

Christian M. Stracke

Interoperability and Quality Development

Overview and Reference Model for e-Learning Standards

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Interoperability and Quality Development in e-Learning: Overview and Reference Model for e-Learning Standards

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e-Learning standards and specifications, interoperability, quality development, standardization committees and initiatives, e-Learning standards classification, ISO/IEC JTC1 SC36, IEEE LTSC, IMS, ADL, Quality Initiative E-Learning in Germany (Q.E.D.)

Abstract:

This article presents the generic multi-dimensional Reference Model for e-Learning Standards as the main outcome. First the importance and the tasks of interoperability as well as quality development and their relationship are analyzed. Especially in e-Learning their connection and interdependence is evident: Interoperability is one basic requirement for quality development. In this paper, it is shown how standards and specifications are supporting these crucial issues. After a short introduction of the relevant e-Learning standardization committees and initiatives (ISO/IEC JTC1 SC36, IEEE LTSC, IMS, and ADL) their published standards and specifications are used to evaluate the Reference Model for e-Learning Standards. As a result it can be stated that the reference model is covering all kinds of e-Learning standards and that it is applicable and appropriate for their differentiation and categorization. In conclusion a vision of the challenges and potentials for e-Learning standardization is outlined for the future.

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0 Introduction

If we are talking about e-Learning there are two main challenges:

- How to ensure the interoperability of e-Learning?
- How to develop the quality in e-Learning?

This contribution will address these two questions and provides some first answers how to assure and to improve the interoperability and the quality of e-Learning. A general finding is that standards can support both objectives by providing international accepted solutions.

The main objective of this contribution is to start the discussion about the interoperability of e-Learning offers and about the quality development resp. the quality improvement in e-Learning supported by learning standards and specifications. The particular benefit of learning standards and specifications for interoperability and quality development will be pointed out by proposing the reference model for e-Learning standards concluding with a vision and needs analysis for further activities.

Generally speaking, interoperability means the ability of exchange and re-use of information and resources between different systems. In this way it is a requirement for the quality development in e-Learning facing the access to the best learning, education, and training solutions and their usage.

Therefore interoperability is a precondition and a request for quality development that can be described and defined in different ways. Standards are offering a special support and have been accepted widely for the aims of interoperability.

Focussing the educational sector, interoperability is an objective and a task only for few use cases and application scenarios at present. Educational and learning standards providing interoperability have been discussed and developed for only a short time. They can be classified by their focuses on domains, entities, and implementation scenarios.

e-Learning as a special lively part of the educational sector has approached open questions of interoperability from the very first, due to the precondition to solve the technological problems. Based on the debate on the development of technological and learning technology standards, interoperability has to be addressed in respect of the quality of learning, education, and training offers and learning processes.

So this contribution is structured in several parts:

The first part defines *interoperability* and describes characteristics of good practice. And also the general preconditions of *quality development* and quality improvement in e-Learning are focussed based on these findings.

The second part provides the *fundamentals* for a later discussion in detail: Analyzing learning, education, and training in general and especially in the field of e-Learning the relevant dimensions are differentiated first. Using these distinctions a generic classification model of educational and learning standards is proposed that is applicable for e-Learning.

The third part carries out the *evaluation* of these categories and classifications. An overview over the e-Learning standardization committees and standardizations initiatives is followed by the description and analysis of their standards and specifications allocated and matched to the dimensions of the classification model.

At the end the *vision* and the further needs of interoperability and quality development are outlined. The perspective will be broadening up to the horizon of future chances for the improvement of e-Learning by the application and implementation of standards and specifications for interoperability and quality development. The contribution concludes with current activities and the identification of the most important topics for research and development in e-Learning standardization.

1 Interoperability and Quality Development

In this chapter we will define the terms *interoperability* and *quality development* first. Then the relationship and interdependence between these two concepts will be pointed out. Finally we will describe the support and the importance of *quality standards and specifications* for the objectives of interoperability and quality development.

Interoperability and quality development are the main challenges of e-Learning today. The acceptance, the realisation, and the success of e-Learning offers depend on their interoperability and quality. In this contribution we will show that interoperability and quality development cannot be prescribed in a specific manner, but there is always the need for an adaptation and specification concerning the given situation.

