

**Proceedings
of the
9th European Conference
on e-Learning**

Instituto Superior de Engenharia do
Porto
Portugal
4-5 November 2010

Volume One

Edited by
Paula Escudeiro
Instituto Superior de Engenharia do Porto
Portugal

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Papers have been double-blind peer reviewed before final submission to the conference. Initially, paper abstracts were read and selected by the conference panel for submission as possible papers for the conference.

Many thanks to the reviewers who helped ensure the quality of the full papers.

These Conference Proceedings have been submitted to the Thomson ISI for indexing.

Further copies of this book can be purchased from <http://academic-conferences.org/2-proceedings.htm>

ISBN: 978-1-906638-82-5 Book

Published by Academic Publishing Limited
Reading
UK
44-118-972-4148
www.academic-publishing.org

About The Nature And The Identity Of Learning Objects

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Abstract: Web 2.0 applications have made large amounts of educational resources available for public sharing and reuse. However various problems emerge as a result of this proliferation of materials, such as their increasingly difficult management. In this context, semantic technologies seem to offer great opportunities for teachers, learners and instructional designers to retrieve and share learning objects (LO). Ontologies and semantic mark-up represent the core of knowledge network on the semantic web. Actually, although the term “ontology” (deriving from philosophy) has become very common in computer science, it was often adopted without perusing the original meaning and the analytical tools that philosophers offer to support ontologically well-founded analysis. In the recent years, different “semantic educational projects” have been proposed aiming to develop ontology-based LO repositories. These latter represent an interesting framework for supporting learning processes; they are usually based on the development of ontologies aiming at representing the knowledge domain, as well as technical and pedagogical LO features. However, from a literature analysis, LO ontologies appear frequently to be designed more on the basis of the pragmatic convenience of the specific application frame and the developers’ personal intuition than on an ontological analysis. The main disadvantage of this approach is the development of inconsistent models which cannot support logical reasoning processes and cannot be easily reused in a different context from that in which they have been designed. This study takes an approach developed in the “applied ontologies” field, which implies the adoption of an interdisciplinary method aiming at developing well-founded ontologies that can be applied in specific application contexts. More specifically the authors’ proposal is based on DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) as theoretical reference framework; it is a foundational ontology, developed at the Laboratory for Applied Ontology (LOA) of the Italian National Research Council (CNR), describing very general conceptual primitives. Therefore this study offers a preliminary analysis about the nature and the identity of learning objects in order to support the formulation of an ontological LO definition, which should be provided before any LO ontology engineering process.

Keywords: learning objects, ontologies, semantic web, e-learning

1. Introduction

The contemporaneous evolution of the World Wide Web, web 2.0 applications and educational technologies has made large amounts of learning resources available for public sharing and reuse. As a matter of fact, the number of educational contents which is nowadays available online is rapidly growing, but some problems emerge as a result of this proliferation of materials, such as their increasingly difficult management and accessibility. For this reason new models are required to support the process of instructional content management, based on environments and tools enabling users to build, represent and share their knowledge.

The application of semantic technologies (Berners Lee et al. 2001) in this context seems to offer great opportunities for teachers, learners and instructional designers in order to reach these goals. Ontologies and semantic mark-up represent the core of knowledge network on the semantic web. Actually, the term “ontology” derives from philosophy and its meaning is nowadays widely debated among philosophers (Poli 2009); according to Aristotle, it can be defined as the “*theory of being qua being*” (and it is related to the study of the nature of being as well as the basic categories of being and their relations). This term is nowadays quite common in computer science too. One of the most cited definitions in this domain has been provided by Gruber (2009): “*an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse (...) The representational primitives are typically classes, attributes, and relationships. The definitions of the representational primitives include information about their meaning and constraints on their logically consistent application*”. However the term has been often adopted in this context without perusing the original meaning and the analytical tools that philosophers offer to support ontologically well-founded analysis.

