Improving LO Quality through Instructional Design Based on an Ontological Model and Metadata

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Abstract: The activities developed in this paper were aimed at providing an awareness of the elements that should be considered in quality learning objects instructional design for e-learning systems. We thus propose our own LO definition taking into account aggregation level number 2. On this basis, we analyze cognitive theories for promoting learning and we explain issues relating to the LO characteristics that help to improve their quality for suitable management. To achieve this we propose an instructional design based on an ontological model which explains the relationship between the instructional design elements and a specific classification to improve their management.

Keywords: Learning Objects, Instructional Design, Ontology, Quality
Categories: H.1.1, H.3.1, H.3.3, J.1

1 Introduction

The challenge of defining the type of information to manage for e-learning is a topic that has led to the emergence of new concepts for resource development. One of these concepts is the learning object, which considers resources as independent units that can be re-used for new educational situations.

Since there are many LO definitions, we propose our own LO definition, which is addressed to LOs with aggregation level number 2. Aggregation level is used in [IEEE LOM 2002] to describe "the functional granularity" of a learning object, and aggregation level number 2 means a collection of level 1 learning objects, e.g. a lesson. In this way it is possible to clarify what we understand by LOs and what kind of LOs we are managing for instructional design. Nowadays, specifications and standards are being developed to promote the interoperability of LOs on different kinds of platforms. However, the LO in itself, with its characteristic of reusability, is not synonymous with a good quality result. Currently much research work is aimed at achieving LO interoperability without taking into account instructional design.

As stated before, the purpose of this paper is to provide an awareness of the elements that should be considered in quality LO instructional design for e-learning systems, taking into account certain classifications to improve their management. To achieve this, in section 2 we analyze the cognitive theories state of the art for promoting learning as well as explain issues relating to the LO characteristics which help to improve their quality for suitable management. On this basis we suggest some issues to be taken into account in order to obtain a good LO design.

Section 3 shows the relationship between LO instructional design components through an ontological model proposing some classifications that could be considered for an application profile in order to improve LO management. Finally we offer our conclusions and discuss future work.

2 LO instructional design

E-learning systems based on reusable LOs mean that specific contents can be accessed according to learners' needs. To avoid interoperability problems, there are

some organizations that are working to develop standards and specifications to manage resources for e-learning systems.

At present there are many definitions for LOs [IEEE LOM 2002], [Moreno and Bailly-Baillière 2002], [Polsani 2003], [Wiley 2000]. In order to manage them for e-learning systems, it is important to make clear what we understand by LOs. We define an LO as a "unit with a learning objective, together with digital and independent capabilities containing one or a few related ideas and accessible through metadata to be reused in different contexts and platforms" [Morales et al. 2005]. According to this, our proposal is addressed to LOs that have a number 2 aggregation level: for example, a lesson [IEEE LOM 2002].

Instructional design methods make it possible to apply designs for contents taking into account different learning situations. Different kinds of learning theories exist to explain how learning occurs. Regarding this concept, [Reigeluth et al. 1999] explain that instructional design is a theory that offers an explicit guide about teaching how to learn.

Instructional design theories are related to the kind of information to be used, depending on what and how to teach. Certain instructional design theories exist concerning LOs.

One of these [Merrill 1999] proposes the instructional transaction theory, addressed to a mechanized process. According to his definition "it is an attempt to extend the conditions of learning and component display theory so that the rules are sufficiently well specified to be able to drive automated instructional design and development". This theory describes knowledge in terms of three types of knowledge objects: entities, activities, and processes. It also identifies many other aspects, such as interrelationships among knowledge objects including: components, properties, and associations between entities, activities, and processes.

However, Merrill's theory has been criticized for its excess structure because it is difficult to put into practice and also it does not facilitate the content developers' work. Based on Merrill's theory, Cisco Systems [Cisco Systems 2004] suggests a guide for the creation of reusable learning objects. This guide proposes specific structures for any kind of specific learning object. It also provides a help guide and examples for their classification.

To ensure solid structures for multi-courses, Cisco Systems [Cisco Systems 2004] provides five levels of hierarchy: course, module, lesson, topic, sub-topic. Each of these levels has specific elements to structure it. The general structure is composed of the following elements: *Course*: introduction, module, lesson, topic, sub-topic, practice, evaluation; *Module*: Overview, lessons, summary, practice and evaluation; *Lesson*: Overview, topics (concept, fact, procedure, processes, and principles), summary, practice and evaluation; *Topics*: contents related to concepts, facts, procedures, processes and principles.

