AN OWL ONTOLOGY FOR METADATA OF INTERACTIVE LEARNING OBJECTS

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ABSTRACT

The main purpose of this paper is to present the importance of Interactive Learning Objects (ILO) to improve the teaching-learning process by assuring a constant interaction among teachers and students, which in turn, allows students to be constantly supported by the teacher. The paper describes the ontology that defines the ILO available on the Internet. Besides, it shows the implementation of tests conducted on the virtual environment eTutor. Finally, it presents the assessment of the results based on the use of ILO in the subject Introduction to Hardware and Computing taught to 20 students.

KEYWORDS

Learning Objects, Interaction, Ontology, e-Learning, education

1. INTRODUCTION

Thanks to the use of Technologies of Information and Communication (TIC) combined to the Internet, several resources have been providing great support to teachers in the teaching-learning process [6]. Besides, time and location have been eliminated as obstacles in the educational field.

Among the several technological resources, there are the Learning Objects (LO), which are units of learning that exist in order to support the teaching-learning process. Although creating LO is complex due to the absence of user friendly tools of creation [7], they can promote significant progress in the teaching-learning process through TIC [6]. The Learning Objects (LO) help to create knowledge by incorporating features of interaction, adaptation and reutilization in several diferent contexts [24].

All tutoring contents tagged as Learning Objects (LO) should allow access and understanding by both: computers and users. However, they are generally described using language that can only be interpreted by human users. Therefore, to allow them to present meaning both to users and computers, [18] and [2] presented the Semantic Web.

The Semantic Web enables users to create data archives on the Internet, as well as to write the rules to ensure their interoperability. One way of linking these data is through the data model called ontologies [8] [12] [13]. Besides the specification of concepts about domains [12] [20], the ontologies are also applied to improve the machine's learning process and recovery of information [12] [13].

Several authors have pointed out the importance of using the Learning Objects (LO) in the educational context [4] [5] [6] [7] [24] [27]. The goal of this paper is to describe the Learning Objects (LO), which are an extension of the models described by [5], [26] e [27], using an ontology.

With the resources mentioned above, teachers can follow each student's learning curve and make appropriate interventions according to the individuals needs. The developed ILO were implemented on and assessed through the virtual environment eTutor. This paper assesses the ILO's application during the *Introduction to Hardware and Computing* classes attended by 20 students from the Computing Science course.

This paper is organized as follows: section 2 presents the use of ontologies for e-Learning; section 3 mentions the definition of standards for ILO; section 4 shows the ontology that has been created; section 5

discusses and validates (with eTutor support) the ontology offered during classes of the Computing Science course; finally, section 6 shows the conclusion.

2. E-LEARNING ONTOLOGY

The ontologies are contemplated in several fields of Computing Science such as Web information recovery, through online products and services like Ontoweb [10], which is a smart system of agents that work towards the contextualized search on the accessed sources; SEAL [19], which enables the creation of semantic portals based on ontologies; and the OntoSearch [23], which facilitates the reutilization of the ontologies on the Semantic Web.

The paper [9] presents the development of an ontology server that, by using LOM implements an ontology navigation service that dynamically develops HTML pages (including images and textual documentation), which shows the ontology's hierarchy and uses HTML forms to permit users to edit and translate the ontology straight from the LOM's model to the OntoLanguage.

[14] focus his paper on cooperative learning, which utilizes one ontology to form groups focused on individual and group learning goals, roles and instructional learning events.

Considering the models of domain, student, cooperation and pedagogical, [3] defines an ontology to build Interactive Learning Environments in order to answer the questions What, When and Where to study?

To optimize search and the distance learning proccess, [11] has developed a tool based on agents, which is called Web Semantic Search (WebSS). Its main goal is to give conditions for recovering educational contents in the servers of a Learning Management System (LMS) that offers a highly respected and efficient tutoring platform also known as AulaNet.

[17] applies ontologies in order to explicitly characterize the project and the learning objects, as well as the relationship among them. According to the authors, the application of ontologies may result in more efficient semi-automatic tools of extraction, which will , in turn, increase its reuse value. The authors also present a tool based on IMS-LD called Learning Object Context Ontology (LOCO).

Some papers have been adopting ontologies to define learning objects, as presented in [1] which shows an ontology represented through the Web Ontology Language (OwL) [28] to demonstrate the Learning Design semantic (IMS-LD). Meanwhile, [25] describes the ontology as a Web based tool for the development of Learning Units. [25] mentions the use of ontologies to explicitly characterize learning projects, learning objects and the relationship among them.

[22] employs an ontology to represent the Constructivist Learning by being able to identify the competencies and abilities that can be generated by the LO. Besides, they assure the reuse of the objects.

