Peer Reviewed Papers

The ontological identity of learning objects: an analysis proposal

Alessandra Gattino[1], Gianni Vercelli[2], Giuliano Vivanet[2]

[1] I.T.S. Gastaldi-Abba, Genoa - profgattino_a@yahoo.it

[2] DIST - University of Genoa - {gianni.vercelli, giuliano.vivanet}@unige.it

Keywords: learning object, ontology, semantic web, digital libraries, e-learning

Abstract

In the recent years, several semantic-based educational projects have been carried out, focusing on improving content retrieval within digital object repositories. Usually these projects are founded on the use of ontologies and semantic markup to represent the knowledge domain, as well as technical and pedagogical content features.

However, from a literature analysis, learning objects (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 a rigorous ontological analysis. This approach has as main disadvantage the development of incongruous models which cannot support logical reasoning processes and cannot be easily reused in a different context from that in which they have been designed.

Therefore a preliminary analysis on the ontological identity of learning objects is here proposed in order to support the formulation of a well-founded LO definition, which should be provided before any LO ontology engineering process.

1 Introduction

In the last years, we have witnessed the development of different semantic-based projects aimed at creating educational digital repositories. These projects are usually based on the use of ontological schemes or other types of controlled vocabularies and semantic markup languages for resources indexing (representing the knowledge domain, as well as technical and pedagogical LO features, such as the instructional strategy, users profile, pedagogical objectives, and so on). The focus of ontology-based systems are the enhanced performances of content retrieval functions by means of improved (semantically speaking) precision of results with a significant reduction of retrieval time.

However, there are two main critical situations related to these projects: the first one is a problem of "internal consistency", while the second one is a problem of "external consistency". Each of them has been caused by the fact that ontologies are often designed more on the basis of the pragmatic convenience of the specific application frame and the developers' personal intuition than on a precise ontological analysis.

In the first case (internal consistency) the foremost disadvantage is represented by incoherent models, not rigorous, and not able to support logical reasoning processes. In the second one (external consistency) disadvantages are represented by the fact that (i) these models cannot be re-used in different contexts from those in which they are originally designed; (ii) different repositories and their content retrieval systems cannot interoperate due to the lack of a common terminological and syntactic structure. It is the problem of "the tower of Babel" of databases (Ferraris, 2008) and it is originated by the fact that, for example, the same keywords are used with various meanings or, alternatively, different keywords are adopted to represent the same meaning.

Given this context, a preliminary analysis will be here proposed on the identity and nature of instructional resources in order to provide a well-founded ontological definition of learning objects, without which any LOs ontology development process could be affected by the previous mentioned internal and external consistency problems.

This study is part of a more extensive project which will be carried out in the following different stages in order to develop a formal theory of LOs: (a) formulation of a LO ontological definition; (b) classification of LO entities (development of a taxonomy and the related vocabulary); (c) development of a mereological theory of LOs; (d) elaboration of a primitive formal LOs ontology.

2 Reference framework

The term "ontology" derives from philosophy and its meaning is nowadays widely debated among philosophers (Poli, 2009). Conforming to the traditional aristotelic conception, the Ontology is related to the study of the nature of being as well as the basic categories of being and their relations. The 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, "ontology" was often adopted in the scientific literature without perusing the original meaning and the analytical tools that philosophers offer to support well-founded ontological analysis.

With reference to our objectives, a first distinction can be made between "formal ontology" and "foundational ontologies". The former is intended as a descriptive ontology aiming at studying formal categories regardless of their material realization (Poli, 1993); the latter represents 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).

The theoretical reference framework of this study is mainly based on DOLCE, Descriptive Ontology for Linguistic and Cognitive Engineering, a foundational ontology of particulars developed at the Laboratory for Applied Ontology (LOA) of the Italian National Research Council (CNR). The distinction between universals and particulars is probably one of the most debated topic in the history of philosophy; briefly we can say that particulars are entities which cannot have instances while universals are entities that can have instances (Masolo *et al.*, 2002). The DOLCE's taxonomic scheme is based on the primitive distinction between endurants and perdurants. According to OntoClean (a methodology developed at the same LOA-CNR with the aim of evaluating the ontological adequacy of taxonomic relationships), these categories are intended as rigid properties (Guarino & Welty, 2004):

«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»

Endurants are entities which are always wholly present (every their parts are present) when they are present, such as a book; perdurants 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 lesson (Masolo *et al.*, 2002).

