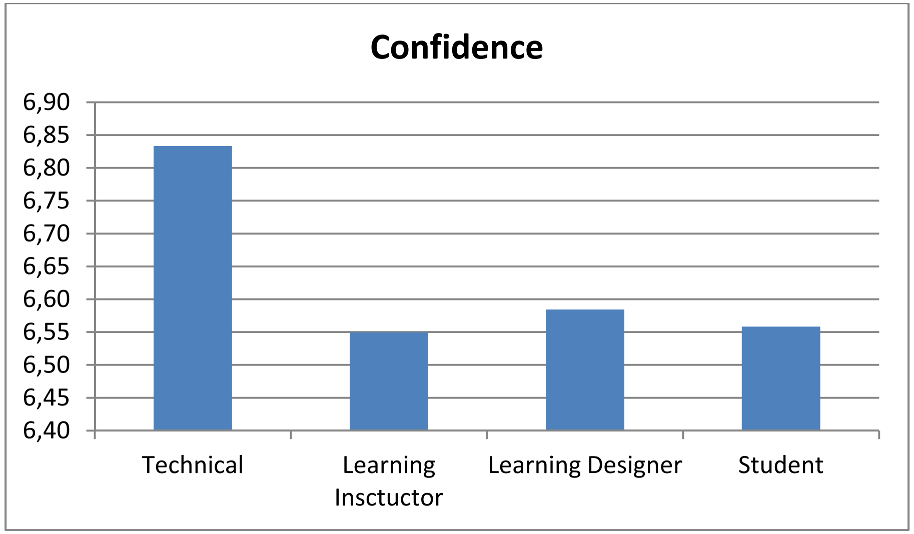


Figure 194. Completion rate, Time task (min), Completion rate/Time task, Error-rate graphs

2.4.3.5. Confidence and Satisfaction Graphs



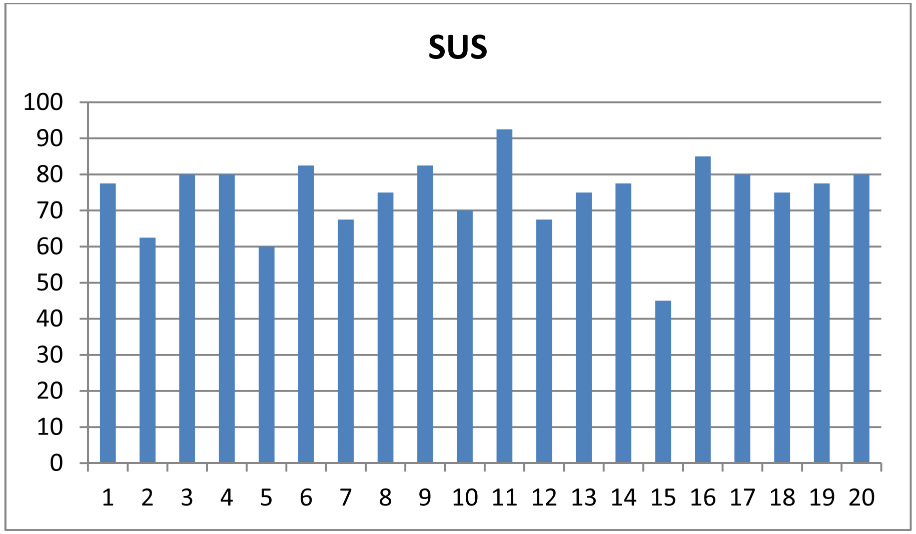


Figure 195. Confidence and Satisfaction per participant graphs

2.4.3.6. Web Performance Graphs

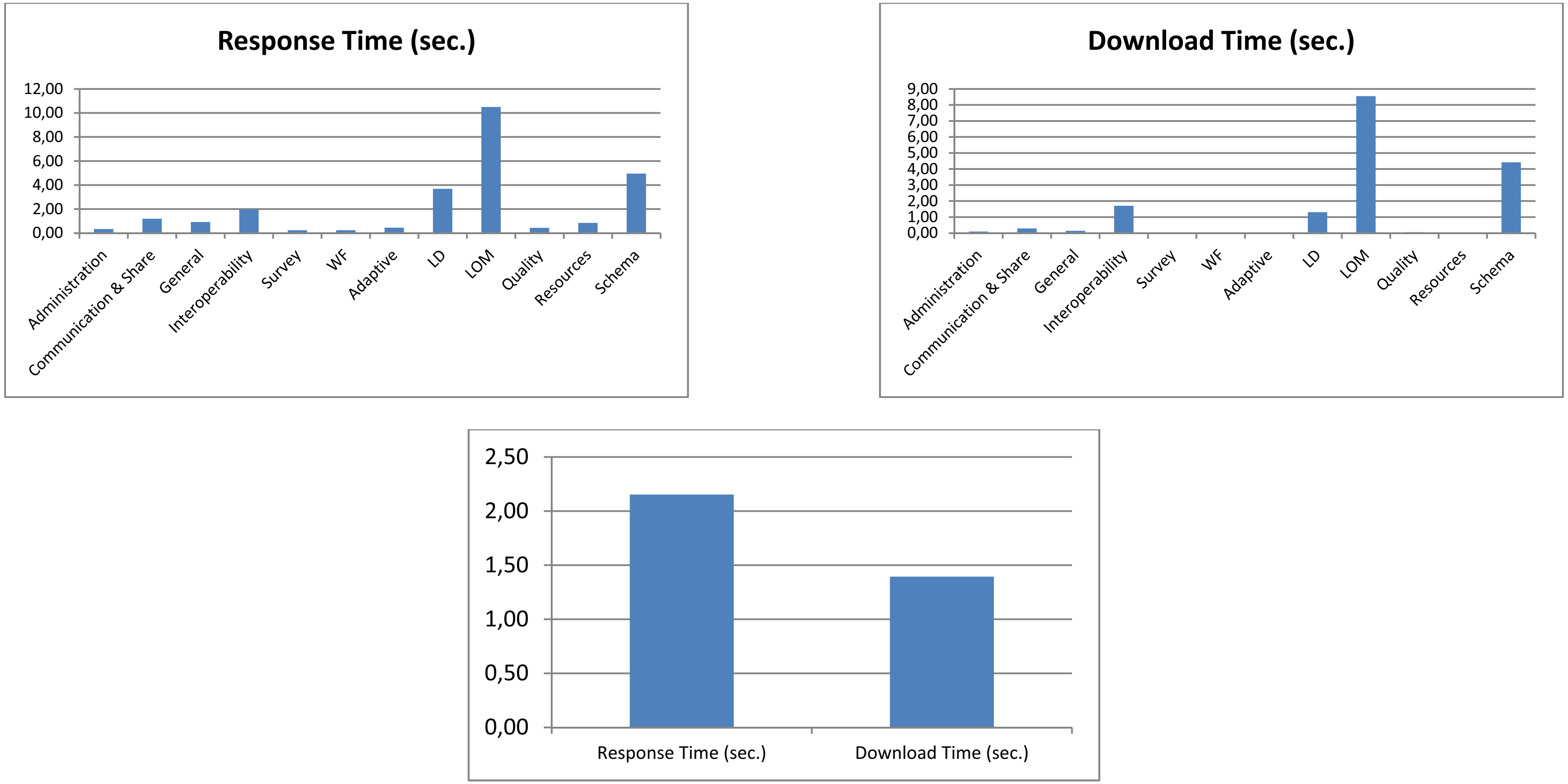


Figure 196. Response time, Download time and Overall Performance Graphs

2.4.3.7. Overall two phases graphs comparison

The following graphs represent the comparison between the two phases of testing regarding usability results and performance.

First in Figure 197 are presented graphs comparing the two phases of testing, regarding Completion rate, Error rate, Time on task and Completion/Task time ratio.

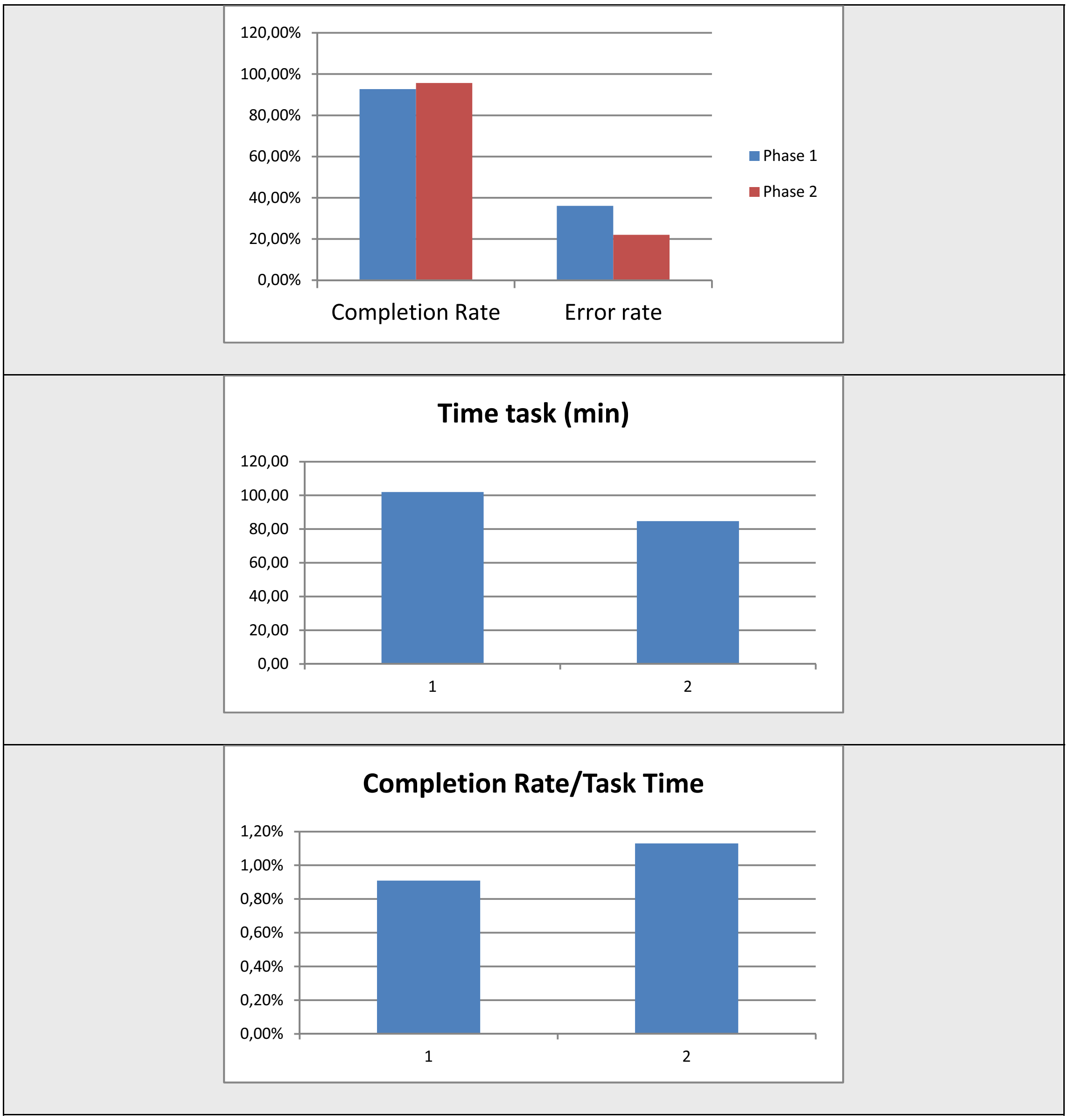


Figure 197. Completion and Error rate, Time task and Completion rate/Time task – Graphs of overall comparison two phases

Also, in Figure 198 are presented graphs comparing the two testing phases, regarding subjective results like Confidence and Satisfaction and more objective like performance.

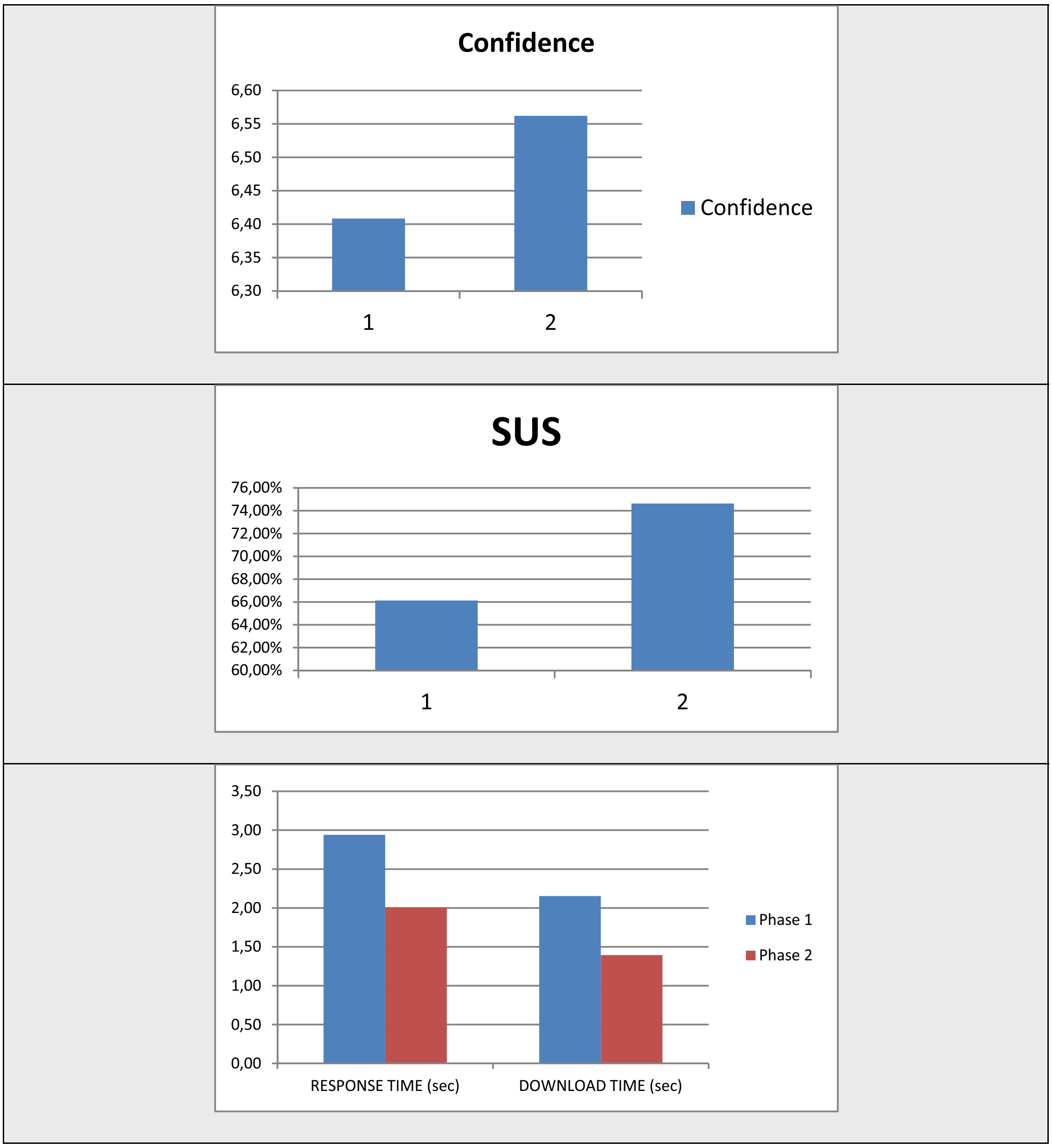


Figure 198. Confidence, SUS and Performance – Graphs of overall comparison two phases

For more conclusive results in Figure 199 are presented the improvement rate graphs over the two phases of testing.