While much attention has been devoted to develop semantic-based LOs systems and architectures, not the same has been dedicated to understand the underlying fundamental concepts and relationships in order to formalize a LO theory. This problem emerges in various “semantic educational” projects, for example related to the development of ontology-based LO repositories.

These latter represent an interesting framework for supporting learning processes, they are usually based on the development of ontologies aiming at representing the knowledge domain, as well as technical and pedagogical LOs features. However, from a literature analysis, LOs ontologies appear frequently to be designed more on the basis of the pragmatic convenience of the specific application frame and the developers' personal intuition than on an ontological analysis. The main disadvantage of this approach is the development of inconsistent models which cannot support logical reasoning processes and cannot be easily reused in a different context from that in which they have been designed.

This study takes an approach developed in the "applied ontologies" field, which implies the adoption of an interdisciplinary method aiming at developing well-founded ontologies that can be applied in specific application contexts. More specifically the authors' proposal is based on DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) as theoretical reference framework (Masolo et al 2002); it is a foundational ontology, developed at the Laboratory for Applied Ontology (LOA) of the Italian National Research Council (CNR), describing very general conceptual primitives. Therefore this study offers a preliminary analysis about the nature and the identity of learning objects in order to support the formulation of an ontological LO definition, which should be provided before any LOs ontology engineering process. It is part of a more extensive and ambitious project which will be carried out in different stages: (a) formulation of a LO ontological definition; (b) classification of LO entities (development of a taxonomy and the related vocabulary); (c) development of a meronomical theory of LOs; (d) development of a primary formal LOs ontology.

2. The theoretical framework

According to Husserl, a first distinction can be made between "formal ontology" and "material ontology". The former is descriptive and involves analytic a priori judgments (Poli 1993); it is related to the study of formal categories (for instance set, part and whole, relation, and so on), since they characterize the form of an entity regardless of its material realization. The latter involves synthetic a priori judgments (Poli, 1993) and investigates how these general forms are filled out "materially" in different entities types; and it could be differentiated in various "regional ontologies" aiming to analyze the ontological organization of different circumscribed domains of entities (Bottani e Davies 2007).

A second distinction can be made between "formal ontologies" and "foundational ontologies" which represent a specialization/extension of the former by means of "*relations and properties that, even though they refer to material domains, have a vital role for ontological analysis*" (Masolo et al. 2003). Foundational ontologies, far from regarding only theoretical speculation, provide interesting perspectives and relevant tools in the analysis of specific knowledge domains ("domain ontologies") (Borgo and Leitão 2004).

As previously said, this work is based on DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) as theoretical reference framework. It is an ontology of particulars, whose root element is *Particular*. The distinction between *universals* and *particulars* is probably one of the most debated topics in the history of philosophy. According to Neuhaus et al. (2004) a universal is "*an entity with a spatiotemporal existence which is yet distinct from its extension (the set of its instances) at any given time*", for example The Scream is a paint because he instantiates the universal *paint*; therefore particulars are entities which cannot have instances while universals are entities that can have instances (Masolo et al., 2002). In order to briefly introduce DOLCE, the authors will refer to documents developed in the context of the WonderWeb Project and in particular to Masolo et al. (2002). DOLCE provides a limited set of categories (organized in a taxonomy), relations, axioms, definitions and theorems (see Figure 1).

It is founded on a basic distinction between *endurants* and *perdurants*. Conforming to OntoClean (a methodology developed at the same LOA-CNR with the goal of supporting the analysis and validation process of the ontological adequacy of taxonomic relationships), these categories are considered as rigid properties: "*a property is rigid if it is essential (and then true in every possible world) to all its possible instances, for example the property being a human is typically rigid because every human is necessarily so*" (Guarino and Welty 2004). Endurants (continuants) are entities which are always wholly present (every their parts are present) when they are present, such as a book; perdurants (occurrents) are entities which are always partially present when they are present, because some of their parts are in the past and some in the future, such as a process or an event like a lesson (Masolo et al. 2002).

