Modeling the Characteristics of a Learning Object for Use within e-Learning Applications

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ABSTRACT

Educational content plays a significant role in the process of delivering knowledge, that's why it needs to be designed carefully, following designated principles. Learning Objects (LOs) constitute a novel approach in the educational content's organization, bearing features that if effectively used could lead to enhanced e-learning services. What is missing from literature, though, is a common agreement about the LO's attributes and structure. For this reason, we initially try to specify the main characteristics of a LO and determine its functionality, especially in the context of distance education. Having realized its fundamental role in the instructional design process, we make explicit its correlation with educational objectives and other aspects of learning. Finally, in an attempt to capture all LO's characteristics and make them utilizable by e-learning applications, we propose a metadata schema, reflecting all features of a LO, as described in this work.

Categories and Subject Descriptors

K.3.1 [**Computer and Education**]: Computer Uses in Education – *Computer-managed instruction*, *distance learning.*

General Terms

Documentation, Design, Standardization, Theory.

Keywords

Learning Objects, Educational Metadata, Distance Learning, e-Learning.

1. INTRODUCTION

Distance learning is a continuously evolving and growing field in education, with hundreds thousands of students across Europe pursuing courses through distance learning technologies. The amount of educational material that e-learning systems should manage and deliver is continuously increasing and students often require services of higher quality by their distance learning providers.

Conference'10, Month 1–2, 2010, City, State, Country.

LOs constitute a novel approach in organizing educational content, which is found in the core of a whole new instructional design paradigm developed in the field of distance learning [2]. The main idea is to decompose the educational content into smaller chunks and construct self-contained learning units. These learning units can then be combined in almost infinite ways in order to create collections and build sections, lessons, or courses. LOs can be reused in different educational contexts whereas the order in which they are presented to the learner (i.e. the learning path), can vary depending on the learner's needs.

LOs have been widely used for the creation of web educational content by many modern e-learning systems, such as Learning Management Systems or Learning Content Management Systems [16]. However, there is no agreement about the structure and the core characteristics of a LO, given that each of these systems usually assigns different attributes to it, according to their end-users' needs.

Through this work we make an attempt to clearly define all aspects of a LO, thus making it able to efficiently serve its scope within a distance learning environment. More precisely, our aim is to propose the exact definition and structure of a LO and then to determine its exact role in the instructional design process, by correlating it with other core concepts of distance education and by making a suggestion about its size and content. Finally, we try to capture all this information in a set of metadata elements that would enable the use of LOs by e-learning applications.

This work is organized as follows: In section 2 we outline the various definitions that have been assigned to a LO, according to literature. Section 3 analyzes the role of a LO in the instructional design process. In the next section 4, the importance of using an appropriate metadata schema for characterizing LOs is explained and a brief overview about the proposed set of metadata elements is given. The outcomes of this work are summarized in the last section 5.

2. LEARNING OBJECTS IN E-LEARNING

According to what McGreal points out at [11], a LO may ranges "from anything to everything". The lack of a common definition about the notion of a LO stands as a barrier to the aim for sharable, interoperable and reusable LOs. This is precisely the reason that a common and widely acceptable definition for LOs is needed. Such a definition can set a framework for the structure of LOs and provide a basis for clarifying several ambiguous characteristics, like size, metadata, content and relationship with learning objectives.

2.1 Definition

Despite a number of different definitions that have been assigned to the term "Learning Object", the educational community and all involved parties have not reached yet an agreement. The most popular ones, according to literature, are given below:

- According to the IEEE Learning Technology Standards Committee [9], the LO is defined as "any entity -digital or non-digital- that may be used for learning, education or training"
- Wiley in [18] describes a LO as "any digital resource of content that can be reused to support learning"
- L'Allier in [10] considers a LO as "the smallest independent structural experience that contains an objective, a learning activity and an assessment"
- For Polsani [14] a LO "is an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts"

Contrary to the lack of consensus regarding the conceptual definition of a LO, there is a broad understanding among the members of the LO community about their functional requirements. These requirements are presented below, as are summarized in [14]:

- *Accessibility*: A LO should be tagged with metadata so that it can be stored and referenced in a database
- *Reusability*: Once created, a LO should function in different instructional contexts
- *Interoperability*: A LO should be independent of both delivery media and knowledge management systems

Considering the above definitions, in combination with the functional requirements of LOs, we end up with the following definition: *"A LO is a self-contained and independent unit of digital educational content, which is associated with one or more learning objectives and it has as primary aim the ability of reuse in different educational contexts"*.