Within endurants it is possible to identify the following sub-categories: physical endurants, non-physical endurants and arbitrary sums (these latter will not be introduced here because are not relevant for our purposes). The distinction between physical endurants and non-physical endurants is founded on the identification of direct spatial qualities, the main feature of the former is their specific spatial location (Probst & Espeter, 2006). On the basis of the concept of unity, intended as the possibility of identifying every parts of an entity by means of a unifying relationship, the physical endurants category is in turn splitted into amounts of matter (endurants without unity, such as "copper"); object (endurants with unity, such as a "book"); and finally feature ("parasitic entities", usually depending on physical objects which host them, such as a "whole of a glass") (Masolo *et al.*, 2002). The reference framework briefly discussed here (for further information, see the bibliographic references) has been adopted in this study to support the analysis of ontological identity of learning objects.

3 The undetermined nature of LOs

The expression "learning object" is one of the most cited in the e-learning literature (more than 300.000 occurrences in Google's index). However, this term is not cited within relevant terminological reference sources, such as the Oxford English Dictionary, the Merriam-Webster Dictionary, or the WordReference website. Moreover, despite its diffusion, it appears that there is not a shared agreement about its meaning. About this problem, McGreal (2004), in his study on LOs 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 purpose»

This vagueness clearly emerges if we take into consideration some of the most cited definitions in literature. The free encyclopedia Wikipedia proposes the following: "a resource, usually digital and web-based, that can be used and re-used to support learning". It seems to suitably convey the common intended meaning of a LO; nevertheless if a well-founded ontological definition

is required, it entails some critical issues. Its vagueness is mainly originated by the adoption of some ambiguous words. For example, "resource" is a very common term with various meanings and is here specified only referring to "resources" which "can be used and re-used to support learning" (and then even a teacher or a notebook could be justifiably deemed as a LO); the word "usually" is by nature undetermined (according to it, non digital resources could be considered as LOs); the meaning of "web based" is not clear (it may be intended as a resource that can be viewed only by a web browser, or that it is shared or developed by web technologies, etc.).

The similar vagueness characterizes one of the most widespread definition in the literature, that proposed by the IEEE Learning Technology Standards Committee: "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (IEEE, 2002). Conforming to it, anything, existent or not in the world, can be considered as a LO; for example a simple idea, because it is a non digital entity which can be referred in the course of a technology-based learning process, should be considered, in this unrestricted and wired definition, as a LO.

Also the well-known definition suggested by Wiley (2000) is characterized by a certain level of ambiguity: "any digital resource that can be reused to support learning". It, compared to the aforementioned one, states that only a reusable digital resource supporting a learning process can be considered to be a LO. However, once more, some doubts remain about the exact meaning of the definition: "digital resource" is not a clear concept and the same, could be applied to "reusability" (that is a very relevant element of the proposed definition). Moreover, it is worth noting that while the IEEE's definition allows to consider a simple idea to be a LO, according to the Wiley's one, a schoolbook can not classified among learning objects because it is not digital.

Many others definitions have been proposed and various terms have been used to refer to LOs, such as "knowledge objects" (Merrill *et al.*,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); but all these do not appear to be suitable to support a well founded ontological analysis.

Nevertheless, it is interesting to note that in the last years some researches have been carried out with the aim of investigating the LO's domain from a formal ontological perspective, for example the study conducted by Sicilia et al. (2005), starting from the previously cited research of McGreal (2004), proposed an original ontological schema as an investigating tool for learning objects description, underlining that different LOs conceptions necessarily lead to different ontological characterizations of them.

4 About the ontological identity of learning objects

What are learning objects? Are they physical, abstract or social entities? Is it possible to find a common ontological statute for entities that are different from each other, such as a schoolbook, a SCORM object, an educational toy, an instructional software? As already underlined, LOs semantic repositories are usually based on the use of ontologies for indexing and facilitating the instructional materials retrieval. However, it should be clear that a shared and unambiguous LO definition is required in order to identify a LO and distinguish it from a "not-LO", and to select which features should be, or not, represented into a LOs ontology.

Our initial hypothesis is based on the identification of learning objects as "physical objects", as defined in DOLCE. According to Varzi (2007), there are different features that in common sense are associated to physical objects, such as (i) to be perceptible to the senses (for example, it is possible to touch and to sniff a flower); (ii) to have a specific and unique spatial and temporal location (as an instance, this phone is on this desk at this moment and cannot be at the same time in other place); and finally (iii) to have some properties that can be change in the course of the time ("this is a blue, 12 cm tall pencil") (Varzi, 2007).

