Learning Technology Standardization: Making Sense of it All[1]

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Abstract. In this paper, we analyze the role of technical standards in the domain of learning technology, focusing on the way they enable interoperability. We briefly explain some of the alternatives to open and accredited standards and how they impact on the community. The standardization process is analyzed in some detail and the most relevant organizations involved are briefly surveyed. We provide an overview and taxonomy of the more widely adopted standards and specifications.

1. Introduction

Interest in "learning technology standards" has boomed over the past few years. Most of the organizations involved have been active since (much) less than 10 years, but the first commercial products referring to the standards are already appearing on the market. In academic and corporate research and development, the themes of interoperability, learning objects, metadata, etc. have surfaced as important topics [1,2]. Indeed, the first symposium solely devoted to these themes was organized in 2003 [3].

Nevertheless, there remains plenty of confusion and misunderstanding about the role and origin of standards [4]. In this paper, we survey the field, in an effort to try and increase understanding of the process and results of standardization, so that expectations of future results can be more realistic and so that future research and development can be directed at relevant questions and issues.

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2. The Role of Standards

2.1. Looking Back: the Advent of the Web

The role of standards can easily be illustrated through the history of the World-Wide Web. Since the early 1960's, sometimes quite advanced hypermedia systems had been developed, such as Augment [5], Intermedia and others. The main problem was that these systems operated in isolation. As Andries Van Dam remarked in 1987 (!) [6]:

> "we are building docu-islands; none of our systems talk to each other, they are wholly incompatible. So we are all working the same agenda, more or less, but we can't exchange stuff; there is no exchange format, there is no universality, and furthermore, our systems are closed systems. […] So it's not enough to bundle the HyperCard package with every Mac you buy. It really ought to be migrated down, become part of the toolbox, so that application programmers can take their applications and take advantage of a standard linking protocol that works within and between applications.
>
> So I'm going to raise a red-flag word: standards. I'm a firm believer in standards. And everybody will say it is absolutely premature to standardize when we don't even know what the hell we're talking about. We are still in the experimental phase. I believe that. But if we don't start thinking about standards, five years from now we are going to have a wealth of these little docu-islands which are totally incompatible, and that's crazy."

In essence, three standards enabled the World-Wide Web to interconnect what had remained "docu-islands" until the early 90's (exactly as Van Dam predicted):

- HTTP (HyperText Transfer Protocol) enables software clients to download documents from servers;
- A URL (Uniform Resource Locator) makes it possible to identify a document– the difference between URL's, Uniform Resource Names (URN's) and Universal Resource Identifiers (URI's) is not relevant here;
- HTML (HyperText Markup Language) defines a structure for web documents with a simple lay-out and supports hyperlinks that rely on HTTP to request documents identified by their URL.

2.2. Interoperability

The result of standards such as HTTP, URL and HTML is freedom of choice for developers and end users alike: in principle, a browser such as Opera or Apple's Safari can be used to read documents produced with Microsoft

Frontpage or Macromedia Dreamweaver and stored on an open source server such as Apache. Moreover, an organization or an individual can choose to change the software for reading, authoring or storing web pages, without endangering the investment already made.

The essential feature in this context is interoperability: this means that independently developed software components can exchange information so that they can be used together. Technical standards have always aimed to enable this kind of interoperability: the A4 paper size is a successful example of a standard that enables sheets of paper produced by one vendor to be stored in binders produced by another vendor, which can themselves be physically stored on shelves from yet another vendor. (Contrast this with a situation where one would have to procure paper, binders and shelves from the same vendor!) Obviously, standards can boost the uptake of a kind of technology, whether that technology is based on software (the web), hardware (paper) or combinations thereof (WiFi) is quite irrelevant.

2.3. Alternatives

One alternative to open standards (see also below) is the development of de facto standards. This is the prevailing status in the domain of office software, where Microsoft Office can be considered a de facto standard in many contexts. Competing products, such as OpenOffice or StarOffice, have to try and incorporate support for often evolving document types in their own products, which makes fair and open competition quite difficult. Indeed, replacing the de facto Microsoft standards with open XML based document types is one of the aims of the OpenOffice effort.

The main aim of many open standards initiatives is to become not only a “de jure” standard, i.e. a standard developed through an open process, often in a so-called accredited organization, but also a “de facto” standard in the sense that it would be the solution also adopted in practice.

