Conference on ICT for Facilitating
Digital Learning Environments
11th – 13th January 2006
DRTC, Bangalore

Paper: V

Learning Object Metadata and its application

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Abstract

A number of international efforts have been initiated during the past few years leading to the evolvement of various educational metadata specifications for the commonly agreed description of educational resources. Educational metadata can significantly enhance the effective description, search and retrieval of learning objects resulting in efficient organization of educational resources for technology supported instruction. As more and more applications are implemented using educational metadata, it becomes obvious that it would be difficult for a single metadata model to accommodate the functional requirements of all applications. This paper focuses on different existing educational metadata standards with the relative merits of each one, it will also examine the fundamental elements or basic structure of each one of the existing standards, and discuss the interoperability issues. Because of the various E-learning metadata standards that exist, interoperability is a major issue. A major barrier limiting system's interoperability is the use of different specifications that define the structure and content of learning objects.

1. Introduction

Numerous standardization syndicates have been founded during the last few years to develop E-learning or educational metadata standards. Their goal has been to define open technical standards for computer supported learning environments and education products and their characteristic metadata. The pioneering standardization for learning objects was developed by the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) where educational metadata and learning object indexing systems were developed in the mid '90s. The Instructional Management Systems project (IMS) and Advanced Distributed Learning (ADL) initiatives emerged in the US in 1997 in an effort to develop standards for distributed learning technologies.

2. Learning object and their characteristics.

Currently there is no common definition of the term learning object and there is a growing awareness that a common definition may be inappropriate. The objects will ultimately be defined by the requirements of the systems in which they are employed and the roles they are required to play. Some of the learning objects definitions taken from standards organisations; current literature and object repository initiatives are as follows:

1. The IEEE's Learning Technology Standards Committee (LTSC) defines learning objects as 'any entity, digital or non-digital, which can be used, re-used or referenced during technology-supported learning'.
2. Stephen Downes, in his article Fast Buck Artistry (2002) suggests that the difference between a learning object and a textbook chapter is that one is digital and the other is physical.
3. TAFE Frontiers 'Creator to Consumer' digital publishing research project uses the term Dynamic Learning Elements (DLE). DLE would normally be a section of a work and would be the smallest granular component of a learning resource. Its structure and content would be determined by the rules within the training package,

subject or curriculum framework, but it must have ten core ingredients.

2.1 Characteristics of learning objects

According to the research by Higgs et al (2003) essential characteristics of learning objects are as follows:

- **Independent** - learning objects are discrete and coherent chunks of information, activities or assessment, which are self-contained in that they can contain a complete learning sequence, and don't rely on other material in order to make sense.

- **Shareable/ Reusable** - learning objects are small stand alone, reusable components that can be assembled to provide resources in various learning environments, i.e., content developed in one context being transferable to another context. It is this notion of share ability, which is fundamental to leveraging any advantage in using learning objects.

- **Interoperable** - Objects must be interoperable that is: content from multiple sources must work with different learning systems. In order to do this they must be designed to conform to world standards.

- **Instructional value** - In order to be defined as a learning object, there must be some intrinsic instructional value. A learning object is not just a knowledge or information object. It should result in a complete learning sequence, objective, skill or competency.

- **Discoverable** - Objects must be able to be found. This usually entails tagging them with appropriate descriptive metadata that will focus on linguistic semantics.

- **Context** - In order to maximize their reusability, learning objects are required to minimize the amount of information specific to a given

context. However this is often difficult; again we need to accept that some latitude in that learning object can include context-related information either within the object or by some external association to it.

3. Overview of existing learning object metadata schema

Metadata is commonly defined as "data about data". More generally, metadata is information about a resource, either physical or digital. Like a card or record in a library catalogue, metadata describes a resource (e.g., a book, document, video clip, application), but unlike a library record, metadata can either be embedded in the resource it describes, or be located separately from it. Metadata can be generated either manually or automatically, but is most often structured according to semantically understood elements – access points such as author, title and location. The Learning Object Metadata standards focus on the minimal set of attributes needed to allow these Learning Objects to be managed, located, and evaluated. The standards accommodate the ability for locally extending the basic fields and entity types, and the fields can have a status of obligatory (must be present) or optional (maybe absent). Relevant attributes of Learning Objects to be described include type of object, author, owner, terms of distribution, and format. Where applicable, Learning Object Metadata may also include pedagogical attributes such as; teaching or interaction style, grade level, mastery level, and prerequisites. It is possible for any given Learning Object to have more than one set of Learning Object Metadata. However, there is more than one approved standard used to describe the properties of learning objects. Different Learning Object Repositories try to address different needs. Hence, over the last years many educational metadata addressing different needs have emerged and some of the main ones are as follows:

