

# Exploring Learning Objects under Conceptual, Instructional and Didactic Perspectives

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## Abstract

The idea of Learning Objects – “any digital resource that can be reused to support learning” – is emerging as a way to reuse learning materials in different settings and contexts. Standardization efforts have also been conducted, especially related to the establishment of learning object metadata, describing the relevant characteristics that a learning object should present. This work aims at exploring learning objects according to the conceptual, instructional and didactic perspectives, which have been investigated in the context of domain modeling for the development of learning materials. Our goal is to investigate the impact of these perspectives into the set of characteristics specified by the standards for Learning Objects Metadata under development.

**Keywords:** Learning Object, Learning Object Metadata, Conceptual Object, Instructional Object, Didactic Object.

## 1. Introduction

Technology information advances, especially the advent of the Internet and the expansion of WWW, have produced a paradigm shift in terms of learning and education. As a result, changes in the way people learn and how learning materials are designed, developed and delivered have been observed.

Instructional Design theories ([1], [2], [3]), dealing with aspects such as learning and teaching styles, learning objectives and goals, learning strategies, and methods for assessment and revision, are now beginning to be considered into the development of educational contents. The activities and tasks proposed by Instructional Design have been investigated and applied as part of systematic processes aiming at the development of richer and more significative materials, capable of motivating the students and, consequently, to make learning experiences more effective.

Supporting the notion of small instructional components, Learning Objects ([4], [5], [6], [7], [8]) have also emerged as a way to structure learning materials and reuse them a number of times, in different settings and contexts. The fundamental idea behind learning objects is concerned with reusability - content must be reusable, interoperable, and easily manageable at many different levels of complexity throughout the educational environment [7]. However, in attempt to enable them in promoting a positive impact on actual learning, several aspects still must be addressed. The Instructional Design implications of learning objects, standardization aspects, and granularity and combination problems are examples of relevant issues that need more investigation.

Domain modeling also plays a fundamental role into the development process of learning materials. This activity helps the author to determine the main concepts (and their relationships) to be taught, providing a systematic way to structure the relevant parts of the subject knowledge domain. In a previous work we investigated the

development of educational contents under three domain modeling perspectives [9]: **conceptual**, which refers specifically to the content description; **instructional**, which deals with the instructional elements used to perform teaching and learning processes; and **didactic**, which aims at relating the conceptual and instructional elements in order to achieve the learning objectives previously established. Although each perspective addresses a particular aspect in the learning material development, they are intrinsically related and should be considered in an integrated way.

This work aims at investigating the impact of the conceptual, instructional and didactic perspectives into the context of Learning Objects, more specifically in terms of the current standards for Learning Objects Metadata (LOM) [10] under development.

The remainder of this paper is organized as follows. Section 2 presents an overview on learning objects, mainly in terms of the standardization efforts that have been conducted and the related problems that still need to be solved. Section 3 discusses the conceptual, instructional and didactic aspects into the scope of the LOM's standard. Our conclusions and further work are presented in Section 4.

## 2. Learning Objects: An Overview

In attempt to promote the adoption of learning objects as well as to assure the interoperability among them, significative efforts on standardization have been conducted. Several standard organizations, namely the IMS Global Learning Consortium (<http://imsglobal.org>), the Advanced Distributed Learning Network – ADL (<http://www.adlnet.org>), the Dublin Core Group (<http://dublincore.org>), and the IEEE Learning Technology Standards Committee – LTSC (<http://ltsc.ieee.org>), have contributed in this perspective.

The multi-part standard specified by the IEEE LTSC Learning Objects Metadata (LOM) working group defines a learning object as “*any entity, digital or non-digital, that may be used for learning, education and training*” [10]. In practical terms, however, some researchers argue this standard definition is extremely broad and, within its scope, more restricted definitions have been proposed. In this paper, we adopt the Wiley’s proposal, which defines a learning object as “*any digital resource that can be reused to support learning*” ([4], [7]).

The establishment of learning object metadata, i.e. the descriptive information about the object, also plays a fundamental role as part of the standardization efforts that have been conducted. The draft standard for Learning Objects Metadata (LOM) [10] specifies a metadata instance and describes the relevant characteristics of the learning object to which it applies. According to the standard, such characteristics may be grouped in several categories: General, Life Cycle, Meta-Metadata, Educational, Technical, Rights, Relation, Annotation, and Classification.

Besides the standardization aspects, other issues should be considered when designing learning objects. Wiley, for instance, poses the “sequence problem” ([4], [7]): *how to take individual learning objects and combining them in a way that make instructional sense?* This discussion also leads to another connection between learning objects and instructional design – the “scope problem”: *how big should a learning object be?*

In the next sections we investigate the impact of the conceptual, instructional and didactic perspectives into the IEEE’s LOM standard, more specifically regarding the set of characteristics specified in the Educational category.