It is important to emphasize that “open standards” and “open source” are two different concepts. Open standards focus on the public availability of specifications that have been developed in an open and fair process, so that any interested party can influence the evolution of that specification, and develop products and services that rely on the specification. Open standards such as HTTP, HTML and URL allow anyone to develop authoring tools, browsers, web servers and associated tools. Likewise, they allow vendors to export to or import from the Web in their proprietary tools. Open source development relies on the idea that source code for products and tools is made public as well, so that any interested party can debug, modify or otherwise change or rely on the code. It is true that open source software is often based on open standards, but that does not need to be the case. And much of the software that relies on open standards is not developed in an open source fashion.

In fact, commercial companies often take part in the development of open standards, in order to establish a market that would not be viable without such standards. As an example, hypermedia systems only had very little commercial appeal (Apple Hypercard and OWL were among the early commercial initiatives in this area) until the advent of the World-Wide Web. More related to the focus of this paper, both Microsoft and IBM are actively involved in learning technology standardization – that doesn't necessarily mean that they intent to develop their tools and services in this domain using an open source approach!

3. The standardization process

3.1. An Open and Fair Process

The standardization process is illustrated in figure 1: at the basis, represented at the bottom in the diagram, consortia like AICC [7], IMS [8] and ARIADNE [9] produce specifications. These technical documents are based on an internal process, so that they meet the needs and requirements of the members of the organization. However, such specifications are not standards, as they do not need to take into account the requirements and needs of the whole domain of learning, including academic and school education, corporate and military training, formal and informal learning, etc.

Accredited organization like IEEE LTSC [10] , CEN/ISSS WSLT [11] en ISO/IEC JTC1 SC36 [12] explicitly do have an obligation to try and meet the needs and requirements of the whole domain, and to maintain a fair and open process to achieve that aim. That is why drafts of standards are made available publicly at early stages and throughout the process, so as to enable the community to influence the development of the standard. This is all the more important in the world of learning, as this is so culturally determining and determined a domain.

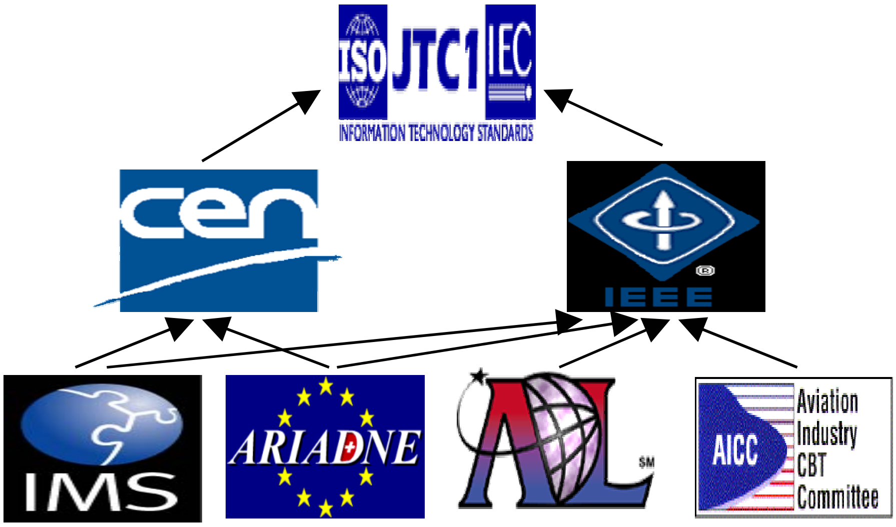

Figure 1: The Learning Technology Standardization Process

3.2. A Difficult Balance

In the ideal case – admittedly, reality can be somewhat different sometimes – the specifications developed in consortia are tested and validated with real users first, before they advance to the accredited organizations that will turn them into standards. A difficult problem is that specifications cannot be validated with end users as such. Rather, the interoperability specifications will give rise to specifications of software tools that will offer a set of functionalities to the end user. The latter specifications can then be implemented and a suitable user interface needs to be designed and implemented as well. End users can then make use of the tool in practice and that use can be evaluated. The evaluation results need to be analyzed in detail to assess whether eventual problems are caused by the interoperability specifications, or rather by the functionality provided by the tool or the user interface through which the functionality is made available to the end user. This is clearly a complicated task, and standards development is often hindered by a lack of experimentation of this kind.

That is why standardization efforts are sometimes considered somewhat premature: on the other hand, it is difficult to argue for elaborate testing of specifications as long as these have not been adopted at some scale in practice. And adopting a specification remains risky as long as the specification has not evolved into a standard. This can be somewhat of a "chicken-or-egg problem". However, allowing for test-and-revisit cycles in the development of the specification (first) and standard (thereafter) can go a long way to tackling this issue.