The structure of Cisco LOs [Cisco Systems 2004] is used by Moreno and Bailly-Baillière [Moreno and Bailly-Baillière 2002], with some changes added. They propose grouping contents into three types: data and concept, procedure and process and finally, reflection and attitude. In this way it is possible to simplify the content developers' work covering other related types of contents. They also suggest adding sequenced activities after the summary and self-assessment for each topic.

Although LO instructional design is currently a much discussed topic, there are certain aspects that must be considered to ensure a quality LO instructional design.

LOs are individual units of learning or modules which need to be enabled with other ones to build larger units (didactic units, courses, etc.). This means that they are part of the whole, but each LO must be capable of being reused by itself in other didactic units. In order to complete an LO as a quality unit of learning and to compose didactic units (DU) with them, we believe the following issues should be considered.

- **Overview:** According to [Cisco Systems 2004] and [Moreno and Bailly-Baillière, 2002] a didactic unit needs a general overview to explain general objectives and introduce the LO content. An introduction is an important element for any kind of contents because as well as providing information about the contents, it sets out the purpose of the topics and gives learners an idea of what they are expected to learn. Furthermore, it is a motivational element that aims to engage the students by letting them know why the subject is important for them.

  An overview must also provide an LO objective. As we explained in the definition of LOs, because of their reusability characteristics, ideally the objective must be simple, with one or several related ideas. We

suggest that an objective should be directed to learning one kind of contents because in this way the whole instructional design would be targeted to achieve this specific objective.

Other important aspects that must be included in an LO overview are: its title and the title of the learning unit, so that students can know what part of a whole they are working with; the sequenced list of topics; and, finally, keywords to inform students about what related areas are involved with the LO content.

- **Contents**: In general, any kind of content must have some quality characteristics that take into account different issues. From a pedagogical point of view, contents must be logical and psychologically meaningful. That means, on the one hand, a logical view of the discipline (content sequence, methodology, kind of activities, etc.) and, on the other, user suitability (level of difficulty, user interests, etc.). Other issues related to any kind of content are information veracity, correct data, good writing and spelling, suitable size, color and font type, etc.

  However, as regards LO characteristics, it is important that contents should not mention anything about time, for example, "this week" or "this semester," etc., because this could delay its reusability for other educational situations. The same must be taken into account regrading the audience, then phrases like "dear engineering students…" must also be avoided.

  Ideally, contents should be presented in multiple formats in order to attend to different cognitive skills and learning styles, e.g. videos, animations, graphics, etc.

- **Activities:** Activities may be addressed to promoting new knowledge acquisition and to preparing users for a final assessment. Activities may be included in any kind of contents during the entire teaching and learning process. They help users to know if they must go on to the next lesson or whether they should seek feedback.

Some authors [Zapata 2005, Del Moral and Cernea 2005] promote constructivist learning environments for Learning Objects. They emphasize that activities must be as diverse as possible to accommodate different kinds of users: case studies, problem solving, teamwork, reflecting on situations, etc. We agree on the need for these kinds of activities, but we feel that deep reflection about them is necessary before they can be applied to LOs.

First, activities are highly related to the contents. This issue may affect the kind of activity to use; for example, if LO contents are merely talking about basic concepts, facts or data, the kind of activities may be directed to reinforcing them, by relating the correct concepts, checking true or false, etc. Most likely, an activity such as a case study does not need to be employed at this level of complexity.

In accordance with this, in order to support different complexity levels of contents and cognitive domains, we suggest taking into account three kinds of activities: Initiation, Re-structuring and Application.

Initiation activities are designed to teach the basic contents of a specific subject. An example of this is a quiz. Re-structuring activities may be directed to promoting new knowledge acquisition, such as activities that promote questions, research, etc. Finally, application activities may be addressed to fostering students' experience in order to strengthen their acquisition of new concepts. An example of this activity is a case study.

A Didactic Unit is composed of a group of individual LOs. Because of the reusability characteristic, some authors [Cisco Systems 2004] [Moreno and Bailly-Baillière 2002] recommend carrying out some activities at the end of the didactic unit to avoid consistency problems with the adaptation of new LOs.

- **Summary or Conclusions**: As with any kind of teaching and learning process, a summary is advisable after a contents review. A good summary should point out the main ideas and the relations between them, making it possible to reinforce the contents. It is also important to

relate the contents to other areas of knowledge by means of diagrams, outlines, conceptual maps, etc.

- **Assessment:** An evaluation must take into account each of the learning objectives. It must thus be addressed to any kind of contents and its level of difficulty. Evaluation may be carried out as activities; however, it is very important that students know what activities will be evaluated prior to the assessment.