2.2 Structure

Many researchers tried to approach the structure of a LO, from educational perspective, by determining the elements of which it consists. In particular, according to Metros [12] a digital resource, in order to be considered as LO, needs to include or link to (1) a learning objective, (2) a practice activity, and (3) an assessment. In a similar way the structure of LO is defined by Mortimer [13], to contain metadata, a learning objective, the content and learning activities supporting that objective as well as the assessment that is mapped to the learning objective. Another approach for the structure of LOs is the one provided by Ann Gallenson et al in [7]. According to this, LOs are focused on supporting a specific learning objective, are described by metadata and may contain opportunities for practice, simulation, collaborative interaction, assessment, and educational resources.

The common denominator of the observations above, is that "*a LO should have educational content, should be associated with learning objectives and needs to be described by using an appropriate set of metadata*".

The above assertion is used to differentiate LOs from *Content Objects* or *Information Objects*. The latter are not clearly correlated with a learning objective, they contain specific information and they can be images, videos, texts, sound recordings, etc.

Considering this, we reach to the conclusion that the main feature, constituting at the same time a criterion for the distinction between Information Objects and LOs, is the explicit connection of a LO with the learning process. But this kind of correlation generates some additional questions and issues concerning a LO, summarized as follows:

- What is the actual relationship between LOs and learning objectives
- What is the exact size of a LO
- What the content of a LO may be
- Which is the most appropriate set of metadata for characterizing a LO

3. LOs IN INSTRUCTIONAL DESIGN

There are various instructional design methodologies that take into account all the required procedures for systematically designing and developing educational content. Although they have been mainly used in the development of courses within traditional forms of education, their application is considered equally important for the development of distance learning courses that are based on LOs. The majority of these methodologies start with the analysis of the educational problem and the educational context, resulting in the specification of the knowledge domain and the learning goal for the course. Subsequently, the learning objectives of the course are determined. Lastly, based on the learning objectives, a series of LOs that lead to their achievement are designed and developed.

The purpose of this section is to identify and clarify those characteristics and aspects of LOs that will enable their integration in the planning and development of courses based on some specific instructional methodology. This will ensure that LOs will be incorporated in the instructional practice bringing the greatest possible benefit. Figure 1 depicts the core elements of which all course designers should take into account when performing an instructional design, based on LOs.

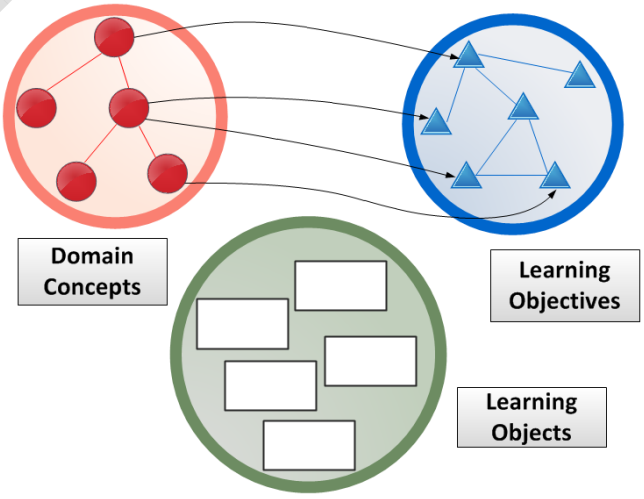

Figure 1. Core elements in the instructional design process and their correlations

3.1 Correlation with Learning Objectives

According to our proposed definition, a LO is associated with at least one measurable learning objective and it is designed so as to support the learning (educational) process. Therefore, at this point

it is essential to define the actual relationship among LOs and learning objectives and in particular the number of learning objectives to which a LO may contribute.

There are various opinions regarding this issue by people that are involved in the design, development and use of LOs. Certain researchers and organizations, like L'Allier in [10]and Cisco [3], argue that a LO should be based and contribute to a single learning objective while others, like Wiley [18] and IEEE [9], leave more freedom towards the number of objectives that a LO may contribute. The restriction that a LO should only satisfy a single learning objective, within a specific context, deprives course designers of flexibility and efficiency during the instructional design process. In practice, it is hard to limit the use of a LO for the achievement of one and only learning objective, when building a course.