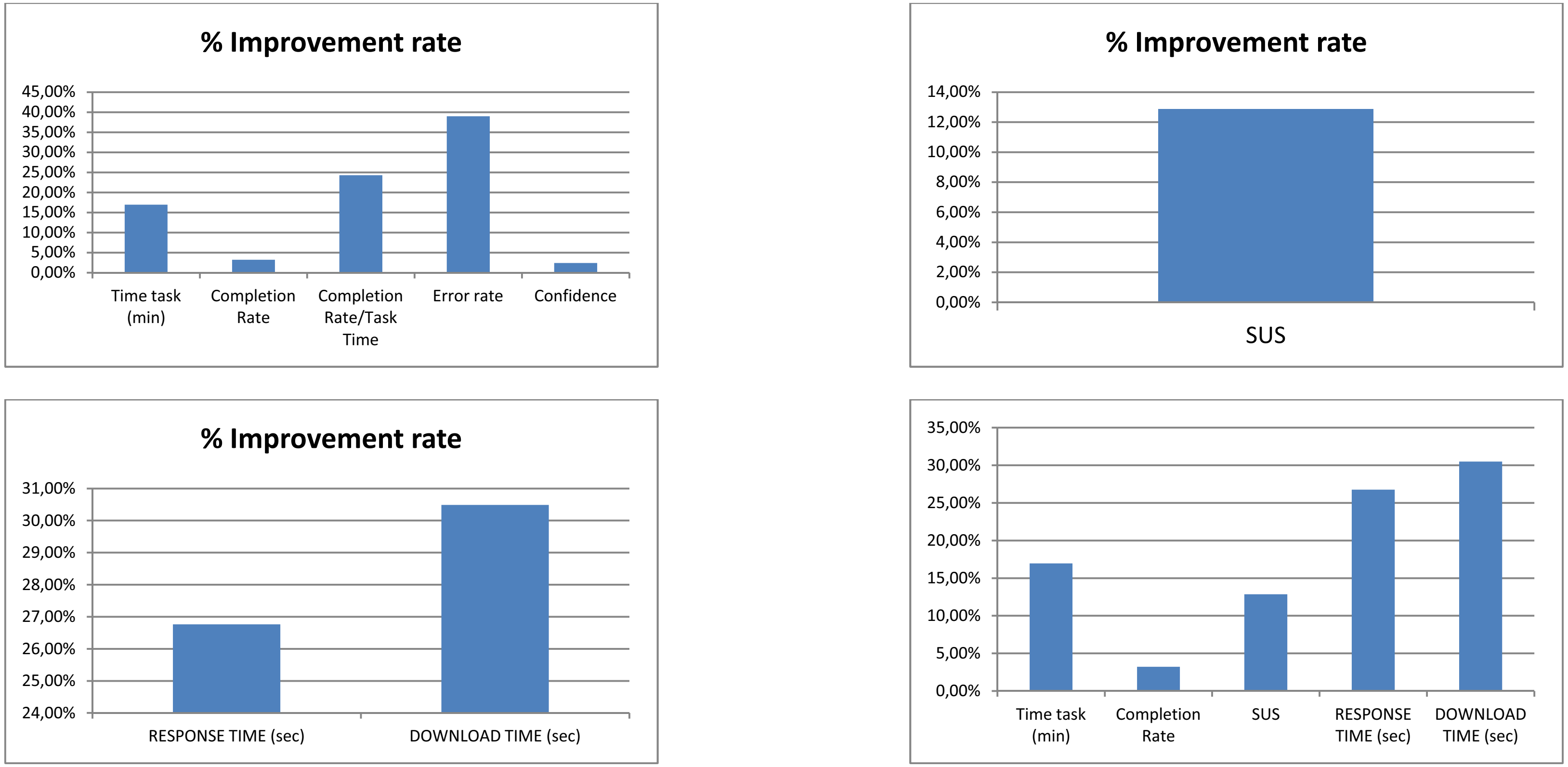


Figure 199. Improvement rate for Usability, Satisfaction, Performanc and, Overall Graphs

2.4.4. Tools Comparison Graphs and tables

Table 78. LOM tools comparison results

LOM Tools												
Tool	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence	SUS	RESPONSE TIME	RESPONSE TIME (sec)	DOWNLOAD TIME	DOWNLOAD TIME (sec)
Reggie	22,56	68,53%	50,17%	100,00%	3,04%	49,83%	4,10	56,6475	15040	15,04	12116	12,116
ADL SCORM	20,54	74,00%	56,15%	100,00%	3,60%	43,85%	4,80	58,1	14250	14,25	11434	11,434
EUN	14,38	77,25%	58,23%	100,00%	5,37%	41,77%	5,20	64,63625	13823	13,823	10998	10,998
LOM Editor	12,62	85,11%	67,33%	100,00%	6,74%	32,67%	5,70	68,99375	13002	13,002	10125	10,125
AHKME LOM	7,26	96,80%	76,00%	100,00%	13,34%	24,00%	6,36	72,625	10489	10,49	8553	8,55

Table 79. LD tools comparison results

LD Tools												
Tool	Time task (min)	Completion Rate (%)	Error-free rate (%)	Completion Success (%)	Completion Rate/Task Time	Error rate (%)	Confidence	SUS	RESPONSE TIME	RESPONSE TIME (sec)	DOWNLOAD TIME	DOWNLOAD TIME (sec)
Reload LD	17,32	89,26%	72,11%	100,00%	5,15%	27,89%	5,90	70,89	4110	4,11	1759	1,759
Alfanet Editor	25,20	78,14%	61,85%	100,00%	3,10%	38,15%	5,30	61,94	4698	4,698	2514	2,514
CopperAuthor	22,05	81,89%	64,20%	100,00%	3,71%	35,80%	5,10	66,42	4912	4,912	2845	2,845
ASK-LDT	20,31	86,67%	68,71%	100,00%	4,27%	31,29%	4,90	68,66	5123	5,123	3101	3,101
MOT+	26,77001845	77,48%	62,33%	100,00%	2,89%	37,67%	5,2	59,7	4803	4,803	2451	2,451
eLive LD Suite	33,06884632	72,29%	56,81%	100,00%	2,19%	43,19%	4,4	52,2375	5890	5,89	3633	3,633
AHKME LD	15,74706968	92,00%	64,00%	100,00%	5,84%	36,00%	6,24	74,625	3690	3,69	1303	1,30

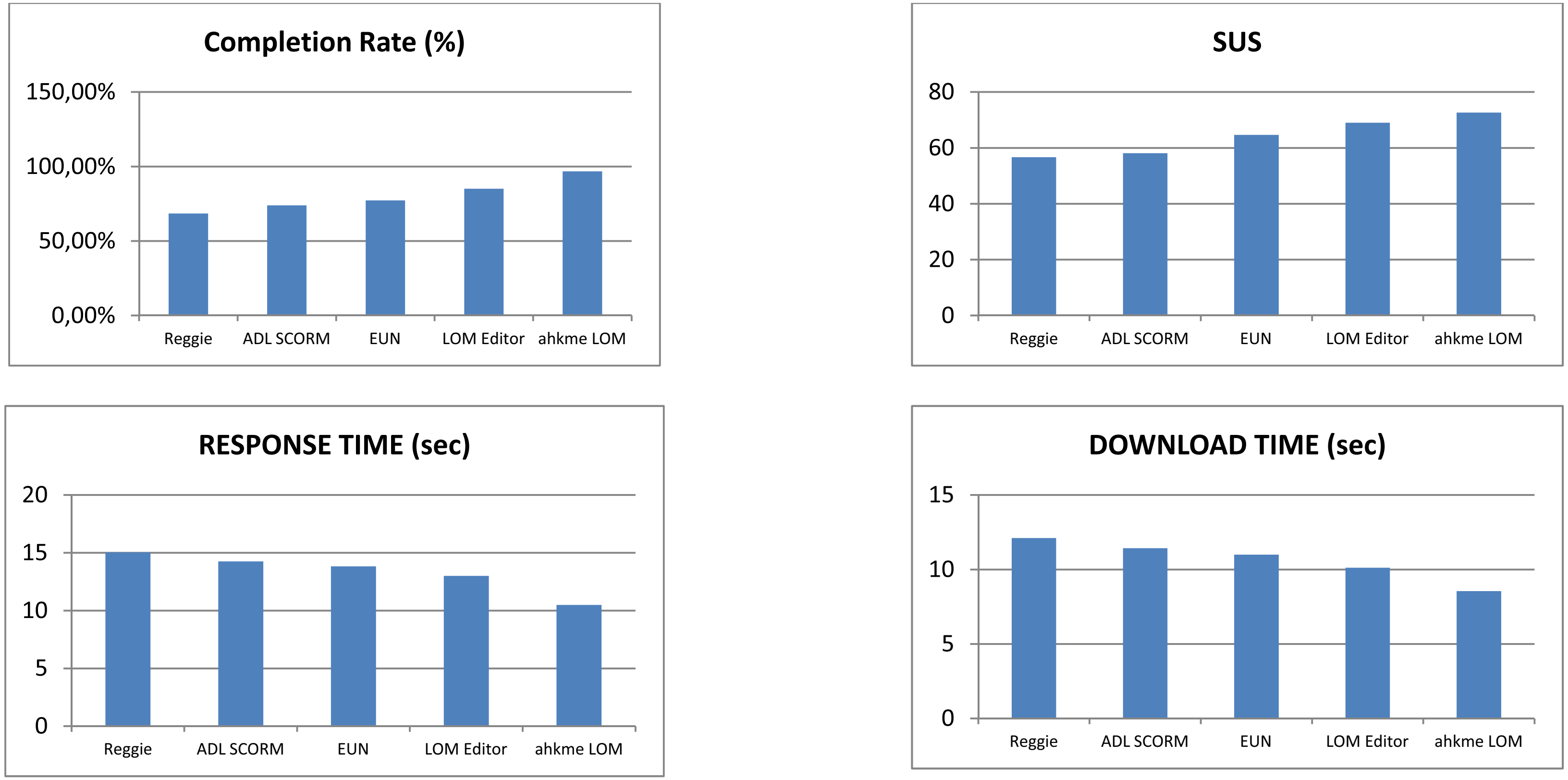
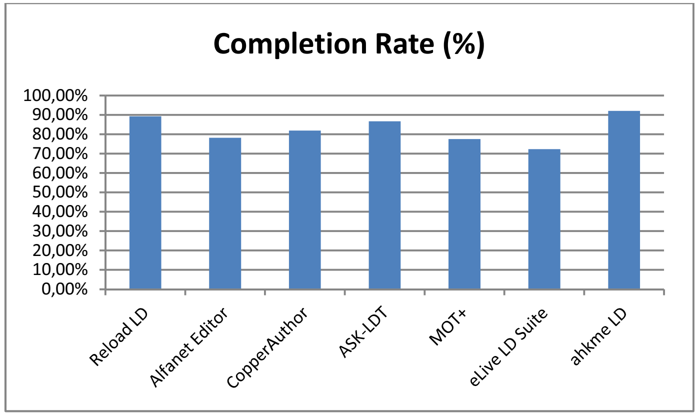
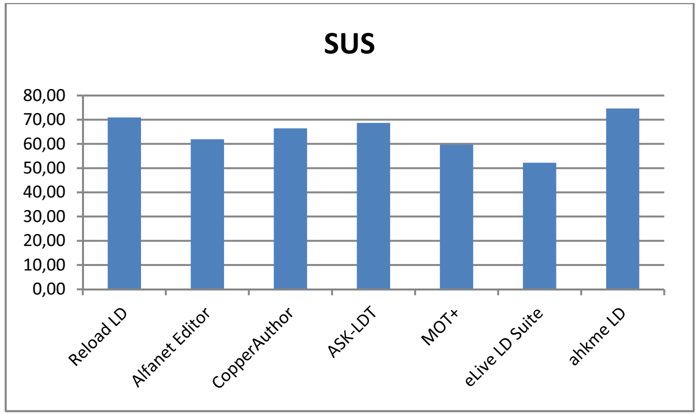
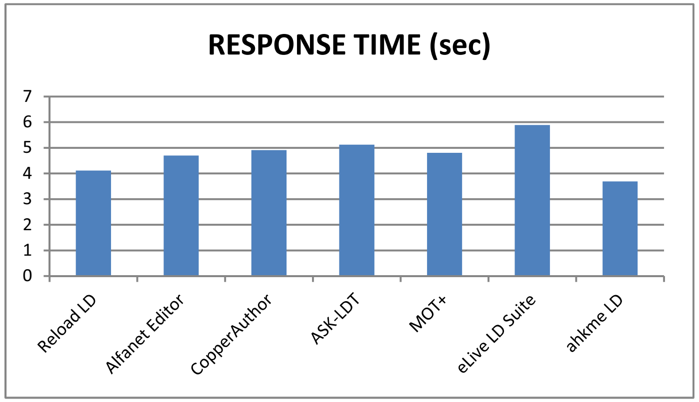


Figure 200. Completion rate, SUS and performance graphs – LOM tools







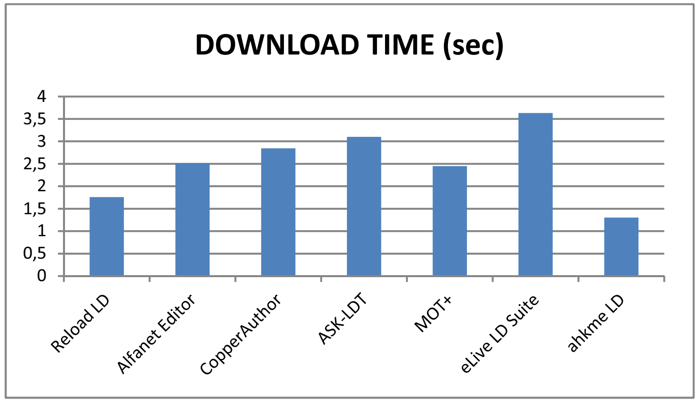


Figure 201. Completion rate, SUS and performance graphs – LD tools

Table 78, Table 79 and graphs in Figure 200 and Figure 201 present the results of the comparison of LOM and also LD tools, with the Completion rate, SUS and performance.

3. QUESTIONNAIRES

It has been designed a series of questionnaires to qualify test participants and to collect subjective feedback from the test participants during and after testing. This section presents the screenshots, samples that have been used in the testing process.

3.1. PRE-TEST QUESTIONNAIRE

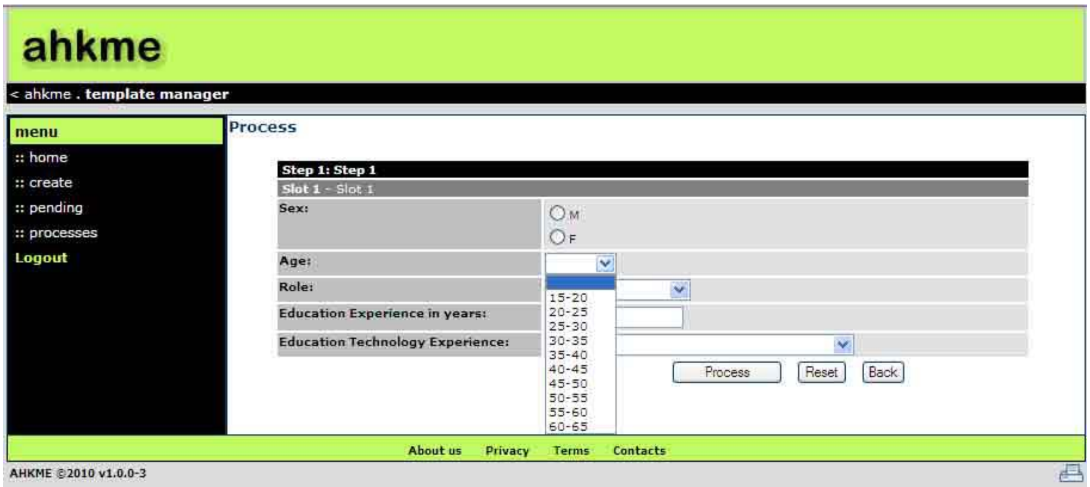


Figure 202. Pre-test questionnaire

To qualify test participants, has been asked a series of questions included in pre-test questionnaire (see Figure 202) designed to collect information regarding age, genre, role, and to assess their level of education and technology experience.

After the test participants completed each scenario, it has been administered a post-task questionnaire as shown in Figure 203.

The questionnaire has been designed to capture feedback about AHKME tasks while the test participant's memory was fresh. The questionnaire asked test participants to rate the ease or difficulty of the tasks and provide free-form comments concerning the tasks.

