Abstract

The following article presents an overview of the different standards developing in the eLearning sector.

As any new technology, eLearning and its various functionalities need to be underpinned by a standard reference schema. The existence of such a standard is mandatory for the development of a new technology, as it allows the interoperability of resources that would otherwise be incompatible. Interoperability is the keyword here, and its lack is the main barrier to resource exchange and sharing. The emergence of standards will allow the exchange of learning resources, which in turn will allow the production of didactic material using ICT at a lower cost thanks to the interoperability of various software systems.

Different aspects of the standardization are reviewed here. After a brief presentation of the main actors of the standardization, the discussion will focus on the description of the most used and the most promising standards. This discussion will include an introduction to flagship concepts, such as metadata, learning objects and learning units, as well as pedagogical modeling languages.

The last part of this article addresses the learner or the learning material designer who considers the use of standard descriptors for his didactic material. This part is centered on technical and pedagogical considerations and provides the reader with some guidelines allowing him to make a choice with full knowledge of the facts.

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1. Introduction

The question of the sustainability and reuse of pedagogical material is essential, in one way or another, for every actor of the eLearning. What is at stake is the medium and long time profitability of the investment made for the preparation of a teaching setup resting on information technologies. This investment is always significant in terms of financial resources as well as in individual commitment from the teachers and from the content designers. More explicitly, it is a matter of avoiding on one hand to redo some work already done elsewhere and, on the other hand, of making sure that the documents, tests, collaborative work procedures, study guides and so on stay encapsulated in the software environment used at the time of carrying out the teaching setup. Designers and developers, for their part, are faced with the coexistence of a variety of norms and standards[1] and, early in the decision process, they have to make political decisions about this question. In a project team, it is then important for every partner to be in a position to evaluate these stakes and to understand other actors' decisions.

Consequently, this review aims at presenting a quick overview of the problems surrounding the pedagogical resources reuse. Four dimensions will be described: the reasons of the standardization problem and its stakes, some active actors in the domain, a brief description of the various standardization levels and of the context of their use, as well as the main set-up steps. This text has been written for a non-specialized public to allow the development of a common perception and of a common vocabulary.

2. Description and stakes of the problem

2.1 Resource multiplication and localization

The quasi-exponential growth of the knowledge accumulated by Man during the last centuries seems to compromise its accessibility. The explosion of the amount of information available caused by the information era has heightened this trend to the point where some of this information is inaccessible, simply because there is no simple means to access it. What is indeed more difficult than obtaining precise information in some particular domain?

This difficulty seems to be mainly due to two factors. First, each library or editor gives out some content in a format that is peculiar to itself, which generally compromises the easy importation of this content – making it dependent on its software environment. Such formats are said to be **proprietary formats**; in opposition to **open formats**, they rely on specifications that are not public. A format is said to be open when the specification on which it relies is part of the public domain (or possibly if its data representation mode is transparent). A proprietary format, by opposition, relies on some specification that is not part of the public domain; the disadvantage of this kind of formats is that they are not fully interpretable by third-party software, the specification being unavailable. The fact that the content it inextricably mixed with its software environment is a recurrent problem in information technologies: one can still recall the painful early times of micro-informatics, when various systems were cohabitating without any possible interoperability.

[1] In this text, no distinction is made between the *standard* and *norm* terms, which both express the normalised or standardised way to express concepts or content.

2.2 Changes in training demand

Such an environment cannot avoid having intended or unintended consequences on the role and practices of the learners. On one side, training institutions cannot stay on the fringes of technological developments becoming omnipresent, and have to familiarize learners and students with communication modes and tools they will encounter in their professional life. It is moreover unavoidable to prepare learners to adapt their practices to the generation of kids grown up in a universe invested by such technologies, who will have integrated some expertise that could be beneficial to the learning. Not integrating these technologies would mean renouncing tools that can be efficient and stimulating if properly used.

Besides, recent developments in our society have as consequence that an ever more important proportion of active individuals has – or will have – to undergo some complementary, or even some continuous, training. Given these circumstances, today's educational system cannot respond efficiently to ever quicker changes of the work market demands [Jackson 2003], which are justified by a more and more versatile and competitive worldwide economy. The courses proposed by educational institutions (universities) cannot follow the frantic pace of subject matter renewal imposed by such new conditions. A university degree can nowadays be sufficient to step into the world of employment, but even third-cycle studies cannot guarantee the skills required to stay competitive in tomorrow's work market.

For all these reasons, the need for new learning modes becomes tangible. These need in particular to meet the following criteria:

- flexibility of the learning towards the learners and the conditions (adaptability) ;
- quick response to changes in the demand ;
- authenticity of the supplied information ;
- effectiveness of knowledge acquisition (high acquisition rate) ;
- development of autonomous learning skills, allowing the learner to update his/her knowledge once the main training is completed.

2.3 The challenge of interoperability

To satisfy these criteria, the learning material – to be understood here as documentary resources and activity sequences aiming to guide the learning – has to be available in a digital form. Such a form is indeed essential to provide content that can adapt to the learner and to the learning conditions, and that can respond quickly to the changes in the demand. It would also allow the reuse of processes – sometimes sophisticated – that have proved their effectiveness.

At this time, a huge amount of digital learning resources exists, mainly elaborated by universities, big administrations or big enterprises. These offer their students or employees various computer-based training (CBT) means, allowing them to acquire some new knowledge or to update it. Nevertheless, and as mentioned earlier, although these resources are locally exploitable – in the range of a university or an enterprise – the fact that numerous software environments (called in this case virtual learning environments, or VLE) are coexisting compromises the exchange of learning material between institutions. A university using one VLE (several hundred are in existence) or possibly a self-made IT development becomes then dependent on it, as the availability of the material depends on the existence or sustainability of the VLE used, or on the stability of the license costs. Moreover, it will be very difficult for such a university to import into its VLE a course from another university using another VLE, or even to provide an exchange of material between its different courses.

The dependence of the learning material on the learning environment has a major disadvantage: the impossibility of guaranteeing the sustainability. Indeed, how can a teacher, who has used a VLE to put his didactic material on line, be sure that the VLE in question will still be usable after some years? The risk incurred is too important: re-developing the content periodically to make it conform to the successively used VLEs is simply unacceptable. Moreover, the huge redundancy existing in the didactic material sector is perceived as a hindrance to development and as a source of supplementary costs.

