

An Ontological Approach to the specification of Semantics for Learning Content. The convergence of knowledge management and technology enhanced learning

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Abstract

The PhD Thesis is concentrating in the convergence of knowledge management and technology enhanced learning towards the effectiveness in the design and exploitation of learning content. The main emphasis is paid to the modelling of the learning content development process and through ontological considerations the thesis contributes in theory and practice as follows: It proposes a Life Cycle model and nine learning processes that formulate the integrated Learning Content Development Framework. The key innovation is the justification and testing of 21 categories of semantics that enrich the learning content in each stage of the Framework and address critical problem of the Learning Objects Paradigm. The practical implications of the thesis are significant since through its propositions provides new insights in the way we build “effective” technology enhanced learning and knowledge management systems. In fact the ultimate outcome is that we cannot consider e-learning without the support of advanced semantics that provide value layers to content, in three categories: Knowledge Management Support, Learning Exploitation and Learning Processes Support. In the last year the key outcomes of the thesis are extended through an intensive application of Semantic Web Concepts and Technologies.

1. Introduction

Mizoguchi (1995) summarized the merits of ontology as following: Ontology provides a common vocabulary, and an explication of what has been often left implicit. According to Mizoguchi, the systematization of knowledge and the standardization constitutes the backbone of knowledge within a knowledge-based system. He also pointed out that a meta-model functionality specifies the concepts and relations among them, which are used as the main building blocks.

Ontology engineering has contributed several interesting aspects to modelling. Usually research on ontologies focuses on upper-level i.e. the equivalent of the meta-level in modeling. Maedche and Staab (2001) stressed that ontologies could be

considered as “metadata schemas providing a controlled vocabulary of concepts”.

An interesting clarification of the philosophical term ontology is provided by Guarino and Giaretta (1995). They summarized several common definitions of ontology and they tried to elaborate further the main consideration that ontology is a specification of a conceptualization:

- A philosophical discipline
- An informal conceptual system
- A formal semantic account
- A specification of a “conceptualization”
- As a representation of a conceptual system via a logical theory
 - characterized by specific formal properties
 - characterized only by its specific purposes
- As the vocabulary used by a logical theory
- As a (meta-level) specification of a logical theory

The above clarification sets the background for discussing ontologies in the context of e-learning. In the course of developing ontology for e-learning we can gain significant wisdom if we try to understand the deeper meanings of its definition.

An ontology as an informal conceptual system in the context of e-learning means that we admit the presence of an (unspecified) conceptual system, which we may assume to underlie a particular knowledge base. This is the common hypothesis in e-learning implementations. Without systematic analysis of the relevant key issues we confront an e-learning system as a knowledge carrier that utilizes a hidden conceptual system which links and integrates several actors, variables and relationships.

Ontology as a formal semantic account

An ontology as a formal semantic account means that we have analysed the phenomenon of e-learning and we have concluded several semantic elements that formulate a value layer capable of exploiting knowledge sources semantically. The major problem concerning this interpretation of ontology is the complexity of e-learning. The combination of learning and technology requires an extensive analysis of required technological

components for the promotion of specific learning objectives. The most common definition of ontology is the specification of conceptualization. The precise meaning of such a definition depends on the understanding of the terms specification and conceptualization. Concerning e-learning, this specification implies a holistic approach to the several critical issues that affect performance. The conceptualization means that reality is reached through revealing causal relations. Entities are distinguished, relations are drawn and several axioms define logic.

The next clarification, which considers ontology as the representation of a conceptual system via a logical theory is quite interesting for e-learning since a theory is a conceptualization of the reality that permits the development of socio-technical systems, according to the guidelines that are derived from the axioms and theorems of the logic. For example let us assume that the phenomenon of e-learning can be described via a logical theory. Then if we admit that a number of specific formal properties characterize learning resources then an enormous effort is required for their specification.

Ontology as a representation of a conceptual theory via a logical theory implies that the level of specification is directly related to the combination of theorems and axioms. So a critical question concerning the enrichment of this logical theory is how we prove the truth of a theorem or how we can expand the basic logical theory by justifying new logical propositions. Research methodologies in general can be followed in order to support research hypothesis, but as it stands for the real world basic axioms have to be taken for self-evident in order to start the building of a constructive learning theory. A slightly different clarification considers ontology as the vocabulary used by a logical theory. This differentiation focuses on logical definitions and clarifications of terms using an agreed syntax. Development of standards requires enormous effort on the specification of a vocabulary but undoubtedly vocabularies and logical theory are just the two sides of the same coin.