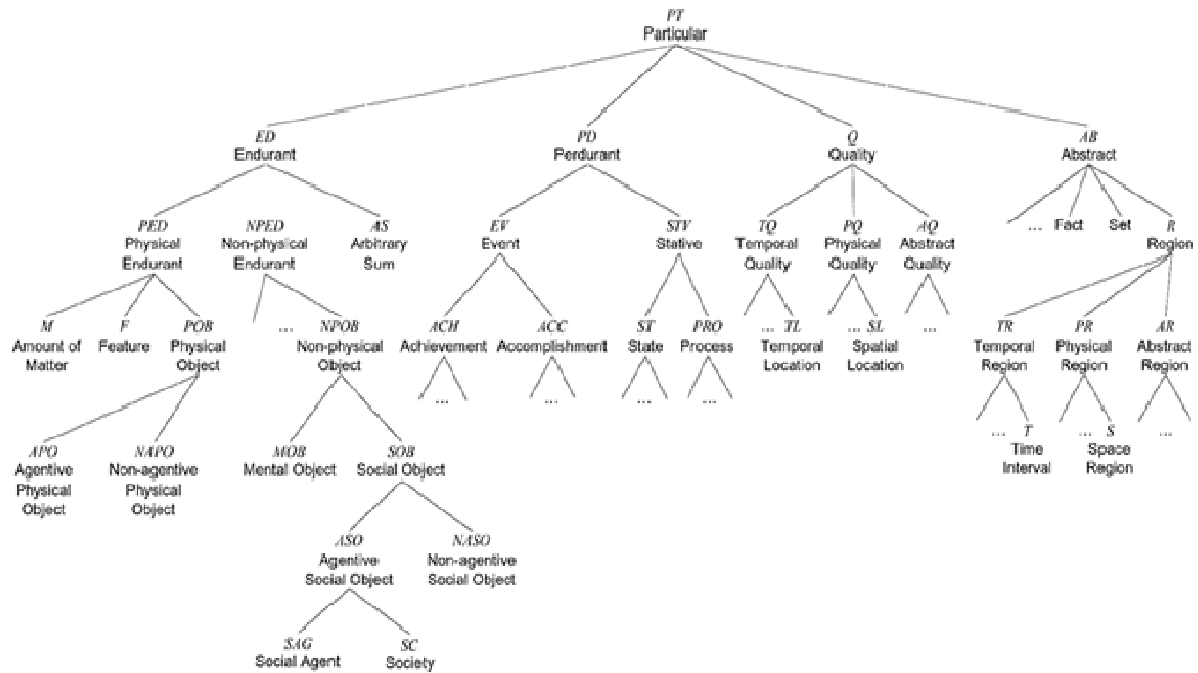


Figure 1: The DOLCE basic categories (from Masolo et al. 2002).

Within endurants it is possible to identify *physical endurants*, *non-physical endurants* and *arbitrary sums* (these latter will not be introduced here because are not relevant at this time). The distinction between physical endurants and non-physical endurants is founded on the identification of direct spatial qualities. In fact, it is possible to distinguish two kinds of quality inherence: direct and indirect. Perdurants seems to have a clear temporal location, but their spatial location appears to derive from the spatial location of their participants; vice-versa endurants seems to have a specific and well-defined spatial location, but their temporal location appears to derive from that of perdurants they participate in (Masolo et al. 2002).

The physical endurants category comprises *amount of matter*, *object*, and *feature* (a categorization based on the concept of *unity* which refers to the possibility of identifying every parts of an entity by means of a unifying relationship). Amount of matter identifies endurants without unity (such as “copper”); object identifies endurants with unity (such as “book”); and finally feature identifies “*parasitic entities*”, generally depending on physical objects which host them (such as a “whole of a glass”) (Masolo et al. 2002). After this brief description of the theoretical framework, in the following section the most cited LO definitions will be discussed.