3.2. POST-TASK QUESTIONNAIRE

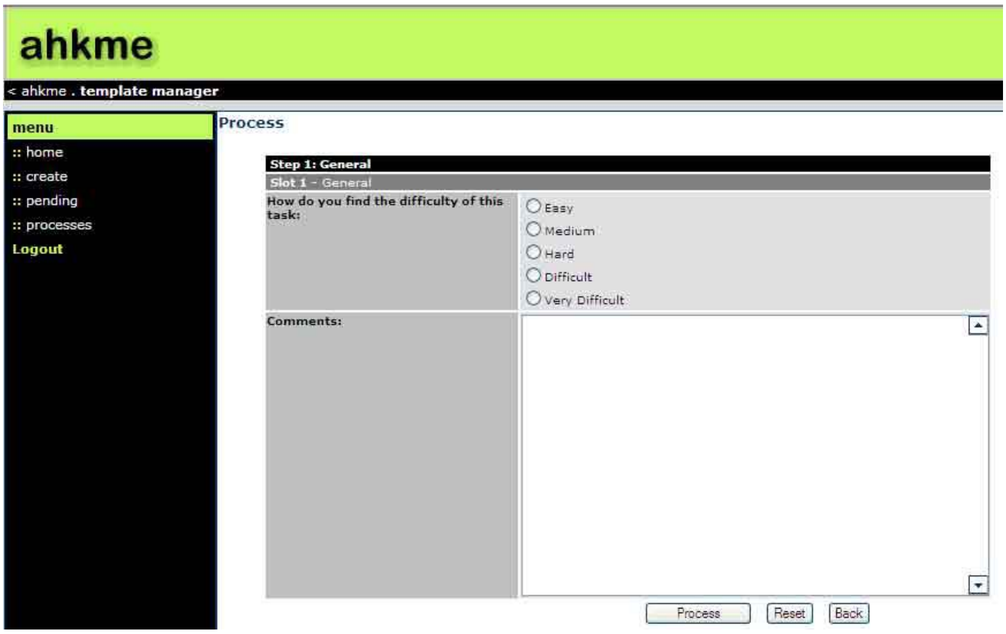


Figure 203. Post-task questionnaire

3.3. POST-TEST QUESTIONNAIRE

After the participant completed the test, it has been administered a SUS post-test questionnaire as shown in Figure 204, to capture the user satisfaction.

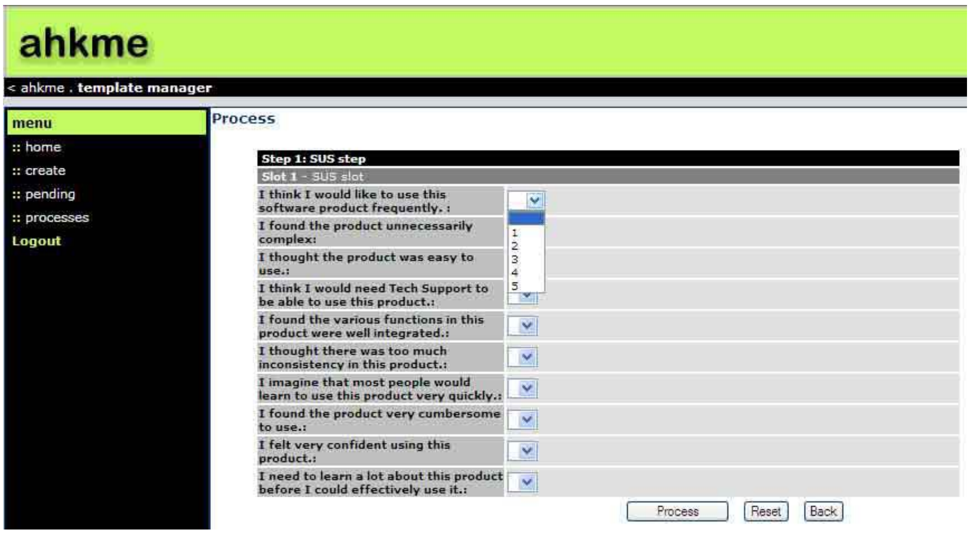


Figure 204. Post-test questionnaire

D. GLOSSARY

Adaptation	System-driven personalisation and modifications.
Adaptability	User-driven personalisation and modifications.
Adaptive Hypermedia Systems (AHS)	Configure applications that present information and route suitable for the characteristics of each user, guiding them in navigation and in the discovery and management of relevant information.
Adaptive Educational Hypermedia Systems (AEHS)	Personalize the learning process with the intention of facilitating the acquisition of knowledge, presenting educational content and courses appropriate to the educational goals, previous training, individual characteristics or level of knowledge of each student.
Collaboration systems	Software designed to help people involved in a common task achieve their goals.
Completion rate	The percentage of participants who completely and correctly achieve each task goal.
Cross-cut tool	Tool that cross-cut the system through their features.
Data Mining	Process of extracting patterns from data.
Decision tree learning	Used in data mining and machine learning, uses a decision tree as a predictive model which maps observations about an item to conclusions about the item target value.
Findings	Usability problems noted during the test.
Heuristic Evaluation	It is an analysis that can be performed by a group of specialists and that evaluates the system in a qualitative way, and that can work as a reference.
IMS Learning Design (IMS LD)	Educational modeling language to define LD. Defines a

pedagogically neutral notation that allows the design processes in order to achieve a learning objective, establishes what activities students and teachers held, at which time, learning what resources or services and under what conditions.

Instructional Design Knowledge used by teachers and instructors when defining the instruction.

Interoperability Ability of diverse systems to work together or interoperate.

Learning Design (LD) A LD describes a teaching method that will enable students, through the implementation of certain activities within a context for instructional purposes, achieve certain learning objectives.

Learning designer Teachers or simply educational, IT professionals that deal with instructional design and learning resources.

Learning instructor Teachers or assistant teachers that work and apply the instructional design and learning resources to the courses.

Learning Object (LO) For IEEE LOM: "Any entity, digital or non-digital, that can be used to learn, teach or train." Any resource posible to include in a LD element.

Learning Social Network Social network for learning purposes and experiences.

Learning Unit Complete training unit and self-contained, for example, a course or a lesson.

Machine Learning Design and development of algorithms that allow computers to evolve behaviors based on empirical data, such as from sensor data or databases.

Marking technologies for educational metadata Identify and list of uniformly techniques, methods and items

	related to training, in order to facilitate the sharing, distribution and reuse in different systems and courses.
Metadata	Data about data (simple definition). Used for annotating, describing and struturing of LO.
Openness	By "opening" application programming interfaces (APIs), protocols, data formats, open-source software platforms and open data, it opens up possibilities for creating new tools.
Performance testing	This type of testing determines or validates the speed, scalability, and/or stability characteristics of the system or application under test.
Post-task questionnaire	Filled by the user after the completion of each task.
Post-test questionnaire	Filled by the user after the completion of the test.
Pre-test questionnaire	Filled prior the test for user characterization.
Recommendations	Recommendations for improving the system.
Recommender or Recommendation System	Compares the collected data to similar data collected from others and calculates a list of recommended items for the user.
Reusability	Ability of a learning resource to be used again.
Satisfaction	Describes user's subjective response when using the product.
Schemas	In the world of web and specifically in markup, a set of rules for document structure and content.
Semantic Web	The Semantic Web equals a Web with a meaning.
Social Semantic Web	Web of collective knowledge systems, which are able to provide useful information based on human contributions

	and which get better as more people participate.
Specification	A specification is a documented description.
Standard	The use of a specification by law (*de jure*) or by fact (*de facto*).
Standard for the definition of educational metadata	Technology, format or method of educational metadata record which has been ratified by an official body of standardization.
Student	Interacts with the courses and indirectly with the learning design and resources.
Technical staff	Manages the system parametrization, users and permission managing, and also tools and template administration.
Time-on-task	Mean time taken to complete task (correctly completed tasks).
Usability testing	Consists in generic terms to evaluate the usage of the system by a sample of users in a specific context and through a set of metrics, and seeks to identify system major problems and errors as well as recommendations for improvement.
Workflow Systems	By the Workflow Management Coalition is "*The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules*".

E. ACRONYMS

.zip	*Zip file compressed archive*
ADL	*Advanced Distributed Learning initiative*
AGR	*AICC Guidelines and Recommendations*
AH	*Adaptive Hypermedia*
AHAM	*Adaptive Hypermedia Application Model*
AEHS	*Adaptive Hypermedia Educational System*
AHS	*Adaptive Hypermedia System*
AHKME	*Adaptive Hypermedia Knowledge Management Elearning (System)*
AICC	*Aviation Industry CBT Committee*
AJAX	*Asynchronous Javascript and XML*
ARIADNE	*Alliance of Remote Instructional Authoring and Distribution Networks for Europe*
CanCore	*Canadian Core Learning Resource Metadata Protocol*
CBT	*Computer Based Training*
CEN/ISSS LTS	*Learning Technology Workshop of the European Committee for Standardization*
CHAID	*Chi-squared Automatic Interaction Detector*
CIF	*Common Inductry Format*
CSCW	*Computer Supported Cooperative Work*
CSS	*Cascade Style Sheet*
EML	*Educational Modelling Language*

ERP	*Enterprise Resource Planning*
EUP	*Experienced User Performance*
GRIAL	*GRupo de investigación en InterAcción y eLearning (GRIAL)*
HE	*Higher Education*
HS	*High School*
ID3	*Iterative Dichotomiser 3*
IEEE	*Institute of Electrical and Electronics Engineers, Inc.*
IEEE LOM	*IEEE Standard for Learning Object Metadata*
IEEE LTSC	*IEEE Learning Technology Standard Committee*
IF	*Information Filtering*
IMS	*IMS Global Learning Consortium, Inc.* (*Instructional Management Systems project*)
IMS CP	*IMS Content Packaging Specification*
IMS LD	*IMS Learning Design Specification*
IMS LIP	*Learner Information Package Specification*
IMS LOM	*IMS Learning Resources Metadata Specification*
IMS QTI	*IMS Question and Test Interoperability Specification*
IMS SS	*IMS Simple Sequencing Specification*
IT	*Information Technology*
KM	*Knowledge Management*

KR	*Knowledge Representation*
LD	*Learning Design*
LCMS	*Learning Content Management Systems*
LMS	*Learning Management System*
LO	*Learning Object*
LOM	*Learning Object Metadata*
LU	*Learning Unit*
MoSoSo	*Mobile Social Software*
OUNL-EML	*Educational Modelling Language* de la *Open University of the Netherlands* (OUNL)
OWL	*Ontology Web Language*
PDF	*Portable Document Format*
PHP	*PHP: Hypertext Preprocessor*
PROMETEUS	*PROmoting Multimedia in Education and Training in European Society*
RDF	*Resource Description Framework*
RDFS	*Resource Description Framework Schema*
SAX	*Simple Api for XML*
SCO	*SCORM Sharable Content Object*
SCORM	*Sharable Content Object Reference Model*
SCORM RTE	*SCORM Run-Time Environment book*

SQL	*Structure Query Language*
SUS	*Satisfaction Usability Scale*
UM	*User Model*
UML	*Unified Modelling Language*
UoL	*Unit of Learning*
URI	*Uniform Resource Identifier*
URL	*Uniform Resource Locator*
WAI	*Web Accessibility Initiative*
WAP	*Wireless Application Protocol*
WBL	*Web Based Learning*
WCM	*Web Content Management*
Wf	*Workflow*
XHTML	*eXtensible HyperText Markup Language*
XML	*eXtensible Markup Language*
XML DOM	*XML Document Object Model*
XSD	*XML Schema Definition*
XSTL	*eXtensible Stylesheet Language for Transformation*

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RESUMEN DE LA INVESTIGACIÓN

1. INTRODUCCIÓN

El Web está en constante evolución, hoy en día se viven tiempos de cambio en la Web, con la Web 2.0, las redes sociales y la colaboración en masa (Downes, 2005) e incluso se tienen muestras de algunos signos de lo que Tim Berners-Lee, predijo, tales como la Web Semántica, la Web Inteligente o en términos más amplios, la Web 3.0 (W3CSW, 2009).

Una de las áreas en expansión dentro de las Tecnologías de la Información y las Comunicaciones (TIC) es la aplicación de los sistemas o plataformas de educación a distancia. En la actualidad, hay muchos sistemas de *eLearning*, pero la principal dificultad radica en la estructuración de los contenidos e informaciones de acuerdo con los modelos existentes de aprendizaje con el fin de lograr una mayor integración y comprensión del ambiente de aprendizaje y con esto proporcionar una educación de mejor calidad. Al mismo tiempo, sin embargo, no hay demasiadas herramientas y SCORM</Author><Year>2009</Year><RecNum>95</RecNum><record><rec-number>95</rec-number><foreigncilitan la aplicación de la Web Semántica, la movilidad de los recursos, así como la universalidad de diseño de aprendizaje.

Para hacer frente a estas necesidades, es necesario estudiar el uso de las especificaciones y normas para la estructuración de los recursos de aprendizaje, objetos de aprendizaje y diseño instruccional (Rego et al., 2005), para permitir que el diseñador instruccional y el profesor tengan acceso a los recursos normalizados y para evaluar la posibilidad de su integración y reutilización en diferentes contextos de *eLearning*, tanto a nivel de contenidos como de estrategias de aprendizaje.. Del mismo modo, es interesante estudiar el posible uso de herramientas de colaboración para la adaptación de los recursos, así como recoger comentarios de los usuarios para proporcionar información al sistema.

Además, sería interesante estudiar la importancia de las tecnologías de apoyo, como por ejemplo los agentes inteligentes, para la aplicación práctica de la Web Semántica con el concepto de Web Semántica Social (Breslin et al., 2009), con la introducción de herramientas de colaboración y sistemas con aplicación en situaciones reales como los entornos sociales y de aprendizaje para el suministro y la distribución de los recursos y estrategias de aprendizaje, así como permitir el acceso a las herramientas de diseño de instrucción que puede proporcionar la autonomía para crear o modificar las especificaciones/ontologías para dar estructura y significado a los recursos. En este sentido también es interesante contar con sistemas de apoyo inteligentes vinculados al contexto, así como con sistemas de recomendación de recursos de aprendizaje.

Asimismo, no se puede obviar el concepto de movilidad aplicada al *eLearning* (*mLearning*), lo que posibilita el acceso de los profesores y estudiantes a los recursos de aprendizaje, independientemente del tiempo y el espacio (Bratt, 2006).

1.1. DESCRIPCIÓN DEL PROBLEMA

Para la estructuración de los materiales educativos se han desarrollado diferentes especificaciones y estándares relacionados con el campo del *eLearning*, que permiten dar forma a la mayor variedad de ambientes de aprendizaje (Wiley, 2003). Entre las diversas opciones existentes se destacan, por su estrecha relación con la presente propuesta: *Sharable Content Object Reference Model* (SCORM), un proyecto de la *Advanced Distributed Learning* (ADL) (SCORM, 2009), la especificación de la *Education Modeling Language* (EML), lo que llevó al *IMS Learning Design* (LD) (IMSLD, 2003), sin embargo, EML no es una norma, es una especificación que se ha quedado obsoleta con la adopción de IMS LD (Koper, 2003), el estándar para la estructuración de metadatos Dublin Core (DC, 2010). Por último, se tienen las especificaciones de IMS, entre las que se destacan IMS Learning Design y IMS Metadata para el diseño y la estructuración de recursos educativos, y el actual IMS Common Cartridge, una nueva generación de estándares de Servicios de Aprendizaje Digital, que fueron desarrollados por el Consorcio del IMS (IMS, 2011).

Si se analizan algunos de los sistemas de *eLearning* más representativos en la actualidad (WebCT/Blackboard, Angel, Intralearn, ATutor, Moodle, Sakai y dotLRN), se identifican como puntos fuertes la capacidad funcional y administrativa, y como debilidades los problemas con la interoperabilidad, la reutilización, la independencia del dominio de aprendizaje, adaptación y capacidad de ampliación (Rego, Moreira, & García Peñalvo, 2010) (Rego et al., 2005).