3.1. SCORM

Sharable Content Object Reference Model: It has been developed by an organization called Advanced Distributed Learning (ADL). The SCORM Metadata Application Profile directly references the IEEE Learning Object

Metadata (LOM) standard. The metadata specification defines a very rich data model of approximately 64 metadata elements. It provides specific guidance for applying metadata to learning resources. SCORM is pretty much accepted as the standard for management of educational content. It is a collection of specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content. Although the SCORM standard is developed by the ADL consortium, but the individual components come from a variety of sources. One of the main contributors is the IMS Project. Its major contribution to SCORM is the set of metadata used. SCORM implements the "Learning Object Metadata" specification, which is based on IMS work and specifications developed by the European group ARIADNE.

3.2. IEEE LOM

The **IEEE LOM** (*Institute of Electrical and Electronics Engineers' Learning Object Metadata*) is a profile for learning object metadata. **LOM** is a multi-part standard that specifies Learning Object Metadata. The IEEE 1484.12.1-2002 Learning Object Metadata standard specifies a conceptual data schema that defines the structure of a metadata instance for a learning object. It contains a description of semantics, vocabulary, and extensions. LOM has a wide set of globally agreed metadata elements which are grouped into nine descriptive categories: General, Life cycle, Metametadata, Technical, Educational, Rights, Relation, Annotation, and Classification. The LOM data model is a hierarchy of data elements, including aggregate data elements and simple data elements. The metadata specification in particular is being used or referenced in international repository efforts like MERLOT (merlot.org) and ARIADNE (ariadne.unil.ch), as well as in the U.S. Department of Defense SCORM initiative (*www.adlnet.org*). The LOM standard ambitiously defines approximately 80 separate aspects or "elements" for the description and management of learning resources. These elements include generic informational items such as title, author, description, and keywords, technical aspects such as file size and type, and also include educational and interpretive aspects like "typical learning time" or "educational context". However, the sheer number and variety of

elements in this metadata specification has created widely recognized difficulties for its implementers. Varying implementations of this element set, moreover, threaten to create problems for the effective searching and exchange of metadata records between projects and jurisdictions. The LOM standard has been adopted by many organizations world-wide. It has also been adopted as a component of other standards necessary for sharing and re-use, most notably SCORM and IMS.

3.3. UK Learning Object Metadata Core

The **UK LOM** Core is essentially an application profile of the IEEE 1484.12.1 - 2002 Standard for Learning Object Metadata that has been optimized for use within the context of UK education . The aim of the UK LOM Core is to identify common practice and provide guidelines for metadata implementers, creators and users. In this respect the UK LOM Core has been heavily influenced by the work of CanCore, the Canadian Core Guidelines for the Implementation of Learning Object Metadata. The current UK LOM Core application profile contains an information model only and is not accompanied by a binding.

3.4. ARIADNE Metadata

ARIADNE - Foundation for the European Knowledge Pool. The ARIADNE Educational Metadata Recommendation is derived from work and experiments performed, since 1995, by many European and international institutions. An ARIADNE metadata instance is an XML formatted document. Every element in this document is characterized using a 'type' attribute. 27 data elements of the 43 ARIADNE elements have been mapped directly into their correspondent LOM data. ARIADNE metadata schema is organized into the following categories of descriptors, which are presented in a logical order:

- General information on the resource itself
- Semantics of the resource
- Pedagogical attributes

- Technical characteristics
- Conditions for use
- Meta-metadata

3.5. IMS Global Learning Consortium

In 1997, the IMS Project, part of the non-profit *EDUCOM* consortium (now EDUCAUSE) of US institutions of higher education and their vendor partners, established an effort to develop open, market-based standards for online learning, including specifications for learning content metadata. IMS is a global consortium of members with an interest in providing access to online learning resources. It is involved in the development and promotion of "open specifications for facilitating online distributed learning activities such as locating and using educational content, tracking learner progress, reporting learner performance, and exchanging student records between administrative systems"[1]. IMS produces a suite of specifications, including a metadata specification and a content packaging specification. IMS uses IEEE LTSC LOM as its base. IMS metadata elements can be mapped to the more general Dublin Core elements, as well as to education-specific element sets.