3. Analysis of the most cited learning object definitions

McGreal (2004) in his study on LO definitions highlighted that there are five types of definitions most used: (i) anything and everything; (ii) anything digital, whether it has an educational purpose or not; (iii) anything that has an educational purpose; (iv) only digital objects that have a formal educational purpose; (v) only digital objects that are marked in a specific way for educational purposes. Actually, wondering about the real meaning of the term “learning object” might seem a little anachronistic, given that a great number of definitions has been proposed by different authors in the course of time. An explicit and shared LO definition should be established nowadays, nevertheless such result does not emerge from a literature analysis and ,as Wiley highlighted, “*the proliferation of definitions for the term ‘learning object’ makes communication confusing and difficult*” (Wiley, 2000).

Let’s consider now some of the most common LO definitions cited in the literature. The following is taken from the collaborative encyclopedia Wikipedia: “*a resource, usually digital and web-based, that can be used and re-used to support learning*”. This definition has been proposed here because it might represent the common intended meaning of LO (since the collaborative nature of the reference), even if we grant for the sake of argument that Wikipedia’s LO definition represents really its common intended meaning. It seems to suitably convey the identity of a LO, nevertheless it entails some critical issues. The term “*resource*” is so ambiguous (it is a very common term with various meanings) and in the proposed definition it is specified only referring to “*resources*” which “*can be*

used and re-used to support learning". As a consequence a pen, a teacher, a scholastic gym equipment could be defined as LO? Actually the definition also specifies that a LO is "*usually digital and web-based*", but the term "*usually*" is by nature undetermined and, according to it, non-digital resources can also be considered LO because "*usually*" does not permit to exclude this possibility. Finally, while "*digital*" is a term that can be precisely defined, the term "*web-based*" is not so clear. What does mean that "a resource is based on the web"? It means that it can be viewed only by a web browser, or that it is shared or developed by web technologies?

Probably the most cited LO definitions are those given by the IEEE Learning Technology Standards Committee (LTSC) and David Wiley. The former is: "*any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning*" (IEEE LTSC). It appears as one of the most ambiguous LO definitions; in accordance with it, anything (an animal, a pen, a person, an event, a concept, ...), existing or not, can be considered as learning object. For instance, the following idea "*Camille Claudel was a French sculptor and graphic artist*" could be considered as LO because it is a non-digital entity which can be referenced in the course of a web-lesson (an infinite number of examples can be made to disclose the IEEE's definition ontological inadequacy).

The latter was provided by Wiley (2000): "*any digital resource that can be reused to support learning*". It narrows the IEEE's definition to consider only digital resources; moreover it replaces the expression "*which can be used, re-used or referenced during technology supported learning*" with "*that can be reused to support learning*". Therefore, according to it, it is not enough that a resource is used during a technology supported learning process, but it should explicitly support it. In Wiley's opinion, such a definition is sufficiently narrow to identify a homogeneous set of things and, at the same time, broad enough to include the huge number of information available on the Internet. Moreover, Wiley deems that his definition captures, as well as the IEEE's one, the most relevant LO attributes (being a digital resource, the reusability, the relation with learning process).

While the IEEE's definition allows to consider any idea a LO, the Wiley's definition has as a consequence that a schoolbook can not be classified among learning objects because it is not digital. And what about the *reusability*? This feature is an essential element in the aforementioned definitions, but it is not explained at a semantic level.

In the course of the time, many others definitions have been proposed, such as "*the smallest independent structural experience that contains an objective, a learning activity and an assessment*" (L'Allier 1997); "*small units of learning, typically ranging from 2 minutes to 15 minutes*" with the following features: self-contained, reusable, that can be aggregated and tagged with metadata (Chitwood et al. 2000). In addition to them, various other terms have been used to refer to an object-oriented approach to computer-assisted instruction, such as the followings: "*knowledge objects*" (Merrill, Li and Jones, 1991); "*pedagogical documents*" (ARIADNE, 2000); "*online learning materials*" (MERLOT, 2000); "*reusable learning objects*" as "*web-based interactive chunks of e-learning designed to explain a stand-alone learning objective*" (RLO-CETL). Each of these definitions, even if they probably capture adequately the common intended meaning of learning objects, does not appear ontologically well founded.

