Sharing and Reusing Information on Web-Based Learning

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Abstract. This paper addresses the use of the Semantic Web in Web-Based Learning. It presents three ontologies created to represent information about: knowledge domains, learning theories, and the students attending the courses. Such ontologies assist on solving Web-Based Learning problems under computational and educational view, because they facilitate the construction and management of adaptive courses, which are based on learning theories. It is important to point out that any ontology was elaborated independently from the knowledge domain. That is why they allow the reuse of components and provide pedagogical support while constructing courses of any knowledge field.

1. Introduction

In the nineties, new technologies were created and others adapted after the integration of the web to distance learning courses. Among them, we can point out the Learning Management Systems, Learning Objects, Intelligent Tutoring Systems and Adaptive Hypermedia Systems. Although the progress obtained in each area is significant, they lack of consolidated results that allow the fusion of their benefits.

This paper explores the use of resources from Semantic Web (SW) (Berners-Lee, Hender and Lassila, 2001), such as ontology and metadata, aiming to solve such problems. These resources allow represent knowledge about the learning contents, instructional strategies and information about students so they can be shared and reused in several courses and systems.

2. Problems on Web-Based Learning

Studies on WBL like the ones presented in Mizoguchi and Bourdeau (2000), Brusilovsky (2003), Koper (2004) and Aroyo and Dicheva (2004), have identified a number of problems, which need to be studied in order to reach better results. The main problems faced by WBL under the computational view are:

1. When constructing new courses or instructional activities, only few materials are reused, making it an expensive and hard task;
2. Ontology is lacking to describe knowledge domains, with the objective to facilitate the reuse of information and the interoperability between systems;
3. For any material to be reused it is necessary to know its location becaue it is not easy to run precise searches in the existing Web;
4. Even though there has already been a few standards to describe other instructional components (i.e. activities and learning objectives), they are still not quite accepted as the standard that describes LO.

From the educational point of view, the problems that stand out are:

5. The majority of authoring tools and of developed systems are not based on instructional and learning sciences;
6. Adaptive and pedagogical techniques are strongly linked to knowledge domain, making it difficult to reuse;

3. Developed Ontology

Ontology developed to describe information used during the construction of courses for WBL are: pedagogical ontology; student ontology and domain ontology.

3.1 Pedagogical Ontology

Pedagogical ontology represents the knowledge about learning process, necessary to solve problems 5, 6 and 7 listed in the previous section. From its information it is possible to help people to build courses' activities, easing students' learning and help them to reach established objectives. Its information derives from proposals of Gagné (1985), Bloom *et. al.* (1956) and Saskatchewan Education (1991).

The classes of pedagogical ontology hold definitions in three aspects of the learning process, as shown on table 1. The three main ones, InstructionalEvents, InstructionalStrategies and CognitiveTaxonomies, do not have straight instances. Their duty is to unite the subclasses which define the information according to an author or specific theory in the learning area. At the moment only one subclass was created for each main one but it will be possible in the future to expand the ontology including new subclasses to represent information according to other learning theories.

3.2 Student Ontology

Student ontology objective is to define the used terms to distinguish the kind of students using WBL systems. Their information is described under two dimensions, the pedagogical and another technical (Figure 1). Properties of *Pedagogical and Technical* classes register the students' characteristics related to both dimensions, being most of their properties based on LOM standard. This way, it is possible to

compare data when selecting LO for a course, aiming to improve the assistance to the student's need.

Through attributes of the *Pedagogical* and *Technical* classes, stereotypes for students are created generating a set of categories at once. As well as creating the stereotype of students and defining their characteristics, it is also possible to determine the knowledge level of students of each pedagogical profile about the concepts regarded in a course, through *knowledgeConcept* property. Each instance of this class has a reference for one of the concepts defined in domain ontology, the indication of students' knowledge level about that concept, and the level they need to achieve once the course is concluded. Definitions of these levels are obtained from the instances of *Cognitive Taxonomies* (pedagogical ontology) subclasses.

