USE OF ONTOLOGIES IN A LEARNING ENVIRONMENT MODEL

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Abstract

A learning environment can be considered as the space where it is possible to manage knowledge or, rather, ignorance, as there is knowledge stored in the environment. What types of knowledge would be useful and necessary in a learning environment? How can this knowledge be formalized? In this article, basic concepts on ontologies are offered, an ontology of knowledge is formulated and a model of a learning environment is presented, based on the management of knowledge and which uses the proposed ontology.

Key Words
Artificial Intelligence, Knowledge, Ontology, University Education, Learning Environment

1. Introduction

Azpiazu and colleagues [1] pointed out that nobody agrees with university as it is now and its benefits. Also, as University arose as an answer to a group of necessities, and because those necessities change with the passing of time, University should advance.

Among the reasons for the deterioration of teaching, Pazos [2] mentions low quality of teaching, widespread and growing disillusion for the traditional classroom and wrong use of available means. Azpiazu and colleagues [1] report that it would be necessary to adapt pedagogy, develop creativity and favour the vision of things from different points of view, boost virtuality and improve the technological support.

In accordance with E. Litwin [3], comprehensive teaching should be favored, favouring development of reflexive processes, and recognition of analogies and contradictions. Also, according to Fainholc [4] discussion should be eased as well as the resolution of problems and the transfer to actual practice and conceptual organization. Thus, education in the frame of this Era of Learning must be adjusted to the new requirements.

This proposal offers a learning environment model to manage knowledge –or ignorance– that allows the student, by accessing different types of knowledge and starting from there, to learn. That is to say, to ease filling the knowledge gap between required knowledge and the student's acquired knowledge.

The model is intended to be applicable to i) any domain of knowledge of intellectual content, ii) to evolving contents, iii) to contain generic teaching strategies that adapt according to the student's behavior and iv) to foment the different learning types. ([5], [3], [6], [7], [8]).

To identify the different types of knowledge in the model, before the fruitless research of an ontology that contains these concepts, it is intended to define one to analyze the knowledge domain, the teacher and the student and to make the supposals explicit. The use of ontologies (and the use of a common language) makes reuse easy and allows opportunities for collaboration, experience reuse and research with appropriate filters.

In the environment model presented, managing of knowledge and use of ontologies are combined, whereas, traditionally in learning environments, both aspects are not linked.

2. Ontologies

Gruber [9] defines ontology like an explicit formal specification of a shared conceptualization. In turn, Uschold and colleagues [10] refer to an ontology as a representation or "account" explicit of (some part of) a conceptualization. Neches and their colleagues [11] indicate that an ontology defines the vocabulary of an area by means of a group of basic terms and relationships among these terms, as well as the rules that combine terms and relationships that enlarge the definitions given in the vocabulary.

Creating an ontology presents the advantage, as Rodríguez-Artacho [12] indicates, that it makes the categorization of the elements and relationships intervening in the knowledge pattern explicit, so that the model can be properly edited, managed and communicated.

Gruber [9] points out, as methodological principles to ontology building, clarity, objectivity, completeness, coherence and maximization of monotonous extension. This last principle implies that new terms, either general or specialized, should be included in the ontology, in such a way that no revision of the existent definitions is required.

The criteria to accept an ontology according to Gutiérrez [13] are primarily theoretical coherence and conformity to experience; but conflicts among these two approaches are settled definitely by a supreme criterion of simplicity.

There are several methodologies to build ontologies, as Fernández [14] refers. Starting from the description of the standard of IEEE 1074-1995 on the process of software development, he establishes that it is possible to apply such standard to the development of ontologies because they are part of the software products. The compared methodologies are, among others: Enterprise Ontology [15], that of Bernaras [16], Methontology [17] and Sensus [18]. The conclusion of his study is that none of the methodologies was completely mature although the most mature turned out to be Methontology [17].

Noy and colleagues [19] suggest a methodology: after enumerating the important terms, the hierarchy of classes is defined, the properties of the classes (attributes or "slots") are defined, the facets of the properties are identified and instances are created.

For Sowa [20] it is possible to distinguish between terminological and formal ontologies. The terminological ones are those in which categories don't need to be totally specified by axioms and definitions. The formal ones tend to be smaller than terminological ones but their axioms and definitions can support complex inferences and calculations.

3. Ontology of knowledge for a learning environment

As Noy and colleagues [19] suggest, it is valuable to review existing ontologies with the aim of reusing. Carrying out the research (among other places, http://www.ksl.stanford.edu/software/ontolingua, www.daml.org/ontologies and www.unspsc.org), up to the moment these lines are written, it was found no ontology for the definition of knowledge to be incorporated in a learning environment model that links or relates the concepts of type of knowledge, student and professor. The only detected exception is the ontology proposed by Rodríguez-Artacho [12], although its work is centered more on a formulation to model the conceptual, didactic, and instructive domains.