One can however imagine two types of solution to these problems. The first one would consist in developing “translating” software that would permit the different VLEs to “understand” each other, thus allowing the learning material to free itself from its software environment. This solution has however its limits:

- a great number of such “translators” would have to be programmed ;
- the architecture of different VLEs can be different, and some functions could hence be “untranslatable”, or incompatible with other VLEs ;
- how to limit the redundancy of the didactic material if each and every material has to be transcribed into a new form as soon as one has to use a new VLE ?

The second solution consists in creating a “**standard** language”, understandable by the various software environments. This solution has the advantage of allowing the accurate description – in a machine-readable language – of any type of digital content and of any type of learning activity. Some content described by such a language would then be independent from any proprietary format, and its designer would only have to worry about the content and not any more about technical considerations bound to the use of this or that software environment. Although VLEs presently used provide as a rule some “translators” allowing exchanging content or even learning activities with some other VLEs, their limitations urge designers to free themselves from the software environment to concentrate on the essentials, i.e. the learning material itself.

The concept of **standard** is recurrent in the information technologies field. From the microfilm reader to the software managing electronic mail, various users quickly got used to handling numerous different readers or software (Eudora, Outlook, Hotmail, etc.). These various readers or software are however all able to read a standard microfilm or to read and write standard electronic mail; it would indeed be unthinkable that each person would use their individual format and would have to turn to numerous translators to be able to interpret different formats. Such a state of things would be at the expense of interoperability, and hence a hindrance to the design and use of resources. The question of standardizing the eLearning contents comes up in the same way, and the imperative conclusion is that the use of standard formats is essential in order to respond to basic criteria of sustainability and interoperability.

3. The actors of the standardization

In order to guide the various practitioners of the eLearning who are content designers, software developers, and users in a common direction, various workgroups or committees have been formed. These groups allow the collaboration between people of different horizons in order to establish standards appropriate to the need of the users and to the possibilities offered by the ICT: they are the actors of the eLearning standardization[2].

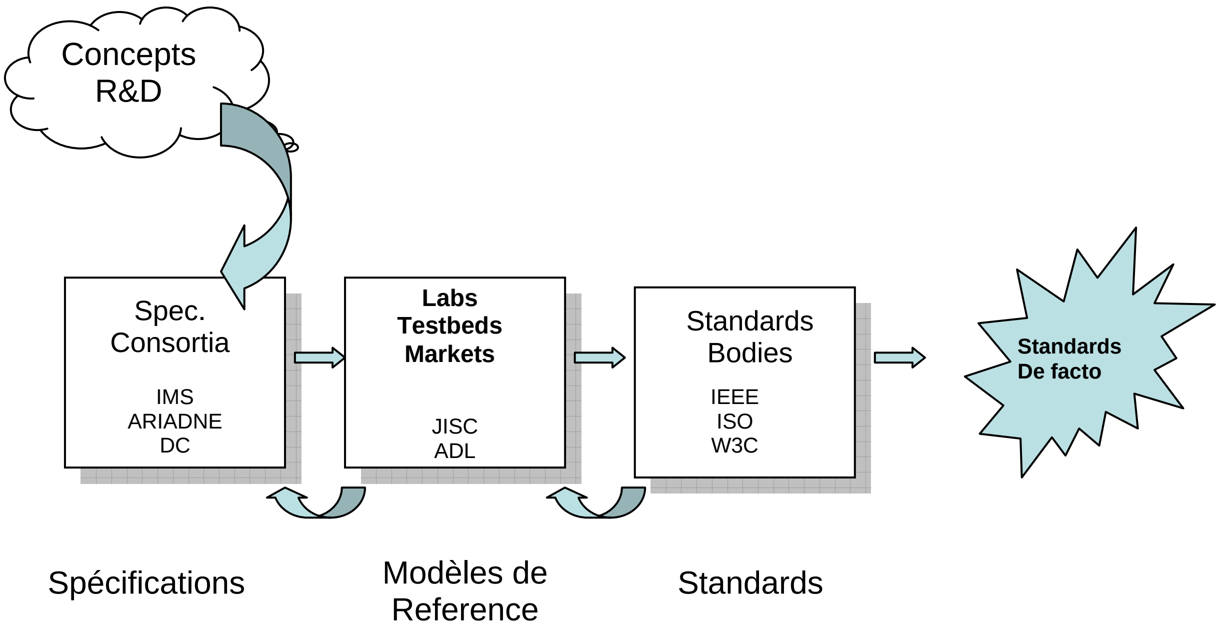

Figure 1: From specifications to standards

3.1 The specifications

The actors involved in the standardization processes are many, and it would be impossible to present them all. Figure 1 schematizes the development process of standards, and only some of the most important organisms will be presented hereafter.

3.1.1 IMS

The IMS project was launched in 1997 by Educom (presently Educause) in the US-of-A within the frame of the National Learning Infrastructure Initiative. It is a worldwide consortium combining educational institutions, commercial entities from the IT sector, and governmental agencies. The project was initially intended to produce a unified specification covering all domains – metadata, content, user data, etc. The resulting specification was however considered too heavy and was rejected by the commercial partners. IMS reacted by splitting the specification into several parts (corresponding to the various components) and by defining distinct workgroups, each of them working on the publication of one of these parts

[2] For the reader wishing to read more about the standardization process itself – which we consider out of the scope of this paper –, some articles focusing on this part, such as [Friesen 2005], are also available.

[IMS 2004, CETIS 2003, CETIS 2004]. The various parts of these specifications are described later, in section 4.

3.1.2 ARIADNE

The ARIADNE foundation [ARIADNE 2002], is a non-profit organization founded in 1996.

The acronym stands for Alliance of Remote Instructional Authoring and Distribution Network for Europe. Its goal is to promote the results of the European projects involved in easing the production, the management and reuse of distance learning materials. ARIADNE took part:

- in standardization activities under the supervision of the committee IEEE LTSC, within the IMS Educause project (a US-funded project). The target was to obtain quickly a set of Metadata for eLearning that were broadly acceptable.
- in the standardization work initiated by the European commission under the supervision of the CEN/LTWS (Learning Technologies Workshop)

3.1.3 DCMI

The Dublin Core Metadata Initiative Education Working Group is part of the DCMI (Dublin Core Metadata Initiative). Its goal is to develop the usage of the Dublin Core metadata for the description of educational resources. The Dublin Core is made of 15 elements which semantic value has been established through an international consensus among professional of various disciplines: library management, text referencing, museology, computer science, and other related areas [Dublin Core 2005]. The main advantages of the Dublin Core are:

- Its simple creation and management
- A semantic value widely understood
- An international recognition
- Its scalability

The Dublin Core can be applied to all file formats conditional on the metadata being readable by both search engines and humans.