En general, hay pocas experiencias herramientas *eLearning* que permitan el uso de tecnologías como agentes inteligentes y minería de datos para la búsqueda adaptativa y la recomendación sobre la base de las especificaciones de la tecnología educativa y las ontologías. También hay pocas experiencias de aplicación efectiva de la combinación de las redes sociales y web semántica (web semántica social) a fin de estructurar los recursos en formatos interoperables, y el significado de adaptación en un entorno de colaboración y de búsqueda de forma automática por el contexto.

1.2. OBJETIVOS

En esta tesis se defiende que: *el profesor debe tener acceso a herramientas de diseño de instruccional sin necesidad de tener que tener un conocimiento previo de una tecnología especializada o de los estándares y las especificaciones*.

Por tanto, se propone un sistema de apoyo al aprendizaje basado en tecnologías de código abierto que se caracteriza por: 1) ser interoperable; 2) ser multipropósito; 3) tener capacidades evolutivas; y 4) presentar automatización y adaptación basadas en agentes inteligentes (Rego et al., 2005).

Por tanto, se tiene como principales objetivos:

- La creación de un sistema de *eLearning* que permita la estandarización de los recursos y contribuya a la interoperabilidad y la reutilización de los mismos.
- El desarrollo de una herramienta de búsqueda de recursos de aprendizaje de los metadatos que mejore la reutilización de recursos de aprendizaje.
- La implementación de una herramienta que genere formas que permitan a los usuarios crear o adaptar sus especificaciones de metadatos y/o la ontología, para que los sistemas *eLearning* se abran a las posibilidades de la Web Semántica.
- La definición de una herramienta colaborativa para adaptar los recursos de aprendizaje y sus metadatos y de una herramienta de recomendación automática orientada a mejorar la personalización y la adaptación de dichos recursos.

1.3. CONTEXTO DE LA TESIS

Este trabajo se desarrolla en las líneas de investigación del *eLearning*, ingeniería web y arquitectura de *software* del grupo de investigación GRIAL de la Facultad de Ciencias, Universidad de Salamanca.

Esta tesis se centra, principalmente, en tres líneas de investigación. En primer lugar, desde una perspectiva educativa, los sistemas *eLearning* basados en tecnologías web, con un soporte al diseño instruccional y los recursos educativos estandarizados. En segundo término, la Ingeniería Web, con una aproximación arquitectónica que da soporte a la funcionalidad básica esperada para satisfacer la primera línea, pero con la introducción a los flujos de trabajo colaborativos. En tercer y último lugar, los Sistemas Hipermedia Adaptativos (SHA), con técnicas de recomendación y adaptatividad basadas en minería de datos y agentes inteligentes.

La combinación de los tres ejes de investigación mencionados confieren a esta tesis un carácter multidisciplinar y aplicado, que propone la evolución de los sistemas de *eLearning* hacia los contextos semánticos, de interoperabilidad e inteligencia que defiende el enfoque o filosofía de la Web 3.0.

2. SISTEMAS WEB Y ELEARNING

Esta tesis se centra en el uso educativo de la Web, concretamente en los sistemas de *eLearning*.

Una definición simple del término *eLearning* es "aprendizaje o de capacitación que está dispuesto, entregado, o gestionados utilizando una variedad de tecnologías de aprendizaje y que puede ser desplegado de forma local o global" (Waller et al., 2001). La promesa del *eLearning* es que proporciona potentes herramientas para el desarrollo de los procesos de enseñanza/aprendizaje de una forma eficiente especialmente cuando se quieren eliminar barreras espacio-temporales. Así como las tecnologías de la información han cambiado, fundamentalmente, la naturaleza de cómo se hace el trabajo en las organizaciones, el surgimiento de las tecnologías *eLearning* ha proporcionado medios que dotan a los procesos de aprendizaje de un grado de flexibilidad tal que está cambiando la naturaleza del canal por el que se imparte la formación por excelencia, especialmente cuando está vinculada al puesto de trabajo.

.Desde la perspectiva que ofrece la experiencia en el desarrollo y explotación de plataformas *eLearning* y una perspectiva de la calidad, García Peñalvo (2008) ofrece su propia definición de *eLearning* como "un proceso de enseñanza/aprendizaje, orientado a la adquisición de una serie de competencias y destrezas por parte del estudiante, caracterizado por el uso de las tecnologías basadas en web, la secuenciación de unos contenidos estructurados según estrategias preestablecidas a la vez que flexibles, la interacción con la red de estudiantes y tutores y unos mecanismos adecuados de evaluación, tanto del aprendizaje resultante como de la intervención formativa en su conjunto, en un ambiente de trabajo colaborativo de presencialidad diferida en espacio y tiempo, y enriquecido por un conjunto de servicios de valor añadido que la tecnología puede aportar para lograr la máxima interacción, garantizando así la más alta calidad en el proceso de enseñanza/aprendizaje".

En la actualidad se está produciendo una revolución en las aplicaciones educativas con la adopción generalizada de Internet como una plataforma de distribución (*eLearning*).

El *eLearning* está teniendo mucha importancia en diferentes ámbitos de la sociedad, tanto en el sector de la educación como negocio a través de la capacitación y el entrenamiento.

Así, a continuación se va a estudiar las tendencias de los sistemas de información web, la disponibilidad de datos y la representación, la adaptación, la interoperabilidad de los datos, la colaboración entre los usuarios, y más concretamente su aplicación en el ámbito del *eLearning*. Al final, las debilidades y tendencias de mejora. Por lo tanto, se comienza por analizar en paralelo la evolución de la Web y del *eLearning*, sus características, sistemas y herramientas.

2.1. EVOLUCIÓN DE LA WEB Y DEL ELEARNING

La evolución de la Web y del *eLearning* han discurrido en paralelo a lo largo del tiempo.

Las principales características en relación con la evolución de la Web son principalmente:

- Concepto;

- Tecnologías involucradas;
- La cobertura pública;
- Datos.

Yihong-Ding (2007) se refiere al espacio de reflexión a la evolución de Internet, la definición de tres etapas que se presenta a continuación.

Primera etapa, la tradicional World Wide Web, también conocida como Web 1.0, es una Web de lectura o escritura.

En general, los autores de páginas web, escriben lo que quieren compartir y publicar en línea. Los lectores pueden ver estas páginas web y subjetivamente comprender los significados. A la Web 1.0 conecta a las personas con un entorno público, compartido - World Wide Web. Pero esencialmente la Web 1.0 no facilita la comunicación directa entre lectores y escritores web.

En una etapa intermédia hubo una Web 1.5, en que para una definición la "Web 1.5 es que la información se transmite de forma diferente por el profesional de la industria, pero el profesional de la industria no entiende que 0.5 del "valor añadido" viene del comentarista que no está de acuerdo con la publicación, o añadir más información que el mensaje se transmite". Son ejemplos de servicios Bloglines, BlogRolling and Xmarks (Regan, 2010).

La segunda etapa de la evolución de la web es la Web 2.0. Aunque su definición sigue siendo vaga, la Web 2.0 es una Web de lectura y escritura.

En la Web 2.0 no solo los "autores" pueden aportar contenidos a la Web, sino que cualquiera se puede convertir en "autor", pudiendo leer y escribir, en términos generales, en un mismo espacio web. Este avance permite establecer una comunicación amigable entre los usuarios de la web social sin obligación de divulgación de las identidades particulares. Por lo tanto, aumenta significativamente el interés por participar de los usuarios "normales" de la Web.

La tercera etapa es la Web Semántica o Web 3.0. Se trata de una Web de lectura, escritura y petición automática de servicios entre agentes software. Es una etapa que todavía no se ha desarrollado por completo, pero que ineludiblemente marcará el futuro no lejano de la Web. El cambio fundamental se encuentra todavía en el espacio web. Un espacio web deja de ser una simple página web como en la Web 1.0. Tampoco es un espacio para un *blog* o una *wiki* que facilite la interacción y comunicación humana al estilo 2.0. Cada espacio ideal en la Web Semántica se convertirá en un pequeño espacio de reflexión. Contiene la semántica procesable por una máquina aprobado por sus propietarios. Un espacio de la Web Semántica al mismo tiempo es también un agente automático "vivo". Estos espacios reciben el nombre de *Active Semantic Spaces* (ASpaces) (Ding et al., 2007).

Una Web Semántica en la práctica requiere que cada usuario de la Web deba tener espacio web para sí mismo. Aunque parece anormal en primer vistazo, este requisito es de hecho fundamental. Es difícil de imaginar que los usuarios todavía tuvieran que realizar todas las peticiones ellos mismos en una Web Semántica. La aparición de la Web Semántica eventualmente elimina la distinción entre los lectores y escritores en la Web. Cada usuario humano de la Web debe ser lector, escritor y solicitante al mismo tiempo, por lo que sería más propio hablar de partícipes web.

En resumen, la Web 1.0 conecta a la gente real con la World Wide Web. La Web 2.0 conecta a las personas reales que utilizan la World Wide Web. La Web Semántica, en un futuro, sin embargo, conectará representantes virtuales de personas reales que utilizan la World Wide Web.

2.1.1. WEB 3.0

La próxima generación web implica la búsqueda de contexto para obtener información en línea.

La guerra de palabras entre los evangelistas de la tecnología sobre la Web 3.0 sigue y, en particular, como una prueba de esto fueron una serie de intercambios en los *blogs* de Tim O'Reilly (2010) y Nova Spivack (2007) acerca de los méritos de la "Web 3.0".

Así que, ¿cuál es la diferencia entre la Web 2.0 y la Web 3.0?

Mientras O'Reilly cree que la Web 3.0 es una extensión de la Web 2.0, Spivak - considerado como un defensor del término Web 3.0 - cree que será una red de tercera generación de aproximadamente entre 2010 y 2020. Para entender la Web 3.0, se debe hacer balanza en contra de la actual Web 2.0. En el universo de la Web 2.0, la búsqueda en Google de una sentencia dará lugar a una gran cantidad de accesos independientes. La

Web 3.0 resuelve este problema proporcionando el contexto para la búsqueda de información en línea (O'Reilly, 2010).

Allan Cho (2008) defiende que para diferenciar los dos términos se debe hacer un análisis de los siguientes conceptos:

- Web inteligente.
- Apertura.
- Interoperabilidad.
- Una base de datos global.
- Web 3D y más allá.
- Control de la Información.

Web "Inteligente"

La Web 2.0 se relaciona con las redes sociales y la colaboración total, además de abogar por una difuminación de la frontera entre creador y consumidor, mientras que el contenido de la Web 3.0 se basa en las aplicaciones Web "inteligentes" mediante:

- Procesamiento del lenguaje natural.
- Machine-based learning y razonamiento.
- Aplicaciones inteligentes.

Apertura

La Web 3.0 se caracteriza por basarse en especificaciones abiertas en sus protocolos, interfaces de programación, formatos de datos, etc., lo que facilita su evolución, extensión e interoperabilidad.

Interoperabilidad

Al abrir el acceso a la información, las aplicaciones Web 3.0 se puede ejecutar a la diferencia de la Web 2.0, donde programas tales como Facebook y MySpace existen en silos separados, la Web 3.0 permite a los usuarios moverse con más facilidad entre aplicaciones.

Una base de datos global

Conceptualmente, la Web 3.0 puede verse como una gran base de datos.

Conocida com “la Web de datos”, la Web 3.0 utiliza registros estructurados los datos publicados en la Web en formatos reutilizables.

Web 3D y más allá

Web 3.0 utiliza un modelo tridimensional y se transforma en una serie de espacios 3D. Servicios tales como Second Life y el uso de avatares personalizados será una característica común de la web en 3D. Web 3.0 se extenderá más allá en lo físico; imaginar una web relacionada con todo, no solo con el teléfono móvil, sino que también con el coche los electrodomésticos, la casa, la ropa, etc., lo que se traduce en una experiencia más integrada e integradora.

Control de la Información

La Web 3.0 es acerca del control de la información, mientras la Web 2.0 es acerca de la sobrecarga de información. El ejemplo más evidente es en la explosión pura de los programas y las contraseñas en la Web que pretenden fomentar la creación de redes y la socialización. Web 3.0, intenta poner orden y permitir a los usuarios para ser más precisos en la búsqueda y encontrar exactamente lo que quieren.

Web Semántica en comparación con la Web 3.0

Lo más confuso es la diferencia entre la Web Semántica y la Web 3.0 - ambos son entidades conceptuales. Mediante la adición de la Web Semántica a la Web 2.0, la Web se aproxima al paradigma 3.0.

Las tecnologías básicas de la Web Semántica, que enriquecen el contenido y la inteligencia de la Web Social, pero con carencias en la gestión de identidades, por lo que deben combinarse en la Web 3.0 para trabajar (Catone, 2008).

Nova Spivack Twine (2010) fue uno de los primeros servicios en línea para utilizar tecnologías Web 3.0. Su objetivo es organizar, compartir y descubrir información sobre los intereses de un usuario en las redes de personas de ideas afines. Mediante el uso de tecnologías semántica, Twine organiza automáticamente la información, aprende acerca de los intereses específicos de los usuarios y hace recomendaciones. Twine es un ejemplo de Web 3.0 en el trabajo, la combinación de los elementos sociales de la Web 2.0 con herramientas específicas del usuario de la Web Semántica (Cho, 2008).

En conclusión, las nuevas tendencias principales en la nueva generación de la Web y su relación con *eLearning*, se pueden identificar como:

- ❖ Web semántica.
- ❖ Móvil.
- ❖ Colaboración.
- ❖ Inteligencia Artificial.

2.1.1.1. Web Semántica

La Web Semántica se refiere a una Web con un significado (W3CSW, 2009). La Web Semántica es, por tanto, una Web que es capaz de describir las cosas de manera que las computadoras las puedan entender.

Las declaraciones se construyen con las normas de sintaxis. La sintaxis de un lenguaje define las reglas para la construcción de los estados del lenguaje.

Esto es de lo que la Web Semántica se trata, de describir las cosas de manera que las aplicaciones de las computadoras pueden entender (Semweb, 2011).

El término "Web Semántica" se refiere a la visión del W3C de la Web de los datos vinculados. Las Tecnologías de Web Semántica permiten a las personas crear almacenes de datos en la Web, crear vocabularios, y escribir las reglas para el manejo de datos. Los datos vinculados se encuentran facultados por tecnologías como RDF, SPARQL (lenguaje de consulta para RDF), OWL (Ontology Web Language), y SKOS (Sistema de Organización Simple de Conocimiento) (W3CSW, 2009).

Las tecnologías relacionadas con la Web Semántica no son intuitivas ni están orientadas a los usuarios finales, lo cual está repercutiendo en una penetración y crecimiento moderados.

2.1.1.2. Web Semántica Social

El concepto de la Web Semántica subsume la evolución social de forma que las interacciones sociales dan lugar a la creación de representaciones del conocimiento explícito y semánticamente ricos. La Web Semántica Social puede entenderse como el conjunto de los sitios web de conocimiento colectivo, que son capaces de proporcionar información útil sobre la base de las contribuciones humanas y que mejoran a medida que participen más personas. La Web Semántica Social combina tecnologías, estrategias y metodologías de la Web Semántica, el software social y la Web 2.0 (SocialSoftware, 2010).

Se desea una nueva generación de aplicaciones Web que combinen los puntos fuertes de estos dos enfoques: la flexibilidad y portabilidad de datos que es característico de la Web Semántica, y las ventajas de escalabilidad y la autoría de la Web Social.

La Web Semántica Social (S2W) tiene como objetivo complementar la visión de la Web Semántica formal mediante la adición de un enfoque pragmático basado en lenguajes de descripción para la navegación semántica, que utilizan la clasificación heurística y ontologías semiótica. Un sistema socio-semántico tiene un proceso continuo para provocar el conocimiento fundamental de un dominio a través de ontologías semiformales, taxonomías o folksonomías (Garshol, 2004). La S2W, en lugar de confiar exclusivamente en la automatización de la semántica sobre la base de ontologías formales y mecanismos de inferencia, se apoya en el factor humano para la construcción de semántica de forma colaborativa con ayuda de sistemas de información socio-económica. Mientras que la Web Semántica permite la integración de procesos de negocio, mediante inferencia lógica, la red socio-semántica abre para una interfaz más social a la semántica de las empresas, lo que permite la interoperabilidad entre los objetos de negocio, las acciones y sus usuarios.