Interoperability means more than technical conformance: It covers the whole range of requirements and characteristics from any systems and has to be addressed at all different levels and domains. The term 'system' is used here in its broadest sense including human beings, societies, and any kind of technical and natural networks: A system consists of internal communication and relationship between all its elements, entities and members and can be defined against its external environment. (cf. Luhmann 1998; Maturana/ Varela 1992). The epistemological problems regarding the recognition of a system by another system can be suppressed here especially if we are focussing on e-Learning: It is impossible for external systems (e. g. teachers or other persons or systems) to observe and follow the internal learning processes of a learner. Learning progress, knowledge and competencies are always built by the learner itself and we cannot prove a causal connection between learning offers and learning processes, we can only assume some relationships and effects (cf. for the theory of cognition Luhmann 1998).

Implying these preconditions we can therefore define interoperability as follows:

Interoperability means the ability of exchange and re-use of every kind of information and resources in any way within or between different systems.

Based on this definition four different scopes of interoperability can be differentiated in relation to given systems:

- **Internal:** The interoperability is only established between the internal elements, entities and members within one system.
- **Directional:** The interoperability exists in the direction from one system towards another system, but there is no feedback loop or reciprocal relation (e.g. only import without export).
- **Mutual:** The mutual interoperability allows the exchange between different systems in both directions.
- **General:** The interoperability looks for achieving exchange between all given systems in general.

The different interoperability scopes are applicable for the formal distinction of interoperability. But interoperability is a complex subject with many facets and dimensions: A detailed differentiation is needed for the application sectors regarding the specific domains and implementation scenarios. That is also true for the multi-dimensional term of quality development.

In a general way quality development can be defined as follows:

Quality development covers every kind of measurement, assurance, optimization, and continuous improvement of the quality within given systems.

According to interoperability quality development can also be described formally by the chosen scope. Quality is not a fixed characteristic belonging to subjects or systems but depends amongst others on the point of view and the scope. The following differentiation of the scope into three quality dimensions has become widely accepted (cf. Donabedian 1980):

1. **Potential dimension:** What are the potentials for the quality development in the future?
2. **Process dimension:** How can the processes be described and optimized for the purpose of quality development?
3. **Result dimension:** How can the quality development be supported regarding given results and systems?

Here the space is missing to discuss the whole long-term debate on the quality issues, aspects and approaches (cf. Deming 1982, Juran 1951, and for an overview cf. Stracke 2006). Therefore we focus only on the common characteristics of interoperability and quality development and their relationships in the field of e-Learning.

Focussing the educational sector in general interoperability is an objective and a task only for several use cases and application scenarios at present. Educational and learning standards providing

interoperability have been discussed and developed only for a short time. e-Learning as a special lively part of the educational sector has approached open questions of interoperability just from the beginning due to its need and precondition to solve the technological problems. But the focus was only technological interoperability first. Based on the debate on the development of technological and learning technology standards, interoperability has to be also addressed in respect of the quality of learning, education, and training offers and learning processes. In this understanding interoperability is a requirement and an enabler for the quality development (not only, but especially) in e-Learning facing the access to the best learning, education, and training solutions and their usage and improvement.¹ There is no development and improvement of the e-Learning quality without interoperability between the involved systems (in the broadest understanding): Learners, teachers, and learning objects and technology systems need to exchange and re-use information and resources between each other.

Therefore interoperability is a request and a precondition for the quality development: Both can be described and defined in different ways using the same domains, entities and implementation scenarios. Standards are offering a special support and have been accepted widely for the aims of interoperability as well as of quality development.

¹ For the quality development in e-Learning a three steps model has been developed starting from the individual level over the organizational level up to the involvement of all stakeholders (cf. Hildebrandt/ Stracke/ Jacovi 2006).

2 Generic Reference Model for e-Learning Standards

This chapter provides the *Generic Reference Model for e-Learning Standards* based on differentiation of the mainly relevant dimensions and categories. After a short survey on standards in general categories of e-Learning standardization are presented pointing out especially the *three main dimensions of e-Learning standards* on which the Reference Model for e-Learning Standards is based.

2.1 Overview on standards in general

First we have to point out the main objectives of standards in general: Standardization always aims at achieving benefits in the ratio of effects and efforts. One main benefit of a standard should be its economical benefit that could be reached e. g. by the establishment of the interoperability of different systems or by the re-use of learning objects (interoperability of resources). And also quality tasks could normally raise economical benefits in a long-term, e. g. by harmonization of the terminology or by introducing a quality reference model. Interoperability (in its broad sense) and quality development can be called the two main purposes of standardization to gain economical benefit especially in the field of e-Learning.

