

Trends in e-Learning Standards

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ABSTRACT

International e-learning standards and specifications have been widely studied and developed for over one decade. The literature on e-learning standards and specifications consists of approaches, tools and empirical results which are gaining special attention in the last years. Two main contributions are made in this paper: (1) a survey of the international e-learning standards, specifications and organizations; (2) the results of a review which provide evidence that e-learning standards and specifications are reaching a state of applicability, while the topic of e-learning itself is the subject of increasing interest. Finally, the main potential e-learning standardization fields are identified.

General Terms

Standardization, Design.

Keywords

Standards, specifications, e-learning

1. INTRODUCTION

Most e-learning software has been conceived as ad-hoc solutions, while not considering the need to integrate the educational software with student information, financial services, human resources, and other academic computing systems. High financial cost and failure-prone systems are two effects associated with extending and maintaining these customized in-house developments. To overcome these problems, three types of learning systems can be found: Content Management System (CMS), Learning Management System (LMS) and Learning Content Management System (LCMS). A CMS is a software application designed for the storage, indexing, searching and retrieval of information captured digitally and delivered to learners in a variety of formats, such as text, hypertext, images, graphics, audio, video, animation, simulation or whatever learning object (LO) [1]. A LO is any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning [2].

The LMSs, also known as virtual learning systems, are used for managing and delivering e-learning courses in academic institutions. These tools provide online course creation, maintenance, delivery, student enrollment and management, student performance reporting and so on. LCMSs are LMSs which can also support the management of LOs. Open source initiatives such as Moodle, Sakai and Atutor are gaining popularity in academic institutions, although proprietary solutions such as WebCT/Blackboard and Gradedpoint are also being widely used in this scope. In this context, e-learning standards and specifications play an important role. They allow to regulate the interoperability between applications and the

exchange and reuse of LOs across different LCMSs, independently of the heterogeneity of formats and metadata descriptions across domains [3]. Now, the main challenge is to create new digital contents compatible with existing standards so they could be reusable in different contexts and through different LCMSs. This paper aims at presenting (1) the state of applicability of the international e-learning standards and specifications, (2) the most extended e-learning standardization fields in the last two decades, and (3) which could be tackled in future studies.

This paper is structured as follows: Section 2 presents the main international organizations working on the standardization. Section 3 presents the most important e-learning standards and specifications. Section 4 introduces the design method of the review. Section 5 offers a quantitative analysis of the development work on e-learning standardization and the main findings. Section 6 discusses the results of the review. Finally, Section 7 draws some conclusions.

2. E-LEARNING STANDARDS BODIES

There are several international organizations working on the standardization of e-learning technologies. Each one addresses different issues related with learning technology standards. E-learning standards consist of a set of definitions, requirements and design guidelines for e-learning systems and are defined by official standardization organizations (see Section 2.1). In contrast, specifications, although usually called standards by many authors, refer to recommendations and guidelines created by different organizations (see Section 2.2) which have not been approved yet by a standardization body. This classification is used to present the main educational standardization and specifications institutions, all of which are published by CEN (European Committee for Standardization) [4].

2.1 Recognized Standardization Bodies

- **The Learning Technologies Standardization Committee (LTSC) from the IEEE** [5]. The main objective of this Committee is to develop technical standards, recommended practices and guidelines for software components, tools, technologies and design methods to facilitate the development, implementation, maintenance and interoperation of educational systems.

- **The CEN Workshop for Learning Technologies (WS LT) and Technical Committee 353 (CEN/TC 353)** [4]. Their main efforts are devoted to reuse and interoperation for educational resources, educational collaboration, metadata for educational contents and learning opportunities, learning process quality, and European learner mobility models.

- **The ISO/IEC JTC1 SC36** [6]. Its focus is on interoperability, both at technical and social level.

2.2 Specification Bodies

- **The Advanced Distributed Learning (ADL) Initiative** [7]. This organization provides access to the highest quality education and training that can be tailored to individual needs and delivered cost effectively, anywhere and anytime. Its work is coordinated with other organizations like IEEE, IMS and AICC.