Table 1. Pedagogical Ontology Classes and Instances

Class/ Subclass	**Meaning**	**Instances**
Instructional Strategies - Saskatchewan	Instances of this class represent the different instructional strategies that can be used while constructing a course.	Direct Instruction, Indirect Instruction, nteractive Instruction, Experimental Learning and Independent Study
Instructional Events- Gagne Instructional Events	Instances of this class represent instructional events in which the student needs to pass to turn learning more effective.	Gaining Attention, Informing the objective, Recall of Prerequisites, Presenting the Material, Learning Guidance, Eliciting the Performance Providing Feedback, Assessing the Performance and Enhancing Retention and Transfer
Cognitive Taxonomies – Bloom Cognitive Taxonomy	Instances of this class represent a student's knowledge level about a subject and also classify the learning objectives.	None, Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation

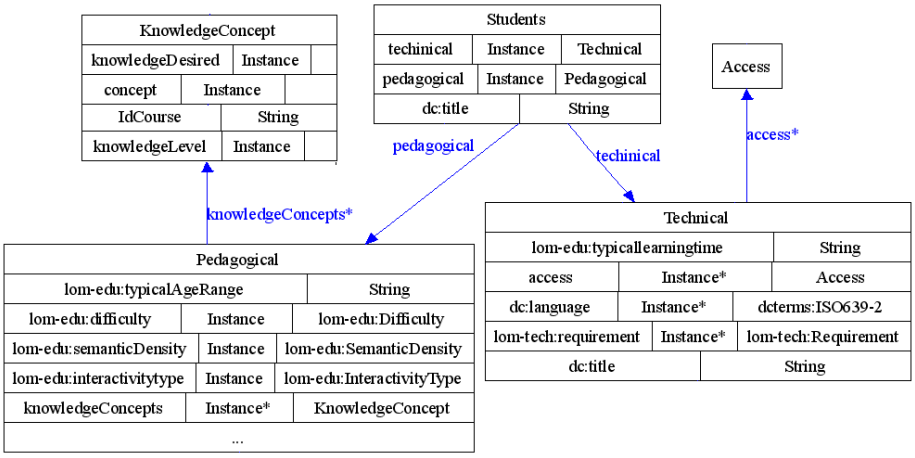

Fig. 1. Classes structure of the student ontology

3.3 Domain Ontology

Instances of *Concept* class represent the concepts of a knowledge domain. Each of them has a name and can be related to other concepts in two ways: as a pre-requisite or as sub-concept, forming the domain's conceptual map. Instances of *LearningObjects* class represent the learning objects used in the course. In addition to *dc:keyword* attribute, that relates it to an instance of the class *Concepts,* there are many more, also defined on standard LOM standard, which describe their technical and pedagogical characteristics.

Learning activities are formed by a group of LO and they constitute the information presented to the user in order to achieve their learning objectives. Each, among others has a property called *instructionalEvent,* that it designates which stages of the instructional process are covered by them. This property associates the instances of *LearningActivities* class to instances of one of the *InstructionalEvents* subclasses defined in the pedagogical ontology. It makes possible to detect inconsistencies on activities structuring, verifying if in a group, they fulfill every stage needed in the instructional process. Learning activities are also associated to one or more learning objectives which indicate the level of knowledge a student should obtain about some concepts after accomplishing them.

Learning activities are joined and displayed in hierarchy to form the different structures of organization and presentation of a course contents. A group of learning activities is represented in the ontology as instance of *Organization* class, which should be related to one of the profiles defined in the student ontology. Finally, the most embracing structure of domain ontology is reached, the *Course* class, the one that represents the course being created as a whole.

4. Discussion and Related Work

A number of work have been published about the use of ontology in the WBL, such as Simic, Gasevic and Devedzic (2003), Henze, Dolog and Nejdl (2004) and Devedzic (2004). However, a strong computational approach is noticed in the suggested solutions. Furthermore, some works like the one presented by Power *et. al.* (2005), allow the reuse in a closed environment. Only the contents created in the system are considered for reusing and the resulting course should be performed in a property system that makes the access difficult for a large amount of people.