Focussing on standardization in a theoretical way we have to distinguish between different general types of standards and specifications:

- **Formal standards:** Formal standards also known as "de-jure standards" can only be developed in consensus processes by the official standardization organizations that are the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) on the international level and are always publicly available.
- **Community specifications:** Community specifications are developed by communities or forums and they are normally available in public as open specifications. Examples for such communities with relevance for e-Learning are: the Institute of Electrical and Electronics Engineers, Inc. (IEEE) and the World Wide Web Consortium (W3C).
- **Industrial specifications:** Industrial specifications are developed mostly domain-specific for branches by industrial consortia and could be open specifications, i. e. publicly available, or closed specifications, i. e. only available for the consortium members.

- **Organizational specifications:** Organizational specifications are developed internally as closed specifications.

This classification is used generally for standards and specifications. In addition it is to mention the special case of the term "de-facto standards" that is used for proprietary organizational, industrial or community specifications with worldwide acceptance (e. g. Microsoft Windows). The specifications are often also called "standards" for facilitating the communication. Therefore we will also adopt this practice in this article from now on.

After this general view on standards and specifications we are now analyzing the different categories of e-Learning standards.

2.2 Categories of e-Learning standards

A lot of categories can be identified focussing on the complex field of e-Learning standards. The reason is that e-Learning standardization has to deal with many dimensions and stakeholders ranging from technical over didactical to quality issues. Before we are analyzing the three main dimensions more in detail other additional categories that could also be addressed are listed in the following.

On the one hand it can be distinguished between *providers* and *users* of e-Learning that have often different interests, needs, and preferences. e-Learning standards can mainly address and support either the users or the providers, or both.

Regarding the organization using or providing e-Learning it is possible to differentiate the organizational levels on which an e-Learning standard is focussing: *learning offers* (e. g. content, learning objects), *processes*, and (business units of) the whole *organization*.

This list is not exhaustive, there could be also added other categories. It serves only the purpose to spotlight the multi-dimensional complexity of e-Learning standards.

Next to these listed categories of e-Learning standardization there are three categories of e-Learning standards that can be regarded as the main dimensions.

The three main dimensions of e-Learning standards are:

1. **Types of e-Learning standards**
2. **Domains of e-Learning standards**
3. **Entities of e-Learning standards**

2.3 Three main dimensions of e-Learning standards

In the following the three main dimensions of e-Learning standards will be described shortly by their classifications.

2.3.1 Types of e-Learning standards

Three types of e-Learning standards can be differentiated:²

- **Implementation standards:** Implementation standards are developed to ensure the interoperability within all domains of e-Learning.
- **Conceptual standards:** Conceptual standards are offering generic and theoretical solutions to compare and harmonize the entities and objects corresponding to the standard.
- **Level standards:** Level standards define the quality level that should be reached by the application of the e-Learning offer and are often used for certification aims.

These three types of e-Learning standards can be attributed to the two main purposes and functions of e-Learning standardization which are interoperability and quality development (see above). Implementation standards are focussing the interoperability within all domains (see next chapter 2.3.2) and level standards are addressing the quality development. Conceptual standards can support both the quality development (e. g. by providing generic frameworks or reference models) as well as the interoperability by implementing and adopting the concept.

The following figure 1 shows that relationship:

² These three levels are following a typology from Lindner (cf. Linder 2005) with modifications of their scopes and renaming of the first level.