After research of many classifications of knowledge, common aspects were found ("shared conceptualization") that may be used in the formulation of an ontology of knowledge. In this way we arrived to:

- *descriptive knowledge:* it is the knowledge with which a situation is described, a concept or an idea. The similar terms that refer to this idea are: **systematic** (Wiig [5]); **explicit** (Nonaka and colleagues [21], Bryan-Kinns and colleagues [22]); **descriptive** (Paradela [23]); **declarative**, (Gómez and colleagues [24], Poggioli [25]); to **know why** (Boyett [26])
- *procedural knowledge:* it is the knowledge required to take an action, procedure or process ahead. Similar ideas are identified with the names of: **pragmatic** (Wiig [5]), **explicit** (Nonaka and colleagues [21]), **operative** (Gómez and colleagues [24]), **procedural** (Poggioli [25]), to **know how** (Boyett [26])
- *heuristic knowledge:* it represents lessons learned, the practical and the heuristic ones. It is related directly with the concept of: **tacit** (Nonaka and colleagues [21]), **heuristic** (Gómez and colleagues [24]), **community** (Bryan - Kinns and colleagues [22]), **strategic** (Poggioli [25])
- *anecdotic knowledge:* it refers to anecdotes, histories and stories linked to a knowledge (Paradela [23])

As Gómez and colleagues [24] point out, the frame formalism is the technique of knowledge representation that is most used in artificial intelligence when knowledge of the domain is organized based on concepts. The frames organize knowledge in trees (also called hierarchies) or in graphs. There are two types of frames: class frames and instance frames. The class frames are used to represent concepts, classes or generic situations described by a group of properties. Examples are the "Person", "Man" or "Woman" frames. In a working domain, elements or instances of classes exist. For example, Patricia, Ismael and Esteban are instanced frames of the Woman and Man classes. The relationships between concepts are represented with relationships between frames, the most common relationships being: subclass of and superclass of, instance and represent, disjointed, not disjointed, fraternal, "ad hoc" or to measure (examples: married-to, divorced-from).

The ontology is presented as elaborated after relating, integrating and unifying presented proposals and concepts. “Person”, “Professor”, “Student” and “Topic” concepts are included. The methodology of Noy and colleagues [19] was followed, for its simplicity. A summarized form is presented in the Diagram 1 Hierarchy. It offers the basic terms and their relationships, like Neches and colleagues suggest [11].

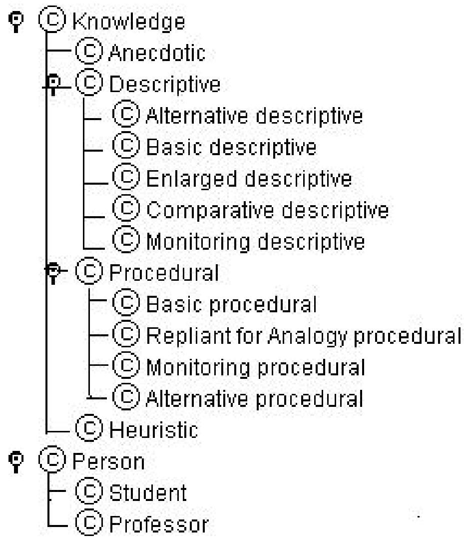

Diagram 1 Hierarchy

Knowledge class represents knowledge itself. The attributes of knowledge are: description, learning strategies [27], importance (fundamental, non fundamental), medium (text, video, sound, multimedia), required level (basic, medium, advanced), professor responsible and topic. This class is sub classified, as already shown and explained, in anecdotic, descriptive, procedural and heuristic.

The *alternative descriptive* knowledge represents the bonds to other versions of the same concept, ideas or situation, the *basic* one represents a first form of descriptive knowledge. In turn, the enlarged descriptive one presents a descriptive knowledge in a general way, the *comparative* descriptive one describes a knowledge as compared with another and that of *monitoring* is an exercise for checking the understanding of a descriptive knowledge.

The *basic procedural* knowledge represents the fundamental procedural knowledge, the *repliant* for analogy is knowledge that may be obtained as a replication of another, by means of analogy; that of *monitoring* is an exercise for checking the understanding or application of a concept, idea or procedure, and the *alternative* one is another form of carrying out a procedure.