2.1.2. ELEARNING

La *World Wide Web* ofrece tanto a los profesores como a los estudiantes muchas oportunidades de aprendizaje, permitiendo a los estudiantes aprender a su propio ritmo, mejorar sus habilidades de comunicación oral y escrita, desarrollar habilidades para resolver problemas de orden superior, la alimentación y la reflexión crítica (Peck & Doricott, 1994).

Las tecnologías de aprendizaje basadas en la Red, según Mir (2003) surgen a partir de 1995 en formas diversas, y abarcan un esos troqué va desde paquetes de instrucción en papel o tutoriales interactivos multimedia en CD-ROM, hasta los módulos web de aprendizaje, es decir lo que comenzó a denominarse *Web Based Learning* (WBL).

Por *eLearning* se entiende como el proceso de aprendizaje eficiente creado por la combinación de contenidos digitales con el despliegue de (aprendizaje) y los servicios de apoyo (aprendizaje) (Waller et al., 2001). Cabe destacar términos como:

- Eficiente: Hay muchos tipos de procesos de aprendizaje, algunos de los cuales no son efectivos.
- Los contenidos desplegados digitalmente.
- Apoyo: En teoría, un programa basado en CD/DVD-ROM puede utilizarse en cualquier lugar y cuando el usuario quiera, pero suelen carecer de un apoyo de tutores (Waller et al., 2001).

La forma y estructura de la enseñanza y el aprendizaje está cambiando debido a la rápida evolución de las comunicaciones. Los cambios en la economía mundial y los avances en las comunicaciones y la tecnología tiene un gran impacto en la sociedad.

No obstante, se identifican problemas como el alto costo de desarrollar cursos para estos sistemas, o la poca posibilidad de reutilización/adaptación de contenidos cuando cambia algún factor, como, por ejemplo, la plataforma o el contexto educativo (Fernández-Manjón & Fernández-Valmayor, 1997). A partir de estas necesidades básicas surge el modelo de contenidos basado en objetos de aprendizaje, con fuertes raíces en el paradigma de la Orientación a Objetos (Koper, 2001). El modelo consiste básicamente en el diseño de los cursos como agregación de objetos independientes y reutilizables de aprendizaje. La combinación de Internet como una plataforma para desarrollar estos nuevos modelos de cursos y el uso de tecnologías de marcado (por ejemplo, los estándares XML y relacionados), simplifican la creación de nuevos sistemas educativos que se proponen para mejorar el paradigma educativo basado en la máxima "el estudiante es el centro" (Koper, 2001). Esto signfica, en esencia, que el proceso de aprendizaje puede adaptarse a las características de cada estudiante y no al revés como es habitual en los métodos de enseñanza tradicionales. Bajo este punto de vista, hay dos características clave que permiten a un ambiente de aprendizaje el alcanzar este objetivo:

1. La calidad del contenido educativo reutilizables.
2. La personalización de los sistemas de aprendizaje.. Una enseñanza adaptada a las necesidades de los estudiantes desde tres ángulos diferentes::
    a. Nivel de conocimiento inicial del estudiante.
    b. Objetivos de conocimiento de los estudiantes.
    c. Metodología de aprendizaje preferida por el estudiante.

Nuevas tendencias de *eLearning*

La comunidad de *eLearning* esta adoptando rápidamente muchas tecnologías Web que incluyen entre otras XML, XML Schema, o P3P. Las especificaciones y estándares dentro de la tecnología educativa se ha desarrollado significativamente, entre las que cabe citar, entre otras, a incluidas las organizaciones como IMS Global Learning Consortium (IMS, 2011), IEEE (IEEELOM, 2002), Dublin Core (DC, 2010), ISO (JTC1/SC36 de 2007) (2007), o ADL (SCORM, 2009).

Por otra parte, es evidente que hay una falta de penetración de la Web Semántica en el ámbito educativo pese a sus beneficios potenciales.

Además, muchas aplicaciones de *eLearning* son monolíticas y poco flexibles (Rego et al., 2005). En estos sistemas el comportamiento inteligente y las descripciones semánticas no se han tenido en cuenta, y claramente se tiene un área importante de mejora de estos sistemas en la combinación de los principios delante Web Semántica y de la Web Social.

En resumen, se ha llegado a la situación, un tanto sorprendente y paradójica, de que tal vez en la comunidad de *eLearning* falte la tecnología de representación del conocimiento.

En este sentido, la tecnología de Web Semántica no ha sido ampliamente utilizada y estudiada para aplicaciones educativas.

A pesar de que este trabajo se centra en los beneficios específicos de la próxima generación de tecnologías Web en cpmtextos educativos muchas de las lecciones aprendidas son aplicables a las implementaciones en otros campos de aplicación (Rego, Moreira, Morales et al., 2010) (Liu, 2009).

2.1.2.1. eLearning 3.0

¿Cuál será el *eLearning* del futuro? Cuando Stephen Downes estableció su manifiesto para el *eLearning* 2.0 en 2005, dio unos golpecitos en el espíritu de la época de las nuevas tecnologías sociales (Downes, 2005).

Como señalan por Sue Waters (2010) y Darcy Moore (2010), en una discusión de lo que el aprendizaje sería en un mundo Web 3.0, y cómo puede diferir de aprendizaje actual. Esto llevó a revisar algunas ideas acerca del "*eLearning* 3.0".

El *eLearning* 3.0 tendrá por lo menos cuatro factores clave (Wheeler, 2009):

1. Computación distribuida;
2. Extensión de la tecnología móvil inteligente;
3. Colaboración y filtrado inteligente;
4. Visualización 3D y la interacción.

Si la Web 1.0 era la "Web de Escribir" y la Web 2.0 es la "Web de lectura/escritura", la Web 3.0 será la "Web de lectura/escritura/colaboración". Pero no sólo promoverá un aprendizaje más rico en colaboración, sino que también permitirá a los estudiantes a acercarse a en cualquier momento y en cualquier lugar al aprendizaje a través de soluciones inteligentes para búsquedas en Internet, gestión de documentos y organización de los contenidos.

2.1.2.2. Sistemas eLearning y herramientas

Hoy en día, existen varias soluciones para apoyar el *eLearning*, algunas están más centradas en contenidos y otras lo están en los estudiantes.

A continuación se presentan brevemente algunas de estas herramientas.

Los enfoques actuales de *eLearning*

En general, las plataformas de gestión de cursos y de contenidos incluyen típicamente una combinación de las siguientes herramientas:

- ❖ Comunicación - Herramientas que permiten la comunicación entre los usuarios de la plataforma. Ej: *chat*, foro.
- ❖ Administración - Permiten la gestión de usuários, informes y estadísticas.
- ❖ Gestión de Recursos - Relacionadas con la gestión de los recursos como la creación, edición y autoría.
- ❖ Gestión de cursos - Define las unidades de aprendizaje, las actividades y su secuencia.
- ❖ Evaluación - Gestión de la evaluación, los tipos de tests y cuestionarios permitidos.

Hay diferentes plataformas en el mercado, tanto plataformas comerciales como Blackboard (Bb, 2010), el ex WebCT (Bb Learning System) (WebCT, 2010), IntraLearn (2010), Angel (2010) como plataformas *freeware/open-source* como Atutor (2010), Moodle (2010), Sakai (2010) y dotLRN (2010).

La mayoría de las plataformas de *eLearning*/sistemas tienen buenas herramientas de administración y la comunicación, el cumplimiento de estándares como SCORM, AICC y algunas especificaciones IMS. Estas plataformas tienen alto nivel de ejecución y una buena documentación. Por otro lado, estas plataformas tienen algunos problemas relacionados con la gestión de los objectos de aprendizaje, evaluación de la calidad, el intercambio y la reutilización. También tienen algunos problemas relacionados con la adaptación de los recursos a las características de los estudiantes, entre otros. De la comparación de plataformas comerciales y de código abierto se encontró que las comerciales tienen más dificultades para la integración con otros sistemas y el apoyo a diferentes tipos de pedagogías y por supuesto los costos. Puede verse en el Apéndice A un análisis más detallado de estos sistemas.

Las debilidades encontradas están relacionadas principalmente con los problemas relativos a la interoperabilidad, la reutilización y la calidad de los recursos de aprendizaje, el aprendizaje de dominio la independencia, la adaptación y capacidad de ampliación de las plataformas.

2.2. ESPECIFICACIONES Y ESTÁNDARES EDUCATIVOS

Los estándares y especificaciones ayudan a asegurar las siguientes características esenciales para el éxito y retorno de las inversiones en *eLearning* por parte de las organizaciones:

- Interoperabilidad - ¿Puede un sistema para operar con otro sistema?
- Reutilización - ¿Pueden reutilizarse recursos (objetos de aprendizaje, módulos, etc.) de otros cursos?
- Gestión - ¿Puede un sistema de encontrar la apropiada información sobre el estudiantes, profesores o recurso?
- Accesibilidad - ¿Puede acceder un estudiante al contenido apropiado en el momento oportuno?
- Durabilidad - ¿Evoluciona adecuadamente la tecnología para evitar la obsolescencia?

La proliferación de plataformas web diseñadas para soportar ambientes educativos, ha generado nuevos conceptos sobre cómo los procesos de enseñanza y el aprendizaje deben llevarse a cabo, las ideas innovadoras para establecer cómo deben interactuar los agentes implicados, y los nuevos requisitos relativos a la forma de definir los elementos educativos para que sean interoperables, reutilizables e intercambiables entre los distintos sistemas y plataformas.

2.2.1. TECNOLOGIAS DE MARCADO PARA METADATOS EDUCATIVOS

Una de las mayores dificultades del aprendizaje electrónico y de las plataformas de *eLearning* es en la estructuración de los contenidos y de la información mediante el uso de los modelos pedagógicos, para que puedan llegar a una gama más amplia de los sistemas educativos y obtener una mayor calidad de la enseñanza.

Entre estas normas y las especificaciones las hay que están más centradas en el diseño y en la estructuración de los cursos, mientras que otras tratan de incluir, de manera general, todo el proceso de enseñanza/aprendizaje. Entre las primeras especificaciones cabe mencionar a *Sharable Content Object Reference Model* (SCORM) (2009), un proyecto de *Advanced Distributed Learning* (ADL), y la especificación de la *Educación Modelling Language* (EML) (Koper, 2003).

SCORM es más un integrador de una especificación, lo que lo hace dependiente de las demás normas que se integra, además de no considerar la evaluación y caracterización de los estudiantes. EML es una especificación que quedó obsoleta cuando el IMS (*Instructional Management Systems*) Learning Design (LD) (IMSLD, 2003) surgió, sin embargo, permite la construcción de la experiencia de aprendizaje basada en actividades de aprendizaje, está abierto a cualquier otra teoría de aprendizaje, e incluye aspectos como la secuencia de actividades, roles y evaluación.

Mención a parte merecen las especificaciones de IMS, que se utilizan como guía para la estructuración de contenidos, y que han sido desarrolladas por el consorcio IMS. IMS basa su especificación de metadatos en el estándar IEEE LOM (2002).

Las tecnologías de marcado de metadatos educativos identifican y anotan de manera uniforme, las técnicas, métodos y elementos relacionados con la formación, con el objetivo de facilitar su intercambio, distribución y reutilización en los diferentes sistemas y cursos. A través de estas tecnologías se pueden identificar, por ejemplo, recursos de aprendizaje, los perfiles de los estudiantes, pruebas y evaluación, repositorios, formatos digitales para el intercambio de recursos, conocimientos, lenguajes de modelado, educativos o vocabularios y glosarios.

Así, surgen iniciativas encaminadas a la definición de propuestas conocidas como normas, especificaciones o perfiles de aplicación, según sea el caso, que establecen cómo deben especificarse los elementos de marca.

Dos conceptos importantes dentro de las normas y las especificaciones son los objetos de aprendizaje (OA) y los metadatos.

Un OA se ha definido de diferentes maneras:

1. Cualquier entidad, digital o no digital, que puede ser usado para aprender, educar o entrenar (IEEELOM, 2002).
2. Cualquier recurso digital que puede ser reutilizado para soportar el aprendizaje (Wiley, 2002).
3. Una entidad que lo digital puede ser utilizada, reutilizada y referenciada durante el aprendizaje apoyado por la tecnología (Rehak & Mason, 2003).
4. Cualquier recurso digital, reproducibles y que puedan ser localizados, que se utiliza para llevar a cabo actividades de aprendizaje o de apoyo, y están disponibles para su uso por otros (Hummel et al., 2004).
5. Una unidad educativa con un objetivo mínimo de aprendizaje asociado a un tipo concreto de contenido y actividades para su logro, caracterizada por ser digital, independiente, y accesible a través de metadatos con la finalidad de ser reutilizadas en diferentes contextos y plataformas (Morales et al., 2007).

El campo del *eLearning* está en constante crecimiento, al igual que las fuentes de información asociadas a los procesos formativos, por lo que se está haciendo más y más difícil de encontrar y utilizar la información pertinente. El propósito y la utilidad de los metadatos en *eLearning* es que proporcionan la capacidad de describir e identificar el contenido de aprendizaje para que se pueda encontrar, reunir y entregar los contenidos de aprendizaje adecuados, a la persona adecuada, y en el momento adecuado.

Los metadados simplemente se definen como los datos que describen a otros datos o información que describe otro tipo de información, y, como tal, los metadatos son un maravilloso ejemplo del poder de las cosas simples. El contenido se divide con mayor frecuencia en trozos más pequeños para que pueda ser mezclado entre sí, y organizarse, así, en “Objetos de Aprendizaje” adaptados a las necesidades concretas. Sin metadatos esto sería inviable.

2.2.2. DEBILIDADES DE LAS TECNOLOGIAS EDUCATIVAS DE MARCADO

Hasta ahora, el uso de las especificaciones y normas entre los posibles usuarios potenciales (es decir, profesores, diseñadores instruccionales, proveedores, instituciones educativas, etc.) no está muy extendida. Su propagación y, por tanto el éxito a largo plazo depende de su calidad, funcionalidad y valor en el “mundo real” (Walker, 2003).

En consecuencia, asumir la utilidad de las normas para el marcado de metadatos educativos para los entornos de *eLearning* es arriesgado. En primer lugar, es evidente la confusión sobre el significado del concepto de objeto de aprendizaje, su extensión y su grado de granularidad. Las diferencias entre las definiciones propuestas causan confusión entre los usuarios potenciales (Friesen & Nirhamo, 2003), lo que provoca que no entiendan su propósito, o lo entiendan mal, o que lo consideren exclusivamente una cuestión de investigación, fuera de los contextos prácticos.

Por tanto, el grado de adopción es muy bajo y la complejidad técnica está más allá del alcance actual de los no expertos. Uno de los principales problemas para la adopción de esta tecnología es, sin duda, la falta de herramientas de autoría para definir los elementos educativos que cumplan con las normas o especificaciones, que, a su vez, son fáciles de utilizar y ocultar los metadatos de los usuarios (Duval & Hodgins, 2004). En este sentido, algunos estudios sugieren el desarrollo de herramientas para buscar, recomendar, clasificar, y automatizar la entrega de objetos de aprendizaje similares a los concebidos para fines comerciales, por ejemplo, Google, Amazon o eBay (Duval & Hodgins, 2004).

En cuanto a los atributos educativos de las tecnologías de marcado, Friesen y Nirhamo (2003) sostienen que una especificación “pedagógicamente neutral”, según la definición de IEEE LOM, SCORM o IMS LD, no puede ser pedagógicamente pertinente. Por su parte, Downes (2003) sostiene que existe una incompatibilidad con los principios de diseño instruccional como un diseño de instrucción no pueden ser reutilizadas en otros contextos, pues la definición inicial está diseñada para una experiencia de aprendizaje específico que utiliza objetos de aprendizaje específicas para contextos específicos.

Aunque estos resultados se contrastan fuertemente con la reutilización de las especificaciones como IMS LD y SCORM Berlanga (2006) la perspectiva es importante señalar que una especificación se define como "pedagógicamente neutral", ya que no establece ninguna enseñanza especial enfoque, que permite a los caudales de diseño de aprendizaje que sea necesario. La pertinencia pedagógica está en el diseño de la lógica y en cómo se realiza el proceso de aprendizaje, no en la especificación utilizada.