  [Clark and Mayer 2002] are in favor of practice activities and evaluation activities. The first has to help students to acquire new knowledge by providing feedback, pointing out the most important information, and to prepare them for a final evaluation. The second type must be a final experience that lets the students know whether they have mastered the objectives or not, i.e., whether they have passed or failed.

3 Instructional Design Based on an Ontological Model

In order to achieve a quality LO instructional design, it is important to define and relate its components. On this basis, in order to manage them in a suitable way, we think it is necessary to normalize them in accordance with our definition and with certain instructional design issues, so that, on the one hand, a suitable degree of granularity and, on the other, pedagogical consistency will be guaranteed.

[Figure 1] shows the components of our proposed knowledge model and the relationships between them. On this basis, we suggest the following steps:

1. *Define LO components*: According to our LO definition for LOs with aggregation level number 2 we suggest that their components must be defined as we explained in [section 1], to wit: Overview, Contents, Activities (practice and evaluation), Summary or Conclusions.
2. *Classify LO components*: LOs can be classified for different purposes by "classify metadata element". According to this, it is possible to define some of their characteristics by adding a vocabulary to the metadata schema. To achieve better LO management we suggest the following LO classification.

2.1. *Classify LO objectives according to their cognitive domain*. In this way, it is easier to determine their compatibility for suitable new educational situations. We thus suggest the Bloom cognitive domain taxonomy [Bloom 1956] because it defines what and how to learn according to complexity levels: low level (knowledge, comprehension and application) and high level (analysis, synthesis and evaluation). To achieve this we propose the metadata classification shown in [Table 1].

9.Classification	**Example**
9.1 Purpose	Cognitive Domain
9.2 Taxon path: A taxonomic path in a specific classification.	
9.2.1 Source: A specific classification	Comprehension
9.2.2 Taxon: An entry in a classification.	
9.2.2.1 Id: Taxon identifier in taxonomic system	The number of an objective table
9.2.2.2 Entry: Taxon name or label (other than identifier)	The value of an objective table (describes, explains, etc.)
9.3 Description: A textual description of the learning object relative to its stated purpose.	In this cognitive domain students are able to describe, interpret and extrapolate the information.
9.4 Keyword: Main words relative to its stated purpose.	Comprehension, description, explanation, etc.

Table 1: Example of LO classification according to its cognitive domain.

2.2. *Classify LOs into three kinds of contents*: data and concept, procedures or processes, and reflection or attitude. This classification aims to define the kind of content according to the learning objectives. This is an issue that may be important when teachers search for LOs to structure their courses.

IEEE LOM Metadata proposes nine optional metadata information categories in order to describe LOs. The "9.classification" metadata element aims to classify LOs according to certain "purposes" (discipline, idea, prerequisite, educational objective, accessibility restrictions, educational level, security level and skill level). However, IEEE LOM Metadata does not consider a specific metadata element in order to classify LOs according to the type of skills which an LO needs to promote in order to achieve its learning objectives.

9.Classification	**Example**
9.1 Purpose	Kind of Contents
9.2 Taxon path: A taxonomic path in a specific classification.	
9.2.1 Source: A specific classification	Data and Concept
9.2.2 Taxon: An entry in a classification.	
9.2.2.1 Id: Taxon identifier in taxonomic system	The number of a table of contents
9.2.2.2 Entry: Taxon name or label (other than identifier)	The value of a table of contents (data, numbers, fact, etc.)
9.3 Description: A textual description of learning object relative to its stated purpose.	A group of objects, symbols, ideas or events that are defined by a single word or term.
9.4 keyword: Main words relative to its stated purpose.	"Internet History"

Table 2: Example of LO classification according to its kind of content.

On this basis, we suggest the purpose "cognitive domain" be included within the "9.classification" category. [Table 2] shows both metadata elements of the "9.classification" category and an example of how to classify LOs according to their cognitive domain. In this case we give the example of the "comprehension" cognitive domain.

Furthermore, according to our LO instructional design proposal we suggest the purpose "kind of content" should be included within the "9.classification" category; in this way it is possible to define the specific LO content. This kind of information allows teachers to find and retrieve LOs as really minimal lessons and composes didactic units more easily.