Having these in mind, we come to the conclusion that the relationship between LOs and learning objectives should be many-to-many (M:N). This means that a learning objective can be served by one or more LOs and correspondingly a LO may contribute in the achievement of one or more learning objectives.

3.2 Level of Aggregation

An important factor, which should be also taken into account during the design and development of LOs, is their size. The size is in fact related with a LO's reusability. Therefore, we need to pose an upper and a lower limit.

A common metaphor for LOs is that they can be compared with LEGO pieces which can be combined and assembled in various ways [8]. The combination of LOs leads to educational structures of superior aggregation level (e.g., Lessons, Modules, Courses, etc.). The aggregation level varies depending on the Content Model (e.g., SCORM, Cisco RIO/RLO, Learnativity, IEEE LTSC LOM etc.) that is used each time but the size of a LO is increased as we progress to higher aggregation levels in all Content Models. Despite the plethora of Content Models, most of them do not specify the amount of information and data that constitute a LO [1].

In the context of this study when we refer to a LO's "size" we mean the volume of educational information that a LO encompasses and not its physical size or the time it takes learner to complete it. The smaller the LO is, the greater the flexibility for reuse in different educational contexts [17] and vice versa. However the reusability of LOs is not the only issue that concerns us. We must keep in mind that the unity of educational process is also vital and the risk to lose it by creating "too small" LOs is visible. *So the determined-lower limit for the size of a LO is posed by the fact that, according to the definition given above, a learning object must be associated with at least one learning objective.* This ensures that LOs don't lose their learning dimension and furthermore that the unity of educational process is maintained. On the other hand, the upper limit for the size of a LO varies in each case and it is hard to be predetermined accurately. *In this case the volume of educational information that a LO includes, should be such so that it preserves its fundamental functional requirement of reuse*.

3.3 Content

As it is inferred from what mentioned in the previous section about the structure of LOs, two trends exist as far as the content of a LO is concerned. According the first one, a LO should necessarily consist of the triptych "content – practice – assessment" while according the second, a LO may contain educational resources, practice activities, assessments etc. or a combination of them. The incorporation of content, practice and assessment in a LO leads to larger LOs that is more difficult to be reused in different educational contexts. But most important is the fact that the triptych "content – practice – assessment" fundamentally simulates the implementation of deductive instructional strategy (i.e. traditional directive learning) for teaching a specific subject-concept. This strategy, which is mostly used in face-to-face learning (classroom mode), starts from a general rule (theory) continues with examples and practices and is completed with assessment.

Considering the above, as well as the fact that in distance learning a variety of instructional strategies can be used (e.g. experiential instruction and indirect instruction) in addition to the deductive one, we infer that there is a need of relatively small LOs which can be combined in several ways. This enables the implementation of multiple strategies during the learning process of a distance learning program that is being delivered via an e-learning system. Thus we conclude that the second approach leads to reusable LOs and fits better the needs and requirements of an adaptive e-learning system by providing greater flexibility regarding the implementation of multiple instructional strategies.

Therefore, as far as its educational content is concerned, a LO may for example be or consist of case study, example, lecture, simulation, serious game, demonstration, problem statement, etc.

4. EDUCATIONAL METADATA FOR LEARNING OBJECTS

A very important task when creating LOs is the adoption of an appropriate metadata schema, so that the requirements of accessibility, reusability and interoperability are met.

Metadata is structured information which describes the characteristics of a resource (digital or not) thus making easier its management and retrieval. A common definition about metadata is provided by the National Information Standards Organization in [15] where they are characterized as "*structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource*". Metadata schemas are sets of elements, which serve a particular purpose, like the description of certain types of information resources.

Educational metadata are meant for educational resources, like LOs, providing ways for the description of their educational specific characteristics. By transcribing the learning attributes of a LO in a machine readable format, both tutors and students can be facilitated in searching, evaluating and retrieving educational content from within e-learning systems. This well formatted information has a key role that enables the interrelationship of LOs with the other aspects of instructional design, like learning objectives and the domain concepts (see Figure 2). Consequently, all information captured by metadata could be utilized by an e-learning application for the dynamic construction of the "learning path", i.e. the order in which LOs are finally delivered to the end-users, depending on their individual needs.