This also explains why the role of consortia is so important: they can develop tools and guidelines for their members and thus facilitate the experimentation with and validation of the specifications they have developed, so that the latter can be progressed to tested and reliable standards.

The role of an organization such as ADL in figure 1 is somewhat different: through the “Sharable Content Object Reference Model” (SCORM), ADL has defined a way to rely on existing standards (such as IEEE LTSC LOM) and specifications (such IMS Content Packaging) to define a more comprehensive approach to interoperability [13]. In as far as SCORM is widely implemented in tools and relied upon in practical experiments, this can be considered a thorough validation of the specifications and standards that SCORM relies upon.

3.3. Different Kinds of Organizations

In figure 1, the lower layer includes some of the more relevant organizations with a certain standing that have actually contributed to the standards development. However, at this layer, there are hundreds (!) of other organizations, projects and consortia with more or less standing and stability that often fade away once their ad hoc funding disappears, and that sometimes produce specifications that actually do make it into the standards process.

The upper layer of figure 1 represents quite stable organizations, active since several decennia in the field of standardization. Historically speaking, the IEEE was the first organization to set up a committee that focuses specifically on Learning Technology Standardization. It was followed quite soon by a more European oriented workshop in the CEN/ISSS context. Recently, the more global ISO/IEC JTC1 has set up a sub-committee to deal specifically with this domain.

It is important to note that IEEE LTSC and CEN/ISSS WSLT rely on contributions of (small teams of) individual experts: anyone can attend meetings, comment on drafts, propose new specifications or new solutions for problems under consideration, etc. ISO/IEC JTC1 SC36 on the other hand operates with representatives of countries: currently, 22 countries are actually represented in the subcommittee. Typically, so-called “mirror committees” are organized on a national basis, so as to collect and consolidate the requirements and needs and forward them to the SC36. In the opposite direction, national mirror committees also disseminate the state-of-the-art and the newly developed standards to their national community.

4. A Concise and Incomplete Overview of Learning Technology Standards

4.1. Introduction

In this section, we survey some of the currently more relevant standards and specifications. In section 4.2, we focus on learning content. Section 4.3 deals with metadata, i.e. descriptive data on learning objects. Standards and specifications that deal with the navigational structure or topology that can be superimposed over a set of learning objects are presented in section 4.4. Finally, section 4.5 deals with interoperability between learning objects and Learning Management Systems (LMS's).

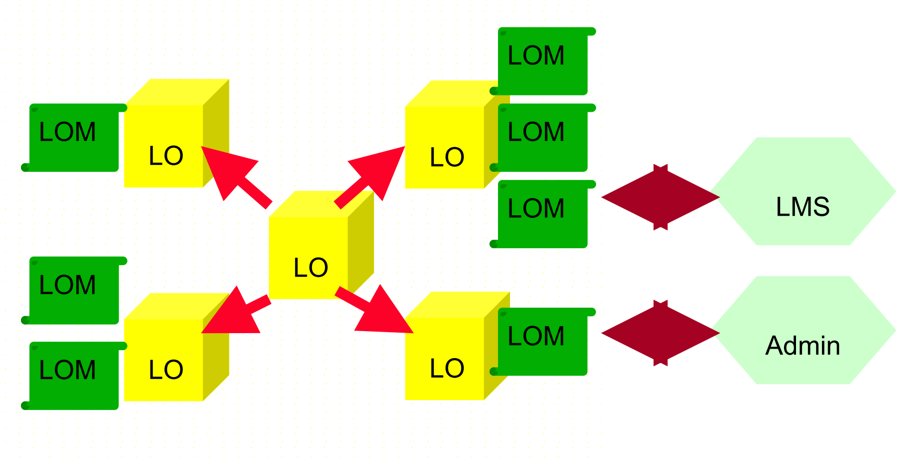

Figure 2: The Role of Different Kinds of Standards and Specifications

Figure 2 illustrates the role of these different kinds of standards and specifications. In the remainder of this section, we will further detail the different components of figure 2.

4.2. Learning Content Related Standards and Specifications

The fundamental notion for learning content these days is that of a "learning object", represented as a yellow cube with an "LO" label on figure 2. In the IEEE LTSC LOM standard, a learning object is defined as "any entity –digital or non-digital – that may be used for learning, education and training". This is a quite vague and general definition – on purpose. In fact, there is ongoing work on the development of a so-called learning object content model, that details the above definition through a taxonomy or ontology of learning object components of different granularities [4].

