Learning objects application profile for granularity and reusability: Integrating Dublin Core with IEEE-LOM

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Abstract

A repository of learning objects (LOs) is being built to investigate the usability aspects of LOs, as part of a doctoral dissertation project. Enhanced description of LOs is considered an important step in this effort. Among other things, use of metadata and taxonomies are being explored for enhancing the description, so as to promote use and reuse of LOs. Our initial review indicated that the various metadata schemes currently in use do not adequately support description of two special features of LOs, i.e., granularity and reusability. However, features from different schemes can be combined to develop a profile that can effectively support the peculiarities of LOs. Leveraging on the flexibility in the design of Dublin Core and its provisions of refinement and extension of elements, we decided to extend certain DCMI-EMS (Dublin Core Metadata Initiative Education Metadata Set) elements by integrating some elements from IEEE-LOM (Institute of Electrical and Electronics Engineers–Learning Object Metadata) (IEEE, 2002), so as to meet the requirements of LOs. This paper describes the elements from the two schemes and discusses the issues that need to be addressed to make this work. We also suggest the addition of new metadata fields that describe granularity and reusability. We hope that this example may be useful for developing an application profile to describe learning objects in various repositories.

Keywords: domain metadata (education); interoperability; learning object granularity; learning object reusability.

1. Introduction

As part of a doctoral research project, this study aims to explore how current metadata standards can be used to tag learning objects (LOs). The main objective is to develop an application profile of metadata that will better describe the LOs and so enhance their reusability. Given the special nature of LOs, the following factors are considered important:

1. A clear conceptualization of learning objects. In this study, LOs are conceptualized as digital objects which are used to effect "a particular knowledge discovery". That particular knowledge discovery is termed the *learning point* (Abdul Karim, 2005). This is a basic criterion for any digital object to qualify as a learning object.
2. An important characteristic of the LO is that atomic LOs can be combined to form more complex LOs.
3. There is a need to measure the reusability of LOs not only in terms of frequency of use, but also in terms of variation of purposes and number of users.
4. While any new proposed application profile for LOs will cater to a specific need, it should also be in keeping with emerging and prevailing metadata standards, especially those related to educational resources.

Established standards in metadata development of educational and non-educational electronic resources include those of the Dublin Core Metadata Initiative (DCMI, 2006), the IEEE-LOM (Institute of Electrical and Electronics Engineers – Learning Object Metadata) (IEEE, 2002), SCORM – Sharable Courseware Object Reference Model (Advanced Distributed Learning Initiative, 2004), as well as GEM – Gateway to Educational Materials (n.d.). This project aims to take into consideration and adhere to, as far as possible, these standards.

DCMI is an obvious starting point due to the manageability of the 15 core elements as a foundation for the formulation of an application profile. In particular, the Dublin Core Metadata Initiative Education Metadata Set (DCMI-EMS) can be used as a base for our project. While DCMI-EMS has an extended set to describe educational resources, it does not have terms specific to learning objects. Nevertheless, as evidenced by the different DCMI communities, Dublin Core's design philosophy provides for refinement of its elements. We thus decided to extend certain elements by using its extension scheme. This enabled us to use Dublin Core as a base for our metadata scheme. This paper discusses some analysis done to enhance this base to better account for granularity and reusability.

Another standard we considered was the IEEE-LOM standard. With a base schema of more than 70 metadata fields, IEEE-LOM is arguably the most extensive metadata set specifically designed for LOs. By integrating elements from both DCMI-EMS and IEEE-LOM, we hope to take advantage of the simplicity of Dublin Core and the comprehensibility of IEEE-LOM.

It is clear that the focus of DCMI-EMS is not LOs *per se* but the development of an application profile "relevant to education including value spaces and best practices within the context of education and training" (http://dublincore.org/groups/education/index.shtml). DCMI-EMS has a wider scope than LOs, which are centered on content. On the other hand, IEEE-LOM is focused on building metadata standards specifically for LOs. The need for some kind of integration and collaboration is not lost on the two different standards initiatives. The integration of DCMI-EMS and IEEE-LOM is an ongoing process which has been kick-started by the Memorandum of Understanding between DCMI and the IEEE Learning Technology Standards Committee P1484 (IEEE LTSC) [2]. They have expressed a joint commitment to collaborate on the development of interoperable metadata for learning, education and training. As a result, a Joint DCMI/IEEE LTSC Task force is already at work to bridge the two standards[3]. Such collaboration with a view to some kind of integration is welcome. Our project should be seen in the context of such integration.

