A two LOM Aplication Profiles: for Learning Objects and for Information Objetcs

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Abstract. Learning Objects are the central concept of the current paradigm of E-Learning, but curiously, there is still a widespread confusion about how much to include, how big should be, or what is the "correct" granularity for a Learning Object. Because of this, different works use the same term to different things. This paper attempts to differentiate the concepts of Learning Objects and Information Objects, and analyze the potential for achieving adaptivity in the two levels. Particularly, studying the design of two LOM application profiles for exploit the specifics of each level of granularity.

Keywords: Learning Objects (LOs), Information Objects (IOs), Learning Object Metadata (LOM).

1 Introduction

Learning Objects (hereafter LOs) are the central concept of the current paradigm of E-Learning. They were conceived as building blocks, which we can build a lesson, a unit, or a course. LOs are for the E-Learning what the objects are for the Object-Oriented Programming paradigm. They allow benefits in terms of reuse, economy and distributed development; because it is possible the widespread use of LO repositories, and the automation of the search, selection and use of LOs.

A traditionally metaphor for LOs was the LEGO blocks[1] [1]. As Wiley notes, the main problem with this metaphor is that any piece can be combined with any other in almost any way. This generates a LEGO-type thinking, which can conduce to the idea of "open a box of learning objects and have fun assembling them". In [2] Wiley proposes to differentiate between several types of LOs, some of these composed of other LOs. However, all objects are called LOs, whatever their granularity.

In [3] CISCO Systems presents its Learning Object Strategy, with a hierarchy of objects, locating the LOs (in CISCO's terminology RLOs, meaning Reusable Learning Objects) into the hierarchy, following the Learnativity's content ecosystem (see Figure 1). In this work, the term RLO is an object with a specific level of granularity.

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[1] Coined by Wayne Hodgins while watching their children play, in 1990

This kind of disagreement in terminology (different works using the same term to different things) has caused much confusion in the literature. However, there is consensus among most authors in consider a LO should be centered in an objective.

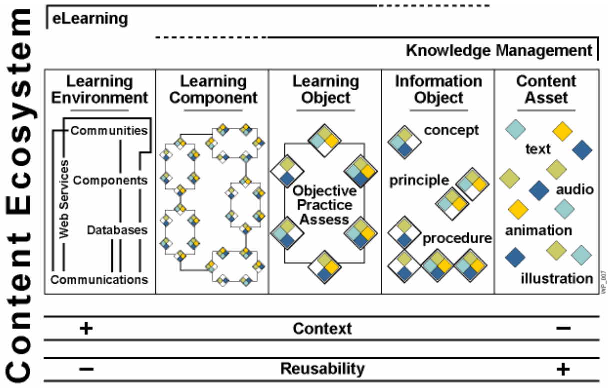

Fig. 1. A 2003 image of the Learnativity's content ecosystem of Wayne Hodgins, from [3]

In those days, the adaptivity goal appears on the scene, causing a movement of attention toward more fine-grained objects. As far as I know, the only approach is to reduce the granularity of LOs, and in the worst case, this may cause LOs to lose their objective.

In respect to education, there are two important trends in E-Learning: one focused in pedagogy (e.g. instructional design, educational modeling) and one focused in adaptivity; and not many works emphasize the two trends. Adaptivity relies on reusability, and in the LO context, the statement "smaller is better" apply. But for the instructional design defenders it is clear that a LO should not be so small, in order to perform its pedagogical function.

One solution might be to begin to differentiate between LOs and IOs in the practice. This might be supported by the use of some specific metadata to each kind of object.

The most widespread metadata standard to describe educational content is LOM [4]. Some authors, like [7, 8], have already extended LOM, but have made only one extension to fit the needs of their LOs.

The aim of this paper is to suggest the convenience of differentiate the concepts of LOs and IOs in the practice, and hence, have different metadata formats to describe them. This is a new alternative way to explore.