Es también necesaria la investigación para definir los mecanismos generación automática de metadatos para los objetos de aprendizaje.

2.3. SISTEMAS HIPERMEDIA ADAPTATIVOS

La gran expansión en los últimos años que han tenido los sistemas de hipermedia se debe, en primer lugar, a la popularización de la Web (Berners-Lee, 1996), y en parte a su capacidad de estructurar piezas de información de naturaleza dispar de manera asociativa, que pueden simular, en cierta medida, el proceso de relación y conexión propia de la mente humana.

Sin embargo, los sistemas hipermedia "clásicos" no tienen en cuenta las características, intereses u objetivos de los usuarios, sino que interactúan de la misma forma y siempre muestran la misma información y enlaces a todos los usuarios, ya que no disponen mecanismos para ayudar en la navegación o en la búsqueda la información pertinente.

Por el contrario, un Sistema Hipermedia Adaptativo (SHA) puede configurar las aplicaciones para que presenten la información y las rutas adecuadas a las características de cada usuario, los guía en la navegación y en el descubrimiento y la gestión de la información pertinente. Esto representa los objetivos, preferencias y conocimientos de cada usuario a través de un modelo que se utiliza para llevar a cabo la adaptación, que cambia en función de la interacción del usuario con el sistema.

Entre las diferentes áreas de aplicación de los SHA está la educación. Los Sistemas Hipermedia Adaptativo para los propósitos Educativos (SHAE) persiguen personalizar el proceso de aprendizaje con la intención de facilitar la adquisición de conocimientos, la presentación de contenidos educativos y los cursos adecuados a los objetivos educativos, a la formación previa, a las características individuales al nivel de conocimiento de cada estudiante. Uno de los objetos de estudio de esta tesis es la definición de un sistema de aprendizaje adaptativo. Antes de profundizar en su aplicación a la educación, es deseable proporcionar una visión general de los SHA.

El propósito de un SHA es que el sistema se ajuste a las características del usuario y no viceversa, como en un hipermedia "clásico", que muestra el mismo contenido y enlaces a todos los usuarios (Bra, Brusilovsky et al., 1999). Para lograr este objetivo se debe construir un modelo que represente las metas, preferencias, características y conocimientos de cada usuario, dicho modelo se utiliza para realizar la adaptación y el cambio de acuerdo a la interacción con el sistema. De esta manera, estos sistemas son capaces de adaptar el contenido y los enlaces a las necesidades específicas de cada usuario, Brusilovsky (1996) llama a la primera adaptación de la presentación y apoyo a la adaptación de la navegación a la segunda.

Al observar la evolución de SHAE puede ver claramente los dos aspectos que están empezando a concentrar los esfuerzos de los investigadores. Por un lado, el desarrollo de herramientas que permiten a los usuarios no especializados en hipermedia adaptativo para crear contenidos y cursos, lo que facilitará la difusión de estos sistemas. Además, la inclusión en el ámbito de las tendencias actuales SHAE en el desarrollo de la Web como el uso de metadatos normalizados y la identificación de la estructura de conocimiento de dominio, lo que resulta en la expansión de sus capacidades y funcionalidad.

Resulta preocupante, sin embargo, lo poco que se han considerado los aspectos pedagógicos y didácticos para desarrollar los sistemas de revisión y, por el contrario, la atención que reciben las cuestiones técnicas, así como la tendencia a ver el proceso de la enseñanza como una simple transferencia de conceptos. En este sentido, en la creación de SHAE es esencial tener en cuenta los objetivos educativos que deben alcanzarse, las teorías del aprendizaje que deben utilizarse, y el proceso por el cual los estudiantes adquieren los conocimientos. Estos aspectos deben ser analizados y detallados en equipos interdisciplinarios formados por técnicos, educadores y diseñadores instruccionales.

Otro aspecto a considerar es la falta en los enfoques actuales del uso de herramientas de colaboración y características para el proceso de adaptación.

Por último, cabe destacar lo interesante que resulta introducir herramientas de recomendación para sugerir caminos adaptativos y recursos a los estudiantes.

2.4. COLABORACIÓN Y SISTEMAS DE RECOMENDACIÓN

A continuación se presentan los principales aspectos en relación con dos áreas que más influencián la Web en estos días - sistemas de colaboración y la recomendación y sus principales características.

2.4.1. COLABORACIÓN

El *software* de colaboración es un *software* diseñado para ayudar a las personas implicadas en una tarea común de alcanzar sus objetivos.

La intención del diseño de *software* colaborativo (*groupware*) es transformar el formato de los documentos y los medios de comunicación ricos son compartidos con el fin de permitir una colaboración en equipo más eficaz.

Un tipo de herramientas de gestión de la colaboración son los sistemas de flujo de trabajo, cuyo objetivo principal es facilitar y gestionar las actividades de grupo (Brickley, 1995).

Sistemas de flujo de trabajo (*Workflow*)

La definición del concepto de flujo de trabajo por la *Workflow Management Coalition* (WfMC, 2010) es "La automatización de un proceso de negocio, en su totalidad o en parte, durante el cual los documentos, se pasan información o tareas de un participante a otro para la acción, de acuerdo con un conjunto de normas de procedimiento". Participante significa aquí recursos (humano o máquina).

Normalmente, un sistema de flujo de trabajo tiene tres componentes principales

- ❖ Las personas involucradas en el proceso.
- ❖ La lógica de negocio de los componentes, que controla las transiciones entre las tareas del proceso.
- ❖ Los componentes de datos, que los datos del proceso de flujo de trabajo.

2.4.2. RECOMENDACIÓN

Típicamente, un sistema de recomendación se compara el perfil del usuario para algunas de las características de referencia, y trata de predecir el peso que un usuario le daría a un elemento que todavía no había considerado (Gediminas & Alexander, 2005). Estas características pueden ser desde el punto de información (el enfoque basado en el contenido) o del entorno social del usuario (el enfoque de filtrado colaborativo).

Al construir el perfil del usuario se hace una distinción entre las formas explícitas e implícitas de la recogida de datos (Fournier, 2010).

Ejemplos de recopilación de datos explícitos pueden ser los siguientes:

- ❖ Hacer que un usuario vote un artículo en una escala móvil.
- ❖ Hacer que un usuario clasifique una colección de artículos de más a menos favorito.
- ❖ La presentación de dos productos a un usuario, pidiéndole elegir la mejor.
- ❖ Pedir que un usuario cree una lista de artículos que a él/ella le gustan.

Ejemplos de recopilación de datos implícitos pueden ser los siguientes:

- ❖ Observación de los elementos que un usuario ve en una tienda en línea.
- ❖ Análisis de tiempos de visualización del usuario.
- ❖ Llevar un registro de los elementos que un usuario compra en línea.
- ❖ La obtención de una lista de elementos que un usuario ha escuchado o visto en su ordenador.
- ❖ El análisis de la red social del usuario.

El sistema de recomendación compara los datos recogidos con los datos recogidos de otros similares y calcula una lista de temas recomendados para el usuario.

Este tipo de sistema son alternativas útiles para algoritmos de búsqueda, ya que ayudan a los usuarios a descubrir elementos que no seria complicado que hubieran encontrado por sí mismos. Curiosamente, los sistemas de recomendación se han implementado utilizando motores de búsqueda de indexación de datos no tradicionales.

A partir del análisis de los sistemas de recomendación que se pueden identificar cinco de sus principales problemas o debilidades (MacManus, 2009b):

1. La falta de datos - Quizás el mayor problema que enfrentan los sistemas de recomendación es que necesitan una gran cantidad de datos para hacer efectivas las recomendaciones.
2. Cambio de datos - Esta cuestión fue señalada por Paul Edmunds (2010), que sugirió que los sistemas suelen estar "sesgados hacia lo viejo y tienen dificultad para mostrar lo nuevo".
3. Cómo cambiar las preferencias del usuario.
4. Elementos impredecibles - Por ejemplo, el tipo de película que la gente ama u odia, como *Napoleon Dynamite*. Este tipo de elementos son difíciles de recomendar, porque la reacción del usuario sobre ellos tiende a ser diversa e impredecible.
5. La complejidad de las cosas.

2.5. DEBILIDADES O OPORTUNIDADES PARA LA MEJORA DE LOS SISTEMAS ELEARNING BASADOS EN TECNOLOGIAS WEB

Las debilidades encontradas están relacionadas principalmente con los problemas relativos a la interoperabilidad, la reutilización, la calidad de los recursos de aprendizaje, la independencia de dominio de aprendizaje y la extensibilidad de los sistemas. También la dificuldad de implementar los conceptos de la Web Semántica y Web 3.0 al *eLearning*, por la necesidad de conocimientos técnicos.

Así, se tiene la oportunidad de crear sistemas con flexibilidad, con colaboración y aprovechando la realimentación de los usuarios, lo que permitiria adaptar el sistema a las personas.

Estos problemas son las oportunidades para establecer las piezas de los principales temas del presente trabajo de investigación y, en consecuencia, del desarrollo de la propuesta.

3. HACIA LA WEB 3.0: PROPUESTA

Los sistemas de *eLearning* están en constante evolución y desarrollo.

Por lo tanto, las debilidades que se han señalado en el análisis de sistemas se han convertido en los objetivos de este estudio, y por esto se han tratado de combinar diferentes tecnologías para lograr un nuevo concepto y desarrollar de la propuesta.

Concepto

La propuesta de este estudio es abordar los problemas y puntos débiles que se encuentran en los sistemas de *eLearning* y su preparación hacia la Web 3.0.

Para este fin los objetivos de la propuesta tienen cobertura doble:

- Innovar los sistemas y herramientas existentes tanto en concepto como en características.Mejorar las funcionalidades existentes en los sistemas *eLearning*, en combinación con los requisitos no funcionales especialmente relacionadas con el rendimiento y la usabilidad.Por tanto, se propone el desarrollo de un sistema *eLearning*, especialmente orientado a los actores involucrados. El principal objetivo no es la tecnología utilizada, sino preparar un cambio de paradigma.

Se propone, enfatizar un enfoque centrado en el usuario donde se prime la simplificación y a reutilización de recursos, sobre la carga de conocimientos del usuario.

De esta forma se es congruente con el principio de la sencillez propio de la ingeniería de la usabilidad, *keep it simple*, que se podría entender como "lo simple es mejor".

Así que el sistema funcionará simultáneamente como un sistema de *back-office* de diseño de aprendizaje para los profesores y también como el *front-end* para la presentación de recursos de aprendizaje y de colaboración. También para las entradas, el sistema tendrá el contexto del aprendizaje, las encuestas de retroalimentación y los datos almacenados en bases de datos de apoyo, y para las salidas los recursos de aprendizaje y el diseño teniendo en cuenta las aportaciones y el tratamiento realizado por los profesores y profesionales para lograr la información y en última instancia el conocimiento, dar calidad a los recursos y su publicación en un *front-office* de la interacción, donde las principales características son la colaboración y el intercambio.

En este sentido, se deben tener en cuenta y manejar aspectos relacionados con:

- Interoperabilidad.
    - Movilidad de los recursos e independencia del contexto.
    - Base de datos global - la recogida y la interacción de todos los datos de aprendizaje e información.
- *Machine learning*.
    - La minería de datos – para extraer patrones a partir de datos e información.
- Colaboración avanzada.
    - Flujo de trabajo, para automatizar el proceso, las tareas, los documentos o los recursos.
    - Herramientas de comunicación tanto síncronas como asíncronas.
    - Herramientas multimedia.
        - Creación de redes sociales - comunidades sociales web de aprendizaje.

Por tanto, se trata de introducir una primera versión de las tecnologías y conceptos sobre la Web Semántica o Web 3.0, lo que debería convertir a la Web en una Web *machine-readable* mediante la anotación de datos en función de su significado (EmergingTech, 2011).

Otra innovación busca ofrecer independencia a los diseñadores de aprendizaje mediante el uso de estándares tecnológicos educativos:

- Importar estructuras externas de aprendizaje utilizando esquemas XML.
- Personalización de los esquemas existentes.
- La creación de sus estructuras de aprendizaje.

Así, la combinación de estos conceptos es la principal innovación de la presente propuesta.

El objetivo del sistema es ofrecer un espacio de encuentro entre profesores y tecnologías de eLearning, marcado por los principios de la Web Social-Semántica y del trabajo en red.

3.1. CONTRIBUICIONES PRINCIPALES

Las principales aportaciones de esta propuesta están relacionadas con la aplicación de una evolución en los sistemas de *eLearning*, a través de las siguientes características:

- La posibilidad que tienen los profesores para crear o personalizar su diseño de aprendizaje, sus esquemas o la ontología de las estructuras del diseño instruccional y los recursos de aprendizaje. Al mismo tiempo esta estructura se almacena en bases de datos.La inclusión del concepto de red social y sus funcionalidades asociadas dan la posibilidad a los profesores y los estudiantes de interactuar.La inclusión de colaboración avanzada con funcionalidad de flujo de trabajo a disposición de los profesores para el diseño de instrucción y adaptación de los recursos.La adaptación de los recursos a través de la colaboración y de los sistemas de recomendación.La aplicación de un *middleware*, entre sistemas Web 2.0 y Web 3.0, debido a la dificultad para aplicar la Web 3.0 a través de las tecnologías avanzadas.La interoperabilidad se introduce mediante el uso de estándares.Aplicaciones inteligentes, cuyo objetivo es adaptar la búsqueda en línea a las preferencias de los usuarios y sus necesidades. Aunque la Web Inteligente parece similar a la Inteligencia Artificial, no es lo mismo. Por tanto, el objetivo

principal es contribuir para al desarrollo y aplicación del concepto de una manera más sencilla y coherente.

3.2. NORMAS Y ESQUEMAS

La propuesta busca la independencia a los profesores en el proceso de diseño del aprendizaje. Sin embargo, tiene que seguir una estructura específica, un modo de trabajar como base para el diseño o la adaptación de la estrategia de aprendizaje, para lo que se han elegido las especificaciones de IMS..

¿Por qué IMS?

Se han analizado las especificaciones IMS (2011), AICC (2010), SCORM (2009) y Dublin Core (DC, 2010), en relación con lo siguiente (Rego et al., 2005):

- Metadatos - formato para representar los metadatos para describir los recursos de aprendizaje.
- Perfil del estudiante - el formato para registrar y administrar el historial de aprendizaje, metas y logros.
- Paquete de Contenido - formato de paquete de cursos y recursos por lo que pueden ser transportados fácilmente a otros sistemas.
- *Question & Test Interoperability* - la estructura de la representación de las preguntas y los datos de prueba y sus informes de resultados correspondientes.
- Repositorios de datos sobre interoperabilidad - la descripción de cómo interactúan entre repositorios de datos.
- Estructura de contenido - formato al contenido de la estructura.
- Comunicaciones de contenido - formato para promover la comunicación de contenidos.
- Diseño de Aprendizaje - Especificaciones para describir los elementos y la estructura de cualquier unidad de aprendizaje.
- Secuencia - formato para representar la información necesaria a la secuencia de actividades de aprendizaje en una variedad de formas.
- Accesibilidad - tiene en cuenta las cuestiones relacionadas con la accesibilidad.
- Enlaces a XML y RDF - Especificaciones para describir los recursos en XML o RDF.
- Manuales de usuario - la información disponible.
- Registro del estudiante - formato para registrar la información relacionada con el estudiante.

Gracias a este análisis se ha pudido verificar que las especificaciones IMS cubren la mayor parte de los aspectos analizados.

Por tanto, en base a este conjunto de especificaciones propuestas por IMS, se ha construido la estructura de contenidos educativos y desarrollado un sistema de *eLearning*, polivalente que permite la reutilización y la interoperabilidad entre sistemas, que se basa en la información de la estructura de almacenamiento en archivos XML, los paquetes de contenido, con archivos de manifiesto y sus esquemas (IMSCP, 2009).

Factores que han influido en la elección:

- ❖ Basado en el estándar IEEE LOM.
- ❖ La interoperabilidad y reutilización - almacena los metadatos en archivos XML.
- ❖ La creación de paquetes dentro de un archivo de manifiesto, con esquemas, archivos XML y archivos de recursos;
- ❖ Tener especificaciones para modelos de gran parte del proceso de aprendizaje:
  - o *Learning Resource Metadata.*
  - o *Learning Design.*
  - o *Learning Information Package.*
  - o *Content Packaging.*
- ❖ Proporcionan un pliego de condiciones con futuro y que se están desarrollando lineamientos y especificaciones para RDFS.