For example consider the case where the logical theory that supports our ontology for e-learning assumes axiomatic that a number of e-learning processes facilitate the value diffusion of learning objects. Then we have to use specific definitions for each process that is not only declarative, but also syntactic by using logical operands.

Every time we need to analyse an aspect of reality, several levels of abstractions can be used. A common approach is to set an upper level or a

meta-level where the emphasis of the analysis is on the specific object and the main logics.

To this end, we tried to set a context for ontological exploitation. In the next section we will elaborate further the main explanations provided in the introduction. The overall objective is to concentrate on practical aspects on how to build an ontology according to the main facets of clarification that Guarino and Giaretta contributed.

2. Towards an Ontology for Technology Enhanced Learning

Several researchers have tried to justify a scientific way for developing ontologies. (Perez and Benjamins 1999) propose design criteria and a set of principles that have been proved useful in the development of ontologies: Clarity and Objectivity, Completeness, maximum monotonic extensibility, Minimal ontological commitments, Ontological Distinction Principle, Diversification of hierarchies, modularity, minimization of the semantic distance and standardization of names. These principles according to (Perez and Benjamins 1999) provide general guidelines for the development of an ontology, which consists of Concepts, Relations, functions/processes, axioms and instances. The ontology building process is a craft rather than engineering activity (Gruber 1995). In this next section we will present the craft approach for the development of ontology for e-learning. Our scope is not to illustrate exhaustively the several aspects of this process but to set a context for further exploitation. The conceptual and the technological character of ontology are balanced and a combination of conceptualizations, formalizations and technological specifications in XML are provided. The initial scepticism of the need to clarify ontology for e-learning derives its origin to the numerous approaches for e-learning. The diversification of approaches and our involvement in several e-learning projects had convince us that in e-learning puzzle there is a need to propose a holistic approach for integrating several conceptual and technological aspects.

The first phase in our approach deals with some primitive specifications. Our involvement in several e-learning projects formulated a deep belief that several principles are self-evident even though specific research approaches could support their justification. The three primitive specifications refer to learning objects, learning processes and learning scenarios. So a learning object is defined as a value integrator of learners' needs, knowledge, motivation elements, problem solving capacity team synergy, packaging features and other learner-centric value ingredients.

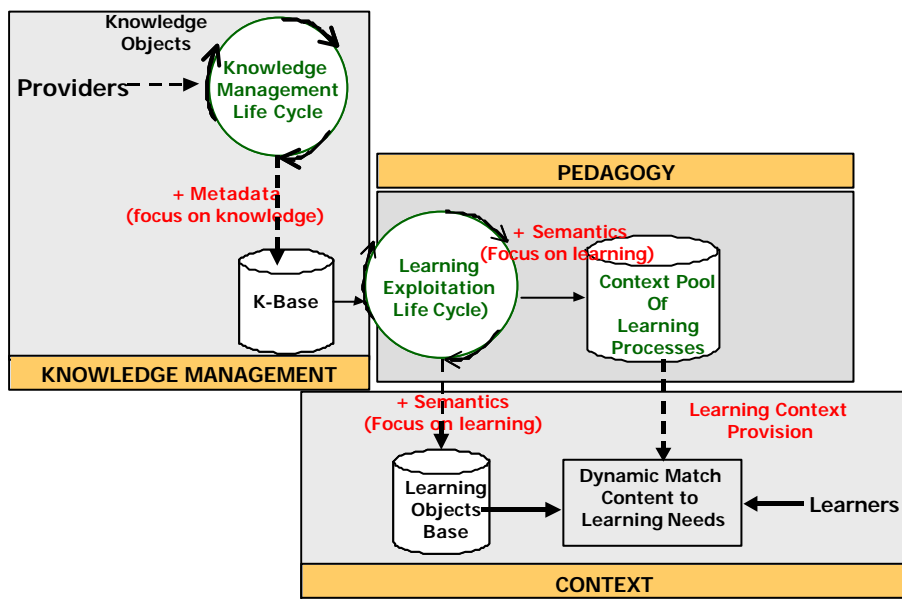
Additionally for each learning object there are several learning processes, which can be applied, and reveal the embedded value ingredients of the learning object. Finally the primitive specifications recognize that a combination of several learning processes provides a learning scenario, a mode of interaction between learners and learning objects.