3.2 The reference models

3.2.1 ADL

The ADL (Advanced Distributed Learning) initiative was launched in 1997, on an initiative of the US-of-A department of defense. ADL is made up of several Co-Labs, and among them is the Academic Co-Lab of Madison, which works especially in the higher education interest. Its goal is to compile the works of specialized organisms with the intention of offering a model allowing the interoperability of learning tools and of contents. Its flagship project, SCORM (Shareable Content Object Reference Model, see section 4.3.1), aims mainly at defining a content structure model – derived from the work of the AICC. This content structure model allows among other things the assembly and sequencing of learning resources and activities, using LOM and IEEE metadata as well as IMS Content Packaging descriptors and metadata XML binding. These points will be detailed in the following sections.

3.2.2 CETIS

The Centre for Educational Technology Interoperability Standards [CETIS 2003] is a project of the British government funded by the Joint Information System Committee and coordinated by the Bolton Institute, in cooperation with the Universities of Wales, of Bangor and the OUNL (http://www.ou.nl, see section **Erreur ! Source du renvoi introuvable.**).

CETIS is divided into special interest groups (SIGs), each one of them working on one of the main specifications – such as metadata (see section 4.1), Question and Test (see section 4.3.3.2), etc. According to the progress of the various specifications, these groups represent the United Kingdom's arguments concerning the specification development, follow the developments of the standardization in one specific domain, and test and evaluate the new specifications, preferably using practical cases. The last part of their job consists in disseminating the results of their work in the country, especially in the HE/FE institutions.

3.3 The standardization bodies

3.3.1 IEEE

The Institute of Electrical and Electronics Engineers is a standardization organism, mainly known for having developed standards for the electronics and informatics industries. It was founded in 1963 by merging the former AIEE (American Institute of Electrical Engineers) and IRE (Institute of Radio Engineers), and now includes contributing members from about 150 countries. It includes a committee dedicated to eLearning, the LTSC (Learning Technology Standards Committee), which has in particular taken charge of the coordination of the works on learning objects metadata (LOM, see section 4.1). Among many other norms ratified by the IEEE, let us mention in particular the IEEE 802 standards concerning local area networks (LAN) and, more recently, the 802.11 standards concerning wireless networks.

3.3.2 ISO

The ISO (International Organization for Standardization), founded in 1947, is a worldwide federation of standardization organisms. It groups together standardization organisms from more than a hundred different countries, as for instance the AFNOR (Association Française de Normalisation, the French Normalization Association) in France or the SNV (Schweizer Normen Vereinigung, the Swiss Normalization Association) in Switzerland.

Within ISO, the JTC1 (Joint Technical Committee 1) mission statement is to "Develop, maintain, promote and facilitate Information Technology standards required by global markets meeting business and user requirements". JTC1 is organized in 18 subcommittees among which SC36. The latter develops International Standards in Information Technology in the areas of Learning, Education, and Training. SC36's technical work is performed in Working Groups (WGs) and Rapporteur Groups (RGs). SC36 operates according to a business plan, which is approved annually by the JTC1. In June 2006, the list was as follows:

- WG1: Vocabulary
- WG2: Collaborative Technology
- WG3: Participant Information
- WG4: Management & Delivery
- WG5: Quality Assurance and Descriptive Frameworks
- WG6: International Standardized Profiles
- WG7: Culture, Language, and Human Functioning Activities

See also section 4.4, which is related to quality standards.

3.3.3 W3C

The World Wide Web consortium [W3C 2003, W3C 2004A, W3C 2004B, W3C 2005A, W3C 2005B] is in charge of normalizing all the internet protocols:

- The basic standards : HTTP, HTML, DOM, XML, XSL ...
- The standards towards the interoperability and the Web services : SOAP, WSDL and Web services
- The standards for the multimedia content : HTML, XML, CSS, SMIL, VML, MathML, SVG
- The standards for accessibility : WAI
- The standards for the description of the resources and the semantic content: XML Schema, RDF, OWL ontology and anything that deals with Semantic Web.

RDF (Resource Description Framework) first appeared as a metadata framework. The goal was to promote interoperability among computers exchanging information on the Web. The RDF type of metadata can be used in various ways:

- To improve the capacities of the Web search engines
- For the indexation of the documents, the description of their content and the relationship between these contents
- In the usage of the smart agents to make the exchange of information easier
- For content rating purposes
- To describe a collection of resources that forms a unique logical entity

RDF current goal is to provide the following improvements:

- Data interoperability
- A machine-readable semantics for meta data

- Enhanced search capabilities.

The future developments should allow the usage of third parties' metadata and provide an uniform request format for resource search/recovery [W3C 2004A].

4. Which standards?

Once it is established that standards are essential to the future development of information technologies-assisted learning, it remains to determine which standards types are required, and for what purpose. In summary, the objectives pursued by the establishment of standards are:

- Accessibility to the information, that is to allow the search, access and delivery of the distance learning material in a distributed fashion.
- Interoperability: to allow the usage in different environments of some material developed by a given institution on a specific platform.
- Duration: Components should undergo technology change without need for major reengineering. The contributes to the diminution of the material development costs ;
- Reusability: to build on the top of existing material by reusing and/or accessing existing components in other environments. This can be done through the development and use of digital libraries or repositories dedicated to the reuse of didactic material.
- Adaptability of the learning material towards a learner or an institution ;

These standards are often multi-part, typically consisting of:

- a “data model”, specifying the standard contents in an abstract manner ;
- a “binding”, specifying how the data model is expressed in a formal idiom (usually in XML, see section 6.2.1) ;
- an “API” (application programming interface) – which is less often provided – aiming at providing contact points between different software, or between content and runtime software.

The present discussion however will strictly focus on the *data model* and *binding* elements of the considered specifications, as the use of the API is usually restricted to software programmers and has little or no influence on the publication of the content itself.

As mentioned, the first condition the information has to fulfill is accessibility. Any content that has to be found by means of a search engine therefore has to be described in a sufficiently significant way, i.e. not only by a title and a file name, but by a set of descriptors or keywords, called **metadata**. These descriptive metadata can contain various description levels, from simple keywords helping to define the application field to a set of attributes allowing the description of use criteria (copyright, pre requisites, etc.), and can be considered as “data about data”. These metadata have to be standardized so that the various content designers and users can use the same keywords, and so that an adequate search engine can interpret requests to make available the corresponding content.