Our working definition for LOs is any object used to make a learning point. A learning point is in turn defined as an identifiable instance of knowledge discovery on the part of the learner AND/OR a specific knowledge discovery that a teacher wants to facilitate in the mind of the student (Abdul Karim, 2005). This means that an object (digital or otherwise) needs to be associated or tagged with a learning point for it to qualify as an LO, i.e., treat the learning point as a metadata element to be tagged onto a digital object.

2. Metadata Fields of DCMI-EMS and IEEE-LOM

DCMI-EMS is based on the 15 core elements of the original Dublin Core metadata set. After the Education Working Group's (DC-Education Community) face-to-face meeting in Australia in 1999 and subsequent developments, the metadata elements *conformsTo* and *audience* were approved and entered into the general DCMI terms namespace (DCMI, 2006).

Other metadata fields include the DC-Ed extensions approved and added to the general DCMI namespace and three from the IEEE-LOM metadata schema. The DC-Ed extensions which are

[2] A copy of the memorandum of understanding is available at http://www.ischool.washington.edu/sasutton/dc-ed/DCMI-IEEE-MOU.rtf

[3] See http://dublincore.org/educationwiki/DCMIIEEELTSCTaskforce

already entered into the DCMI namespace are *Audience* and *Audience.Mediator*. Table 1 lists the adapted metadata schema for DCMI-EMS[4].

TABLE 1. Selected elements from DCMI Education Metadata Set (DCMI-EMS).

Element Name	RDF Property	Element Definition
Title	dc:title	A name given to the resource
Contributor	dc:contributor	An entity responsible for making contributions to the content of the resource
Creator	dc:creator	An entity primarily responsible for making the content of the resource. Datatype
Publisher	dc:publisher	An entity responsible for making the resource available
Subject	dc:subject	The topic of the content of the resource
Description	dc:description	The topic of the content of the resource
Date	dc:date	A date associated with an event in the life cycle of the resource
Type	dc:type	The nature or genre of the content of the resource
Format	dc:format	The physical or digital manifestation of the resource
Identifier	dc:identifier	An unambiguous reference to the resource within a given context
Language	dc:language	A language of the intellectual content of the resource
Relation	dc:relation	A related resource
Source	dc:source	A Reference to a resource from which the present resource is derived
Coverage	dc:coverage	The extent or scope of the content of the resource
Rights	dc:rights	Information about rights held in and over the resource
Audience	dcterms:audience	A category of user for whom the resource is intended
Audience.Mediator	dcterms:mediator (subproperty of dcterms:audience)	An entity that mediates access to the resource
Education Level	dcterms:educationLevel (subproperty of dcterms:audience)	A general statement describing the education or training context. Alternatively, a more specific statement of the location of the audience in terms of its progression through an education or training context

Also proposed at the 1999 Australian meeting was the inclusion of the IEEE-LOM metadata fields pertaining to interactivity and time taken to use the LO to learn. However, the efforts at reconciling XML declared elements with their proposed RDF counterparts vis-à-vis DCMI and IEEE-LOM have not received the final approval of the Usage Board of DC. The integration and unification of the underlying data models have not yet allowed DCMI to accept the IEEE-LOM fields. This will involve deeper conceptual clarification and further resolution of technical requirements, requiring more time and effort. However, we regard the interactivity and learning-time fields as important, based on the recommendations on IEEE-LOM by the Alexandria Digital Earth Prototype (*ADEPT*, 2001), that they should form part of the mandatory IEEE-LOM fields. Besides, these elements are not in DCMI. We have thus included the following fields based,

[4] Adapted from http://www.schemas-forum.org/registry/schemas/DCMI-Education/index.html

firstly, on the proposal made by the DCMI-Education Working Group and already accepted by IEEE-LOM, as well as on the fact that these fields will complement the existing set of metadata fields in Table 1. The additional metadata fields that we suggest using are listed in Table 2.

TABLE 2. The IEEE-LOM Interactivity and Learning Time Metadata Set.

Element Name	RDF Property	Element Definition
InteractivityType	ieee-lom:interactivityType	The flow of interaction between this resource and the intended user
InteractivityLevel	ieee-lom:interactivityLevel	The degree of interactivity between the end user and this resource.
TypicalLearningTime	ieee-lom:typicalLearningTime	Approximate or typical time it takes to work with this resource.