- **The Aviation Industry CBT Committee (AICC)** [8]. It aims the definition of software and hardware requirements for student computers, needed peripherals, multimedia formats for course contents, and user interface properties in aviation and educational software.

- **The IMS Global Learning Consortium** [9]. IMS GLC creates standards for the development and adoption of technologies that enable high-quality, accessible, affordable learning experiences. Its specifications address requirements in different learning contexts, including higher education, course K-12 schools and government training.

- **The Schools Interoperability Framework (SIF) Association** [10]. It is an organization of over 2200 stakeholders in primary and secondary markets, with the aim of creating a set of rules and definitions which enable software programs from different companies to share information.

- **The Dublin Core Metadata Initiative (DCMI)** [11]. It is an open forum engaged in the development of interoperable online metadata standards that support a broad range of purposes and business models.

3. E-LEARNING STANDARDIZATION

In this section, the main e-learning standardization fields [4] are classified into two categories: (1) management-centered standardization (description, storage, search and retrieval of learning contents); and (2) development-centered standardization (development of educational digital resources, including pedagogical aspects, content formats and models, and accessibility). Note that there are some e-learning issues covered by several specifications and/or standards, and other important aspects for which there are none of them [12].

3.1 Management-Centered Standardization

- **Architectures and Interfaces.** The aim of the architectures and interfaces specifications is to reduce the cost and complexity of system integration and to ensure that the learning systems are built on a reliable, scalable and flexible architecture in such a way that they meet the needs of the current learning styles. Critical interoperability interfaces and services are identified in these standards.

- **Digital Repositories.** Success in the sharing of LOs depends on how well the objects can be found, screened, and retrieved for use in a new instructional context [12]. A digital repository is a system which provides the infrastructure for the storage, management, search and gathering of all types of electronic content (for example, text, images, video and audio).

- **Content Aggregation.** The development of formats and procedures for packaging learning resources into units of instruction aims to represent, communicate, and reproduce the

structure and behavior of the learning resources across heterogeneous environments.

- **Metadata.** Metadata standards were developed to support the information exchange and to facilitate the management, discovery and retrieval of resources on the World Wide Web.

- **Vocabularies.** Agreed common glossaries and vocabularies are two standard ways for specifying, identifying and referencing concepts, their features and components. They facilitate the interoperability and interchange of information in learning, education, and training.

3.2 Development-Centered Standardization

- **Runtime.** The runtime environments deliver content to the student, interact between the content and the LCMS, and decide the order of the contents according to the course structure, and previous student actions.

- **Assessment.** Assessment specifications define common formats and procedures for the exchange of evaluation material among different e-learning tools.

- **Accessibility.** Digital learning contents should be easy to access and use and should be open to a wide range of individual learning styles, preferences and abilities, in general, and students with disabilities who use technology aids to interact with the information source, in particular.

- **Competency Definitions.** The competencies specifications provide a means to specify competencies, skills and learning objectives in a standardized manner and thus enable the exchange of information between the LCMSs of the educational entities.

- **Educational Modeling Languages (EMLs).** They are process-based languages to create models of educational units, focused on the description of tasks that have to be performed, assignments of participants to roles and transfer of data. The EML-based course material might be useable and customized for individual students.

- **ePortfolios.** Electronic Portfolios are devoted to collect, store, update, and share a record of student accomplishments, either to show progress in mastering a field or to document educational outcomes. An ePortfolio specification allows to make ePortfolios interoperable across different systems and institutions.

- **Learner Information.** Learner Information specifications provide data models to describe the characteristics of a learner. Skills, knowledge and abilities, learner preferences and styles, or learner performance are some examples. Moreover, different roles might be given, depending on the people accessing that information: students, faculty, management, family, etc.

- **Quality.** Quality specifications allow users and providers to specify quality needs in the development of technology-based learning systems. Quality criteria and metrics such as cultural appropriateness, usability, technical features or openness are identified.

4. THE REVIEW

4.1 Aim And Search Methods

The goal of this paper is to prepare an overview of the research investigating the use of e-learning standardization. In particular,

this study aims at answering the following questions: (Q1) what e-learning standards and specifications are the most extended among researchers between 1980 and 2010? and (Q2) what e-learning standardization fields should be tackled in future studies?