It is important to note that learning objects are related to the notion of objects in object-oriented software engineering, but that they do not necessarily display the same characteristics of encapsulation, inheritance, etc.

Most of the content related standards and specifications currently rely on XML for their encoding, by defining either an XML Document Type Definition (DTD) or an XML Schema Definition (XSD). For general content, OASIS maintains a number of such specifications. A typical example is DocBook, an XML Schema for books and papers. The OpenOffice specification for office applications has also been submitted to OASIS. The WWW Consortium also maintains a number of relevant specifications in this area, like (eXtensible) HypertText Markup Language for example.

A content specification more specifically oriented to learning applications is the “Question and Test Interoperability (QTI)” specification developed by IMS. QTI relies on XML for its binding. Apart from QTI, it seems that most content related specifications currently used in a learning context are of a more general nature: in this sense, learning content is “just content”.

4.3. Metadata Standards for Learning

In the metadata arena, there has been much more action recently on learning specific standards and specifications [14]. The most relevant development here is the finalization in 2002 of the IEEE LTSC Learning Object Metadata (LOM) standard. (LOM instances are represented in green on figure 2. Note that the figure explicitly indicates that more than one LOM instance can be associated to one learning object.)

The underlying technology mostly (though not exclusively) used for exchange of LOM instances is XML based. An official XML binding of LOM is under development in the IEEE LTSC LOM working group.

A more general and more limited standard for metadata is the “Dublin Core” metadata element set that defines 15 metadata elements. In this more general context, the World-Wide Web consortium is developing a metadata framework called “Resource Discovery Framework (RDF)”, which is a part of the more general evolution towards the semantic web. The “Open Archives Initiative (OAI)” defines a protocol for metadata harvesting.

A specific metadata standard for dealing with intellectual property rights is under development within the IEEE LTSC. This “Digital Rights Expression Language (DREL)” aims to enable the precise definition of appropriate rights for a learning context. In the “Creative Commons” initiative, a number of more generic, simple and flexible licenses have been developed.

Finally, some specifications deal with metadata of learners rather than content. In IMS, a so-called “Learning Information Package (LIP)” has been developed. The IEEE LTSC has recently started work on “Reusable Competency Definitions”.

4.4. Standards and Specifications on Structure

The red arrows in figure 2 denote structure that can be superimposed over a set of learning objects. (The navigational structure of figure 2 is rather limited, in that it only allows navigation from the central learning object to the four other learning objects. The latter are dead ends from a navigational perspective.)

It is important to emphasize that content and structure can be separated in this way: this principle has been well-known and its importance has been recognized since many years in the hypermedia community. This approach allows the definition of different navigational topologies on the same set of content components, for instance in order to personalize navigational facilities to the specific characteristics of the learner. (Similarly, lay-out and presentation should also be dealt with in a separate layer. As there are currently no specific developments in this area for learning applications, we do not deal with lay-out and presentation in this paper.)

For generic purposes, the “Synchronized Multimedia Integration Language (SMIL)” has been developed by the WWW Consortium for the specification of potentially quite sophisticated multimedia presentations. More specifically for learning contexts, the IMS has developed the “Simple Sequencing” specification that enables learning objects to be sequenced, based on a branching mechanism that can refer to earlier interaction with the content.

Also related to structural aspects are so-called “Educational Modeling Languages”, of which there exist quite a few. The IMS based its “Learning Design” specification on early work in the Dutch Open University. Support for this specification in practice remains very limited.

4.5. Standards and Specifications for Interoperability between Learning Objects and Learning Management Systems

Technical support for learning often relies on interaction between different system components: in order to facilitate such interaction, an interoperability framework is required.

The “Course Managed Instruction (CMI)” standard, under development within the IEEE LTSC, relies on more than ten years of standards development within the AICC. This standard covers interaction between learning objects and a “Learning Management System (LMS)”, enabling a learning object to report results for a learner to the LMS, and enabling the LMS to “launch” a learning object.

5. Conclusion

It is important to emphasize that learning technology standards realize a certain level of interoperability, but that conventions need to be developed within a community of users to enable a common use of standards. Such conventions are typically captured in a so-called “application profile”. As an example, the IEEE LTSC LOM standard is based on early work by ARIADNE. Once the LOM standard was finalized, ARIADNE has developed a profile to make the LOM standard meet the specific requirements of its multilingual community.

In conclusion, it is useful to remember that standards often evolve slower than people think (and wish) on the short term, but that their impact is often much deeper than expected in the long term…

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