The next section provides background on the most widespread metadata standards for educational content, as well as a vision (rather subjective) of current and future trends. Section 3 explains how adaptivity relies on reuse, and finally, on metadata. Section 4 summarizes the most related works. Section 5 introduces the two LOM applications profiles, one for LOs and another for IOs. Finally, Section 6 presents some conclusions and future work.

2 A few words about standards

To achieve the benefits of a LO strategy, standards must exist. The two most outstanding standards are LOM [4] and SCORM [5].

LOM (an IEEE LTSC standard basically unchanged from 2002) means Learning Object Metadata. It is a conceptual schema that let to describe educational content (but not only LOs) through an element hierarchy grouped in nine categories. An element can be simple or compounded, and the simple elements has a data type and a domain, typically a predefined vocabulary or a reference to another standard. There has been many criticisms of the generality of LOM [6, 7]; the IEEE recognizes LOM is generic, and describe the way to extend it, through application profiles. It's interesting to see LOM as an uncoupled standard, in the sense that each object has its own metadata, and that it is all that sets the standard. A few projects [8] have developed their own uncoupled platforms based on repositories of objects described by LOM, in most cases extending LOM through their own application profile. The roadmap of LOM evolution (as suggested by Erik Duval to the LTSC-LOM list in 26 June 2009) includes finishing the corrigenda process in order to resolve a small number of minor inconsistencies, then work in the DCAM and RDF binding, and finally "discuss what other items people want to work on".

SCORM (an ADL standard in constant development since 2001) means Shareable Content Object Reference Model. It was born to take the best from the early efforts, specifications and standards. SCORM integrates several existing standards, including LOM for descriptive metadata. In SCORM's terminology, a LO is a Shareable Content Object (SCO). In October 2001, SCORM 1.2 was the first real release of the standard. SCORM 2004 was a significantly improvement of the standard: eliminating ambiguities, making SCORM conformant with IEEE standards (including LOM), supporting ECMAScript (JavaScript), and adding optional features for sequencing and navigation. SCORM is not only about the metadata of the objects, but also about the packaging, sequencing and communication with the LMS. Nowadays, while ADL [9] will continue to develop SCORM 2004, LETSI [10] is working in a SCORM successor, called SCORM 2.0, because today's requirements go beyond the SCORM's original design scope. SCORM 2.0 has a modular architecture and goes in the direction of actual trends, like Web Services.

It is still unclear, but we can expect the imminent RDF binding of LOM together with SCORM 2.0 may contribute to a Semantic Web Services approach, to allow the exploit of common semantic and the delivery of learning "as a service". The future is promising, but the technology will not solve the conceptual issues.

3 Why to use LOM Metadata?

The use of standard metadata as LOM, provides a consensus vocabulary in order to made explicit some intrinsic concepts. The usefulness of this approach is that LOM is an excellent model to illustrate LOM's properties.

A simple adaptivity feature can choose to use a high quality or a low quality image, depending on the bandwidth. A more complex adaptivity feature can choose between first present the basic definitions or the key concepts, based in the learner's cognitive style. In any case, the adaptive features rely, at the end, on metadata. There should be metadata that describe the size of the images, and the instructional type of the objects. The richer the metadata, the greater the opportunities to achieve adaptivity. Noting the content ecosystem, we see that adaptivity could be achieved at several levels of hierarchy. For example, to choose between images of high or low resolution, we need metadata in the level of content assets. According to cognitive style, we could organize the IOs within a LO, in order to have first a definition or an example, and we need the instructional type of the IOs. According to the skills needed and the time available for the student, we could offer a sequential or a discover approach through LOs, and in the first case we need the suggested flow.

Adaptivity can be achieved by the use of LOM (or a LOM application profile) and algorithms that exploit these metadata. In the Activemath project [6, 8], a LOM application profile was used, with advanced Artificial Intelligence techniques to select and order the LOs.