Moreover, novel architectures and frameworks for ontology-based educational repositories have been investigated and proposed in recent years; however, only few works seem to be based on a formal ontological approach to representing and annotating LOs. In 2005, Sicilia et al. (2005), starting from the previously cited research of McGreal (2004), proposed an ontological schema as a tool for research on achieving flexibility in learning objects description and underlined that different conceptions of learning objects necessarily lead to different ontological characterizations of them.

In our opinion, it is worth noting that most of the works propose interesting technological solutions to the problem of ontology-driven content retrieval in the specific field of educational repositories. But, in order to produce a better solution, they need some simplified assumptions on the LO "nature", reducing de facto a LO to the SCORM SCO definition. This simplified framework has the direct advantage of imposing a strict characterization of LO and of metadata application profiles, but there is an evident lack of semantic expressiveness from a foundational point of view.

4. What are really learning objects?

According to an established school of thought, Barry Smith (2006) identifies philosophical ontology essentially as *descriptive ontology*, aiming not at explaining but rather at describing reality in terms of a classification of entities. However, in order to describe an entity it is firstly necessary to unambiguously define such a entity; and this is the main purpose of this study: to disambiguate the LO meaning in order to propose a primitive well-founded ontological definition of LO.

Our initial hypothesis is that learning objects can be considered as “*material objects*” (used here as synonymous with “*physical objects*”, as defined in DOLCE). In order to corroborate it, we should firstly investigate the nature of physical objects. Actually, it is worth noting that there are different philosophical perspectives on this issue (Varzi, 2007). In accordance with the common sense, physical objects may be defined as entities that (i) are material and then can be sensed (for example, we can touch and weigh this pen); (ii) are particular entities and then have a specific and unique spatial and temporal location (this pen is here now and cannot be at the same time in other places); and finally (iii) are variously qualified and then they have different properties which can change (this pen is red and has a specific length that can change in the time) (Varzi, 2007). However it’s clear that the common sense intuition is not enough to support our thought, but it can only assumed as starting point.

Regarding the first point, Markosian (2000) highlights that there are serious difficulties with this perspective (that he names the “*sensational account of physical objects*”), mainly because what can be sensed greatly varies from subject to subject (an entity might be sensed and then considered as physical object by a certain animal, but not sensed and then considered as non-physical object by a particular human). This result is certainly undesirable, if a well-founded definition is needed, because it depends on a relativistic concept.

Referring to the conception of physical objects as objects with various properties which can change in the time, it can certainly be considered suitably in a common sense-based perspective, but not adequately if a formal conception is required, because these properties, in conformity with the previously mentioned theoretical framework, are universal entities that can be treated independently from material objects hosting them. As a consequence the essence of physical objects can be investigated regardless of their properties.

With reference to the conception of physical objects as entities which have a specific and unique spatial and temporal location, it seems to be a more consistent criterion (furthermore it appears similar to the Hobbes’ idea: “*a body is that, which having no dependence on our thought, is coincident or coextended with some part of space*”). This conception differs a little from that of physical objects described in DOLCE, according to which, if we understand correctly, physical objects are featured by, besides being always wholly present (when they are present), direct spatial qualities, while their temporal location derives from the that of perdurants they participate in.