The second point, technically the most difficult to realize, consists in using standards to describe the content itself. Some content described with these standards would then not only be independent from it software environment (VLE), but would also be interpretable by a wide variety of various VLEs. It would then respond to the demands made earlier, in particular to the ones concerning interoperability and sustainability. Such contents are usually called **learning objects**[3]. The underlying idea is to accumulate many of these learning objects in digital repositories – or databases – accessible by users and providing a dedicated search engine.

The development of such standards for resource or learning activities description implies the creation of dedicated workgroups (see section 3). These workgroups have to be made up of members of educational institutions together with software (for instance, VLE) developers, because only an active cooperation between these two circles can allow the creation of relevant standards. At this time, several of these workgroups have elaborated and adjusted various standards allowing various description levels. The next section proposes an overview and a description of the main types of standards presently available in the eLearning domain.

4.1 Metadata

A first level of metadata is necessary to allow a general description of the content. This level contains attributes allowing filing and searching the information using various criteria. Usually present attributes at this level are: the resource name, keywords, author name, intended public, language used, copyright info, and so on. Among the most frequently used standards, let us mention:

- IEEE LTSC LOM (Institute of Electrical and Electronics Engineers’ Learning Technologies Standards Committee Learning Object Meta-data – or norm IEEE 1484): set of content-description metadata, issued by the IEEE ;
- DCMI (Dublin Core Metadata Initiative) : set of metadata developed by the Dublin Core consortium [Dublin Core 2004] ;
- IMS MD (Instructional Management System Global Learning Consortium Metadata): set of metadata based on the IEEE LOM developed by the IMS consortium [IMS 2001A].

The goal here is not to go deeply into the details of each usable metadata schema, but rather to supply the user with some tool allowing him to make a choice in the most pertinent way. The important point is that various specifications are coexisting, each of them allowing a detailed description of the content and the use of keywords. One can moreover note that Dublin Core

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[3] This term is here used in a wide sense and describes any form of resources useful for learning, including tests, work guides, document aggregates, etc., provided that they are diffused in digital format. Some intense controversy has taken place about the definition and ideal granularity of resources, but it seems to us that these are beyond the scope of this review.

and IEEE metadata are compatible and interchangeable by simple mapping [Dublin Core 2004], whereas IMS is using a schema that is practically equivalent to the IEEE one.

These workgroups – among others – have made the establishment of metadata schemas very widely applicable. Indeed, the above-mentioned norms recommend using a minimal set of metadata (such as title, keywords and author name, for instance), but leave to the user's judgment the use of a multitude of other ones, allowing the refinement of the description down to the desired level.

4.2 Learning objects

The metadata layer described earlier is only a data addition to the content, which allows finding this one more easily when using search engines. However, in order to be accessible to third parties, this content has to be described at a structural level by standardized schemas. This is why the learning object notion has been adopted in order to be able to set in a common form all the didactical material [Downes 2001].

The definition of a learning object is quite broad, depending on the interpretations. This means that any type or set of resources providing information can be considered as such. A higher description level is necessary here, in order to be able to define relations between the learning object components. If a one-page text-format document is considered, the case is trivial and metadata will do in most cases; but if one considers a whole course made up of several document types (texts, diagrams, possible interactive items), supplementary descriptors are needed to reproduce the original structure from its various components.

According to our definition, a **learning object** is then a digital entity dedicated to learning, and containing one or several resources, a metadata layer allowing identification (and finding it within a repository), and a descriptors layer allowing the description of links existing between these resources. Various workgroups have erected various models allowing the development of such learning objects; among these, the most important two are ADL SCORM Content Package and IMS Content Package.

ADL (Advanced Distributed Learning, see section 3.2.1) proposes a reference model for the creation of reusable learning objects (Shareable Content Object Reference Model): ADL SCORM Content Package. This model is not a specification by itself, but consists in a collection of various pre-existing technical specifications. One can note for instance that SCORM is using the IEEE LOM for its metadata layer [ADL 2003].

IMS (Instructional Management System Global Learning Consortium, see section 3.1.1) is another workgroup, proposing a series of standards covering various description layers (see following sections). The metadata layer uses, like SCORM, the IEEE LOM norm. An additional specification allows the creation of learning objects, named here in accordance to a more general nomenclature « Content Packages ». IMS CP will hereafter designate, depending on the context, as well the considered specification as the content package itself.

So, both ADL SCORM Content Packaging and IMS Content Packaging allow the creation of reusable learning objects of various complexity levels. These two norms are almost equivalent and present a high interoperability level because they both rely on the IEEE LOM norm for their metadata, and because SCORM relies on the IMS CP norm concerning Content Packaging [ADL 2003]. The SCORM CP norm actually introduces some extra parameters that do not exist in the IMS CP specification; so a SCORM Content Package is compatible with IMS CP but the reverse isn't true. These Content Packages, or learning objects, appear as a computer file (usually a compressed ZIP file) including the learning resources themselves, or links pointing towards them, metadata and a description of the relationships between the various resources (for instance, hierarchical structure). These can then be interpreted by a range of VLEs that will be able, from the metadata and other descriptors that are in the file, to rebuild the original structure of the learning object in their own environment. At this level of content description, the learning object can be reused in a new VLE, but the teacher himself will have to implement the pedagogical aspects.

4.3 Learning units

At this level of content description, learning objects (as defined in the last section) are entities, which are independent of the context of their creation. Their portability is enhanced by the Content Packaging, which reduces the number of files to transfer down to one, whereas the metadata and various attributes associated with Content Packaging allow importation into various environments.

Only a part of the initial objectives is however fulfilled in this approach. Indeed, learning objects created this way are importable into various environments, but the descriptors brought by metadata and Content Packaging allow only to reproduce the content structure, not the didactic approach used to teach the content.

What are the demands to which a learning unit has to respond?

- the smallest unit satisfying a learning objective ;
- cannot be divided without losing learning efficiency ;
- for instance: course, studies program, workshop, exercises, case study … ;
- widely used concept, but not strictly defined: “entity, digital or not, that can be used during technology-supported learning”.

However, one has to scale down a little bit the above-mentioned demands. Such a definition – even if it covers a broad application field – has to be considered with care. Indeed, concerning the first two points, the fact that the learning unit should be as small as possible will enhance its portability – its small size will allow its incorporation into a higher number of units of higher granularity – but a unit which doesn’t respond to this demand still has to be considered as a learning unit. Later on in this text, the **learning unit** term will be used in its broad sense, as defined here, that is: an object encapsulated in a package, satisfying a learning objective, and consisting of metadata which allow the rebuilding of a didactic scenario (for instance, activities sequencing; see sections 4.3.1 and 4.3.3).