The second phase of the ontology development refers to an informal conceptualization of the main issues that enlighten the phenomenon of e-learning. According to our conceptualization the e-learning phenomenon is mainly characterized from a content development process. Several knowledge resources are evaluated and through a constructive process and a hidden transformation mechanism are transformed to learning objects. This process is realized in two stages. A general knowledge management life cycle where knowledge artifacts are selected and organized and a learning exploitation life cycle where specific knowledge artifacts are enriched in order to get exploitable learning value (Lytras, Pouloudi and Poulymenakou 2002a).

2002b). The whole conceptualization underlies on an interactive learning scene, where a dynamic learning scenario is dynamically formulated integrating several learning process that correspond to specific learning objects which combine several knowledge artifacts and other value ingredients.

In phases A,B,C the focus of the development process of ontology is mainly on the clarification of conceptualizations without paying attention to technological issues. The specified logic is to this end descriptive implying several technological considerations that require formal descriptions (Lytras et al. 2002c).

By identified that formalization has to be concentrated on semantics that are applicable to a learning object according to three value layers of enrichment then the next step in the development of the ontology for e-learning is to enlighten further the specification. From this perspective the specification of the semantics for each exploitation layer provides a formal semantic account. The detailed definition of each semantic element provides the extended vocabulary.

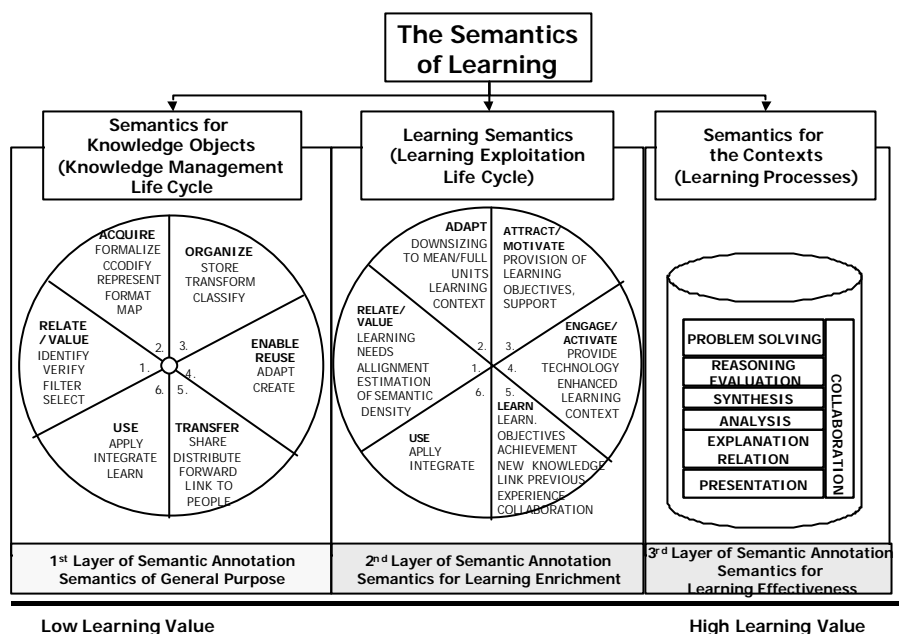


In Phase C, the specification of the conceptualization provides a richer picture. Through extensive research both empirical and bibliographical the two major transformations indicated in phase B, are specified in more detail. The knowledge management literature is supporting the first cycle while learning theories and analysis of three case studies provides the 6 stages of the second cycle. One more level of analysis is indicated. In an e-learning environment learning processes provide the interface and the value carrier for learners (Lytras, Pouloudi and Poulymenakou

The level of formalization influences directly the capability of an ontology to be machine-readable. In the case of our approach this aspect of ontology is of critical importance. The development of dynamic e-learning systems capable to adapt on a learning value basis require technological specifications. Several XML-oriented languages have been developed and used for the presentation of ontologies. In our approach we selected RDF and currently we develop an extensive RDF vocabulary

and a Java based platform for the realization of the ontology as an adaptive e-learning system.

and “personalization” be realized through applied technologies?