Based on this reasoning, we will assume that learning objects are physical objects because they have a unique spatial location (and, on the other hand, according to DOLCE, they cannot be treated as perdurants or qualities or abstracts). Probably no one would doubt the physical nature of a schoolbook, but what about a digital LO, such as a SCORM LO (Shareable Content Object Reference Model) (ADL, 2006)? Digital objects, like web-pages or digital images, are a particular kind of entity with which classical philosophers have not been obviously concerned. If we consider learning objects as physical objects due to their unique spatial location, we should wonder about the spatial location of digital objects in order to establish if they can be treated as material objects or not. For that matter, it stands to reason that a SCORM object cannot be leaned on a desk as can be done with a book, neither it is possible to take and put it on the breast pocket of the jacket as can be done with a pen; and yet a digital object seems to have a spatial location like to that of the other material objects. Simply the spatial location of a digital object is not the traditional three-dimensional space, but the memory space of electronic storage media.

If a SCORM object of x kB is stored into the memory space of an electronic storage medium, it will take up a certain space; this can be demonstrated by a decrease (equal to x kB) in the memory space available. Referring to the unique spatial location, it is true that SCORM objects, as well as any other digital objects, can be endlessly copied and stored in the same form into different storage media (in

the same manner other material entities, such as books, can be reproduced in many identical copies). As a matter of fact, each of these objects is a different object, whose content is the same of the original copy, but physically different. To demonstrate this, it is possible to store two copies of a SCORM object into the computer memory and verify that the space, measured in kB, occupied by them is equal to the double of the space occupied by a single copy (furthermore the two LOs will have a different spatial location identifiable by means of their memory addresses. Based on this reasoning (only briefly summarized here), we will assume that learning objects (digital and not digital) are “a kind of physical objects” (as defined in DOLCE).

But a LO is not obviously a simple material object, and then what makes a LO (for example a schoolbook) different from other material objects (like “simple” books)? Every LO, in our opinion and according to some of the previous cited definitions (“a resource [...] that can be used and re-used to support learning”; “any digital resource that can be reused to support learning”; “the smallest independent structural experience that contains an objective”; “web-based interactive chunks of e-learning designed to explain a stand-alone learning objective”), is designed and developed (for example by a teacher or an instructional designer) with a certain educational intention, in other words it is created in order to support users to reach some learning objective. This feature is proposed here as an essential property of learning objects (we cannot imagine a LO which does not have a learning purpose), every LO has necessarily a learning objective. Therefore a schoolbook, an educational game, a SCORM object, a didactic software are all good examples of LOs, but what about the school gym equipment or a pen or a drawing book? These latter are all physical objects which can be used during learning process, but are not necessarily designed in order to support users to reach some learning objective, for example a pen can be used during a learning process (like to learn to write) but it is not properly a LO according our definition, because it is not explicitly designed with the aim of supporting users to reach some learning objective.

With reference to the aforementioned definitions, how to avoid the paradox of considering a simple idea and a teacher as LOs? The former cannot be classified as LO merely because it is not a physical object, while the latter requires a more detailed explanation. According to the Oxford English Dictionary, a teacher is “one who or that which teaches or instructs; an instructor (...); one whose function is to give instruction, esp. in a school”, but conforming to DOLCE, a teacher is not properly a physical object because “being a teacher” is not a rigid property, but rather it is only one of the roles that a human (which is the physical object, but is not “created” with a educational intention) plays for a certain period of time. In conclusion, according to this perspective, a LO can be ontologically defined as “any physical object which is purposively designed and developed in order to support learners to reach at least one learning objective”.

5. Conclusions

In this study an ontological analysis of LOs nature and identity has been proposed. It is part of a more extensive research project aimed at developing a well-founded LOs ontology. It stands to reason that this is a preliminary work and different issues need to be addressed, such as the potential social nature and identity of LOs; the problem of the change in the time of LOs; the possibility of applying the concept of agentive or not-agentive object (as defined in DOLCE) to LOs; the different states that a LO can assume in the time and their significance for LOs’ identity; and the ontological nature of digital objects.

However the development of an ontological definition of LO is essential for the next stages which will be mainly focused on a primitive classification of LO entities (by means of the design of a taxonomy and the related vocabulary) and the development of a mereological theory of LOs.

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