The IEEE Digital Library and ACM Digital Library were used to search for publications related to a variety of e-learning standardization fields. Terms, acronyms and hyphenated words related to the particular standard or specification were used in each search string. Nevertheless, the search procedure was suitably adapted to the search engine features of each digital library. Searching was initially conducted in November 2010. Title of all and abstract of some papers (if necessary) were screened in light of relevance to the focus of the review.

4.2 Search Outcome

A total of 2701 citations were selected through an electronic search. Table 1 shows the list of standards and specifications included in the study. Note that, in the period analyzed, the most cited standardization documents were: two metadata standards (ISO 15836 and IEEE LOM); two content aggregation specifications (ADL CAM and IMS CP); one EML (IMS LD); and one learner information specification (IMS LIP). It is also interesting to point the number of publications related to the IMS QTI which describes a basic structure for the representation of question (item) and test (assessment) data and their corresponding results reports.

5. ANALYSIS OF RESULTS

To know the most active e-learning standardization fields, the number of publications by e-learning standardization fields were analyzed. These results are depicted in Figure 1. Note that there are four outliers: Metadata, Content Aggregation, Learner Information and Educational Modeling Languages. To understand the general trend for the e-learning standardization research field, the number of publications by year was analyzed (Figure 2). The reader will also notice that 2010 is a less productive year than the year before. The reason for this, is that searching was conducted in November 2010. Therefore, some relevant papers may exist which have not been included. From this analysis is clear that e-learning standardization remains an active research field with growing interest.

In order to take a closer look at the growing trend of the research work on e-learning standardization fields, it was classified into two groups. The first category (Figure 3) includes the publications on the most prolific areas: Digital Repositories, Content Aggregation, Metadata, Assessment, Educational Modeling Languages, Learner Information and Vocabularies.

The second category (Figure 4) includes publications on less productive areas of application: Architecture and Interfaces, Runtime, Accessibility, Competency Definitions, ePortfolios and Quality. From 2000 to 2008, most of the research work appears to shift to the Metadata, Content Aggregation, Learner Information and Educational Modeling Languages fields. It is also clear to see that Accessibility, Competency Definitions and Vocabularies work is increasing by year, except in 2009.

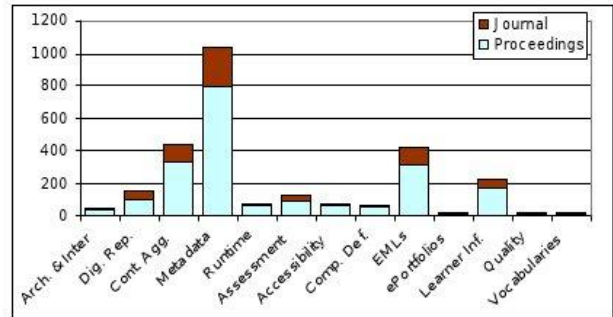


Fig. 1: E-learning standardization publications (1980-2010). Arch. Inter.: Architectures and Interfaces. Dig. Rep.: Digital Repositories. Cont. Agg.: Content Aggregation. Comp. Def.: Competency Definitions. Learner Inf.: Learner Information.

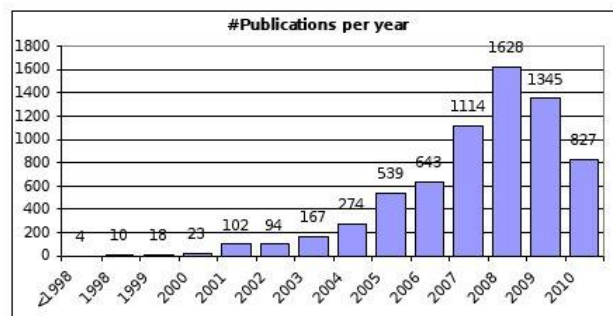


Fig. 2: E-learning standardization publications from 1980-2010

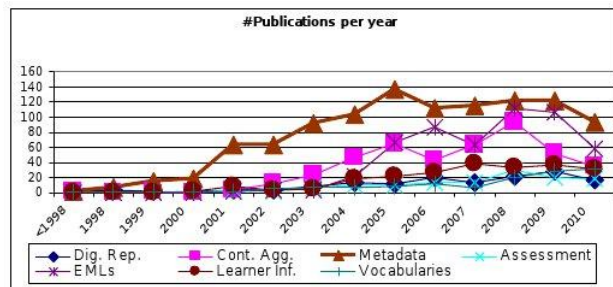


Fig. 3: E-learning standardization publications from 1980-2010 (prolific areas)