This means that a higher description level, taking into account the entire pedagogical aspect, has to be added to the learning objects to qualify them as learning units. This description level has to add a series of didactic descriptors containing a precise definition of the various roles (teacher, learner, and staff) and activities related to the resources of the learning object. Without this last level, the learning object in the form of a Content Package (containing metadata and arranged resources) can then be likened to a simple written course support (having a title – metadata – and resources – texts, graphs, etc. – arranged into ages or chapters). By inserting into it the pedagogical aspect, that is, the expected objectives, the roles played by the various participants, and the various contexts within which these roles have to be played (collaborative or research work, exercises session, etc.), the learning object becomes a **learning unit**. This learning unit can be likened to a course, as it contains a description of every role and activity necessary for the completion of the associated learning objectives.

Questions arising at this point are: how can a very broad range of pedagogical approaches be represented by a technical standard? and what has to be included into the specification? The standard has on the one side to respond to the interoperability conditions, and to contain comprehensive specifications. However, on the other side, the more detailed the specifications, the more difficult it will be to comply with the standard [Attwell 2004A]. These standards indeed risk narrowing the eLearning into a (small) set of existing pedagogical practices, whereas one would expect them to support new ones. These possible new pedagogical approaches still have to be developed but could for instance draw on the possibilities made available by CBT/CBL. Such a standard language aiming at the description of pedagogical approaches should not suffer from such limitations.

The remainder of this section will propose a brief overview of some of the most important specifications allowing the implementation of pedagogical approaches in learning objects, making them learning units.

4.3.1 ADL SCORM

As mentioned earlier, the SCORM reference model is not a standard itself, but rather a set of technical specifications grouped into a “reference model”. Such a reference model may include only some items from the global set; this is then a “specification profile”. This means, than a SCORM Content Package may, as an IMS Content Package, contain only resources (arranged or not), contain metadata, and contain or not specifications about the pedagogical approach that should be used [CETIS 2003, ADL 2003].

To build learning units, the whole SCORM reference model has to be used, in order to be able to include some technical specification of the pedagogical approach to use.

The development of SCORM has been done according to four objectives: sustainability, interoperability, accessibility, and reusability. There is however some debate about its pedagogical neutrality (see section 4.3). Indeed, although considered pedagogically neutral by its designers, SCORM is considered favoring conservative pedagogical schemas, that is, **behaviorist**, **didactic**, and **instructive** ones. Moreover, it is focused on individual use: the approach is self-paced and self-directed, and does not allow any form of collaborative work (see section 4.3.3.1). This is probably due to the fact that SCORM initially was devoted to instruction inside the US-of-A department of defense (see section 3.2.1), and that it therefore implies a pedagogical model that is closer from the ones used in military in and industrial training [Attwell 2004B].

4.3.2 EML and other modeling languages

EML (Educational Modeling Language) is a notation system, developed in the nineties by the OUNL (Open University of the Netherlands), which aimed at the description of a wide variety of pedagogical scenarios. It was the first complete “educational modeling language”, allowing a formal description of learning scenarios, reusable and context-free [Koper 2001, CETIS 2004]. Since then, EML formed a basis for the establishment of the IMS LD norm. EML still exists, but it isn't updated any more since February 2003, due to the appearance and application of IMS LD.

The main difference between these is that, as EML presents a simple approach of the process (every facet of the learning scenario design is included in it), IMS LD belongs to a structure integrating other IMS norms: Content Packaging, Metadata, Question&Test, Simple Sequencing, etc. – and therefore is just an additional "layer" [Tattersall 2003B].

Let us notice furthermore that other content modeling languages do exist – allowing to define the integration of mathematic formulae or of multimedia content. These usually use mark-up languages, such as XML or one of its variants, in order to be able to benefit from the advantages of a structured language (hierarchical structure, machine readability, etc., see section 6.2.1). Let us cite as examples SMIL (Synchronized Multimedia Integration Language) [W3C 2005B], which allows the simplified creation of audiovisual interactive presentations, and MML (Math Mark-up Language) [W3C 2005A], which provides a description language dedicated to mathematical expressions.

4.3.3 IMS Learning Design

The IMS Learning Design specification, on her side, supports the use of a wide variety of pedagogical scenarios [CETIS 2003, IMS 2003C]. This specification is generally considered from this point of view as pedagogically neutral [Attwell 2004A]. It provided indeed a generic and flexible language, developed to allow the expression of a great number of various pedagogies. An undeniable advantage of such a structure is that only a set of design tools and of runtimes has to be implemented.

This language was initially developed at the OUNL (Open University of the Netherlands) under the name of EML (Educational Modeling Language, see section 4.3.2) [Koper 2001], after having examined a wide set of pedagogical approaches and of associated learning activities.

The IMS workgroup on Learning Design works on the establishment of specifications for the description of the elements and of the structure of any learning unit. There exist for instance conceptual models to describe structured interactions (practical work, group projects, etc.) or learning activities (for instance, problem-based learning). The goal here is to allow the creation of various pedagogical scenarios, using a standardized notion that can be uniformly implemented in various courses or learning programs.

The IMS LD norm is divided into three implementation levels, each one resting on the inferior level, and adding some functionality to it. Level A includes the system basis, which allows to define roles and activities for each actor of the pedagogical scenario: actors are playing different roles in order to attain some objectives, using support or learning activities (depending on their role) within the frame of an environment consisting in learning objects and services (as a discussion forum, for instance). Level B adds to these the concepts of *properties* and of *conditions*. A property may have to be fulfilled for an activity to be considered accomplished – and conversely, the completion of an activity may influence a property. The use of conditions can trigger some events only under certain circumstances. Level C adds the possibility to use *notifications*: these allow not only the automatic notification of an event of a role, but also to trigger or to fulfill a property or a condition [Tattersall 2003B].

One has however to keep in mind, that the IMS LD norm is only the upper layer of a set of norms prescribed by IMS, starting from metadata and content packaging and resulting in learning design. It seems here relevant to cite and describe briefly the other IMS norms concerning the description of learning objects and units – notice in passing that the existence of each "layer" is not obligatory and depends on the use one wishes to make of the learning object or unit. A brief description of other IMS specification directly bound to the pedagogical approach can be found in the next two subsections.