The SCORM 2004 adopters have to face the fact that SCO is the minimum unit of interaction, but can achieve personalization introducing show-nothing SCOs [11], which allow executing instructional algorithms that decide what will be the next SCO. SCORM 2.0 changes direction and propose a modular approach that includes the consideration of specialized orchestration services.

4 Related work

In 1999 and 2000, Wiley [1, 2] argues that the LEGO metaphor generates a "LEGO-type thinking", in which the blocks can be assembled in any manner, and by anyone. Because of this way of thinking, some people generate educational content combining blocks without care about the absence of an instructional theory. The atoms metaphor is presented, and it is obvious that the atoms need to be assembled in certain structures prescribed by their own internal structure, and the assembler should have some training. Beyond the metaphors, the criticism is about treating LOs like components of a knowledge management system and the author suggest the term Information Object would be appropriate in this case. Also, he presents a taxonomy that differentiates between five types of LOs. The Wiley's work is an early proposal of differentiate types of LOs, with one designed to support instructional strategies.

In 2003, a CISCO Systems whitepaper [3] identify Reusable Learning Objects (RLOs) and Reusable Information Objects (RIOs) in its strategy , depicted in see Figure 2). An RLO consist of an overview, a set of RIOs, a summary, a practice. The CISCO's view, maps the terms "lesson" for a RLO and "topic" for a RIO (however, in the RLO's definition it says that many RLOs can be combined to form a lesson). A RIO is classified based on their instructional purpose: concept, fact, process, principle or procedure.

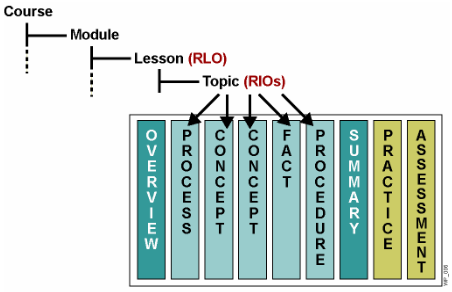

Fig. 2. The hierarchy of CISCO's Learning Object Strategy, from [3]

In 2006, Roberts and Blackmon [11], tell the story of evolution of the grain size of SCOs in SCORM adopters. In the beginning, some course designers had one SCO per course. So, the SCORM adoption only assured the inter-LMS interoperability. The goal of reuse, led the grain size move from the course level to the learning objective level. The equation SCO = LO has been usual, but nowadays, the authors says that the goal of adaptivity can be reached with even more fine-grained SCOs and SCORM sequencing rules. What is clear is that the SCO's shrink cause the loss of context, and the need of more relationships. Hopefully, seems to be the trend support the shrinking of the SCOs: one of the enhancements of the SCORM's 4th edition is the possibility to share additional objective data and learner tracking information between SCOs. The equation SCO = IO may be the usual in the future.

In the "old-days", accordingly to the Wayne Hodgins content ecosystem, the fine-grained objects appear more related to Knowledge Management than to E-Learning. But in 2006, Wayne Hodgins says in an interview [12] that there is a meta-trend of "getting small", applied to E-Learning standards. The standards are "taken down to the smallest possible unit size and made to be interoperable", and he also warns us to "be prepared to see this trend continue every downward on the smallness scale as today's standards are themselves broken down into smaller individual components".

5 A two LOM application profile

For this work, the hierarchy presented in the content ecosystem of Wayne Hodgins is adopted (see Figure 1). A Content Asset is basically a file. An Information Object is a set of one or more Content Assets that can be identified with an instructional type (e.g. definition, motivational example). A Learning Object is a set of one or more Information Objects which is focused on an atomic objective (e.g. "know the concept of entity", "motivate about the need of attributes in relations"). A combination of Learning Objects, where each has its own objective, is a Learning Component, although the Learning Component may have an objective of higher granularity (e.g. "mastering the relational model"). Finally, the Learning Environment includes not only the objects but also people and technology.