2. The Open Research Agenda of Semantic (E-) Learning

Over the last few years, Semantic Web approaches to e-learning have emerged as a new value proposition (Sampson et al, 2004). A rapidly growing research community is conducting research, experimenting and exploiting the developments of the Semantic Web. Although this research is producing important results, several open questions remain from a semantics perspective of the learning domain:

- Which are the implicit, formal and powerful semantics of the learning domain?
- How do we apply automatic and semi-automatic methods to enrich content with the required semantics in order to expand the learning potential of dispersed content?
- How can we embed pedagogical strategies into formalizations through semantics?
- How can the metadata-imperative of learning objects and learning designs be transformed into semantic-enabled multi-context approaches?
- Which are the tools that bring new insights and delivery methods for learning content from a Semantic Web perspective? In other words, how can the tricky words and lofty visions of “adaptability”, “interoperability”

- How do we convince, learners, teachers and other non-technocratic communities of the usefulness of the new generation of learning tools?

- What is the lifecycle of learning content, and how do we integrate its supply and demand perspectives?
- How can intelligent agents and knowledge/learning portals exploit the Semantic Web capabilities towards a better match of learning needs and learning resources?
- How can we apply rules and logic at an upper layer of learning content, in order to diversify the underlying logic of content exploitation?
- And the most important question of all: How do we apply leading-edge learning research in our daily learning life?

The emerging semantic learning research agenda requires a number of ontological agreements for the learning domain. This step is critical in order to exploit the synergies of the various scientific communities involved. In our humble opinion, there is a significant knowledge gap in understanding how technology-oriented researchers can expand the value contribution of pedagogues. The bridging of these two worlds requires open standards and community-aware campaigns for the specification of requirements.

Another critical objective for the semantic learning research community is to provide transparent tools and services for the citizens/learners at every level of formal and informal education, for diverse kinds of scenarios (Sicilia and Lytras, 2005). This transparency is critical in order to overcome the knowledge deficit of the mediators, i.e., the teachers, in the use of emerging technologies. Several times we take for granted that the high-level research propositions that are transformed to advanced frameworks and tools are also usable by the average learner. But this is definitely wrong. So the relevant debate on how to promote technology enhanced learning in the context of everyday use - and not only in experiments or lab assignments - requires down-to-earth practices. If we evaluate the “learning objects era” of the current decade from a teacher’s perspective, then the outcomes are rather disappointing. We have developed theories, standards and guidelines, but unfortunately we haven’t brought learning objects in touch with the everyday learning community. If you ask or explain to a teacher in primary schools or in secondary education what a learning object is about, then the average reaction is not the expected.

So this is what Semantic E-learning is all about: To provide a transparent upper layer for the educational domain, which focuses on the learner, aiming to use learning needs and personal characteristics as input to the manipulating mechanisms of content distribution. Naeve (2005) provides a memorandum on the need to further promote the vision of a Human Semantic Web. The strict emphasis on justifying and promoting the Semantic Web as a machine-understandable data primer requires a reconsideration. Because if we rely on this perspective alone, we lose the high-level conceptual aspects that are characteristic of human-to-human interaction.

From this perspective, the Semantic Learning community needs to exploit the lessons learned in other domains put most important

It seems that such ontological agreements cannot be easily achieved on the spot but it is required a systematic interchange of ideas and demonstrations of how technology activates pedagogy. Moreover, it is our opinion that this cannot be achieved in a top-down manner that forces us to reach consensus, but instead requires a bottom-up approach, such as the conceptual calibration process described in Naeve (2005), where we build ontological bridges between different perspectives by (i) agreeing on what we agree on, (ii) agreeing on what we don’t agree on, and (iii) documenting (i) and (ii) in a way that we agree on.

Moreover, we must see how the roles of teachers or academics are affected by the new requirements of semantic learning. It is obvious that new emerging roles need to be addressed in a way that encourages OPEN learning.

3. The Pitfalls of Semantic ELearning – what SW cannot do for learning

Today, the Internet is universally hailed for its fantastic possibilities to enhance learning. But there might be another side of this coin. We will discuss here an extremely interesting presentation - called *ICT: The Way to Paradise or Hell?* - given at the Online Educa conference in Berlin in December 2005 by Roni Aviram and Nimrod Matan from the Centre for Futurism in Education at the Ben-Gurion University in Israel. According to these educational researchers, there is a need for formation of long-term strategies and policies towards the development of e-learning based on deep and wide analysis of the long-term impact of the Internet on users. If, as McLuhan claimed, “the medium is the message”, then we must take into account that the Internet is:

- *Defining*: It changes our nature, personality, cognition, sociability, even our most basic “physiological” tendencies.
- *All-engulfing*: It relates to all areas of our lives and pertains to most of our waking time, either directly, when we spend time in front of the Internet, or indirectly, by changing, or “internalizing” all aspects of our physical environment.
- *Environment*: It creates (both directly and indirectly) the environment we live and act in, and hence all our practices, and in this way, our very selves.