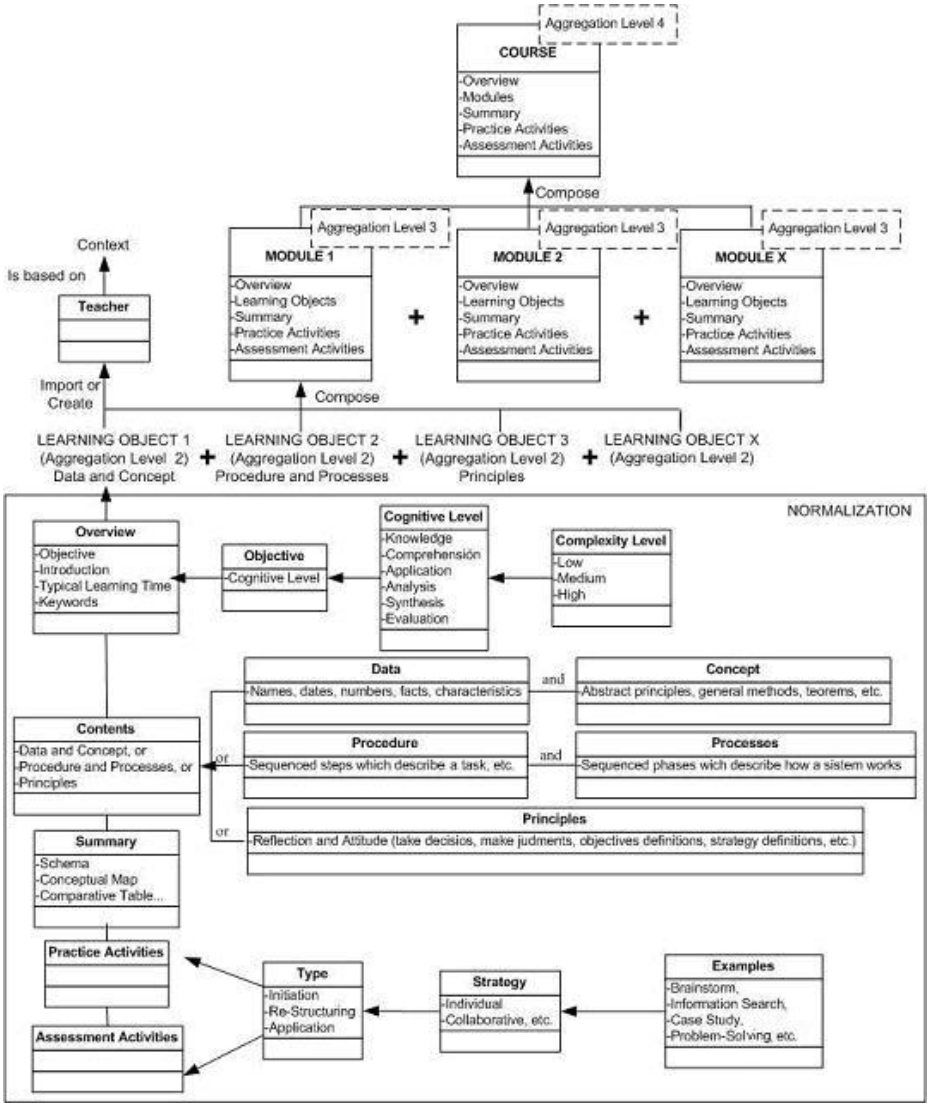

Figure. 1. An Ontological Model for Instructional Design.

The LO classification suggested above is a way to facilitate LO management according to instructional design characteristics. Cognitive domain aims to define which student skills are to be developed and what they will be able to do. This information is important from a pedagogical point of view in order to determine their reusability in another educational context. On the other hand, content classification is for deciding whether they are suitable for other educational objectives and aims to determine the contents sequence. This issue is useful for providing students with the specific LO contents they need.

According to the proposed knowledge model, activities are classified into practice and evaluation as we explained in section 1. Both have the same classification and strategy; however, the evaluation activities must determine whether students can move on to another learning stage or not.

LO Normalization is a way to prepare LOs for their management and evaluation, thus making it possible, on the one hand, to standardize their characteristics by promoting their quality criteria, and, on the other hand to answer an important question for knowledge management: what to manage.

4 Conclusions

LOs have lately come under much discussion. Most LO proposals are addressed to achieving a suitable LO management from a technical point of view in order to guarantee their characteristics of reusability, accessibility and interoperability for automatized processes. Today it is possible to find a vast array of tools to help with this task, such as metadata editors, e-learning platforms, and so on. However, in the educational area LOs need special attention. According to LO definitions they must be addressed to teaching a small unit of contents, but to achieve this objective LOs must have a suitable instructional design aimed at achieving their educational objective.

Regarding LO instructional design, we have analyzed some of the most important proposals, all of which define certain components that promote educational goals. Nevertheless, in order to guarantee a quality LO design it is important to consider

quality criteria by taking into account LO and user characteristics in order to make LOs more useful and efficient.