Regarding the first point, the sensorial perception of physical objects appears to be a weak identification criterion because perceptive capacities varies from subject to subject, therefore 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 (Markosian, 2000). Referring to the conception of physical objects as entities with various properties, it is not a suitable criterion 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 objects hosting them.

The spatial location appears to be a more consistent criterion, according with the DOLCE's conception (that seems very similar to the Hobbes' idea, according to which "a body is that, which having no dependence on our thought, is coincident or coextended with some part of space"). Taking into account this hypothesis, we can consider learning objects as physical objects due to their specific spatial location (and, on the other hand, in accordance with DOLCE, we cannot consider them as perdurants, qualities or abstracts). Nevertheless, if it is true that no one probably doubt that a schoolbook has a physical nature, what about digital LOs, as for example SCORM (Shareable Content Object Reference Model) objects (ADL, 2006)?

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 physical objects or not. It is clear that a SCORM object cannot be leaned on a desk or put on the breast pocket of the jacket as can be done with a pen; and yet it seems to have a proper spatial location, simply this latter does not refer to the traditional three-dimensional space, but to the memory space of electronic storage media.

As is well known, a computer represents data using a binary numeral system. A SCORM object, such as any digital object with an XML-binding scheme, can be converted into a generic string of bits and managed by any computer whose storage space is great enough to contain its binary representation. Moreover, this latter can be identified (and then localized) by means of its memory address. The spatial location of a digital objects would be also demonstrated by the fact that if we store a X kB SCORM object into an electronic storage medium, it will take up a certain space which can be determined by the decrease (equal to X kB) in the memory space available.

Furthermore any digital object can be endlessly copied and stored in the same form into different storage media, but each copy, whose content is the same of the original, is a different object (as the copies of a book); that is can be empirically demonstrated, once more, by the fact that storing two copies of the same LO into a computer, the space memory occupied by them will be equal to the double of the space occupied by a single copy (and each of them will be identifiable by means of a different memory address). Based on this reasoning (only briefly summarized here), we will assume that learning objects (digital and not digital) are physical objects, although we know that arguments in favour of the physical nature of digital objects are not so solid as those related to traditional physical objects, as a rock or a book.

But a LO is not obviously a simple physical object. Each 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 with a certain educational intention, in other words it is created in order to support someone to reach some learning objective. This feature is proposed here as an essential property of learning objects, considering that a LO has necessarily a learning objective.

As a consequence, a schoolbook, an educational toy, a SCORM object, an instructional software should be considered as LOs. At the same time, the school gym equipment, a pen or a drawing book cannot be deemed as LOs because none of them is specifically developed with the aim of supporting someone to reach a specific learning goal, although they are physical objects that can be also used in the context of learning processes.

Therefore, despite at the moment these entities cannot be represented into our LO current ontology, they will be taken into account in our future work aiming at a more complete ontological representation of different types of learning processes, into which these and other entities should be enclosed (such as instructional tools, roles, conceptual contents, etc.).

Moreover, the LO ontological definition here proposed allows to avoid some paradoxical conclusions, according to which a simple idea or a teacher should be considered as LOs. In fact each of them cannot be classified as LOs because they are not physical objects. The former is not a physical object because it does not have a spatial location, while the latter because, according to DOLCE, "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 someone to reach at least one learning objective".

5 Conclusions

This study on the ontological identity of learning objects, proposed in order to support the formulation of a well-founded LO definition, certainly needs further developments and some deeper analysis; it seems to be interesting to reflect on the theory of documents and the pertinence of studies on social objects proposed by Ferraris (2008) with our research domain. Moreover, the problem of the spatial location of digital objects into distributed architectures, such as those typical of peer-to-peer systems, will be investigated with the aim of analyzing the applicability of this criterion in contexts where the spatial distribution of bits is not characterized by unity (in the sense of contiguous spatial location).

The reflections that we are working out will influence the future directions of this research, whose next objective is the design of a primitive LOs taxonomy. For this purpose, a preliminary critical study on existent taxonomies, metadata schemes and international standards, such as the IEEE Learning Object Metadata (IEEE, 2002) and the Dublin Core Education Application Profile (DCMI, 2006), will be carried out in order to evaluate their ontological adequacy. This step will be based, consistently with the previous mentioned theoretical framework, on OntoClean, a methodology developed at the same LOA-CNR to support the evaluation of the ontological adequacy of taxonomical relationships.

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