4.3.3.1 IMS Simple Sequencing – IMS SS

The IMS Simple Sequencing norm [CETIS 2003, IMS 2003B] aims at the description of a simple learning scenario, in the sense that is recognizes only the role of learner. IMS SS so includes only a limited number of widely used pedagogical scenarios. It however allows building quite complex sequencing schemas using selection rules, objectives, and boundary conditions.

One has to note that the SCORM reference model is using the IMS SS norm for the sequencing of the learner's activities, and that this model is hence limited at the level of the pedagogical scenario description to an approach centered on an individual learner. In comparison, a pedagogically neutral description language such as IMS Learning Design or EML (see sections 4.3.3 and 4.3.2) allows to elaborate pedagogical scenarios that do not suffer from these limitations.

4.3.3.2 IMS Question and Test Interoperability – IMS QTI

The IMS QTI norm has been – as its name indicates – developed by the IMS consortium (see section 3.1.1) [IMS 2003A]. It allows the representation, in a machine-readably form, of questions and even tests, together with the processing of the corresponding results. It allows the formulation of various question types such as multiple choice, fill in the blank, true/false, etc., and their exchange between various VLEs. Besides, some software allowing to build and evaluate tests conforming with the IMS QTI norm are emerging (see section 6.2), and it is even possible to convert in a nearly seamless manner questionnaires stored in an LMS proprietary format (such as WebCT for instance) into IMS QTI conformant questionnaires.

4.3.3.3 IMS Learner Information Package

The IMS LIP specification [IMS 2001B] aims at the compilation of information concerning the learner into a package. In this way, this information could be exchanged between various systems.

The LIP package may contain many elements, but most of them are optional and their implementation is left to the appreciation of the user. Among these elements, the main one is the *identification*, which allows identifying an individual through elements such as name and address, among others. Non-comprehensively, other elements include *goals* (personal goals of the learner), *qualifications certifications and licenses* (which reflect his/her accomplishments), *accessibility* (reflecting preferences concerning for instance the language to use), *activities*, *competencies*, *interests* and *affiliations*.

The LIP norm provides further extension possibilities, in order to satisfy everyone's needs. This can be achieved in two ways. It is indeed possible to extend any element of the specification in order to attain a higher granularity or a more detailed description level. It is moreover possible to add elements to the package, which are external to the specification, and so to include virtually any form of extra information needed.

4.4 Quality

More recently (November 2005), the International Organization for Standardization (ISO, see section 3.3.2) issued a "Quality Framework for Learning, Education, and Training": ISO/IEC 19796-1 [ISO 2006]. Specifically aimed at learning, education, and training in their broader sense, it is suitable for use in ODL. It is not a standard for certification, but rather a common quality language helping to make quality interoperable.

As numerous approaches has been developed and implemented, their various scopes and objectives can be quite confusing to the users. Therefore, the ISO developed this quality standard to serve the following purposes:

- harmonizing the quality approaches through the use of a common vocabulary;
- developing quality systems through process modeling:
    1. quality objectives
    2. responsible actors
    3. means to assure quality
    4. means to measure quality;
- extending existing quality approaches;
- combining quality approaches through the use of a clear terminology.

It is thus a reference framework for the description of quality approaches (i.e. is not providing specific requirements or rules, but serves as a guide through quality development), and mainly consists of two parts:

- a description scheme, which allows to interoperable describe quality approaches by documenting all quality concepts in a transparent way;
- a reference model, which serves as guide through the different processes of building learning scenarios.

The workgroup in charge of this specification is presently (May 2006) working on additions to this framework, to help the implementation of this standard. These include a quality model, reference methods and metrics, and a best practice and implementation guide.

Up-to-date and more detailed information (both paper and electronic versions) is available at [ISO 2005].

5. Learning resources repositories

If the use of standards for the description of content allows the development of sustainable solutions concerning resources/learning objects/units (the generic term *object* will be used within this section), the problems of learning objects repository and accessibility remains. Content developers are looking for systems allowing depositing of such objects, without making them prisoners of a proprietary architecture. The desired goal is to be able to reuse, update, archive, and recall them easily. They moreover have to be searchable by search engines, as well as directly by human beings.

Many repositories exhibiting various properties could be cited and described here, but only the citation of a few interesting peculiarities is in the scope of this paper.

Let us cite for instance the FEDORA project (Flexible Extensible Digital Object Repository Architecture), which proposes an architecture allowing combining XML and Web services to form a distributed repository. Another one, MERLOT (Multimedia Educational Resource for Learning and Online Teaching) is playing an important role in the grouping of non-standardized resources: here one may find descriptions of and links towards more than ten thousand courses or learning objects of various forms and granularities.

The ARIADNE KPS [Duval 2001] benefits to its members by allowing each of them to access its own material as well as the description and the content of other members' resources. Based on the confidence and the good will of its members, this network allows the exchange of a large number of pedagogical documents, thanks to its relevant indexation.

GLOBE (Global Learning Object Brokered Exchange) ensures the interoperability between resource repositories. Its founding members were the Ariadne Foundation in Europe, the Educational Network Australia (EdNA Online), eduSourceCanada in Canada, the Multimedia Educational Resources for Learning and Online Teaching (MERLOT) in the US-of-A, the National Institute of Multimedia Education (NIME) in Japan. Those organizations gathered to work collectively on an ubiquous and quality access to educational material.

IMS Digital Repository is an attempt of the IMS Digital Repository Interoperability Working Group (DRIWG) [IMS 2001A] to establish the specifications for the interoperability between repositories regardless of their internal architecture.

6. How to proceed?

The goal of this section is to provide some guidelines concerning the development and the setup of learning objects. Individuals or organizations wanting to develop online teaching content will have to realize that they will have to pursue their objective on several aspects. The two main aspects of this question are:

- considerations about pedagogical strategy (see section 6.1): the question is indeed to know how to optimize the impact of the teaching technique, providing the learners a suitable pedagogy ;
- technical considerations (see section 6.2): once considered the technical constraints of the didactic model used, the rest of the work is to develop the material itself in a manner that ensures sustainability – and hence interoperability.

The two following subsections are aiming at guiding the teacher or the learning material designer in his reflection about these two main aspects of the question.

6.1 Pedagogical strategy

In order to be able to consider the process of developing learning objects or units in a global manner, one has to define creation strategies. Among the various trends aiming to rationalise the use of ICT in the learning processes, two mainstreams stand out.

The *documentary trend* proposes a content-centered approach. This one is linked to the increase of the information mass, and takes advantage of the object-oriented approach, which allows sharing, reusing, and aggregating learning objects. Standardization work in this domain has resulted in the use of metadata, allowing the indexation of objects prior to their cataloguing and reuse (see sections 4.1 and 5) [Pernin 2004A, Pernin 2004B].