Although the ILO presents the same concepts when compared to the traditionals LO [8], the ILO differenciate from the other proposals due to the fact that their main purpose is to promote interaction among students, teachers and environment.

3. INTERACTIVE LEARNING OBJECTS

Although the relationship of tutoring contents and LO with interaction has been described by [16] when presenting his metodology to build interactive LO, the author wasn't concerned about structuring the construction of the LO by following standards such as LOM or SCORM.

[21] demonstrates one tool of creation for LO that promotes for LO that promotes the interaction between the teacher and the LO, as well as among the student and the objects. However, the author doesn't fulfill the demand presented in this paper, which is to assure the teacher is able to intercede depending on the current learning stage of the student.

A LO must take into consideration several possibilities of interaction: between teacher and student, student and teacher, LO and student, and LO and teacher. [16] has pointed out the importance of the interaction processes in the cooperative learning models, which generates a higher demand for the creation of ILO. This interaction is supported through the use of educational tools such as chat, tips, alerts, messages and appendixes.

In order to fulfill the proposed interaction, the SCORM's metadata standard was adapted. Thus, the compatibility with the traditionals LO was maintained. Among them, those from the interaction class are highlighted. They were created to specify all the educational context of the interaction, from the way it is perceived from the users point of view to how it is offered by the environment.

As soon as an activity starts, the ILO offer options of interaction to the students, such as asking for tips or having a conversation with the teacher through chat. Resources such as attached files (videos, presentations and tutorials) are also available for students while they are using tips.

The ILO assure one interaction that can be automatically turned on. For example, after a certain period of time without interacting with the ILO, the student has the option to receive a tip. At this point, the teacher is warned that the student has reached a certain period of time without interacting, which might indicate some difficulties to move forward. The alerts work based on a color code system that indicates where the student stands regarding his/her use of tips and time spent in the acitivity. The resources are implemented in a Virtual Learning Environment built with this purpose, eTutor.

4. ILO´S ONTOLOGY

The ILO's ontology was made possible by using the language OWL and by considering the principles of Semantic Web. Therefore, the intention was to facilitate the search mechanisms and to provide meaning to the data for the computers' interpretation.

Some important levels in the process of creation and validation of the ontologies are: vocabulary; hierarchy (taxonomy); context (level of application); Syntax Level; Architecture; Design and Structure [12].

The LearningObject class refers to the instances of the objects and it is related to the metadata classes: aggregations and content. The content class wasn't described in this version of the ontology due to the fact that it belongs to the Learning Object's tutoring content.

The LearningObject class represents the instances of objects described along with its metadata. The Content class represents the composition of the LearningObject, which is not included in this version of the ontology. The Vocabulary class encompasses, among the Ontologies and Standards used as reference, those metadata that have fixed values composition and can not be altered beyond those already forecasted. The relationship among the classes follows this format: Metadata hasSubClass General.

Each element of the ontology is described in its formality, containing: class name, URI, Equivalent Class, Disjoint Class and Annotations.

All the 55 elements of metadata were used following the ILO Standard and divided in Data Properties and Object Properties. The first one refers to the simple kind of elements that can be directly related to the metadata. Following, in this case, the model **its** <name metadata>**Is.** The second one fulfills the compound elements as indicated in the Aggregations class and having the structure **has** <name metadata>.

In the Properties model of Objects all the relationships like **has** <name metadata> have an inverse relationship identified as **its**<name metadata>**Of.**

The profile used in the OWL Language was OWL-DL, which is an intermediate version as important as the descriptive logic. Therefore, the profile is less formal than OWL Full and it has followed the specifications of the entire domain without further problems. The current ontology is available at: *<http://www.nogueiraluz.com.br/projetos/ILOv1.owl>*.

The ontology presented in the previous section was implemented at the eTutor's ILO tool and tested by 20 students. The tests were given during the *Introduction to Hardware and Computing* classes from the Computing Science course. Assessments, reading archives, questionnaires, appendixes and tips were among the ILO's activities.

Regarding the tests, initially the students were taught how to use the environment, as well as how to ask for support in case of an intervention. The presentation also included the students' perspective during an activity and the options available such as: tips, appendixes and Chat.

The teacher has put together an ILO in a questionnaire format containing 6 multiple choice questions. Each question contained 3 tips configured accordingly. The tips could either pop up automatically, after a 1 minute interval without the student's interaction with eTutor, or could be asked by the student at any time.

After having finished the activities, the students have received a questionnaire, which the main goal was to map the students' opinion about the interaction with the teacher, follow up and the ILO.