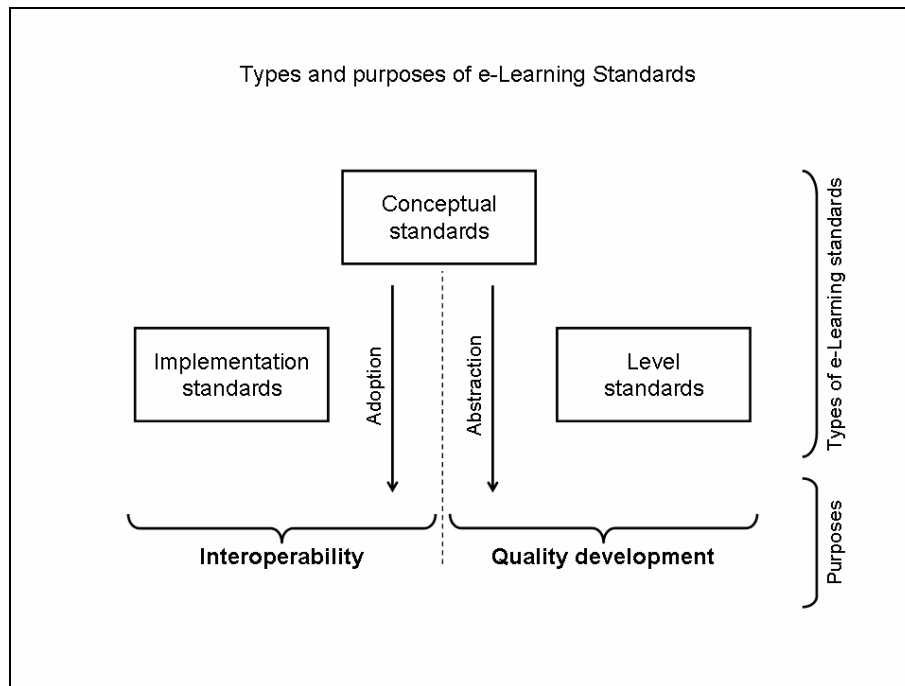


Figure 1: Types and purposes of e-Learning standards

Level standards in e-Learning (and also in general) can be based on different scopes of quality:

- Minimum expectation
- Average expectation
- Maximum (ideal) standard

The differentiation of the implementation standards (and their corresponding conceptual standards) is not so easy. Depending on their focus many different types of implementation standards can be identified: metadata standards, architecture standards, infrastructure standards, interface standards, etc.

2.3.2 Domains of e-Learning standards

The dimension *domain* is describing which topic and subject the e-Learning standard is addressing mainly. There are six main domains of e-Learning with relevance to standards:³

- **Meaning:** The domain *meaning* focuses the general understanding and deals with e. g. the disciplines semiotics, pragmatics, and semantics.

³ For other categorizations of e-Learning standards cf. e. g. Lindner (2005) or Pawlowski (2005).

- **Quality:** The domain *quality* covers all aspects of the development, assurance and management of quality and deals with e. g. results, processes, and potentials.
- **Didactics:** The domain *didactics* deals with all pedagogical questions and issues concerning e. g. methods, learners, and environments.
- **Learning technology:** The domain *learning technology* includes all technological solution especially developed for learning objectives and purposes and deals with e. g. data exchange, interfaces, and accessibility questions.
- **Learning content:** The domain *learning content* covers all aspects that are necessary for e-Learning objects and deals with e. g. the resources, and their aggregation, and packaging.
- **Context:** The domain *context* combines all other disciplines and information with regard to e-Learning and its given context and deals with e. g. rights, laws, and experiences.

e-Learning standards can cover one domain or a combination of these six e-Learning domains.

2.3.3 Entities of e-Learning standards

The domain *entity* depends on the main object that the e-Learning standard is focussing on. Across the domains there are six entities and objects that e-Learning can address:

- **Learning environment:** The entity *learning environment* covers the organizational and pedagogical management and structure of e-Learning offers including the infrastructure and all services and processes.
- **Roles:** The entity *roles* deals with the different defined groups within an e-Learning solution (e. g. learner, teacher, tutor) and includes also the focus on single persons.
- **Methods:** The entity *methods* concerns the used methods defined for and used within an e-Learning environment.
- **Learning systems:** The entity *learning systems* deals with all technological and conceptual questions (including the architecture) regarding the systems used within e-Learning.
- **Learning resources:** The entity *learning resources* covers all content offers that are components of the learning system.
- **Practice:** The entity *practice* concerns all relevant information experiences in respect of the realisation and the usage of an e-Learning offer.

e-Learning standards can also correspond to more than one entity in combination.

2.4 Reference Model for e-Learning Standards

The Reference Model for e-Learning Standards consists of these three main dimensions: Types, domains and entities of e-Learning standards. It can be represented by drawing a cube with these dimensions.

The following figure shows the dimensions of the Reference Model for e-Learning Standards:

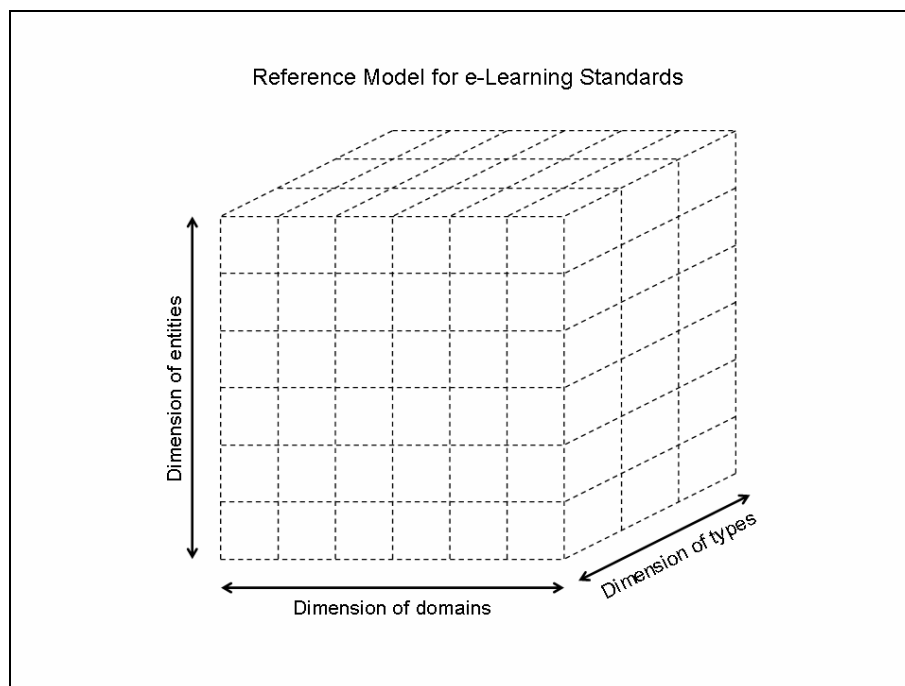


Figure 2: Reference Model for e-Learning Standards

Every e-Learning standard or specification can be classified and specified according to the dimensions with possible combinations and overlapping. Therefore the application of and the integration into the Reference Model for e-Learning Standards should be appropriate for all e-Learning standards and specifications. The next chapter will examine and evaluate this reference model based on the existing e-Learning standards and specifications.

3 Standardization committees and standards in e-Learning

In this chapter a *general overview on standardization* will be given followed by an analysis of the current main *standardization initiatives* in e-Learning and their *published standards and specifications*.

3.1 Overview on standardization in general

A lot of standardization initiatives are working in the fields of e-Learning. According to the committees and initiatives different kinds of standardization can be distinguished:

- **Formal standardization:** Results are formal de-jure standards
- **Standardization by experts:** Results are specifications that are normally open, i. e. publicly available
- **Standardization by organizations:** Results are specifications that can be open or closed, i. e. only available for the involved organizations

In the following the four main standardization initiatives are introduced by an overview, and presenting their structure, scope and developed standards and specifications.

3.2 ISO/IEC JTC1 SC36

SC36 overview:

ISO/IEC JTC1 SC36 is the e-Learning standardization committee of the first joint technical committee from the two international standardization organizations ISO and IEC (see above). Therefore SC36 is the only official formal standardization body for e-Learning at international level. The abbreviation stands for: "International Organization for Standardization (ISO)/ International Electrotechnical Commission (IEC) Joint Technical Committee 1 (JTC1) - Information Technology - Subcommittee 36 (SC36) - Information Technology for Learning, Education, and Training (ITLET)". Members of SC36 are National Bodies (NB), either as participating with the requirement of involvement in standardization activity and of voting or as observing with involvement in standardization activity but without vote. SC36

has also got official liaisons with Liaisons Organizations (LO) for mutual exchange and attendance the meetings without vote.

The structure of SC36:

SC36 is currently divided into seven Working Groups (WG) that are working on the development of new standards:

- WG1: Vocabulary
- WG2: Collaborative technology
- WG3: Learner information
- WG4: Management and delivery of learning, education, and training
- WG5: Quality assurance and frameworks
- WG6: International standardised profiles
- WG7: Culture, language, and human-functioning activities.

In addition there are a Rapporteur Group on Marketing, a Special Working Group on Business Planning, and an Ad hoc group on Privacy. The National Bodies are sending delegates to the SC36 plenaries, nominating experts to the working groups, and voting for new work items, drafts, and standards.

The scope of SC36:

The scope of SC36 is defined as: "Standardization in the field of information technologies for learning, education, and training to support individuals, groups, or organizations, and to enable interoperability and reusability of resources and tools" (SC36 2002).

The standards developed by SC36:

SC36 has developed two de-jure standards:

- ISO/IEC 24703 *"Information Technology - Learning, Education, and Training — Participant identifiers"*
- ISO/IEC 19796-1 *"Information Technology - Learning, Education, and Training — Quality Management, Assurance and Metrics — Part 1: General Approach"*.

In addition there are several standardization projects in progress with one standard on accessibility on the way to publication (ISO/IEC 24751-1).

ISO/IEC 24703 is a formal standard specifying the datatype of participant identifiers in learning, education, and training including bindings and was published in May 2004. It can be regarded as an implementation standard mainly developed for the domain "learning technology" and focussing on the entity "roles".

ISO/IEC 19796 is a multi-part formal standard for the quality management and quality assurance in learning, education, and training. Its Part 1 provides a common framework to describe, specify, and understand critical properties, characteristics, and metrics of quality harmonizing existing concepts, specifications, terms, and definitions for learning, education, and training. The process model is called the Reference Framework for the Description of Quality Approaches (RFDQ) and was published in November 2005. It can be regarded as a conceptual standard mainly developed for the domain "quality" and focussing on the entity "learning environment".