2.1. Discussion on Granularity

None of the metadata fields in Table 1 or Table 2 pertains directly to granularity or reusability. While IEEE-LOM does stipulate *Aggregate level* as a metadata field, the description for this field ("The functional granularity of the learning object") is ambiguous. This explains the explicit relationship IEEE-LOM defines between *Aggregate levels* and the metadata called *Structure*. Note 2 of IEEE-LOM (IEEE 1484.12.1-2002) states, "A learning object with AggregationLevel = 1 will typically have 1.7:General.Structure='atomic'. A learning object with AggregationLevel=2, 3 or 4 will typically have 1.7:General.Structure= 'collection', 'linear', 'hierarchical' or 'networked.'" While the relationship between *Structure* and *Aggregate level* is given in detail, neither is related to *Semantic Density*, which may also suggest granularity – the more semantically dense an LO, the more complex it would presumably be. Clearly, there is a need to provide a metadata description that more precisely captures granularity in terms of complexity - which is missing from the IEEE-LOM metadata base schema as well as from DCMI-EMS.

Confusion surrounding granularity as an important attribute of LOs is apparent in the literature. Thorpe, Kubiak and Thorpe (2003) relate granularity to understandability or learnability. Such a concept of granularity may be related to IEEE-LOM's *Semantic Density*, as discussed above. Duncan (2003) describes "granularization" as a "clumsy word" that "refers to the size of learning objects". Following Duncan (2003), Downes (2004) suggests that the problem of granularity poses the question, "What size will the materials be?" It is interesting to note that IEEE-LOM has already stipulated *size* as a metadata field which refers to the size of LOs in bytes. Barritt (2001), however, maintains that the size and shape of "an object" is open to each organization to define. This decision is based upon the needs, tools, processes, and business goals of the organization, and thus may seem arbitrary. Moreover, *size* hardly captures the idea that refers to the attribute of LOs being versatile components that not only stand alone but can also be used to complement other LOs to create or assemble, as it were, ever more complex LOs. Instead of *size*, granularity suggests that LOs admit of complexity (Abdul Karim, 2005). This is consistent with the idea of modular content hierarchy mentioned by Duval and Hodgins (2003). To understand granularity as a function of complexity, we cite Abdul Karim (2005) and render LOs conceptually as:

(Digital) Object + Learning Point = Learning Object

The above conceptualization makes clear what the simplest LO is, because disassembling, dividing or breaking it up any further would render it no longer an LO. Take away the learning point and we are left with an object *per se*. Starting from the simplest (i.e. atomic) LO consisting of one object (digital or otherwise) and one learning point, we can build ever more complex LOs, made up of any number of combinations of LOs and learning points. Different objects and different learning points can be combined to form ever more complex LOs. While complexity depends on the unit of analysis which in turn depends on the domain of the LOs, such a

conception of complexity when applied to LOs will explain the concept of granularity as discussed above. More importantly, granularity here is not seen in terms of size and shape of an object, which can be arbitrary, but in terms of more conceptual complexity, e.g., whether a single object can be used to make many learning points, whether these learning points belong to different domains, whether several objects combined are required to make a single learning point, and so on. In Section 3.2, we propose a definition of *granularity* as a metadata field that describes precisely which level of granularity a particular LO is at.

3. Some Proposals

3.1. IEEE-LOM's Educational Metadata

Using DCMI-EMS as the base for our project, we propose the addition of the four ADEPT-recommended mandatory fields of the Education category of IEEE-LOM (Table 3). We realize that some users may find the fields irrelevant, given the specific needs of organizations, but these fields will ensure greater interoperability with the LOM standard. We note that DMCI-EMS has already proposed including two of them (the *Interactivity Type* and *Interactivity Level* metadata fields). The *Resource Type* field can be mapped to the DMCI-EMS' *Type* element (Table 1). The fourth field (*Learning Context*) does not refer to the subject matter of the domain within which the LO operates. Rather, as IEEE-LOM explains, it refers to the "typical educational level", which maps fairly closely to *educationLevel* of DCMI-EMS (Table 1). Nevertheless, in both metadata sets, *Learning Context* does not describe the LO in terms of specifying accurately *what is being learnt/taught?* using this LO. We deem this a significant omission, and aim to propose a metadata element that will capture such an important description based on the idea of the learning point.