5. DISCUSSION

All participants answered 6 questions after having finished the activities. The questions were meant to assess the ILO. The percentage, as well as the questions are presented in Table 1 and the quantitative assessment and the percentage of answers found are shown too.

Table 1. ILO Assessment questions

Questions	Yes	No	Does not apply
1- Have you ever been in a Virtual Learning Environment before?	15%	85 %	Does not apply
2- Did you feel like the teacher was supporting you ?	85%	15 %	Does not apply
3- Did you ask for tips during activities?	55%	45 %	Does not apply
4- When needed, Did the teacher offer you help and activity follow up?	65%	5%	30%
Questions	**Excellent**	**Great**	**Regular**
5- What is your opinion about interaction during activities?	45%	30%	25%
6- How do you rate eTutor's tool and the Interative Learning Objects?	55%	30%	15%

According to this assessment, 85% rated the ILO as Excellent and Great. Likewise, 75% of the students rated the interaction of activities as being positive. Only 15% of students had already used other LO in Virtual Environment (AVA) before, against 85% who had never accessed an AVA before.

The students who already knew other AVAs, reported that they felt the teachers gave the needed support when using the ILO in the eTutor. They also rated the possibilities of interaction as being Excellent. In this group, 67% of students were giving the support they needed thanks to the help pointed out by the environment.

6. CONCLUSION

The demand for new tools of support to the teaching-learning proccess is evident and has been growing steadily. This paper presented the ILO, which are intended to improve the monitoring of student's learning curve in order to detect their difficulties and apply the solutions accordingly, individually and immediatly. In addition, the teacher can plan the content to be taught according to the students' needs.

Consequently, this paper has defined the ILO ontology that permits the interaction among all participants: teacher and student; student and environment; and environment and teacher. The above mentioned ontology works according to the SCORM standard, as well as to the Semantic Web principles. As a result, it encourages ILO's creation, padronization and sharing.

eTutor was extremely important during the ILO's assessment, once it permited not only the ILO's assessment but also its testings. All the results were positive.

For further investigation and future research, it is highly recommended not only to map the ILO ontology's main classes: Content and LearningObject, but also to apply assessments with the coolaboration of professors from different fields of study.

REFERENCES

[1] Amorim, R. R., Lama, M., Sánchez, E., Riera, A., Vila, X. A., 2006. A Learning Design Ontology based on the IMS Specification. *In Journal of Educational Technology & Society*, Vol. 9, nº 1, pp. 38-57.

[2] Berners-Lee, T., 2002. Bringing the World Wide Web to Its Full Potential by Dieter Fensel (Editor), Wolfgang Wahlster, Henry Lieberman, James Hendler, MIT Press, 2002. Bowman, M., Debray, S. K., and Peterson, L. L. 1993. Reasoning about naming systems. *In ACM Trans. Program. Lang. Syst.* 15, Vol 5 (Nov. 1993), pp. 795-825.

[3] Bittencourt, I., Bezerra, C., Nunes, C., Costa, E., Tadeu, M., Nunes, R., Costa, M., Silva, A. 2006. Ontologia para Construção de Ambientes Interativos de Aprendizagem. *Proceedings of XVII Simpósio Brasileiro de Informática na Educação* (SBIE) – ISSN 2316-6533. UNB/UCB, Brazil.

[4] Campos, F., David, J. M. N., Braga, R., Nery, T., Santos, N., 2012. Rede de Ontologias: apoio semântico a linha de produtos de objetos de aprendizagem. *Proceedings of Anais do XXIII Simpósio Brasileiro de Informática na Educação* (SBIE), ISSN 2316-6533. Rio de Janeiro, Brazil.

[5] Castro, C. V., Satler, M. F., 2010. Modelo Ontológico para la Secuenciación de Objetos de Aprendizaje. *In IEEE-RITA*, Brazil, Vol. 5, Nº 2.

[6] de-la-Fuente-Valentín, L., Pardo, A., Kloss, C. D., 2011. Generic servisse integration in adaptive learning experiences using IMS learning design. *In Computers & Education*. Vol. 57, Issue 1, pp. 1160-1170.

[7] Durand, G., Downes, S., 2009. Toward simple learning design 2.0. *Proceedings of 4th International Conference on Computer Science & Education*. Nanning, China, pp. 894–897.

[8] Gluz, J. C., Vicari, R. M., 2011. Uma Ontologia OWL para Metadados IEEE-LOM, Dublin-Core e OBAA. *Proceedings of XXII Simpósio Brasileiro de Informática na Educação* (SBIE). ISSN: 2176-4301. Aracaju, Brazil.

[9] Gómez-Pérez, A. 1998. Knowledge Sharing and Reuse. *In Handbook of Applied Expert Systems*, pp. 10-11, USA.