The relationships between classes are presented in the Figure 1 Classes and Relationships and Table 1 Relationships. The diagram is offered using notation like UML [28]. Other possible formats are: RDF (Resource Description Framework) [29], OIL (Ontology Inference Layer) [30], DAML+OIL [31] and OWL (Web Ontology Layer) [32].

This ontology could be classified as “terminological”, according to Sowa [20].

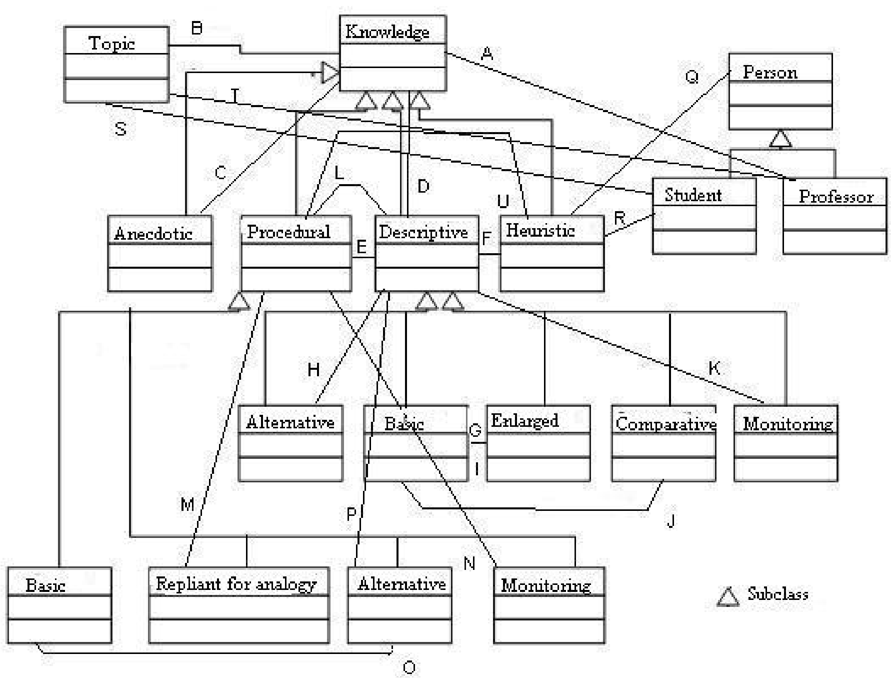

Figure 1 Classes and Relationships

A: Responsible professor	H: Versions	O: Link to basic form
B: Related subject	I: Link to summary	P: Bases
C: Knowledge related	J: Knowledge related	Q: Author
D: Knowledge required or afterwards acquired	K: Knowledge to monitor	R: Student validations
E: Methods of implementation	L: Bases	S: Subjects of interest
F: Suggestions	M: Analogous knowledge	T: Specialization
G: Enlarged knowledge	N: Procedure to monitor	U: Link to procedures

Table 1 Relationships

4. Learning Environment Model

The proposed pattern will consist of:

a) Entity student: it represents the student (apprentice or apprentices' group). It maintains the student's information, their work, binnacle notebook and learning preferences;
b) Entity professor: it represents and maintains the information of the teacher, including their own vision of the knowledge to present;
c) Knowledge Management Module: it contains the knowledge repository, for example: the institutional memory with the best practices, learned lessons, frequent and not frequent questions and the yellow pages;
d) Supervisor process: carries out the intelligent tutorship.

The model is presented schematically in the following illustration (Diagram 2: Architecture of the Pattern)

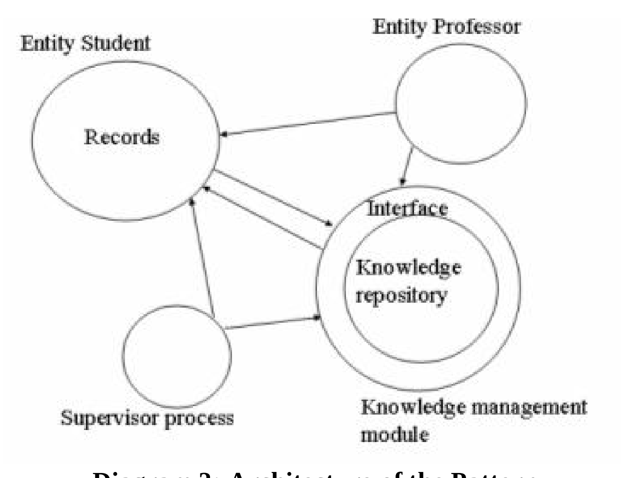

Diagram 2: Architecture of the Pattern

The **entity student** represents a student or a group. When interacting with the environment, through accesses to the knowledge management module, a "portfolio" or "portfolio of works" containing a log of the activities performed and learning preferences is recorded. The entity student can also collaborate in the evaluation of the types of knowledge, to re-classify them as needed and, if necessary, to incorporate learned lessons.