3.6. Dublin Core (DC)

DC is a set of eighteen descriptive elements designed to provide a simple means for describing resources to aid discovery and retrieval. Optionally, qualifiers may be used for a variety of purposes: to refine the semantics of an element or to identify the source of the data content (e.g., the use of the ISO standard for dates. The Dublin Core Metadata Element Set (DCMES) was one of the first metadata standards for digital information to be widely adopted. The Dublin Core Metadata Initiative is an open forum that develops standards for online metadata to describe any type of web resource. DC is the "lowest common denominator", many domain specific standards organizations adopted the Dublin Core set and then added elements to cater for their particular industry information. The working group of the DCMI is involved in the development of education-specific

elements, element qualifiers, and value qualifiers (controlled vocabularies) to be used with the Dublin Core to describe educational materials for the purpose of enhancing resource discovery. **DC-Ed** is yet another metadata specification for learning objects. DC-Ed is a set of extensions to the DCMES—It has 15 DC elements and 5 DC-Ed elements. It even contains three elements from LOM, and is geared towards more general kinds of digital learning resources; DC-Ed can be used for other types of learning resources or for those situations when only basic set of descriptors is needed.

3.7. CanCore Metadata

Canadian Core Learning Resource Metadata Application Profile is based on and fully compatible with the IEEE Learning Object Metadata standard and the IMS Learning Resource Metadata specification. The CanCore Profile is intended to facilitate the interchange of records describing educational resources and the discovery of these resources both in Canada and beyond its borders. CanCore provides simplification and interpretation of the LOM standard to maximize the opportunity for interoperability between projects. In the case of CanCore, these elements have been chosen from only one metadata schema. CanCore has done much more than select elements, it provides a great deal of fine–grained information about each element in the LOM — information that takes the form of recommendations, examples, and references to other interpretations. The CanCore application profile consists of 8 main categories, 15 "placeholder" elements that designate sub-categories, and 36 "active" elements for which data are actively supplied in the process of creating a metadata record. The CanCore profile includes eight of the nine main categories in the LOM standard: General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation and Classification.

3.8. GEM Metadata -The Gateway to Educational Materials

The Gateway to Educational Materials is a large U.S. initiative with the goal of providing Internet access to educational materials. GEM has created a metadata element set based on Dublin Core with the addition of education-specific elements. Although not really seen as a "standard", the GEM

Element Set has been widely used. GEM staff is working closely with Dublin Core Education Working Group.

The major objectives addressed by the GEM project were to:

1. Define a semantically rich metadata profile and domain-specific controlled vocabularies necessary to the description of educational materials on the WWW
2. Develop a concrete syntax and well-specified practices for its application using current HTML specifications design and implement a set of harvesting tools for retrieving the metadata stored as HTML meta tags
3. Encourage the design of a number of prototype interfaces to GEM metadata

GEM uses all the Dublin Core elements. Additional elements could be added to meet the needs of particular domains, and Its elements could be enriched through the use of a broad range of qualifying "schemes" and "types". The GEM element set is an example of both of these extensions. The GEM controlled vocabulary for the Dublin Core Subject element is well developed for curricular materials, providing two levels of classification, one for general academic subject area, and a second for specific topic. Although the full set of GEM elements is designed primarily for curricular materials, it is possible to identify an appropriate subset that can be used to catalogue non-curricular materials. A new controlled vocabulary needs to be designed for each such element. The GEM architecture allows for addition of new controlled vocabularies by means of the Scheme qualifier.

3.9. EdNA Metadata - Education Network Australia

The EdNA Metadata Standard is based on the internationally recognised Dublin Core Metadata Element Set (DCMES) and is consistent with the Australian Government Locator Service (AGLS). The EdNA Metadata Standard comprises a set of guiding principles together with a set of metadata elements, which are situated within the DCMI framework.

Consistent with the extensibility principles of Dublin Core, the EdNA Metadata Standard includes additional elements and element qualifiers, to meet specific requirements applicable to the Australian education domain and to support the operational requirements of EdNA Online. Apart from DC elements, this standard also includes a few EdNA specific categories such as: EDNA.Audience, EDNA.Approver, EDNA.CategoryCode, EDNA.Entered, EDNA.Indexing, EDNA.Review, EDNA.Reviewer, EDNA.Version etc. and these additional categories are primarily for the purposes of administration and maintenance. The EdNA Metadata Standard recognises that specific communities within Australian education and training will further extend and qualify the element set, consistent with the principles of Dublin Core, to meet local needs. Although it is based on the Dublin Core but does not use the Relation, Source, or Contributor elements. The purpose of the EdNA Metadata Standard is to support interoperability across all sectors of education and training in Australia in the area of online resource discovery and management.

4. Metadata storage

The two main formats for metadata are:

- HTML syntax embedded within a web resource.
- XML or RDF syntax in a separate file from the resource.