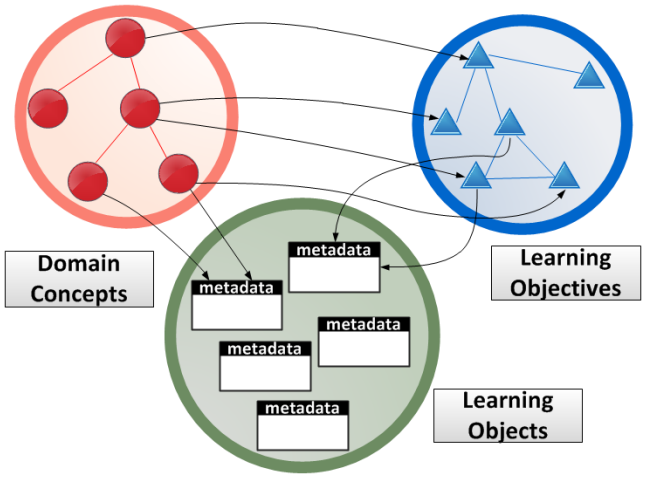

Figure 2. Core elements in the instructional design process and their correlations. LOs have been enriched with metadata

4.1 Existing Approaches

For the characterization of LOs with metadata, several existing standards can be used, in an attempt to achieve interoperability among heterogeneous systems in distance learning. According to each application's intended purpose, either a general or an educational metadata standard can be selected, or an application profile can be constructed. An application profile is an aggregation of metadata elements, selected from one or more metadata schemas and combined in a compound schema [6]. This means that an application profile gives designers the ability to combine schemas as appropriate, in order to meet the functional requirements and needs of a particular application.

Dublin Core (DC) and IEEE LOM are the most widespread and commonly used metadata standards, supported by systems that handle LOs, like digital repositories and Learning Management Systems (LMSs).

The Dublin Core Metadata Initiative ([4],[5]) aims to develop interoperable metadata standards of online resources and is comprised of two levels, the simple and the qualified one. "Simple Dublin Core" contains fifteen elements while the "qualified" consists of three additional elements, as well as a set of qualifiers that refine the basic elements' semantics. Despite the fact that Dublin Core is useful for the description of a wide variety of web resources, it does not make provision for the description of LOs from an educational perspective.

IEEE LOM [9] is a metadata standard that aims at the characterization of learning material and learning resources. The conceptual data schema of LOM specifies both the features of a LO that should be described and the vocabulary that will be used for this description. It contains more than sixty elements that are distributed to a total of nine categories, each of which includes metadata about various aspects of a LO.

4.2 An Educational Metadata Profile

Although, IEEE LOM is intended for the characterization of educational resources, it lacks several features and thus it becomes inefficient for characterizing LOs used within e-learning applications. For example, there is no provision for representing a LO's correlation with learning objectives or for other attributes of the distance learning material (e.g., the instructional context that it fits in). But apart from IEEE LOM, other known application profiles of IEEE LOM (like CanCore[1], AICC LOM[2], etc) do not seem to fulfill this need.

With a view to providing a complete element set for describing LOs, we propose a new educational metadata schema. This schema is actually a subset of the IEEE LOM, namely it constitutes a new application profile, but with a particular orientation in distance education material. This profile adopts the majority of IEEE LOM's elements, augmenting them with some additional attributes in order to represent concepts commonly used in distance education, like learning objectives. The proposed schema is rich enough, so that it can effectively describe all aspects of a LO (educational, technical, etc.), but not exceedingly analytic as to become difficult in use.

The elements that form our proposed metadata schema are summarized in Table 1. The elements that have been directly taken from the IEEE LOM schema are marked with their original numbering, as referred inside the IEEE LOM specification [8]. Additional entries have been marked in bold and have the indication "new".