3.3. AHKME

En ambientes de aprendizaje, la información debe ser percibida y transformada en conocimiento. Uno de los problemas que han surgido de esta transformación es la manera de representar el conocimiento. Por este motivo la normalización es indispensable, ya que proporciona una representación semántica del conocimiento a través de ontologías en el que los conceptos se identifican claramente y sin ambigüedades, además las ontologías ofrecen tipos de relaciónes semántica que permiten la representación de significado mediante la vinculación de los conceptos (Berners-Lee et al., 2001; Mendes & Sacks, 2001).

AKHME un sistema que es compatible con la representación y la gestión del conocimiento sobre la base de metadatos descritos por las especificaciones de IMS. Las principales aportaciones de AHKME son: la gestión de los recursos de aprendizaje y evaluación de la calidad, proceso al que se le ha dotado de un cierto grado de comportamiento inteligente mediante agentes inteligentes; el uso de las especificaciones de IMS para estandarizar los recursos del sistema, y la interacción de todos los subsistemas a través de la retroalimentación entre ellos permitiendo que el sistema pueda adaptarse a los estudiantes/profesores y a las características de nuevos contextos.

La gestión oportuna y correcta del conocimiento es una fuente de ventajas competitivas sostenible, además de una manera de conectar a las personas con el conocimiento de calidad, así como a las personas con las personas, con el fin de obtener el máximo rendimiento. En el área educativa la gestión del conocimiento y los sistemas avanzados pueden utilizarse para explorar cómo las tecnologías permiten aprovechar el intercambio de conocimientos y el aprendizaje para mejorar el rendimiento (Chatti et al., 2007; Grace & Butler, 2003). Se ha implementado un sistema que se adapta a las características de los estudiantes y de los profesores a los nuevos contextos, mediante la gestión de metadatos, la representación y gestión del conocimiento para capturar el comportamiento del usuario y la interacción con el sistema, lo que ha de permitir a quienes deben tomar las decisiones conocer qué recursos, formatos de curso y estrategias de aprendizaje han resultados mejores o peores en contextos determinados, ayudándoles a definir las estrategias sobre cómo tratar ciertos tipos de estudiantes y contextos.

En primer lugar, sería relevante para explicar el significado detrás del nombre AHKME (o *ahkme*). Eso significa:

- AH: Hipermedia Adaptativo o *Adaptive Hypermedia*.
- KM: Gestión del Conocimiento o *Knowledge Management*.
- E: *elearning*.

El concepto detrás de AHKME, es abordar las cuestiones con respecto a la interoperabilidad, la reutilización, la independencia del dominio de aprendizaje, la calidad de los recursos y la apertura, da la posibilidad a los profesores para diseñar y evaluar los recursos de aprendizaje y al mismo tiempo, los estudiantes pueden aprender de los recursos de calidad y mediante las técnicas de aprendizaje apropiadas, de acuerdo a sus características, diseño instruccional y las actividades de aprendizaje.

Las principales características de este sistema son:

- Simplificar y generalizar el diseño educativo - Dar acceso a un conjunto de herramientas que simplifican y aproximan a los profesores a los estándares tecnológicos educativos, pero que también ofrecen la libertad para crear sus propias estructuras de aprendizaje o de ontologías.

- Facilitar la aplicación y la transición a la Web 3.0 - Mediante la creación de una capa intermedia, como un *eLearning* 2.5, adaptación y evolución de las herramientas de *eLearning* a este concepto, lo que hace que sean más "inteligentes" e interoperables.
- Movilidad - Al dar acceso a un conjunto de herramientas para que los recursos más interoperable entre sistemas.
- Apertura - Las herramientas se desarrollan con el apoyo de tecnologías de código abierto y están destinadas a ser integradas y utilizadas con los sistemas de *eLearning* y otras herramientas.

AHKME es un sistema de *eLearning* que se divide en cuatro subsistemas diferentes (ver Figura 205): el Subsistema de Gestión de Objetos de Aprendizaje y Diseño de Aprendizaje, Subsistema de Gestión del Conocimiento; Subsistema Adaptable/Adaptación; Subsistema de Visualización y presentación.

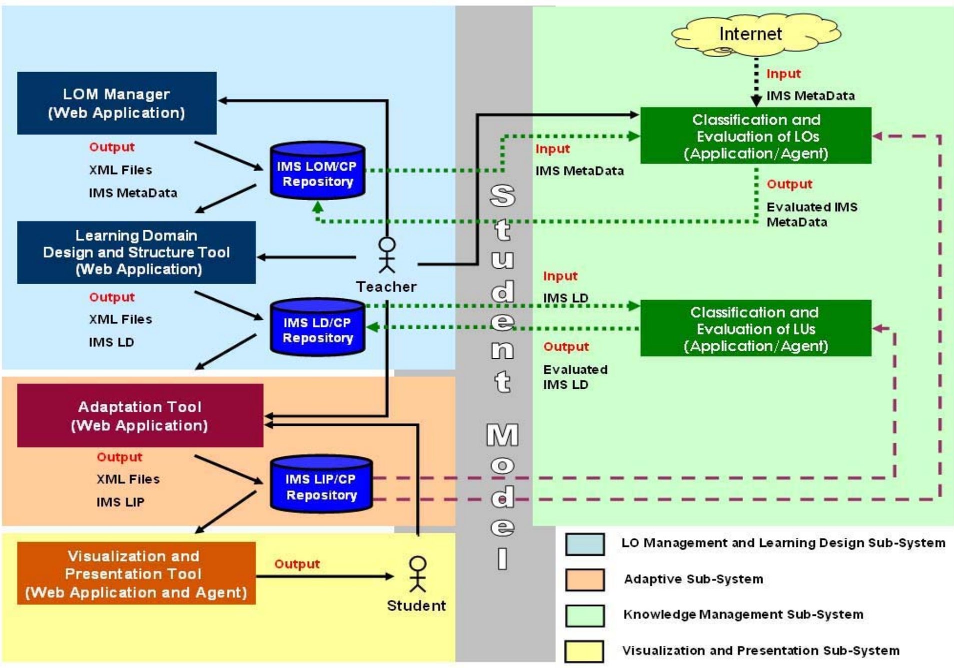

Figura 205. Esquema AHKME

Estos subsistemas están estructurados teniendo en cuenta una línea de razonamiento, donde primero se tene la creación de los objetos de aprendizaje y el proceso de gestión, al que sigue el proceso de creación de cursos a través del diseño de aprendizaje. En paralelo con estos dos procesos el subsistema de gestión del conocimiento evalúa la calidad de los objetos de aprendizaje y cursos. Luego pasan a través de un proceso adaptativo basado en características de los estudiantes y en la colaboración de los profesores.

El sistema tiene diferentes perfiles de aplicación con distintas características y herramientas:

- Perfil del diseñador de Aprendizaje - Diseñadores de aprendizaje que pueden ser profesores o simplemente profesionales de educación, que tienen que ver con el diseño instruccional y los recursos de aprendizaje.
- Perfil del instructor - Instructores de aprendizaje pueden ser profesores o asistentes cuyo trabajo es aplicar el diseño instruccional y los recursos de aprendizaje a los cursos.
- Perfil del estudiante - El estudiante interactua con los cursos y indirectamente con el diseño y recursos de aprendizaje.
- Perfil de administrador - Administra el sistema de parametrización, los usuarios y permisos, así como las herramientas y la administración de la plantilla.

A continuación se presentan los aspectos principales de los diferentes subsistemas que componen este sistema, con más atención a los componentes del sistema que permiten la gestión, diseño y adaptación de recursos a través de sus metadatos – el subsistema Gestor de objetos de aprendizaje (LOM) y Diseño de Aprendizaje (LD), el subsistema de adaptación, y el subsistema de presentación.

El *Subsistema LOM y LD* integra varias herramientas y características:

- *Learning Object metadata manager tool (LOM)*, herramienta que administra los objetos de aprendizaje y su metadata.
- *Learning Design (LD)*, herramienta que administra las unidades de aprendizaje y cursos.
- *Instructional Manager*, conocida aquí como administrador de esquema.

También incluye características de alguna herramienta transversal y como la herramienta de flujo de trabajo, que ayuda en el proceso de diseño de aprendizaje y también la función de búsqueda.

Subsistema de Adaptación

- Herramienta recomendación - Opera como una función de sugerencia de consejos a los diseñadores de aprendizaje sobre la de adaptación de los recursos de aprendizaje.
- Herramienta Colaborativa - La herramienta de flujo de trabajo permite, e introduce el concepto de adaptabilidad en la colaboración entre profesores e instructores.

Subsistema de Presentación

- Herramienta de red social educativa (*Learning Social networking tool*).
- *Learning Design and Learning object play tool* - La herramienta integra el reproductor de diseño instruccional (learning design) de libre distribución CopperCore (2009), una herramienta que da la posibilidad de publicar el objeto de aprendizaje y el diseño de acuerdo a las especificaciones y estándares educativos.
- La posibilidad de interoperar con otros sistemas de *eLearning* con la herramienta de interoperabilidad.

Herramientas transversales

Estas herramientas transversales complementan al resto de los subsistemas. Se distinguen dos bloques de herramientas:

- Herramientas de colaboración.
    - Flujo de trabajo (*workflow*).
    - Comunicación y participación.
    - Comentarios/Encuesta.

- Herramientas funcionales.
    - Búsqueda, ayuda, interoperabilidad y herramientas de administración.

4. EVALUACIÓN DE LA PROPUESTA

En esta sección se presenta el proceso de prueba seguidos para evaluar la propuesta de esta tesis. La sección se organiza como sigue: se explica el diseño conceptual en el que se incluyen los métodos y técnicas para el desarrollo de los escenarios de prueba; después se explica cómo AHKME se utiliza para estructurar, diseñar y adaptar los objetos de aprendizaje, y cómo se lleva a cabo en diferentes escenarios para las pruebas en un contexto de laboratorio, tanto para el entorno de aprendizaje como de enseñanza, por último se introduce el conjunto de las pruebas realizadas, los resultados, análisis y conclusiones de estas pruebas.

4.1. DISEÑO CONCEPTUAL

Para la evaluación de la propuesta se realizó un estudio de algunas de las técnicas y métodos de evaluación del *software* y más concretamente de los sistemas de información web. Por esto, se identificaron tres técnicas principales de evaluación:

- Heurística.
- Pruebas de Usabilidad.
- Pruebas de rendimiento.

Heurística de análisis

El análisis basado en una metodología heurística tiene como principal precursor a Nielsen, en concreto con su conjunto de diez heurísticas para la evaluación de *software*. Es un análisis que puede ser realizado por un grupo de especialistas y evalua un sistema de una manera cualitativa, y que puede funcionar como una referencia, tanto en lo que pueder ser un inicio para identificar las posibles deficiencias de funcionamiento del sistema o su prototipo, o durante las distintas etapas del proceso de desarrollo y aplicación (Nielsen, 2005a, 2005b).

Pruebas de usabilidad

Si bien este tipo de pruebas puede evaluar el nivel de satisfacción de los usuarios, sus opiniones, este tipo de evaluación proporciona una información más subjetiva del sistema en términos de aceptación y calidad del sistema (Nielsen, 1993).

En este sentido se diferencia del enfoque dado por una información más objetiva de los resultados obtenidos por los usuarios a través de escenario de uso y un conjunto de métricas.

Además, se tienen las pruebas de rendimiento, en el caso de los sistemas de web son muy relevantes, ya que su funcionamiento se basa en Internet, está sujeta a la red física y ancho de banda de red, la condición de respuesta y el tiempo de descarga del sistema.

Así, algunos ejemplos de indicadores de rendimiento son:

- Tiempo de respuesta - una medida de la respuesta de una aplicación o subsistema es una petición de cliente.
- Tiempo de descarga - el tiempo que tarda un sitio web o página web para descargar un navegador web.

Se distinguen dos tipos de enfoques:

- Cuantitativo - con los indicadores objetivos definidos para las pruebas de usabilidad y pruebas de rendimiento del sistema.
- Cualitativo - con la medición del nivel de satisfacción y el análisis heurístico de los expertos.

4.2. USABILIDAD

Los parámetros utilizados en las pruebas de usabilidad se asocian generalmente con la eficiencia, la eficacia y la satisfacción, pero existen otros parámetros a tener en cuenta.

Eficacia

Se refiere a las metas de utilizar el producto con la exactitud y la exhaustividad con la que estos objetivos pueden ser alcanzados. Medidas comunes de la eficacia son la realización de tareas por ciento, la frecuencia de los errores, la frecuencia de asistencia al participante de los probadores, y la frecuencia de los accesos a la ayuda o la documentación por los participantes durante las tareas. No tiene en cuenta cómo se lograron los objetivos en la medida en que se hayan logrado. La eficiencia se relaciona con el nivel de eficacia alcanzado a la cantidad de los recursos asignados (NIST, 2001).

En cuanto a la efectividad se puede medir la tasa de finalización y los errores.

Tasa de conclusión

Es el porcentaje de participantes que completa y correctamente cada tarea.

Si los objetivos pueden lograrse parcialmente entonces también puede ser útil informar sobre el logro de la meta promedio, calificada en una escala de 0 a 100% en base a los criterios especificados relacionados con el valor de una parcial resultado. Por ejemplo, una tarea de corrección ortográfica puede implicar identificar y corregir 10 errores de ortografía y la tasa de terminación puede calcularse con base en el porcentaje de errores corregidos (NIST, 2001).

Errores

Los errores son los casos en que los participantes de la prueba no han completado la tarea correctamente, o tuvieron que intentar partes de la tarea más de una vez. La puntuación debe incluir la clasificación de los errores de acuerdo con una taxonomía, como por ejemplo (Norman, 1983).

Tiempo tarea

El tiempo medio necesario para completar cada tarea, junto con la desviación estándar y rango de los tiempos entre los participantes.

Tasa de Terminación/hora de tareas

Tasa de Terminación/Tiempo medio dedicado a la tarea es otra medida de la eficiencia (Norman, 1983). La relación de la tasa de éxito a tiempo permite a los clientes comparar rápidamente interfaces propensos a errores.

Satisfacción

Satisfacción describe la respuesta subjetiva de un usuario al utilizar el producto. La satisfacción del usuario puede tener un correlación importante en la motivación para usar un producto y puede afectar al rendimiento en algunos casos (NIST, 2001).

Los cuestionarios para medir la satisfacción y las actitudes asociadas comúnmente se construyó utilizando escalas Likert y de diferencial semántico.

Existe una variedad de instrumentos para medir la satisfacción de los usuarios de productos de *software* interactivo.

Algunos de los cuestionarios más utilizados son: ASQ (*After-Scenario Questionnaire*), CUSI (*Computer Usability Satisfaction Inventory*), PSSUQ (*Post Study System Usability Questionnaire*), QUIS (*Questionnaire for User Interaction*), SUMI (*Software Usability Measurement Inventory*), y SUS (*System Usability Scale*) (NIST, 2001; Trump, 2000). Si bien cada uno ofrece una perspectiva única sobre las medidas subjetivas de la usabilidad de productos, todos, incluyen medidas de satisfacción, utilidad y facilidad de uso (NIST, 2001; Trump, 2000).

4.3. PROCESO DE PRUEBAS

El formato común de la industria (CIF) para los informes de test de usabilidad especifica el formato para la presentación de los resultados de una evaluación de la usabilidad sumativa. El tipo más común de evaluación de la usabilidad es formativa, es decir, diseñada para identificar problemas de usabilidad que se puede arreglar. Una evaluación sumativa produce métricas de usabilidad que describen cómo un producto es útil cuando se usa en un contexto de uso (Bevan & Macleod, 1994; Macleod et al., 1997). El formato del informe del CIF y las métricas son consistentes con la la definición de la usabilidad ISO 9241-11 (1998):

- El grado en que un producto puede ser utilizado por determinados usuarios para conseguir objetivos específicos con efectividad, eficiencia y satisfacción en un contexto de uso específico.