HTML is a well-established format that people are familiar with and most existing resources are based on this format. The Extensible Mark-up Language (XML) and the Resource Description Framework (RDF), which is encoded in XML are more recent technologies. They have a number of advantages over HTML. Wherever possible, metadata should be created in the XML syntax and stored separately from a resource. Storing metadata in HTML creates a significant maintenance burden should the metadata need converting, whereas metadata stored in XML format could be converted by applying an XSLT style sheet. A common vocabulary or thesaurus is also important to facilitate metadata interoperability.

5. Comparison of Metadata Schema

Since the emergence of the Internet and the World Wide Web, digital technologies have been used widely in education – in distance and classroom education as well as off-line and online training settings. However, these technologies have typically been applied in ad hoc and divergent forms and independent of each other. There is no interoperability in e-learning and metadata standards seek to address these shortcomings by ensuring the interoperability, portability and reusability of this content. However there is a lot of confusion about the implementation as well as the role-played by the metadata standards, how it can be used and applied. This is because, different educational metadata have been developed to take care of different requirements. Most of these metadata have different element sets, attributes etc and to interpret them can be quite a daunting task, especially when we consider that standards like the IEEE LOM have more than 80 elements. As there are no mandatory elements prescribed by the different standards, different implementations can have anything from just two or three elements up to well over a 100.

The recently revamped CanCore initiative, with assistance from the Finnish delegation to ISO SC36, completed a survey of the widely used IEEE standard for Learning Object Metadata (LOM). The findings paint a picture of communities using relatively small parts of the long list of elements that the LOM provides, but they do use their own vocabularies for the elements that are used. What's notable here is that the popular information maps almost straight across to the simpler and very widely used Dublin Core metadata element set. That means that those elements which are the most educational about the LOM, are also amongst the least frequently used. Other findings include the fact that nearly all sets had custom vocabularies in their profiles of the LOM to express characteristics that are mostly relevant to the community from which they came. This is to be expected for a metadata standard, but there were some difficulties in how these vocabularies fitted into the LOM, and how other people can find out what these vocabulary items mean. It isn't always straightforward to deal with LOM metadata record structures in simple tools. IEEE LOM is a complex standard that has been developed specifically for describing learning objects

and capturing pedagogical considerations. It has been developed in alignment with the IMS Global Learning Consortium's Learning Resource Metadata Specification because this is a complex standard, application profiles, such as Canada's CanCore, have been developed to facilitate its implementation. The EdNA metadata set is among the simplest in use for education resources. Subject terms are uncontrolled key words and the vocabulary of users is limited to 'students' and 'teachers'. It is not clear if this set will provide sufficient description for discovery of the full range of resources for the education community. For instance, the Dublin Core element type describes the actual media type, such as ‘text’ or ‘audio’ and is not indicative of the ‘learning’ type such as ‘activity’ or ‘assessment’. EdNA’s curriculum vocabulary defines educational application: ‘lesson plan’, ‘online project’ etc while the IEEE LOM elements provide values for both media format and educational application. Although Dublin Core has not specifically been developed for e-Learning content, it is used in a wide range of education contexts for resource discovery and it has sometimes been augmented with education specific elements. Where and how DC has been modified to increase its relevance for learning content provides a useful perspective for GOL e-Learning metadata implementation. A recent agreement among IMS, Dublin Core, and the IEEE promises "significant harmonization and collaboration...in the areas of educational metadata interoperability and implementation.

6. Learning Object Initiatives

Over the past few years, several different types of digital repositories have been developed for storing learning objects. Several of these have been research prototypes and some have actually had real-world deployments. Global repositories are based on the client-server approach and usually maintain links to learning resources stored elsewhere on the Web. A number of global repositories for learning objects appeared over the past few years, but some are no longer being actively supported. Most learning object repositories are stand-alone and function a lot like portals. They contain a web-based user interface, a search mechanism, and a means of retrieving a learning object.

Some examples of learning object repositories are as follows:

6.1. CAREO (*http://www.careo.org*) is the acronym for the Campus Alberta Repository of Educational Objects. It uses the LOM standard to catalogue learning resources. It is essentially global catalogue for learning objects and does not physically store the learning objects. CAREO lists only about 3800 learning objects.

6.2. GEM (*http://www.thegateway.org/*). The Gateway to Educational Materials is learning object repository housing un-catalogued educational materials. It is supported by a consortium of more than 200 organizations and individuals under the aegis of the US Department of Education and ERIC.

6.3. JA-SIG (*http://www.mis2.udel.edu/ja-sig/*) is the acronym for the Java in Administration Special Interest Group, a collection of interactive online learning materials written in the Java computer language. It was created before the emergence of international specifications in the area of educational metadata.