In order to improve the instructional design of LOs our knowledge model adds a clear and easy way to structure LO elements with quality characteristics. The cognitive domain and kind of content classification is a way to guarantee suitable LO management. On the one hand, the classification provided is useful for any context of use because an LO with aggregation level number 2 must have at least one educational objective and some kind of contents, and our proposal aims to define what a student can do and the suitable type of contents needed. On the other hand, our proposal considers the metadata element "classification", which is part of an official metadata proposal, and it can thus be used for personalized application profiles in order to classify LOs according to particular educational needs.

Our proposed LO definition, applied to aggregation level number 2, aims to introduce some instructional design components as well as quality criteria in order to create a valid and quality learning unit. On this basis it is easier to apply quality criteria for LOs because they have a uniform structure. In accordance with this, we are currently working on defining quality criteria for metadata information in order to promote suitable LO descriptions and their consistency with instructional design.

We wish to emphasize that our proposal is addressed to instructional LO design. However, it does not guarantee quality LO management for e-learning systems because this depends on many issues, such as platform capabilities, usability, accessibility, etc., which are outside the scope of this specific proposal. Nevertheless, this work proposes some ideas for improving the quality of LOs from an instructional design point of view.

5 Future Work

We are considering defining our instructional model as a pedagogical aid to help teachers create quality LOs in an easy way. To achieve this we are going to design a tutorial to guide teachers in creating LOs, taking into account our ontological model and providing some hints about how to promote their quality, also providing advice, links to documents and digital resources.

On the basis of the different kinds of LO classifications mentioned above, the tutorial needs to be able to add this kind of metadata information, thus making it possible to save LOs with a specific classification that will allow teachers to retrieve them according to their needs. In order to facilitate LO retrieval, we are considering applying software agents to compare LOs according to their quality and specific user needs.

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References

[Bloom 1956] Bloom, B.: "Taxonomy of educational objectives: Handbook I, Cognitive Domain"; Davis McKay (1956).

[Clark and Mayer 2002] Clark, R. C., Mayer, R. E.: "E-learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning"; Josey Bass/Pfeiffer, San Francisco (2002).

[Cisco Systems 2004] Cisco Systems: "Reusable learning object authored guidelines: How to build modules, lessons and topics", White papers (2004), http://www.cisco.com.

[Del Moral and Cernea 2005] Del Moral, M. E., Cernea, D. A.: "Diseñando objetos de aprendizaje como facilitadores de la construcción del conocimiento"; Actas del II Simposio Pluridisciplinar sobre Diseño, Evaluación y Descripción de Contenidos Educativos Reutilizables, SPDECE'05, Barcelona, (2005), http://www.uoc.edu/symposia/spdece05/pdf/ID16.pdf.

[IEEE LOM 2002] IEEE Standard for Learning Object Metadata.: ANSI/IEEE (2002) http://ltsc.ieee.org/wg12/.

[Merrill 1999] Merrill, D.: "Instructional Design Theories and Models: A new Paradigm of Instructional Theory". Lawrence Erlbaum Assoc., (1999), 397-424.

[Morales et al. 2005] Morales, E., García, F. Barrón, A., Berlanga A., López C.: "Propuesta de evaluación de objetos de aprendizaje"; Actas del II Simposio Pluridisciplinar sobre Diseño, Evaluación y Descripción de Contenidos Educativos Reutilizables, SPDECE'05, Barcelona, (2005), http://www.uoc.edu/symposia/spdece05/pdf/ID06.pdf.

[Moreno and Bailly-Baillière 2002] Moreno, F., Bailly-Baillière, M.: "Diseño instructivo de la formación on-line. Aproximación metodológica a la elaboración de contenidos"; Ariel Educación, Barcelona (2002).

[Polsani 2003] Polsani, P.: "Use and abuse of reusable learning objects"; Journal of Digital Information, 3, 4 (2003).

[Reigeluth and Moore 1999] Reigeluth, C., Moore, J.: "Cognitive Education and the Cognitive Domain"; Reigeluth, C. (ed.), *Intructional-Design Theories and Models: A New Paradigm of Instructional Theory*. Lawrence Erlbaum Assoc., E.E.U.U., (1999), 51-68.

[Wiley 2000] Wiley, D. A.: "Learning object design and sequencing theory"; Unpublished Doctoral Dissertation, Brigham Young University, Provo, UT. (2000).

[Zapata 2005] Zapata R. M.: "Secuenciación de Contenidos y Objetos de Aprendizaje"; RED (Revista de Educación a Distancia), 4, 2 (2005), http://www.um.es/ead/red/M2/zapata47.pdf.