### 3. Conceptual, Instructional and Didactic Perspectives

In order to explain the Learning Objects idea, Wiley proposed the Atom Metaphor ([4], [7]): an atom is a small “thing” that can be combined and recombined with other atoms to form larger “thing”. In terms of properties: (1) not every atom is combinable with every other atom; (2) atoms can only be assembled in certain structures prescribed by their own internal structure; and (3) some training is required in order to assemble atoms.

Wiley also states that atoms are combinations of smaller bits (neutrons, protons, and electrons), which are combinations of smaller bits (baryons and mesons), which are combinations of even smaller bits (quarks, anti-quarks, and gluons), and so on. It is the particular way in which these top-level bits (neutrons, protons, and electrons) are combined in an individual atom that determines which other atoms a particular atom can bond with [7].

Based on this metaphor, considering a learning object as an atom, our idea is break the learning object into smaller pieces of information: conceptual, instructional and didactic objects (corresponding to the idea of neutrons, protons, and electrons). Actually, conceptual objects would be related to the content description, in terms of the core concepts and their relationships, while instructional objects would deal with the supplementary information (questions, examples, further explanations, problems to be solved, and so on). The manner in which these objects are combined would be established from the didactic purposes associated to them.

In this sense, the conceptual and instructional objects, related by means of didactic objects, determine the way in which the learning object could be combined with other learning objects to originate the learning material. Next we explore each kind of information related to conceptual, instructional and didactic objects into more details.

#### 3.1. Conceptual Objects

In our previous work on domain modeling we defined a conceptual model as a high-level description about the knowledge domain, where the domain elements were characterized in terms of concepts and could be represented by means of a concept map, an ontology, or other technique for knowledge representation [9].

Also, concepts could be associated to each other by means of two classes of relationships ([11], [9]): structural and domain-specific ones. Structural relationships represent a generic category of relations, which can be applied on any knowledge domain. Taxonomy (*type-of*) and composition (*part-of*) relations are representatives of structural relationships. On the other hand, domain-specific relationships have their meaning associated to a particular subject, carrying their own semantics. They are user-defined and represent specific relations, whose interpretation depends on the knowledge domain.

Applying these ideas into the context of learning objects, conceptual objects would be responsible for dealing with concepts and their relationships, corresponding to the core information of a learning object. Based on the relationship in which it participates, a conceptual object can be classified in:

- Atomic: the object is indivisible.
- Hierarchic: the object correspond to a set of other conceptual objects associated by means of a taxonomy relationship.
- Composed: the object correspond to a set of other conceptual objects associated by means of a composition relationship.

- Collection: the object correspond to a set of other conceptual objects associated by means of domain-specific relationships.

The categorization above reflects the structure of a conceptual object. Analyzing the IEEE's LOM standard, more specifically the Educational category, we can observe that the concepts that compose a learning object are not specified in terms of their internal structure. Thus, none characteristic related to the concepts structure is described in this category. It is also important to notice that even though the characteristics *Structure* and *Aggregation Level* described in the General category deal with a similar idea, they are concerned with the learning object as a whole and are not applied to its concepts in separate.

Regarding the content, a conceptual object can be specified in terms of a definition, an enunciate, a description, phases, activities, tasks, and so on. Actually, the kind of "constructor" to be used is defined according the type of information the conceptual object refers to (principle, theorem, axiom, method, criterion, technique, procedure, process, model, etc). Also, different kinds of media (such as text, image, audio, video, and animation) can be combined to describe the object.

### 3.2. Instructional Objects

Learning materials usually include a content description together with questions, examples, further explanations, problems to be solved, suggestions for further study, and so on [9]. In other words, a diversity of supplementary information should be associated with the concepts to better assimilate them. An instructional object corresponds to the elements used for illustrating and practising the concepts, and for evaluating the learner's apprenticeship. In this sense, they can be classified as follows [9]:

- Explanatory objects: deal with the complementary information used for explaining a conceptual object. Examples, hints, comments, and suggestions of study are representatives of explanatory objects. Also, they can play a number of different roles depending on the learning context. An example, for instance, can be associated with a given conceptual object to *motivate* the study of the object, or to *illustrate* its use.
- Exploratory objects: allow the learner to navigate through the knowledge domain and to practise the related concepts. The proposition of a given problem, which enunciates an exercise to be solved and indicates a reference material for its solution, corresponds to an exploratory object. A variety of exploratory objects can be defined, such as simulations, experiments, reading and/or composition assignments, and so on.
- Evaluative objects: allow to assess the learner's proficiency on the subject of learning. A simple problem statement, in which the answer is not provided to the learner in advance, is an example of evaluative object. An exam composed by objective and/or subjective questions, each one representing small problems with a number of possible answers, can be considered an evaluative object as well. According to the object purpose, the evaluation can be:
  - Diagnostic: applied before starting using the learning material as a way to measure the learner's current level of knowledge and expertise.
  - Formative: applied during the use of the learning material as a way to obtain data in order to revise the learner's apprenticeship to make it more efficient and effective.
  - Summative: applied after the use of the learning material.