Concerning the usage of the new standard ISO/IEC 19796-1 the Quality Initiative E-Learning in Germany (Q.E.D.) has been initiated and established to provide support especially for small and medium-sized enterprises (SME).⁴ Q.E.D. is funded by the Federal Ministry of Economics and Technology of Germany, develops tools and guidelines for the adaptation and implementation of the new standard, and supports the international further development of additional standards within SC36.

3.3 IEEE LTSC

IEEE LTSC overview:

IEEE LTSC is the Learning Technology Standards Committee (LTSC) of the international association Institute of Electrical and Electronics Engineers, Inc. (IEEE). Only individual experts, no organizations or enterprises can join IEEE LTSC. Therefore IEEE LTSC is a standardization organization by individuals. Specifications are developed by the working groups and approved by a formal process managed by the IEEE Standards Association.

The structure of IEEE LTSC:

IEEE LTSC is currently divided into four Working Groups (WG) that are working on the development of new specifications:

- WG 4: Digital Rights Expression Language
- WG 11: Computer managed instruction
- WG 12: Learning object metadata
- WG 20: Competency data standards

⁴ For more information see online: <http://www.qed-info.de>

The scope of IEEE LTSC:

The scope of IEEE LTSC chartered by the IEEE Computer Society Standards Activity Board is to develop technical specifications (called "technical standards" by IEEE LTSC), recommended practices and guides for learning technology.

The specifications developed by IEEE LTSC:

IEEE LTSC has developed six specifications ("technical standards"):

- IEEE 1484.1 "*IEEE Standard for Learning Technology — Learning Technology Systems Architecture*"
- IEEE 1484.11.1 "*IEEE Standard for Learning Technology — Data Model for Content Object Communication* "
- IEEE 1484.11.2 "*IEEE Standard for Learning Technology — ECMAScript Application Programming Interface for Content to Runtime Services Communication*"
- IEEE 1484.11.3 "*IEEE Standard for Learning Technology — Extensible Markup Language (XML) Schema Binding for Data Model for Content Object Communication*"
- IEEE 1484.12.1 "*IEEE Standard for Learning Technology — Learning Object Metadata*"
- IEEE 1484.12.3 "*IEEE Standard for Learning Technology — Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata*"

IEEE 1484.1 is a community specification and "specifies a high-level architecture for information technology-supported learning, education, and training systems that describes the high-level system design and the components of these systems". It is describing especially the third layer of system components from the five layer architecture included in the informative annex B and was approved and published in 2003. It can be regarded as a conceptual specification mainly developed for the domain "meaning" and focussing on the entity "learning systems".

IEEE 1484.11.1 is a community specification and "describes a data model to support the interchange of data elements and a runtime service (RTS)" based on the specification "CMI Guidelines for Interoperability", version 3.4, developed by The Aviation Industry CBT Committee (AICC) and was published in 2005 (approved in 2004). It can be regarded as an implementation specification mainly developed for the domain "learning technology" and focussing on the entity "learning systems".

IEEE 1484.11.2 is a community specification describing an ECMAScript application programming interface (API) for content-to-runtime-services communication based on the specification "CMI Guidelines for Interoperability", version 3.4, developed by The Aviation Industry CBT Committee (AICC) and was published in 2004

(approved in 2003). It can be regarded as an implementation specification mainly developed for the domain "learning technology" and focussing on the entity "learning systems".

IEEE 1484.11.3 is a community specification providing a XML binding of the specification IEEE 1484.11.1 using the W3C XML schema definition language to allow data model instances in XML and was published in 2006 (approved in 2005). It can be regarded as an implementation specification mainly developed for the domain "learning technology" and focussing on the entity "learning systems".

IEEE 1484.12.1 is a community specification containing a conceptual data schema that describes the structure of a metadata instance for a learning object. It was approved and published in 2002 and is well-known as the first learning object metadata specification called LOM. It can be regarded as a conceptual specification mainly developed for the domain "learning content" and focussing on the entity "learning resources".

IEEE 1484.12.3 is a community specification providing a XML binding of the specification IEEE 1484.12.1 using the W3C XML schema definition language to allow data model instances in XML and was approved and published in 2005. It can be regarded as an implementation specification mainly developed for the domain "learning content" and focussing on the entity "learning resources".