In addition to the above four fields, we further propose the inclusion of the *Typical Learning Time* field, which has also been proposed by the DC-Education Community but has been stipulated as optional by ADEPT.

TABLE 3. ADEPT-recommended mandatory educational fields of IEEE-LOM.

Educational Label		**This category describes the key educational or pedagogical characteristics of a learning object. This pedagogical information is essential to those involved in achieving a quality learning experience. The audience for this metadata includes teachers, managers, authors, and learners.**
Interactivity Type	interactType	The flow of interactivity between this learning object and the intended user.
Resource Type	learnResType	Specific kind of learning object; most dominant kind first
Interactivity Level	interLevel	The degree of interactivity between the end user and the learning object
Learning Context	learnerLevel	Typical educational level expected for the resource

3.2. Defining Granularity

A distinctive feature of LOs as opposed to other types of digital resources is their capacity to be combined into more complex LOs of different levels of complexity. We propose a granularity metadata field as stipulated in Table 4. We use the prefix *ntuscilom* to signify the element name. The *Granularity* element as specified above answers the question: "At what granularity level is this LO?" The variable description gives us some idea as to how we can frame the answer. We do not place a limit on the level, as it should theoretically be able to accommodate complexity to as high a level as required.

TABLE 4. Proposed *Granularity* metadata field.

Element Label	Element Name (RDF Property)	Variable description	Remarks
Granularity	ntuscilom:granularity	Digital Object= Level 0 Atomic LO = Level 1 Aggregated LO = Level 2… Level n	Reference to Aggregate Levels; LOM 1.8

3.3. Reusability and the Learning Point

Two key characteristics in the LO model are what it is used for and its reusability. In fact, use and reuse are so central to LOs that reusability is regarded as a defining attribute. Wiley (2002) for instance defines a learning object as "any digital resource that can be reused to support learning." Reflecting on the importance of reusability, Plodzien, Stemposz and Stasiecka (2006) propose extending the SCORM standard to include a *reusability* element which they describe as dealing with the "reuse potential of a resource". Within this *reusability* element, they propose *user* as a child element which "represents the person/institutions that have used or are using the resource". We have taken this into consideration in our proposal, but have chosen to label our metadata as *usedby*, in order to be more specific regarding reusability. Furthermore, considering the developments in LO design and creation, we find the need to distinguish between actual use and potential use of LOs. Suggesting best practices for LO Repositories, Nash (2005) suggests classifying LOs by "suggested use" because "it can be difficult to determine how to use them". The LO repository administrator may suggest that a digital object be used to effect a particular learning point, thereby adding it into an LO repository, or newly designed LOs may be created for a specific learning point. But in both instances, the LOs may have yet to be used. For this reason, we propose *usedfor* as a parent metadata for the two child elements: *usedforactual*. and *usedforpotential*. We also find the need to relate reusability with granularity, and thus suggest *usedin* to link atomic LOs with aggregated ones. Our proposed metadata tags for reusability and the explanations for each tag are given in Table 5.

TABLE 5. Proposed *Reusability* metadata field.

Element Label: LO Reusability	Element Name (RDF Property)	Description	Remarks
Used In	ntuscilom:usedin	Shows the Title of the Aggregated LO(s) in which this LO has been used.	An open ended field to allow record of its use in several other more complex LOs. An alternative name for "Used In" may be "Disaggregated from" or "Aggregated in".
Used For	ntuscilom:usedforactual	This LO is used to teach "x", whereby x is the learning point.	Describes what exactly is being taught by using this LO, e.g. "used to teach Nonaka's SECI model". An alternative name for "Used For" is Learning Point. Learning points can be further classified under their respective domains/subject headings.
	ntuscilom:usedforpotential	This LO *can be used* to teach "x", whereby x is the learning point	This field describes what potentially can be taught by using this LO.
Used By	ntuscilom:usedby	Identity of person/institution using the LO	This can be the name of a person or a grouping, e.g. a department of an organization or the organization itself.

4. Future Work

The additions suggested in this report are still work in progress and require further refinements. We plan to examine the SCORM standard as well as developments in GEM, to see if some of the elements in these standards can be appropriated for our use. We are also developing a taxonomy of LOs in the domain of knowledge management, which we will use to organize LOs alongside the metadata elements. When these aspects have been further developed, we hope our example will contribute towards developing an application profile that better describes learning objects in terms of granularity and reusability.

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