Table 2. The set of elements in our proposed educational metadata profile

Category	***Element***
1.General	*Identifier.Catalog (1.1.1), Identifier:Entry (1.1.2), Title (1.2), Language (1.3), Description (1.4), Keyword (1.5), Aggregation Level (1.8)*
2.Life Cycle	*Contribute:Role (2.3.1), Contribute:Entity (2.3.2), Contribute:Date (2.3.3)*
4.Technical	*Format (4.1), Size (4.2), Requirement:orComposite (4.4.1), Duration (4.7)*
5.Educational	*Learning Resource Type (5.2), Intended End User Role (5.5),* ***Instructional Context*** *(new), Typical Age Range (5.7), Typical Learning Time (5.9), Learning* ***Objective:Identifier:Catalog*** *(new),* ***Learning Objective:Identifier:Entry*** *(new),* ***Learning Objective:Description*** *(new)*
6. Rights	*Copyright and other Restrictions(6.2)*
7. Relation	*Kind (7.1), Resource:Identifier:Catalog (7.2.1.1), Resource:Identifier:Entry (7.2.1.2)*

As shown in Table 2, the *Educational* category, compared to the original IEEE LOM schema, contains two additional entries: *Learning Objective* and *Instructional Context*. The correlation of a LO with learning objectives, is expressed through the *Learning Objective* element. In particular, for each learning objective that a LO satisfies, one needs to give its natural language statement (*Description*) and assign an identifier (*Identifier:Entry* and *Identifier:Catalog*), according to a specific identifier system. The *Instructional Context* implies the actual educational context where the learning process takes place, and can accept values like "distance education".

Elements adopted by the IEEE LOM metadata are considered to come with equivalent semantics, as described in the corresponding IEEE LOM specification. For some of them,

[1] http://cancore.athabascau.ca/en/
[2] http://www.aicc.org/docs/tech/dels002v1.pdf

though, we have modified the value space, so as to meet a LO's specific characteristics. More precisely, for those fields that accept a predefined set of values (i.e., a controlled vocabulary) we have either augmented it with additional values, or we have only selected a small subset of the proposed vocabulary. The *Learning Resource Type* field of the *Educational* category is such an example, for which a completely new list of acceptable values is proposed. This list reflects the most common types of educational material, used within distance education courses and e-learning applications. The complete list of the learning types we adopt for a LO is presented in Table 2.

Table 2. List of learning resource types of a LO

Learning Resource Type	
1. Guidelines	**10. Simulation**
2. Presentation	- Interactive
3. Demonstration	- Non Interactive
4. Lecture	**11. Self-Assessment**
5. Definition-Principle-Law	- Multiple Choice Questions
6. Narrative Text	- Open Type Question
7. Analogy	- Problem Statement
8. Example	**12. Experiment**
9. Activity	**13. Serious Game**
- Case Study	**14. Exercise**
- Problem Solving	- Multiple Choice Questions
- Text Composition	- Open Type Question
- Question	- Problem Statement
	15. Project

Another important modification concerns the *Kind* of relation field in the *Relation* category. Through this field, we actually make provision for the following types of relationship between LOs: "has part" and its inverse "is part of", "complements" and its inverse "is complemented by", and the relation "is alternative type". The latter does not exist in LOM and expresses that two LOs are exactly the same and differ only in their technical format. The "has part" and "is part" are used to declare collections of LOs whereas "complements" implies a supportive LO that comes to complement the knowledge that a core LO bears.

5. CONCLUSIONS

What we analyzed here was the various aspects of a LO as a self contained unit of educational material that aims to be utilizable in different instructional contexts and by applications that make use of distance learning technologies. Accessibility, reusability and interoperability should be the basic requirements when designing LOs, whereas a LO's direct correlation with the instructional process is what can differentiate these chunks of educational content from mere information or content objects.

In an attempt to meet all the aforementioned requirements, we assigned a more explicit definition and structure to the notion of LO and made some suggestions about its proper size, content and relationship with learning objectives. By this way, we intended to feature the potentials of LOs in the process of designing courses, and thus enable a more effective exploitation of the educational content in total.

Afterwards, we proposed a metadata schema, able to capture all these features in a machine readable format. Such a well-formed description would render LOs utilizable by computer systems and applications and thus it could lead to a dynamic creation of relations among the structural elements of a course and produce different learning paths, according to the learners' needs. The proposed schema is broad enough and makes provision for all aspects of a LO (descriptive, technical, etc), as well as for its educational specific characteristics. It is actually a profile of the well-known IEEE LOM educational metadata standard, enriched accordingly so as to incorporate our suggestions about a LO's structure and scope in learning.

6. ACKNOWLEDGMENTS

This research described in this paper has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) (Funding Program: "HOU").

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