3.4 IMS

IMS overview:

IMS Global Learning Consortium, Inc. (IMS) is an international standardization initiative with organizational membership. Only organizations as contributing members have the right to develop IMS specifications and charters and the right to vote. The objective of IMS is the development and the promotion of technical specifications for interoperable learning technology.

The structure of IMS:

The development of the specifications is an internal, closed process open only for the organizational members. Finally approved by the IMS Technical Board the final version is published as an open specification made available online on the web for free after registration.

The scope of IMS:

The scope of IMS is to develop and to promote "the adoption of open technical specifications for interoperable learning technology" (also called "technical standards" by IMS).

The specifications developed by IMS:

IMS has developed several specifications, some of them also in updated versions:

- IMS AccessForAll Meta-Data
- IMS Content Packaging (CP)
- IMS Digital Repositories Specification
- IMS Enterprise Services
- IMS Enterprise Specification
- IMS ePortfolio
- IMS General Web Services
- IMS Learner Information Package (LIP)
- IMS Learning Design (LD)
- IMS Meta-data
- IMS Question and Test Interoperability (QTI)
- IMS Resource List Interoperability
- IMS Reusable Definition of Competency or Educational Objective (RDCEO)
- IMS Shareable State Persistence
- IMS Simple Sequencing
- IMS Vocabulary Definition Exchange (VDEX)

The IMS specifications are aiming at direct adoption and implementation. Thus they are normally specific and sometimes small technical specifications developed for particular application scenarios and use cases. The main and well-known IMS specifications are:

IMS Content Packaging (CP) is an industrial specification providing "the functionality to describe and package learning materials, such as an individual course or a collection of courses, into interoperable, distributable packages" by a manifest including metadata, information about resources and organizations, and sub-manifests. Its last version 1.1.4 was published 2004-November-1. It can be regarded as a conceptual specification mainly developed for the domain "learning content" and focussing on the entity "learning resources".

IMS Learner Information Package (LIP) is an industrial specification facilitating the collection and exchange of information about

individual or group learners or producers of learning content by the main elements: accessibilities, activities, affiliations, competencies, goals, identifications, interests, qualifications, certifications and licences, relationship, security keys, and transcripts. Its last version 1.0.1 was published 2005-January-17. It can be regarded as a conceptual specification mainly developed for the domain "didactics" and focussing on the entity "roles".

IMS Learning Design (LD) is an industrial specification providing "a containment framework of elements that can describe any design of a teaching-learning process in a formal way". It is based on the "Educational Modelling Language" (EML) originally developed by the Open University of the Netherlands. This meta-language allows the integration of different pedagogical approaches and the modelling of "units of learning" by adding any content aggregation specification. IMS Learning Design was published 2003-February-13. It can be regarded as a conceptual specification mainly developed for the domain "didactics" and focussing on the entity "methods".

IMS Question and Test Interoperability (QTI) is an industrial specification providing an abstract data model for the description of questions, tests and result reports and their data exchange by using the eXtensible Markup Language (XML). Its last version 2.0 was published 2005-January-24. It can be regarded as a conceptual specification mainly developed for the domain "didactics" and focussing on the entity "learning systems".

IMS Simple Sequencing is an industrial specification providing "a method for representing the intended behavior of an authored learning experience such that any learning technology system (LTS) can sequence discrete learning in a consistent way". It was published 2003-March-20. It can be regarded as a conceptual specification mainly developed for the domain "didactics" and focussing on the entity "methods".

3.5 ADL

ADL overview:

ADL was initiated by the Office of the Under Secretary of Defense for Personnel and Readiness (OUSD P&R) and is part of the Department of Defense (DoD) of the United States of America. Although it is calling itself "ADL initiative" it is a governmental office without membership offers (neither for individuals nor for organizations). The developing procedure and the approval of ADL specifications are closed allowing only review and comments after the publication.

The structure of ADL:

ADL is a governmental office, there is no information given about its internal structure.

The scope of ADL:

The scope of ADL is expressed by its vision "to provide access to the highest-quality learning and performance aiding that can be tailored to individual needs and delivered cost-effectively, anytime and anywhere".

The specifications developed by ADL:

ADL has developed one main specification as an integration of different specifications from standardization initiatives:

1. Sharable Content Object Reference Model (SCORM)

Sharable Content Object Reference Model (SCORM) is an organizational specification providing the support of the conformance and of the data and information exchange between different learning management systems (LMS) and for learning content. Its last version SCORM 2004 3rd edition was published in August 2006. ADL is using the image of a bookshelf for explaining SCORM and its document suite. SCORM consists of four "books":

1. **Overview**
2. **Content Aggregation Model:** It includes the IEEE 1484.12 (LOM) specification (see above), the content structure developed by AICC, the IMS Content Packaging specification (see above), and the sequencing information specification developed by IMS.
3. **Run-time Environment:** It includes the IEEE 1484.11.1 (RTS) specification (see above) and the IEEE 1484.11.2 (ECMAScript API) specification (see above).
4. **Sequencing and Navigation:** It includes the sequencing information and behavior specification developed by IMS.