Moreover, according to Aviram and Matan:

The Internet supports learning by supplying learners with:

- Easy accessibility of updated materials, other learners, experts, teachers.
- Easy authoring of material.
- Easy presentation and distribution of material.
- Individuation and customization of learning processes.
- The facilitation of changes in texts.
- The facilitation of graphic presentations, including 3D.
- The acceleration of feedback.
- The dramatic facilitation of saving, retraction, analysis, and annotation of first level learning

processes, and hence of reflection, or second level learning processes.

- The erosion of differences between process and product: the enhancement of a process-oriented approach.

On the other hand, the Internet threatens learning by:

- Threatening linearity, and hence logical thinking and rationality (= the desire and ability to learn).
- Threatening literacy (in the traditional sense), and hence the ability for abstraction and rationality.
- Threatening depth, and hence curiosity, wonder and rationality.

In our view, these potentially negative aspects of the Internet have been far too little discussed. As with all technological innovations, we tend to take them for granted and focus exclusively on their positive aspects. A prime example of this attitude is television, where a critical debate about its physiological effects on the viewers has been almost completely lacking.¹

So, what can the Semantic Web not do for learning? In addition to the “threatening propositions” of Aviram and Matan listed above on the effects of the Internet in general, we claim that the Semantic Web cannot:

- Discourage knowledge-emulation, which is a disease that seems to be spreading rapidly. In the emerging “knowledge-emulation society”, the important thing is not what you know, but what you can convince other people that you know.
- Increase the motivation for deep and reflective learning. In the information-overloaded, efficiency-obsessed, cut-and-paste environment of today, it is becoming increasingly difficult to find the time (as well as the peace of mind) for the reflection and deep thinking that is crucial for the “magic transmutation” of knowledge into understanding.
- Substitute for our local networks and personal relations that are increasingly neglected as we spend more and more time within our web-based global networks. Today it seems that we are “connecting globally” and “disconnecting locally”.

A notable exception is given by Mander (1978).

4. Synthesizing fantasies / Conclusions

On the first generation of the Internet (which still dominates today), the information is distributed, and anyone can link anything to anything. In fact, this is precisely what has made the Internet such a great success. However, the information about the information (the metadata) is still mostly centralized and resides in databases that are hidden behind portals.

The most important aspect of the Semantic Web is that it allows the information about the information to become as distributed as the information itself. This is possible since, on the SW, every piece of information has a unique identity, and therefore a machine can decide whether or not we are talking about the same thing – even though the machine will never understand what we are talking about.²

This fact has several fundamental consequences, some of which are described in detail in Naeve (2005). They can be summarized in the fact that SW allows a shift from “knowledge push” to “knowledge pull”. Within the field of learning, this enables a shift away from the traditional teacher-centric and curriculum-oriented course perspective, towards a more learner-centric and interest-oriented approach.

As described in Nilsson et al. (2002), metadata is not always objective, but must also allow subjective expressions. Moreover, metadata is not produced once and for all, but is the result of an ongoing annotation process. Hence, on the SW, the distributed quality of metadata makes it possible for learners and teachers to express their experiences with different learning resources (learning objects) so that the user experiences with a certain learning object can be retrieved from the identity of the learning object itself. Such an “experience publication network” represents extremely valuable user-feedback, since these experiences can be aggregated and systematized in a way that highlights quality.³ In fact, from an evolutionary

² Hence, as described in Naeve (2005), the semantics of the expression “Semantic Web” is rather misleading, since it is not a “meaningful web” (for machines) but rather an identity-resolvable web.

³ Such an experience publication network has been implemented in the *Confolio*, which is an electronic portfolio system developed by the KMR-group. Of course, this is useful in many other areas than just learning. In fact it constitutes the essence of a new generation of Customer Relationship Management

perspective, such feedback creates a selection pressure for quality, which lays the foundation for a global, collective production process of learning resources of successively increasing quality. In our opinion, creating such an ecosystem of quality is the most valuable contribution that the Semantic Web can provide for learning, since it can effectively enhance the quality of the global, life-long learning process, and it could also provide enriched approaches to organizational learning.

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