In order to minimize these problems, ontologies presented in this paper were created through Protégé in OWL, so that any system can reuse and store new information. Still aiming to facilitate the ontologies acceptance, the choice was to use properties defined in a standard of metadata already existent like LOM.

In a stage further than the ontology development, a system that uses ontology to generate a course described according to SCORM standard was developed, which allows it to be used by students through any LMS with the support of the chosen standard. Results of this work can be seen in Branco Neto (2006).

5. Conclusion

Some problems faced by the community involved with WBL were presented in this paper. Based on this, objectives were suggested which briefly focuses on the application of Semantic *Web* technologies to promote improvement on WBL. This is possible thanks to the developed ontologies which allow the construction of complete adaptive courses or part of them in a quicker and economic manner, through the reuse of instructional components properly described by metadata defined in the ontology. Furthermore, these same ontology propitiate a support based on instructional and learning theories that assist people who elaborate courses to define their objectives, contents and presentation structure, regardless of the knowledge domain.

Several researches can be carried out as a continuation to the one presented in this article. Between them some are pointed out: studies on other instructional and learning theories and its consequent formalization through ontologies; it was emphasized that a system was implemented to generate courses in SCORM standard based on the presented ontologies; however, other systems can be constructed to generate courses in other standard such as IMS Learning Design.

6. References

Aroyo, L., and Dicheva, D. The New Challenges for E-learning: The Educational Semantic Web. *Educational Technology & Society*, Vol 7(4), (2004), 59 – 69.

Berners-Lee, T.; Hendler, J;. e Lassila, O. The Semantic Web. *Scientific American.* (2001).

Bloom, B.S. *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain.* David McKay, New York, (1956).

Branco Neto, W. C. *Web Semântica na Construção de Sistemas de Aprendizagem Adaptativos***.** 2006. Tese (Doutorado em Ciência da Computação) – PPGCC, UFSC, Florianópolis.

Brusilovsky, P., A Distributed Architecture for Adaptive and Intelligent Learning Management Systems. In *Towards Intelligent Learning Management Systems,* Sydney, Austrália. *(*2003).

Devedzic, V., Web Intelligence and Artificial Intelligence in Education. *Educational Technology & Society*, Vol. 7(4), (2004), 29 – 39.

Gagné, R. M. The Conditions of Learning and Theory of Instruction. New York: Holt, Rinehart & Winston. (1985).

Henze, N.; Dolog, P.; Nejdl, W. Reasoning and Ontologies for Personalized E-Learning in the Semantic Web. *Educational Technology & Society*, Vol. 7(4), (2004), 82 – 97.

Koper, R. Use of the Semantic Web to Solve Some Basic Problems in Education: Increase Flexible, Distributed Lifelong Learning, Decrease Teacher's Workload. *Journal of Interactive Media in Education*. Vol. 1 (2004).

Mizoguchi, R. e Bordeau, J. Using Ontological Engineering to Overcome Commom AI-ED Problems. *International Journal of Artificial Intelligence in Education***.** Vol. 11 (2), (2000).

Power, G. *et. al.* Goal Oriented Personalisation with SCORM. In: Proceedings of IEEE International Conference on Advanced Learning Technolgies. Koahsiung (Taiwan), 2005.

Saskatchewan Education. Instructional Models, Strategies, Methods, And Skills In: *Instructional Approaches: A Framework for Professional Practice*. (1991). <http://www.sasklearning.gov.sk.ca/docs/policy/approach/index.html>.

Simic, G.;Gasevic, D; Devedzic, V.Semantic Web and Intelligent Learning Management Systems**.** In: Proceedings of International Workshop on Applications of Semantic Web for E-Learning, Maceió, Brasil, (2004).