Only LMS products and contents can be conformant to SCORM 1.2 or SCORM 2004. ADL has asked ISO/IEC JTC1 SC36 for a review process of SCORM and has proposed the idea to move the future evolution and maintenance of SCORM to an (not yet existing) International Consortium for Interoperability (ICIL).

SCORM can be regarded as a conceptual specification mainly developed for the domain "learning technology" and focussing on the entity "learning environment".

3.6 Overview on standards and specifications

The application of the Reference Model for e-Learning Standards in this chapter shows the variety of the examined fourteen international e-Learning standards. The following tables summarize the findings:

Types	Implementation standards	Conceptual standards	Level standards
Number of standards	5	9	0

Table 1: Distribution of e-Learning Standards by Types

Domains	Meaning	Quality	Didactics	Learning technology	Learning content	Context
Number of standards	1	1	4	5	3	0

Table 2: Distribution of e-Learning Standards by Domains

Entities	Learning environment	Roles	Methods	Learning systems	Learning resources	Practice
Number of standards	2	2	2	5	3	0

Table 3: Distribution of e-Learning Standards by Entities

In summary these distributions point out the main activities of e-Learning standardization until now: The main focus was on the domain *learning technology* and on *learning systems* as entities. And also the current challenges and potentials for the future can be identified: The *context* domain and the entity of the *practice*, partly recognised by the standardization initiatives. The lack of *level standards* may be explained by the difficulties to reach an international consensus on measurements and agreed levels of quality topics and issues. But in general the most important task for e-Learning standardization in the future is of course the development of e-Learning standards needed, adopted and implemented by e-Learning providers and users.

As final conclusion and evaluation result it can be summarized that it could be proven that the **Reference Model for e-Learning Standards** with its three dimensions is applicable and suitable for the categorization of e-Learning standards.

4 Vision

Finally we would like to broaden the view on interoperability and quality development in e-Learning and on e-Learning standardization in the future.

First we want to outline the vision of future e-Learning standards development: What are the main challenges today? Here are some answers:

- **Consensus:** Interdisciplinary development of consensus between the different subjects as well as the different standardization initiatives
- **Vocabulary:** Common terminology describing the different meanings and applications of specific terms
- **Harmonization:** Harmonization of specifications on the same topic developed by different standardization initiatives
- **Development of a harmonized and international accepted generic reference framework for any e-Learning environments, architectures, systems, and services**

We hope that the presented Reference Model for e-Learning Standards is a helpful and supporting contribution on the long way towards such a generic e-Learning framework.

Interoperability and quality development are crucial and indispensable for the long-term success of e-Learning: To reach an economical benefit through re-use and harmonization e-Learning standards are offering a sustainable support. This article provides an overview on the existing e-Learning standards: Their adaptation and implementation can be regarded as one of the main tasks for the future.

As a final summary the main challenges for the future regarding interoperability for Quality Development are:

- Development of an **international accepted generic reference framework for any e-Learning environments** (see above)
- Improving the **acceptance and usage of e-Learning**
- Promoting and implementing of **standards for adaptation**
- Harmonizing **quality management and assurance** worldwide

These challenges lead us to the long-term visions:

A Global Network for the common understanding and focus on interoperability and quality development is needed for which the

Asian-European Network of Excellence in e-Learning could be a driver and enabler (Vision 2010).⁵

Our overall Vision 2015 is the establishment of **business excellence** in e-Learning by reaching **interoperability within all domains** for the sustainable improvement of **quality development**.

⁵ As it was proposed at the Asia-Europe e-Learning colloquy 2006 in Seoul, for more information see online: <http://www.elearningcolloquy.org>

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Related URL's for more information online:

ISO/IEC JTC1 SC36:

<http://isotc.iso.org/livelink/livelink?func=ll&objId=806742>

<http://jtc1sc36.org> (old website)

<http://www.iso.org/iso/en/stdsdevelopment/whowhenhow/how.html>

IEEE LTSC:

<http://ieeeltsc.org>

IMS:

<http://www.imsproject.org>

ADL:

<http://www.adlnet.gov>

Other standardization initiatives:

<http://www.aicc.org>

<http://www.qed-info.de>

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