The *"pedagogical engineering" trend*, on his side, proposes a process-centered approach. It is important at this stage to differentiate the concepts of *information* and of *knowledge* [Paquette 2002]. **Information** is made up of all data external to people, directly communicated by other people or by the means of some media, whereas **knowledge** is the result of the mental construction made from information. The **learning** process then consists in transforming information into knowledge. A process-centered approach rests on two processes at the heart of knowledge management: firstly, transformation of knowledge (say, from an expert) into information, followed by the transformation of this information into new knowledge through learning.

At this point, it is important to note that these two trends are not mutually exclusive, but rather represent trends observed in the conception of pedagogical objects. At this stage, the teacher or developer wanting to put didactic material online will firstly have to consider the following questions:

- to what type(s) of audience is the learning material intended ?
- what are the learning objectives ?
- what are the (pedagogical and technical) constraints one has to take into account ?

Depending on these points, one has first to determine the adequate form of the material [Shank 2004]. This means, that the various aspects concerning pedagogy have to be considered, beginning with the pedagogical level desired for the didactic material. Various didactic material types may indeed be used, depending on the designers' abilities and the learners' needs. An encyclopedia on an Internet Website *is* didactic material, as well as an online whole course containing exercises and evaluations. The pedagogical level of and encyclopedic site is however far lower, a simple document sequencing being able to guide the learning process, while a course needs the use of higher-level descriptors in order to describe each step of the learning scenario together with the detailed interactions between the various actors (see section 4.3.3).

If a documentary-type pedagogical scenario is needed, a simple sequencing will do in most of the cases. If the pedagogical scenario moreover considers an individual learner-centered approach (not taking into account any type of interaction between learners, such as group works for instance), then a norm such as IMS Simple Sequencing (or a reference model such as SCORM, as it is using the IMS SS norm to sequence activities) will most likely be suitable to express – in a standard language –the wished pedagogical approach.

On the other extreme, if the desired pedagogical scenario is more of a constructivist type, and if its designer wishes to implement every facet of a process-centered didactic, then a more evolved description norm is necessary. Such a choice will favor the "pedagogical engineering" trend (see above in this subsection) and most likely the use of the IMS Learning Design specification (see section 4.3.3). This specification, as mentioned earlier, indeed allows the description of a wide variety of pedagogical scenarios, can be considered pedagogically neutral and therefore the most suitable to describe evolved pedagogical scenarios.

6.2 Technique

The first thing to do at the technical level is to develop a detailed plan of the considered pedagogical scenario. This is usually done by establishing a flow-chart representing every interaction between the scenario actors (professor, assistant(s), learner(s)) and their environment. Such a diagram allows to proof the scenario "on the paper", and then to transcribe it more easily in a machine-understandable format. Such a development requires a double abstraction effort, together with decomposition and analysis of the considered scenario. These efforts are however indispensable, as such an analytical representation of the scenario is essential to its accurate transcription.

The second point to consider is: what resources are available, in terms of informatics means and support? The informatics means should be suitable to the needs of the CBL, whereas informatics support people have to be able to guide designers and users using tools that can be completely new to them, as well as to face possible computer problems.

Once theses points set, the learning material designer has decided to use some precise pedagogical scenario, within a context made of learners, didactical resources, and informatics means. The last step (but to be kept in mind during the whole process) consists in choosing a standard specification suitable to the desired use of the learning material.

6.2.1 XML: eXtensible Mark-up Language

After having chosen a standard to use for the representation of the learning material, one ore more manifests have to be created. These are in the form of a computer text file, complying with the XML (eXtensible Mark-up Language) specification, and describe according to the chosen specification the learning object or unit.

The underlying structure in most of the standard specifications is of hierarchical form; that is, it is made of main elements, themselves made of smaller granularity elements, and so on down to the necessary (or desired) detail level. Mark-up languages, having themselves a hierarchical structure, are perfectly suitable for the informatics representation of such structures.

To the reader who does not know any computer mark-up language, information and examples about two widely used mark-up languages can be found on the World Wide Web Consortium Web page: XML [W3C 2003] and HTML [W3C 2004A].

The internal structure of the created XML document has to correspond exactly to the one of the used specification, in order to be machine-readable. The software environment interpreting the manifest to create some content or activity will indeed be unable to correct any grammatical or syntax error. There is therefore a guiding document for each specification, describing the "XML binding", describing correspondence between specification items and XML-file items, to guide people in composing the manifest files.

6.2.2 Software tools

The structure of the manifests is however too complex to be successfully verified by a human being, so a template has to be defined for each specification. These templates are used to validate newly created XML manifests; these machine-readable templates define the allowed hierarchical levels and the allowed items within these levels. This allows the designer to conceive a manifest, which precisely and unambiguously describes the metadata, learning scenario, and other possible attributes corresponding to the used specification(s).

The use of an XML editor together with specification templates is however anything but easy, and fastidious to discourage the most enthusiastic. It is indeed a matter of:

- transcribing each specification item into an XML item using the XML binding ;
- validating the XML manifest against its template ;
- using the XML manifest in a software environment able to interpret it.

Out of these three tasks, the first one is the most fastidious: it presupposes the conversion (by a human mind) of abstract concepts (roles, activities, environments, etc.) into a computer-interpretable language.

This is a recurrent problem in computer science: the use of new concepts indeed supposes that the first users have to suffer the pioneer/guinea pig role until the software industry provides some tools allowing the seamless use of the new concept. Remember the first word processors, where one had to insert manually tags to define boldfaced or italic text: the new word processors take charge of these functionalities seamlessly and automatically, using intuitive graphical user interfaces. Nowadays, few people still use word processors requiring the use of tags, as the recent user interfaces usually avoid the learning of lots of tags and code words by proposing whole sets of easy to use predefined commands.

The state of progress of the eLearning standardization is presently at this point, and software is beginning to emerge. These software allow the creation and possible the conversion of several manifest types. This discussion will restrict to citing a few important software tools types, without trying to be exhaustive; we aim at showing that some software is emerging, and that using them will make the use of standards possible in practice.