[10] Gomez-Perez, A., Manzano-Macho, D. 2003. OntoWeb Deliverable 1.5: A Survey of Ontology Learning Methods and Techniques. *In Universidad Politecnica de Madrid.*

[11] Goñi, J. L., Fernandes, M. C. P., Lucena, C. J. P., 2002. e-Learning e a Web Semântica. *Proceedings of IV Simpósio Internacional de Informática Educativa*. Vigo, Espanha.

[12] Hazman, M., El-Beltagy, S. R., Rafea, A., 2011. A Survey of Ontology Learning Approaches. *In International Journal of Computer Applications*. Vol. 22, Nº 9. ISSN: 0975-8887.

[13] Isotani, S., Bittencourt, I. I., Mizoguchi, R., Costa, E. 2009. Estado da Arte em Web Semântica e Web 2.0: Potencialidades e Tendências da Nova Geração de Ambientes de Ensino na Internet. *In Revista Brasileira de Informática na Educação*, Brazil, Vol. 17, Nº 1.

[14] Isotani, S., Inaba, A., Ikeda, M., Mizoguchi, R. 2009. An Ontology Engineering Approach to the Realization of Theory-Driven Group Formation. *Proceedings of International Journal of Computer-Supported Collaborative Learning*, Vol. 4, Issue 4, pp. 445-478.

[15] Jiang, Y., Wang, X., Zheng, H., 2014. A semantic similarity measure based on information distance for ontology alignment. *In Information Sciences*, Vol. 278, pp. 76-87.

[16] Kemezinski, A, Costa, I. A., Wehrmeister, M. A., Hounsell, M. S. e Vahldick, A., 2012. Metodologia para Construção de Objetos de Aprendizagem Interativos. *Proceedings of XXIII Simpósio Brasileiro de Informática na Educação* (SBIE). Rio de Janeiro, Brazil.

[17] Knight, C., Gasevic, D., Richards, G., 2006. An Ontology-Based Framework for Bridging Learning Design and Learning Content. *In Educational Technology & Society*, Vol. 9, nº 1, pp. 23-37.

[18] Koivunen, M. R., Miller, E. 2001. W3C Semantic Web Activity. In: Semantic Web Kick-off Seminar in Finland, Nov 2. *Available in <http://www.w3.org/2001/12/semweb-fin/w3csw>*. Access in 13/09/2014.

[19] Maedche, A., Maedche, E., Staab, S., Stojanovic, N., Sure, Y., Studer, R., 2001. SEmantic portAL - The SEAL Approach. *In Spinning the Semantic Web*.

[20] Maedche, A., Staab, S., 2001. Ontology Learning for the Semantic Web. *In IEEE Intelligent Systems, Special Issue on the Semantic Web*, Vol. 16, Nº 2.

[21] Marczal, D. e Direne, A. 2012. FARMA: Uma ferramenta de autoria para objetos de aprendizagem de conceitos matemáticos. *Proceedings of Anais do XXIII Simpósio Brasileiro de Informática na Educação* (SBIE). Rio de Janeiro, Brazil.

[22] Miguel, V., López, M. G., Montaño, N., 2008. "Desarrollo de una ontologia para la conceptualización de un ambiente virtual de aprendizaje constructivista". *In AVFT (online)*. Vol. 27, Nº 2, pp. 125-128.

[23] ONTOSEARCH, 2006. Welcome to ontosearch2. *Available in <http://www.ontosearch.org/>*. Access in set/2014.

[24] Rodríguez, V., Ayala, G., 2012. Adaptivity and Adpatability of Learning Object´s Interface. *In International Journal of Computer Applications*. Vol. 37, Nº 1.

[25] Sánchez, E.; Lama, M.; Amorim, R. R.; Negrete, A., 2007. Web LD: a web portal to design IMS LD units of learning. *In Seventh IEEE International Conference on Advanced Learning Technologies*.

[26] Sosnin, P., 2010. Creation and Usage of Project Ontology in Development of Software Intensive Systems. *In Polibits*, vérsion *On-Line*, Nº 42, pp. 51-58.

[27] Vicari, R. M., Bez, M., Silva, J. M. C., Ribeiro, A., Gluz, J. C., Passerino, L., Santos, E., Primo, T., Rossi, L., Bordignon, A., Behar, P., Filho, R., Roesler, V., 2010. Proposta Brasileira de Metadados para Objetos de Aprendizagem Baseados em Agentes (OBAA). *In CINTED-UFRGS – Novas Tecnologias na Educação*, Vol. 8, Nº 2, Julho, 2010.

[28] W3C. 1994. World Wide Web Consortium. *Available in <http://www.w3.org/2002/ws/>*.