6.4. MERLOT (http://www.merlot.org**)** is the acronym for the Multimedia Educational Resource for Learning and Online Teaching, which houses a collection of high quality interactive online learning materials**.** most of the resources listed by CAREO and MERLOT are freely available, whereas the Telecampus was on commercial basis.

6.5. TeleCampus Online Course Directory (http://telecampus.edu) **The TeleCampus** this repository uses the LOM standard to catalogue learning resources like CAREO it also does not store the learning objects. Telecampus is no longer actively maintained, but at one time had over 66,000 courses and programs listed (mostly harvested from Web sites).

6.6. Edutella (http://edutella.jxta.org/servlets/ProjectHome) is a peer-to-peer exchange network for metadata. Edutella is based on the well-known GNUtella open source application, and its development is supported by the

Wallenberg Global Learning Network, a partnership of organisations in Sweden and Germany.

6.7. EML (http://eml.ou.nl/introduction/) is the acronym for the Educational Modelling Language, a system for codifying pedagogical experiences created by the Open University of the Netherlands in partnership with CISCO. It defines a document type in XML that allows for the modelling of units of study in terms of roles, relations, interactions, and activities.

6.8. PALO (http://sensei.lsi.uned.es/palo/) is a Spanish initiative similar to EML. It is expressed in XML and has different levels for content, activities, structure, sequencing and management.

6.9. iLumina is a repository for undergraduate teaching resources specifically for the areas of science and mathematics. It is similar to MERLOT in that the objects are not centrally stored but rather are accessed via an external link. All the objects are catalogued via IMS compatible metadata.

6.10. The Le@rning Federation distributes learning objects through a central Exchange to individual schools that will then be responsible for their own storage and distribution. The Le@rning Federation's Metadata Application Profile is based on and extends the information model used by the IEEE learning object metadata standard and both the objects and the metadata are stored within the repository.

7. Future directions

In order to accomplish the task of cataloguing and providing access to present and future Web resources it is critical that metadata should be both simple to create and simple to use. The process of creating controlled standard vocabularies for the description of learning objects is an ongoing process. The IEEE LOM specification was approved as a standard in June 2002; however, work still continues focusing on implementation, collaboration with other standards and maintenance and evolution. The EdNA Metadata standard has been established for some time and

successfully implemented but it is currently undergoing a review. Consideration needs to be given to mapping issues between schemas and vocabularies. Current standards have developed to an encouraging level of stability but much of the work done has focused on syntactic and systems-level interoperability and less emphasis has been paid to semantic interoperability (Friesen et al report) Recognizing the limitations of the current e-learning standards, research projects are underway to develop sophisticated mechanisms to promote the reuse of learning objects. Much of this research involves applying principles from Artificial Intelligence and the Semantic Web (Berners-Lee, Hendler, & Lassila, 2001). For example, a major research project is being undertaken by a consortium of six universities in Canada, known as the Network of Learning Objects Repositories (LORNET, 2004). One sub-project within LORNET is the investigation of intelligent techniques for representing a learning object on the Semantic Web. A metadata record format that facilitates web searches for educational materials and cataloguing of such materials by non-specialists can be created from existing technologies and categories of classification. The Dublin Core allows for creation of a manageable set of appropriate classification elements, which can be expanded as necessary by appropriate qualifiers. Established authority lists such as the ERIC thesaurus, which is actively maintained to reflect developing educational usage, provide a valuable source of terminology for controlled vocabularies. But the lack of consistency in selection of vocabularies as values of specific elements poses a substantial problem for metadata creators and searchers.

8. Conclusion

All of the above mentioned specifications are focused on creating an interoperable framework for the organization, management, and transport of educational content. Their goal is to limit the amount of time required to find, assess, and re-purpose existing content, allowing resources to be focused on pedagogical, rather than technical issues.

Standard ways of describing educational materials are needed so that they can be easily searched for and located. Achieving interoperability standards

for learning technology can have such a profound effect in terms of resource discovery of learning objects.

No single metadata element set will accommodate the functional requirements of all organizations or communities of practice. At the same time – whether in the areas of semantic, syntactic or other forms of interoperability (Miller, 2000)-- these metadata standards also present the opportunity for the collaborative development of solutions, and their sharing and reuse across implementations. The underlying problem seems to be that it is simply impractical, if not impossible, to index all objects under all possible and appropriate indexing terms. Thus it appears that better metadata alone cannot be the solution to the dilemma. Let us hope that these and other approaches will provide the basis of a set of approaches and tools to help developers of learning objects support all of their potential educational users' access to their raw assets, as effectively as possible.

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