6.2.2.1 THREE SOFTWARE TYPES: CONVERTERS, EDITORS AND PLAYERS

A first software type is the converter. What could indeed be more useful that being able to put in an easily exportable standard form (that is what it is all about!) some content, which is available in a proprietary format? Let us cite here for instance the Respondus [Respondus 2004] questionnaire and test converter: this piece of software allows – among other functionalities – to extract questions and tests from various VLEs and to convert them into the IMS QTI (see section 4.3.3.2) format. The use of this kind of tool makes sense when all material has already been created in a proprietary format and when, for migration or sustainability purposes, one desires to extract this material to avoid having to complete a whole creation phase again. Some other tools in this category (such as Q-player for instance) allow for instance the conversion of an XML manifest complying with the IMS QTI norm into a Macromedia Flash automated questionnaire. Macromedia Flash can here be considered a standard *de facto*.

The second type of software is the editor. These allow the simplified creation of learning objects or units, using intuitive user interfaces and input masks. Among these, RELOAD (Re-usable E-Learning Object Authoring & Delivery) [RELOAD 2005] is an editor allowing the easy implementation of metadata (IMS and SCORM) and creation of IMS- or SCORM-compliant Content Packages. In its last version, this software moreover allows the creation of IMS Learning Design-compliant learning units (although level A only, see section 4.3.3) – it is the first IMS LD editor. It also allows exporting Content Packages (without the Learning Design layer) into HTML format (using Javascript), which allows their easy publication on any Website and their visualization using any Web browser. The software can so be considered a Content Package “player”, but it does not allow so far the “playing” of IMS Learning Design.

The third and last type of software tool is the “player”. Such pieces of software allow previewing – or even using – standards-compliant learning objects or units, in order to be able to appreciate their quality without having to load them into a VLE. Excepted Reload, cited earlier in this section, many other programs allow the playback or exportation of various standards. Among these, Q-player allows the integration of IMS QTI-compliant questionnaires into a LMS. However, one of the most impressive improvements consists in the apparition of IMS Learning Design players, among which the CopperCore engine [CopperCore 2005]. The CopperCore engine allows the learning designer to preview and test learning units compliant with the IMS LD standard. On the other side, the RELOAD software [RELOAD 2005] includes in its latest version an IMS LD player – actually a graphical administration interface for the CopperCore engine.

Numerous other software tools are existing – in public domain or commercial versions –, allowing the edition or reproduction of some facet of the various standards exposed in this document. Moreover, more and more software allowing the integration of these standards into applications or LMSs – and so aiming at software developers firstly – are now appearing, but their enumeration is out of the scope of this review.

7. Conclusion

All along this study of standards, one can wonder how they are objectively useful. To answer this, one has to remember that the development of pedagogical resources has a cost. Moreover, as standards become more and more complex, their application to pedagogical resources is costly as well. Indeed, the effort needed to fill in the learning object metadata tied to a resource can be felt tedious by the actors. However, adding metadata is mandatory before adding the resource to a repository, thus making it reusable, and therefore sustainable. Actors must be convinced of the benefit of standardization to apply it.

The choice of a given standard is made according to different needs: indexing a learning object, describing a learning unit, performing a learning activity into a virtual learning environment. Each standard addresses one or more of these needs.

We can point out the fact that as standards become mature, they become unified. The example of the Unified Modeling Language (UML) standard is clear, and e-learning standards follow the same trends. As presented in this paper, these are now separated according to their purpose: metadata, content packaging, scenario description, etc. However, higher-level standards rely on lower-level ones (for instance, the IMS Learning Design standard includes resource aggregation and metadata). There is thus a well-established link between these various standard types, and hence the transition from one to the other level is relatively easy.

Standards help the actors to be aware of communities to which they are belonging. With standards, an actor may anticipate the way the other members of the community will reuse their learning unit. In other words, standards may supply a common ground into communities. The use of standards may so be used as a quality criterion of produced learning resources.

8. Glossary

ADL	Advanced Distributed Learning [http://www.adlnet.org]. The ADL initiative is a technology department effort sponsored by the US Department of Defense. They are seeking to have global access and reuse of learning tools and content through development of industry-supported guidelines and specifications, which is how SCORM was developed.
AICC	Aviation Industry Computer-Based Training (CBT) Committee [http://www.aicc.org]: AICC is an international association which develops guidelines for the aviation industry in the development, delivery, and evaluation of CBT and related training technologies
API	Application Programming Interface – some kind of “service definition” providing software engineers some contact points to use for communication between services or between content and services
Behaviorist	Qualifies a teaching pedagogy, in fashion in the 1950s, based on the reproduction of competencies through the use of repetitive exercises; at higher degree, such pedagogy may possibly be used to modify (social or scientific) behaviors by mimicry
Blended learning	combination of distant learning and face-to-face learning
CBT / CBL	Computer-Based Training / Learning
Constructivist	Qualifies a teaching pedagogy favoring knowledge construction from former knowledge or experience
de facto standard	A specification that hasn't been officially established by an accrediting agency but that is accepted and used as a standard by a majority of practitioners
Didactist	Qualifies a teaching pedagogy during which the learner is explicitly driven into following a reasoning, to bring to him conclusions or new knowledge
Documentary	Qualifies a teaching pedagogy during which knowledge is built through the study of documents
EML	Educational Modeling Language – pedagogical description language
Granularity	the degree of detail into which a thing can be broken up into; the granularity of an object is defined in e-learning by the discrete number of content objects it is made of
GUI	Graphical User Interface (opposed to CLI : Command Line Interface)
HTML	Hypertext Mark-up Language – tagged programming language used to design documents that can be displayed on the WWW
ICT	Information and Communication Technologies
Instructive	Qualifies a teaching pedagogy based on instruction (such as activity sequences or templates).

LD	(IMS) Learning Design
Learning object	a set of reusable information, used as an adjustable “brick” to elaborate e-learning content
Learning unit	a learning object containing some didactic scenario
LMS	Learning Management System (see VLE)
LOM	Learning Object Metadata: IEEE specification allowing attaching metadata to a learning object
Open format	Digital format relying on a public specification: www.openformats.org
Metadata	“data about data”, allowing classifying and searching back objects in a database
QTI	(IMS) Question and Test Interoperability
SCORM	Shareable Content Object Reference Model – a set of specifications used by ADL, allowing the production of reusable learning objects
SMIL	Synchronized Multimedia Integration Language
SS	(IMS) Simple Sequencing
VLE	Virtual Learning Environment – learning software platform
W3C	World Wide Web Consortium [http://www.w3.org], an organization developing specifications allowing the interoperability of software and tools across the Internet.
WWW	World Wide Web = the Internet
XML	eXtensible Mark-up Language – hierarchically-structured tagged language (see also HTML)

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