Student data and the history of the followed steps will be kept. This information may be used by the intelligent tutorship.

The **entity professor** will participate and interact directly with the knowledge management module, defining and restructuring it according to the students' use of the environment. When using the environment, the students will be able to indicate their preferences (or they could also be registered by the module supervisor or intelligent tutor). This will allow the professor to adjust the contents of the knowledge management module.

The **Supervisor process** will carry out the intelligent tutorship, observing the user's actions, and suggesting action roads according to the user's preferences. For example, if a student prefers certain types of knowledge, facing new requirements, knowledge of that same type or other alternatives could be offered to him.

The **knowledge management module** will have the knowledge repository as well as an interface to easily "navigate" it. The repository will contain the institutional memory (Heijst and colleagues [33]), composed of the learned lessons, the best practices and the consultations (that include the frequent and not frequent questions with their answers and the specific consultations to discuss with the teacher or in groups), the yellow pages and the knowledge in general. Each element will have describers, such as type of knowledge, to allow searches.

The query system, which includes frequently and not frequently asked questions will have automatic classifiers, as suggested by Azpiazu and colleagues [8]. For instance, re-classify a non frequent question as a frequent one according to the number of queries. This assures that the institutional memory is updated.

The format of the knowledge management module institutional memory is: **Descriptor – Knowledge – Counter**.

The **descriptor** will be one of the following: frequent question, not frequent question, good practice, yellow page, heuristic knowledge, anecdotic knowledge, descriptive knowledge, procedural knowledge.

The **knowledge** refers to an object of the Knowledge class as described in the ontology. Each Knowledge object has already the links to other types of knowledge, according to its subclass.

The **counter** keeps the number of accesses to the record, being increased by one every time it is accessed. This value will be used, for example, to reclassify a non frequent question into a frequent one or to determine the most frequent queried knowledge. This re-classification could be done, for instance, at the beginning of a new term.

The knowledge repository will store, as a start, all the knowledge the professor deems needed. To gather knowledge requirements, knowledge engineering or requirements engineering techniques could be used, such as interviews, protocol analysis and observation, as in Friss de Kereki and colleagues [34].

This architecture would be applied practically to any area of knowledge of intellectual content and where the skills for resolution of problems take an important place. As an example, the model was implemented, applied and evaluated in a basic course of Object Oriented Programming for 1st year students of System Engineering at ORT Uruguay University.

A hierarchy of classes was modeled for the knowledge and a class was used for each type of knowledge. To simplify the teacher's entry of data, instances of knowledge can be uploaded from plain files or from within the system itself.

The following is one possible and simplified case of environment use. The student, who was previously capacitated in knowledge management and problem solving strategies, registers in the system. Now, a list of available topics is offered: for example, "classes", "relationships", "collections". The student chooses "classes" because he recognizes that this topic is new for him. Afterwards, a list of different instances of knowledge about "classes" is displayed, in this case: *basic descriptive knowledge* (the definition or description of the "class" concept) and *basic procedural knowledge* (which describes the procedure to define a class in Java). When he chooses *descriptive*, the definition is presented and also a new list of different knowledge related to the concept "class" appears: *alternative descriptive* (with another definition of the concept), *anecdotic* (which explains the evolution of that concept), *enlarged declarative* (in order to get a detailed description) and *monitoring declarative* (which includes questions and examples about "classes").

In other words, starting from the student's recognition of a lacking knowledge in some topic, or, from the perception of the system itself of this lack, it will be offered what exists in the environment as to the different kinds of knowledge. This puts upon the student the responsibility of knowledge and ignorance management, thus encouraging self-teaching and boosting autonomous and independent work. Moreover, the student will have the institutional memory, wherein answers to frequent questions, knowledge about the best practices and learned lessons may be found and in which new elements can be included so individual skills can be integrated to the group or organization.

Through the experimentation, it was found that the students who used the environment showed a remarkable improvement in the number of ways for solving a problem: they could find, apply and show more ways. Also, those students improved their ability to transfer knowledge.

5. Conclusion

A new learning environments model, based on the administration of knowledge, has been proposed. In order to unify criteria on which knowledge concepts will be represented, it is necessary to define and formalize the different types of knowledge through an ontology.

As a theoretical contribution of this work, the architecture of a learning environment model, based on knowledge management, has been presented. As a methodological contribution, a conceptualization on knowledge type, based on reusable ontologies has also been presented. This ontology is used in the knowledge management module proposed.

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