El tipo de información y el nivel de detalle que se requiere en un informe del CIF se destina a garantizar que:

- Buenas prácticas adquiridas en la evaluación de la usabilidad.
- Hay información suficiente para que un especialista en usabilidad juzge la validez de los resultados (por ejemplo, si el contexto de evaluación adecuada reproduce el contexto de uso previstas).
- Si la prueba se repitió en la base de la información que figura en el CIF, debe producir esencialmente los mismos resultados.
- Indicadores de eficacia y eficiencia.
- Medidas de Satisfacción.

4.3.1. Evaluación Heuristica

Al tratarse de un prototipo, se desarrolló inicialmente un análisis heurístico con especialistas en el área, basado en la heurística de Nielsen y con el objetivo de detectar violaciónes de estos heurísticos, lo que podría crear problemas de uso (Nielsen, 2005b).

Se utilizaron los códigos de severidad para clasificar la gravedad de los problemas de uso en una escala desde 1, problemas que no permiten cumplir la tarea, hasta 4 problemas de molestia menor.

El resultado medio de severidad en todas las heurísticas fue de 2.5, que indica alguna gravedad en los problemas pero también recomendaciones de mejoría.

4.3.2. Las pruebas de usabilidad

Las pruebas de usabilidad de AHKME se realizaron con veinte usuarios de diferentes perfiles, que es el número de usuarios recomendado por Nielsen (2006). Los roles incluían a profesores, estudiantes y personal técnico. A todos ellos se les proporcionó una cuenta de acceso al sistema, una guía del usuario, un escenario de prueba, y una lista de tareas. Después de haber pasar algún tiempo familiarizándose con ella, se les pidió que navegar por el sistema de gestión de un esquema, el aprendizaje del diseño y LOM, así como a utilizar las herramientas de adaptación y prueba de la interoperabilidad del sistema.

Las pruebas se dividieron en dos fases de tiempo distintas, con el objetivo de ver la evolución del sistema de una fase a la otra. La primera fase de prueba se hizo el 28 y 29 de diciembre de 2009 (en el período de mañana y tarde). La segunda fase se hizo el 15 y 17 de febrero de 2010 (en el período de mañana y tarde).

Para la presentación de los resultados es importante hacer una correlación entre los resultados y los objetivos del estudio, para comprobar la conformidad de los objetivos de nuestro estudio. A continuación se presenta los resultados globales y se hace una comparación entre los resultados obtenidos en la general, los objetivos de escenario y estudio.

Tabla 80. Resultados totales de las dos fases de las pruebas en comparación con los objetivos de los escenarios

Fase	Tiempo de tarea (min)	Tiempo del Escenario (min)	Tasa de terminación	Tasa de terminación del Escenario	Tasa de error	Tasa de error del Escenario	SUS	SUS del Escenario	Tiempo de respuesta (seg.)	Tiempo de respuesta del Escenario (seg.)	Tiempo de descarga (seg.)	Tiempo de descarga del Escenario(seg.)
1	102,53	82,75	92,65%	90,00%	36,38%	20,00%	66,13%	70,00%	2,75	1,00	1,86	10,00
2	85,20	82,75	95,86%	90,00%	21,09%	20,00%	74,63%	70,00%	2,02	1,00	1,30	10,00
%Tasa de mejoría	**16,90%**		**3,46%**		**42,03%**		**12,85%**		**26,58%**		**30,39%**	
Diferencia valor	**-17,33**		**3,21**		**-15,29**		**8,50**		**-0,79**		**-0,61**	**0,00**

Tabla 81. Clasificación de métricas y indicadores de medición de los objetivos

Clasificación de Métricas		Indicador de medición del objetivo	
Valor	**Descripción**	**Valor**	**Descripción**
1	Superado	>= 83%	Superado
0,5	Cumplido	>= 50%	Cumplido
0	No cumplido	< 50%	No cumplido

Después de la terminación de las dos fases de prueba se puede indicar un cambio en los resultados. La tabla general (ver Tabla 80) refleja esta evolución en todos los indicadores, pero con mayor relevancia en términos de la tasa de error con una mejora de 42,03%.

Aunque la tasa de error no es inferior al 20%, que es el considerado como un valor aceptable, se aproxima con un valor de 21,09% y con la tendencia entre las dos fases de las pruebas. Los demás resultados como la tasa de terminación tienen un valor por encima de la media con un 92%. El tiempo de tarea también supone una mejora de 16,90%, hasta situarse por debajo de los objetivos fijados para el escenario de pruebas de usabilidad.

La mejora de estos indicadores también se justifica por la mejor familiaridad del usuario con el sistema, especialmente en el tiempo de tarea, lo que significa la adquisición de algunas rutinas, pero principalmente en la tasa de terminación de la evolución del sistema de acuerdo a las conclusiones y recomendaciones de la primera fase de las pruebas.

Desde el punto de vista de los resultados de satisfacción en términos de escala SUS ya tenía resultados superiores a la media, y ahora registró una ligera mejora. La justificación de acuerdo a los comentarios de los usuarios, se debe a que de ellos ven sus necesidades se refleja en la evolución de la funcionalidad del sistema.

En cuanto a los resultados de rendimiento, el tiempo de descarga superó las expectativas en términos de metas escenario. El tiempo de respuesta están muy cerca de los objetivos de los escenarios de registrar una mejoría importante de 26,58%. Esto se debió principalmente a la optimización de código fuente.

Por tanto, los indicadores de los objetivos fueron asignados a las mediciones de prueba y clasificados de acuerdo a una escala específica. La Tabla 81 muestra la descripción de la clasificación de métricas. Además, muestra el indicador de medición definidos por los objetivos.

Si el promedio de todas las métricas se obtiene un valor de acuerdo con el indicador de medición del objetivo, entonces el objetivo alcanza la meta fijada. Como se muestra en la tabla, los objetivos del estudio, en una visión genérica han cumplido las expectativas, de acuerdo con los indicadores de medición de los objetivos.
La Figura 206 ilustra esto en términos de herramientas AHKME.

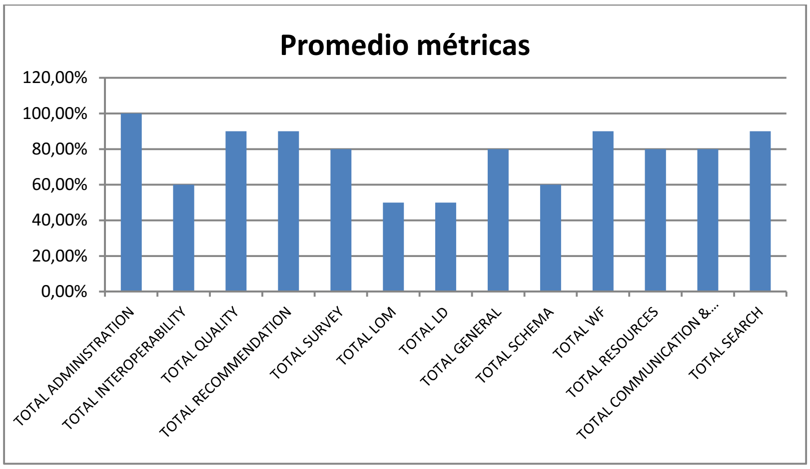

Figura 206. Los resultados promedio de los indicadores

En la Tabla 82 se agrega un promedio del indicador y de los subsistemas para encontrar los resultados en términos de logro de la meta.

Tabla 82. Objetivos del estudio – logro de los objetivos por Subsistema

Objetivos del Estudio – Logro de los Objetivos por Subsistema	
Subsistema	**Promedio del agregado de las métricas**
Presentación	100,00%
LOM and LD	62,00%
Gestión del conocimiento	90,00%
Adaptación	90,00%
Realimentación	80,00%

Como se muestra en la Tabla 82, todos los subsistemas AHKME han obtenido resultados satisfactorios. Como se ilustra en la Figura 207.

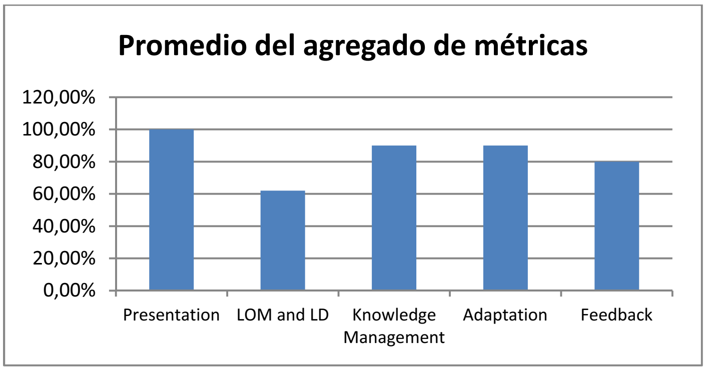

Figura 207. Promedio del agregado de métricas por Subsistema

Además, los resultados de otras pruebas como el funcionamiento de una unidad de aprendizaje en CopperCore y comparando varias Herramientas LOM y LD con las herramientas LOM y LD de AHKME, confirmó los objetivos del estudio en términos de reutilización y la interoperabilidad.

Por lo tanto, la ejecución de estos procesos de prueba y los resultados obtenidos se destacan con gran importancia para confirmar los objetivos del estudio, así como la hipótesis, ya sea en términos de usabilidad y satisfacción, tanto en términos de rendimiento del sistema

Además de la satisfacción de los usuarios, aún, la segunda fase de prueba también se manifiesta a los usuarios comentarios en el post-cuestionarios y las tareas posteriores a la prueba, que fueron vistos como recomendaciones y oportunidades de mejora del sistema (HotmailUsability, 1999).

5. CONCLUSIONES

La Web ha sufrido una evolución desde sus primeros días, hasta la actual Web 2.0, con las redes sociales, como un claro exponente de penetración y fenómeno social, con la aparición de un nuevo estadio de Web, llamado 3.0. Al mismo tiempo, los sistemas web, también evolucionan en paralelo y fiel reflejo se tiene en *eLearning*.

El análisis del estado del arte los sistemas de *eLearning*, las normas y los sistemas adaptativos hipermedia educativos ha denotado problemas con la interoperabilidad, la reutilización de los recursos y la adaptación. Por otro lado la Web 3.0 tiene dificultades para su implantación, ya que requiere conocimientos técnicos especializados y la exigencia de la reestructuración del sistema y páginas web. Los sistemas *eLearning* no escapan a esta situación, y en este sentido la necesidad de adaptar los sistemas *eLearning* a esta transición y prepararlos para este nuevo concepto.

Esta tesis plantea una alternativa para diseñar el proceso de aprendizaje en los sistemas de *eLearning* a través de componentes llamados Objetos de Aprendizaje. Estos componentes permiten y proporcionar a cada estudiante en un flujo de aprendizaje personalizado en las condiciones previamente definidas por el diseñador de aprendizaje. La definición del diseño instruccional se centra tanto en el uso de una especificación para dar forma al proceso de aprendizaje como en la separación de los elementos que hacen que el diseño de aprendizaje.

Por lo tanto, como la propuesta se ha desarrollado un prototipo de un sistema de *eLearning* - AHKME - que combina diferentes tecnologías para facilitar el uso del diseño de instruccional a los profesores.

Para la evaluación de la propuesta, se ha llevado a cabo un proceso de prueba. En primer lugar, el prototipo pasó el análisis heurístico de los especialistas. En segundo lugar, el sistema fue sometido a un proceso de pruebas de usabilidad dividido en dos fases de prueba independiente.

Como se muestra en la Tabla 83, los objetivos del estudio, en una visión genérica han cumplido con las expectativas, de acuerdo con los indicadores de medición de los objetivos, han alcanzado la meta definida.

Tabla 83. Objetivos del estudio – logro de los objetivos

Objetivos del Estudio – Logro de los Objetives				
No Objetivo operacticional	**Objectivos generales del estudio**	**Meta**	**Promedio métricas**	**Meta de logro**
1	learning domain independence/reusability/interoperability	Cumplir: Valor medio de las métricas de los objetivos >= 50%. Superar: Valor medio de las métricas de los objetivos >= 83%.	71,25%	Cumplido
2	learning domain independence/reusability/interoperability		80,00%	Cumplido
3	learning domain independence/reusability		80,00%	Cumplido
4	learning domain independence/reusability		50,00%	Cumplido
5	Interoperability		80,00%	Cumplido
6	learning domain independence/reusability		50,00%	Cumplido
7	Adaptation		90,00%	Superado
8	Adaptation		90,00%	Superado
9	learning domain independence		60,00%	Cumplido
10	learning domain independence/reusability/interoperability		60,00%	Cumplido
11	learning domain independence/reusability		80,00%	Cumplido
12	Adaptation/Quality		80,00%	Cumplido
		TOTAL SISTEMA	**72,60%**	**Cumplido**

Por lo tanto, los resultados confirman los objetivos del estudio y la hipótesis, en relación con los problemas de rendimiento, usabilidad, la satisfacción del sistema.

Por último, los resultados obtenidos permiten concluir que el sistema ha alcanzado los objetivos. Por esto, se llega a la conclusión de que la propuesta contribuirá a mejorar la reutilización y la interoperabilidad de objetos de aprendizaje, así como colaborar para aplicar los nuevos conceptos sobre la Web y la investigación de los sistemas de *eLearning*.

Contribuciones principales de la investigación

La propuesta consistía en la creación de un prototipo de un sistema de información - AHKME - que actuara en el campo del diseño instructivo, con aportaciones relacionadas con la introducción de técnicas de gestión de paquetes estandarizados de recursos de aprendizaje para la interoperabilidad entre los sistemas. Asimismo, se pretendia incluir una capacidad de reutilización de los recursos a través de metadatos y la capacidad de adaptarse a los perfiles de uso.

Al crear este sistema se ha pretendido añadir la capacidad de integrarse con otros sistemas, como LMS o redes sociales.

Más allá de eso, se hace un especial hincapié en el desarrollo práctico de la Web Semántica, con herramientas para crear/personalizar las especificaciones y ontologías para transmitir el significado, así como mecanismos para la búsqueda automática por el contexto y la recomendación de adaptación. Las características utilizadas por la colaboración y las herramientas sociales, ayuda a poner en práctica el concepto de Web Semántica y más concretamente refuerza el papel de la Web Semántica Social.

El resultado final de esta tesis aporta un nuevo sistema de aprendizaje basado en tecnología estándar y abierta, que se distribuye bajo licencia creative commons, para enfatizar el intercambio de fuentes de conocimiento abierto, en las que la innovación abierta llega al profesor que participa en el proceso de diseño y estructuración del aprendizaje y los contenidos de una materia o curso. Esto se traduce en lo que se presenta al estudiante, que a su vez será el evaluador real de la calidad del sistema, tanto en términos de usabilidad y calidad de las unidades de aprendizaje desplegadas en el sistema.

Líneas futuras de investigación

De acuerdo a las recomendaciones de las pruebas realizadas, vale la pena abrir a partir de los resultados de esta tesis nuevas líneas de investigación para mejorar la funcionalidad de AHKME, la autonomía en el diseño instruccional, introducir el concepto de la colaboración y la minería de datos para sistemas adaptativos, potenciar más el concepto de Web 3.0. Concretamente:

- Introducir asistentes en AHKME para ayudar a los usuarios hacer anotaciones en objetos de aprendizaje y en el diseño de aprendizaje.
- Actualización de la red de origen social abierto a la nueva versión, para mejorar la interfaz de colaboración e intercambio con los usuarios.
- Mejorar la función de ayuda para incluir la contextualización.
- Mejorar la interfaz de usuario para el subsistema de presentación y la personalización de la interfaz para ser más sencilla.
- Mejorar la herramienta de búsqueda, para soportar búsquedas semánticas más avanzadas.
- Poner en práctica el nivel A, AA y AAA de conformidad de acuerdo a las WCAG de accesibilidad.
- Abrir AHKME a las plataformas móviles y tecnología
- Poner en práctica las tecnologías semánticas, en cuanto a lenguages como ontologías OWL (2009) y RDF (2004).

PALABRAS CLAVE:. Web, *eLearning*, Diseño de Aprendizaje, Normas, Adaptación, Colaboración, Web Semántica, Sistemas de información Web.