The adaptivity goal causes a movement of attention toward more fine-grained objects. Instead of simply focus our attention in the selected level of granularity, calling LOs to these objects, we can distinguish between LOs and IOs. Adaptivity can take place (at least) at the LO level and at the IO level. We advocate the convenience of particularly differentiate LOs and IOs, because these two intermediate levels of granularity allows the best possibilities for reuse.

Beyond the granularity issue, there are other conflicts between pedagogy and adaptivity. An instructional design imposes some structure for LOs, and the freedom degree of an adaptivity algorithm should not allow break these structure. There is an apparent dichotomy between instructional design demanding structure and adaptivity demanding freedom.

We argue this dichotomy can be reconciled: depending on a student's cognitive style, the system may choose a LO with the appropriate instructional design for the cognitive style. In this way we achieve adaptivity in terms of cognitive style and LOs with an appropriate instructional design.

We consider the following kinds of reuse for this work:

- **Redeploy**: reuse content "as is", like redeploy a SCORM course in a LMS, or reuse an entire Learning Component
- **Rearrange**: reorder LOs within a Learning Component, like choose to see first a LO to "motivate about attributes in relations" or directly see a LO to "know about attributes in relations". Here, we need metadata in LOs.
- **Rewrite:** borrow assets from IOs to create new IOs, like changing an image format based on the browser's support, or the image quality based on the session bandwidth.

LOM is not enough to describe rich metadata, and we want different metadata at each level. Because of this, We propose a LOM application profile for Learning Objects (LOM-LO) and a LOM application profile for Information Objects (LOM-IO).

The application profiles add new elements to capture metadata not considered in LOM, define some elements as Required (R) or Forbidden (F) to ensure minimal descriptions and prohibit descriptions that do not apply, define constant values for some required elements, and create (or extend) some vocabularies.

The following tables describe the conceptual schema of the LOM-LO and LOM-IO application profiles.

Table 1. The General category.

Element	LOM-LO	LOM-IO
1. General	R	R
1.1. Identifier	R	R
1.1.1. Catalog	R	R
1.1.2. Entry	R	R
1.2. Title	R	R
1.3. Language	R, "es-UY"	R, "es-UY"

	1.4. Description		
	1.5. Keyword		
	1.6. Coverage		
	1.7. Structure	F	F
	1.8. Aggregation Level	F	F
new	1.9. Object Type	R, “Learning Object”	R, “Information Object”

In the *General* category, we can highlight the prohibition of the *Aggregation Level* element, and the inclusion of a new element *Object Type* to differentiate between LOs and IOs. This is an improvement in terms of shared semantic, and can be used as a first point of access. Another important point is that we can not see the *Structure* as a *General* attribute, but an *Educational* attribute (see *Instructional Theory* on Table 5).

Table 2. The Life Cycle category.

Element	LOM-LO	LOM-IO
2. Life Cycle	R	R
2.1. Version	R	R
2.2. Status	R	R
2.3. Contribute	R (author)	R (author)
2.3.1. Role	R (author), “author”	R (author), “author”
2.3.2. Entity	R (author)	R (author)
2.3.3. Date	R (author)	R (author)

In the *Life Cycle* category, *Version*, *Status* and at least one *Contribute* element with the role author are required. Here there is no difference between LOs and IOs.

Table 3. The Meta-Metadata category.

Element	LOM-LO	LOM-IO
3. Meta-Metadata	R	R
3.1. Identifier		
3.1.1. Catalog		
3.1.2. Entry		
3.2. Contribute	R (creator)	R (creator)
3.2.1. Role	R (creator), “creator”	R (creator), “creator”
3.2.2. Entity	R (creator)	R (creator)
3.2.3. Date	R (creator)	R (creator)
3.3. Metadata Schema	R, “LOM-LO”	R, “LOM-IO”
3.4. Language	R, “es-UY”	R, “es-UY”

In the *Meta-Metadata* category, at least one *Contribute* element with the role creator, *Metadata Schema* and *Language* are required. While the classification of the object can be made through the *Object Type* element of the *General* category, the *Metadata Schema* can be useful to identify the specific application profile being used.