Analyzing the LOM's Educational category, although the characteristic *Learning Resource Type* specifies the kind of learning object (exercise, simulation, questionnaire, diagram, figure, graph, and so on), it does not take in account whether the object is explanatory, exploratory or evaluative, or even conceptual or instructional.

Furthermore, even that most of the characteristics specified in the LOM's Educational category are appropriated to the scope of the instructional objects (*Interactivity Type*, *Interactivity Level*, *Context*, *Typical Age Range*, *Difficult* and *Typical Learning Time*), other relevant instructional information, derived from the Instructional Design theories, should also be specified:

- Learning Domain: refers to the learner's skills that can be stimulated by using the instructional object. Based on the Bloom's Taxonomy [12], three different types of learning can be identified:
  - Cognitive: involves knowledge and the development of intellectual skills.
  - Affective: includes the manner in which the learner deals with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes.
  - Psychomotor: includes physical movement, coordination, and use of the motor-skill areas.
- Learning Style: specifies the type of learner for which the instructional object is more appropriate [13]:
  - Visual/Verbal: people who learn best when information is presented visually and in a written form.
  - Visual/Nonverbal: people who learn best when information is presented visually and in a picture or design format.
  - Auditory/Verbal: people who learn best when information is presented aurally. They benefit from participating in group discussions and interacting with others in listening/speaking activities.
  - Tactile/Kinesthetic: people who learn best when doing a physical "hands-on" activity.

Regarding the content, the core information related to instructional objects can be specified in terms of a description, phases, activities, tasks, and so on. Supporting tools, establishing the specific tools (related to the subject of learning) and educational tools (supporting collaboration, content delivery, learner's assessment) should also be specified. Similar to the conceptual objects, different kinds of media can be grouped to describe the content of an instructional object.

### 3.3. Didactic Objects

As we said before, one of the main ideas behind learning objects is their capability to reuse the same content in a variety of educational settings and contexts. When defining the conceptual and instructional objects, we are interested in the content of the learning object – what kind of information (basic and supplementary, respectively) it deals with. How to combine these objects depends on the information provided by the didactic objects:

- Learning Goals and Objectives: establish what the learners are expected to know after exploring the concepts and the related activities specified in the learning object.
- Sequence: specifies the precedence order among conceptual and instructional objects.

The LOM's Educational category does not specify any characteristic related to the goals and objectives of the learning object. The internal order in which concepts and instructional elements should be explored is not described as well. In terms of precedence order, the LOM's Relation category defines some characteristics to describe the relationships between learning objects. However, these relationships are specified in general terms, not dealing with the internal sequence among the learning object components.

### 3.4. Metadata

The specification of the other characteristics of a learning object follows the LOM's descriptions, but in a more simplified manner, dealing with some of the categories and characteristics defined by the standard [10]:

- General category: specifies the general information that describes the learning object as a whole. Characteristics: *Title, Language, Description, Keyword*.
- Life Cycle category: describes the history and the current state of the learning object and those entities that have affected the learning object during its evolution. Characteristics: *Version, Status, Contribute*.
- Technical category: describes the technical requirements and characteristics of the learning object. Characteristics: *Location, Requirement, Installation Remarks, Other Platform Requirements*.
- Rights category: describes the intellectual property rights and conditions of use for the learning object. Characteristics: *Cost, Copyright and Other Restrictions*.

## 4. Conclusions and Further Work

In this work we analyzed learning objects under three related perspectives – conceptual, instructional and didactic. The fundamental idea is that a learning object correspond to small units of instructionally sound content (represented by instructional objects), based on a learning objective or outcome (defined by didactic objects), intended to teach focused concepts (corresponding to conceptual objects).

We also investigated the impact of the conceptual, instructional and didactic perspectives on the IEEE's standard for Learning Object Metadata (LOM). In short, based on these perspectives, we identified some additional characteristics that can be considered into the scope of the LOM's Educational category.

As a further work, we intend to specify a set of learning objects, structured in terms of conceptual, instructional and didactic objects, for dealing with the Software Testing knowledge domain. The additional characteristics here identified should also be considered in the development of these objects.

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