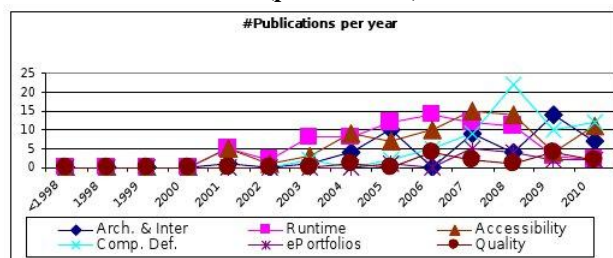


Fig. 4: E-learning standardization publications from 1980-2010 (less productive areas)

Table 1. E-learning specifications and standards citations. J.: Journal. P.: Proceedings. T.: Total

Name	J.	P.	T.	Name	J.	P.	T.
Architectures and Interfaces	12	37	49	Accessibility	13	66	79
IMS Abstract Framework	4	12	16	IMS Access For All Digital Resource Description	0	0	0
IMS Learning Tool Interoperability	0	1	1	IMS Learner Information Package Accessibility	4	21	25
IMS Guidelines for Developing Accessible Learning Applications	4	15	19	ISO/IEC 24751	5	30	35
IMS Basic Learning Tool Interoperability	0	0	0	Competency Definitions	7	55	62
IMS Enterprise Services	0	1	1	IMS Reusable Definition of Competency or Educational Objective	4	32	36
IMS Learning Information Services	0	0	0	IEEE Data Model for Reusable Competency Definitions	3	19	22
IEEE Learning Technology Systems Architecture	2	11	13	IEEE Simple Reusable Competency Map (SRCM)	0	2	2
AICC Package Exchange Notification Services	0	0	0	ISO/IEC TR24763	0	2	2
CEN Simple Publishing Interface	0	0	0	EMLs	104	318	422
Open Service Interface Definitions	6	9	15	IMS Learning Design (LD)	98	279	377
Schools Interoperability Framework	0	3	3	Open University of the Netherlands EML	3	20	23
Digital Repositories	45	103	148	PALO	3	19	22
IMS Digital Repositories Interoperability	8	20	28	ePortfolios	5	9	14
IMS Learning Object Discovery and Exchange	0	0	0	IMS ePortfolio	5	9	14
AGR011, CBT Package Exchange Notification Services	0	1	1	Learner Information	63	163	226
Content Object Repository Discovery and Registration/Resolution Architecture	8	9	17	IMS Enterprise	6	9	15
CWA Simple Publishing Interface	2	4	6	IMS Learner Information Package (LIP)	39	110	149
CWA 15454 Simple Query Interface	27	69	96	IMS Learning Information Services	0	0	0
Content Aggregation	107	331	438	Europass	1	11	12
ADL Content Aggregation Model (CAM)	33	137	170	ISO/IEC 19787 ITLET	0	0	0
IMS Content Packaging (CP)	45	121	166	ISO/IEC 24763	0	0	0
IMS Simple Sequencing (SS)	20	56	76	IEEE LTSC Public and Private Information	17	33	50
IMS Resource List Interoperability	1	0	1	Quality	4	10	14
AICC Course Structure	2	1	3	ISO/IEC 19796	4	10	14
AICC Packaging	0	0	0	Assessment	31	97	128
IMS Common Cartridge	6	16	22	IMS Question and Test Interoperability (QTI)	31	97	128
Metadata	235	795	1030	Vocabularies	9	5	14
IMS Learning Resource Metadata Information Model	7	42	49	ISO/IEC 2382	7	5	12
IEEE LOM (Learning Object Metadata)	90	278	368	AICC glossaries	0	0	0
Dublin Core Metadata Element Set (ISO 15836)	135	462	597	IMS Vocabulary Definition Exchange	2	0	2
Metadata for Learning Resources (ISO 19788)	2	5	7	Runtime	13	64	77
Dublin Core interoperability	0	2	2	ADL SCORM Run-Time Environment	9	44	53
Metadata for Learning Opportunities-Advertising	1	6	7	AICC/CMI Guidelines for Interoperability	4	20	24
				IMS Shareable State Persistence	0	0	0