Table 4. The Technical category.

Element	LOM-LO	LOM-IO
4. Technical	R	R
4.1. Format		R
4.2. Size		R
4.3. Location		
4.4. Requirement		
4.4.1. OrComposite		
4.4.1.1. Type		
4.4.1.2. Name		
4.4.1.3. Minimum Version		
4.4.1.4. Maximum Version		
4.5. Installation Remarks		
4.6. Other Platform Requirements		
4.7. Duration		

The only distinction between LOs and IOs in this category is the requirement of the *Format* element for IOs. One LO can be materialized and have a format or may consist only of metadata (like a view over the IOs).

Table 5. The Educational category.

	Element	LOM-LO	LOM-IO
	5. Educational	R	R
	5.1. Interactivity Type	R	R
	5.2. Learning Resource Type	F	F
	5.3. Interactivity Level	R	R
	5.4. Semantic Density	R	R
	5.5. Intended End User Role		
	5.6. Context		
	5.7. Typical Age Range		
	5.8. Difficulty	R	R
	5.9. Typical Learning Time		
	5.10. Description		
	5.11. Language	R, "es-UY"	R, "es-UY"
new	5.12. Media Type	F	R
new	5.13. Instructional Type	R	R
new	5.14. Instructional Theory	R	F

In the Educational category, we can highlight the replacement of the controversial element *Learning Resource Type*, for the elements *Media Type* and *Instructional Type*, and the inclusion of the new element *Instructional Theory*, only for LOs. Examples of vocabularies for these elements are showed below:

- Media Type = {text, diagram, figure, graph, slide, table}
- Instructional Type = {exercise, example, simulation, question, questionnaire, exam, index, experiment, problem statement, self assessment, lecture}

- Instructional Theory = {sequential, learning by doing, learning by example, exploration}The *Instructional Theory* element replaces, with advantages, the *Structure* element in the *General* category.

For the *Rights* category we define all elements, except *Description*, as required.

Table 6. The Relation category.

Element	LOM-LO	LOM-IO
7. Relation	R	
7.1. Kind	R (has part), “haspart”	
7.2. Resource	R	
7.2.1. Identifier	R	
7.2.1.1. Catalog	R (URI), “URI”	
7.2.1.2. Entry	R	
7.2.2. Description		

The *Relation* category, with at least one haspart relation required, allows us to describe the composition of a LO in terms of the IOs which compose it.
Extensions are not presented for categories Annotation and Classification.

6 Conclusion and Future Work

The search of adaptivity has led to a trend to decrease the granularity of LOs. However, the consideration of instructional design associated with LOs, implies a limit to this trend. In this work, we present a two LOM application profiles to manage the difference between LOs and IOs. This approach is based on the distinction between LOs and IOs, and focuses on the capture of metadata at these two levels.

Because LOM may remain current, and conceptually unchanged, for a while longer, the way to adapt it will be through application profiles. Two LOM application profiles are proposed, that exploits the particularities of each level of granularity.

Thisl work requires a proper empirical validation, and this is the most direct future work. However, there are have a couple of interesting issues to address.

Many of the descriptions can easily be generated automatically, as the size of the IOs. Some others may also be generated automatically, but not as easily, as the haspart relationships within an authoring tool. In other cases where the metadata exists, it might be interesting to validate it. The automatic generation and validation of the metadata are an interesting issue to investigate.

Another interesting issue is the attempt of reconciliation between pedagogy and adaptivity, through a mapping between cognitive styles and instructional design. In technology terms, a system may search and choose, or automatically build, a LO with the appropriate instructional design for the cognitive style.

In either of these two issues, we need to work with more educational people in our teams that help us with their pedagogical knowledge.

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