6. DISCUSSION

The aim of this paper is to gain insights into the maturity and adoption of e-learning standards. The results reveal that the international e-learning standards and specifications have been increasing used in the last decade. Moreover, the correlation between year and the number of citations suggests that the number of publications will continue growing in coming years. In a recent experimental evaluation of nine LMSs [13], findings suggest that standards are fairly supported, thus concluding that the main problem in e-learning is not the identification of suitable standards and specifications, but the adoption of these standards and specifications and their application in e-learning practice. To reduce this problem, one possible solution consists in defining application profiles. These are a refinement or implementation reference of an existing specification to make it more suitable for its application by a particular community of practice. For example, Shareable Content Object Reference Model (SCORM) [14] is a well-known application profile based on a combination of the most relevant e-learning specifications and standards (IEEE, IMS, AICC, and so on) for sharable learning object packaging, delivering and sequencing.

Using an application profile as comprehensive as SCORM or CC, a standard specification such as IEEE LOM, or employ simpler conventions that are more uniquely suited to the particular needs of an application, are issues that system developers have to consider [15]. Moreover, either the excessive or lack of details and the complexity of some standards can be a barrier for developers. The use of tools to automate the process of LOs and courseware development [3], the provision of a repository of reusable requirements catalogs [16] and a development process might mitigate this problem by making details of built-in standards transparent to developers.

Currently, the e-learning platforms are being re-oriented towards a service-based approach, thus achieving designs more modularized to facilitate the integration and exchange of new functionality, tools, semantics, and control in a dynamic and seamless fashion [17]. Also, a significant increase in software development in a distributed and collaborative setting (groupware) has been observed in recent years. Therefore, new techniques, tools and practices from various disciplines will be needed to meet the new challenges and opportunities: (1) supporting the definition of e-learning software product lines; and (2) helping in the production of e-learning systems with emphasis on reuse, standards and globalization issues.

6.1 Threats to Validity

Four e-learning standardization fields were not included in the study: (1) user interfaces, (2) intellectual property and digital rights, (3) localization and internationalization, and (4) platform and media. User interfaces standardization is related to the specification of widget and graphical metaphors in computer managed instruction systems. Despite of the increasing number of metaphors, analogies and similes reported in the educational literature, only the AICC has issued some proposals in this field. Intellectual property and digital rights specifications are related with the syntax and grammar needed to specify how a digital content may be distributed or used. Creative Commons appears at present to have most acceptability among the educational communities; the reader can find hundreds of publications addressing Creative Commons. Other standard licensing models come from the CEN works and IEEE Digital Rights Expression

Language. Localization and internationalization specifications consider the language and cultural diversity in the provision of e-learning experiences. CEN, IEEE and ISO groups have worked in this realm. Platform and media specifications aim to achieve interoperability on the different media formats used by courseware systems: digital audio, digital video, graphic and image files, etc. The most outstanding work is being developed by AICC and ISO.

On the other hand, specifications and standards which are not targeted specifically to the learning technologies field were not considered. We have considered only two digital libraries (ACM and IEEE), although they, in turn, include other important electronic sources such as Elsevier, Springer-Verlag, Wiley, DBLP or CiteSeer. We may also have erred in including papers that were not very related. In the light of the above-mentioned, findings must be interpreted with caution.

7. CONCLUSIONS

In this paper, a survey of the international e-learning standards, specifications, organizations and practice has been presented. A result analysis provides evidence that e-learning standards and specifications are reaching a state of applicability, while the topic of e-learning itself is the subject of increasing interest (1345 citations of e-learning specifications and standards in 2009). The metadata is the most applied e-learning standardization field and ISO 15836 is the most cited standard.

8. ACKNOWLEDGMENTS

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