Improving Collaborative Learning Processes by Using Structured Information

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Abstract. *It is possible to notice an increasing interest in educational contexts to use a collaborative approach to learning where students are able to interact and share information developing team competences. Furthermore, there is a huge amount of information available on the Web, which could be reused to support learning. But to take full advantage of this potential it is important to have mechanisms supporting semantic interoperability. However, it is difficult to integrate and share information that was developed using different vocabularies and different perspectives. This paper is a contribution to solve this problem and aims at exploring the benefits of using structured information in a collaborative learning approach. In order to structure information it is proposed the use of RDF. An example of providing semantic interoperability according to the proposed approach is presented.*

Keywords: *Collaborative Learning, Learning Objects, Structuring Information*

1. Introduction

The collaborative learning approach has caught attention over the last years, influenced by the need of today's society to have workers capable to solve problems and take decisions as a team. On the other hand, there is an increasing number of worldwide content available on the Web, which could be used to support this process. However, this explosion of information not only implies on using systems that require new skills for accessing, organizing and retrieving it, but also implies on structuring the information, mainly considering the growing need of sharing information and makes it understandable. In this context, it has been observed a movement towards representing learning content through Learning Objects (LOs): "an entity, digital or non-digital, which can be used for learning, education and training" [IEEE LTSC 2002].

Although this definition is too broad, usually LOs are considered reusable content units. However, they are still complex units, usually corresponding to multimedia files and their respective metadata. Therefore, the work presented in this paper focuses on small portions of digital LOs, obtained through a segmentation process

– which comprises to segmenting a LO in small portions, according to a user's need or interest [Oliveira et al 2008a]. Once created and properly described, segments could be reused in learning approaches. So, instead of reusing a whole LO, the segmentation makes it possible to reuse specific parts of its content, which are appropriated to a particular need. This segmentation approach was evaluated and the results were presented at [Oliveira et al 2009a]. With respect to the information structuring, the work presented at [Oliveira et al 2008b] proposes a conceptualization approach (based on using content models) for LOs segments, allowing to explicit the information embedded on LOs, which is important when considering scenarios of information sharing.

The work presented in this paper follows the ideas discussed in [Oliveira et al 2008b] in order to improve the structuring of learning content, focusing on using it in a collaborative learning approach. Particularly, it is considered that a learning process that is executed by a learner can also be useful to others. In fact, according to [Smith and MacGregor 1992], collaborative learning creates the conditions in which learners can build knowledge, for instance, from artefacts created/used by other learners. So, learners could search for LOs, create segments (according to their needs and interests) and share these segments in learning scenarios. In this context, by sharing segments, they could not only absorb new information but also create knowledge as they consider and analyse other learners' assumptions and points of view – which are embedded in the segments.

Although it is important to structure information in order to promote its sharing, the semantic interoperability problem could make difficult this sharing. Actually, insofar as different learners make use of learning segments, different views over these segments could be considered. Therefore, it is observed a heterogeneity regarding to the meaning of these segments. Thus, structured information by itself is not enough to provide the benefits of sharing information. In this context, the work presented in this paper proposes an approach that allows sharing segments considering the need to perform semantic mappings between these segments. It is proposed to use RDF, a general-purpose language for representing information in the Web, for representing content models. RDF not only provides a way to represent information in a standard syntax, but also makes it possible to apply approaches to find correspondences among entities, providing semantic interoperability among different entities. Through RDF vocabularies, it would be possible to comprise categories of a particular content model, which could be used to describe LOs segments. Mappings would be performed over different content models in order to discover the similarities in the meaning of LOs segments.

The remaining of this paper is structured as follows. Section 2 introduces the case study, presenting the results regarding to collaboration approach involving the sharing of LOs segments and the use of content models to structure segments, also discussing the influence of structuring information in a collaborative learning scenario. Section 3 discusses the proposal of using RDF to represent content models. Section 4 presents an example of semantic interoperability – based on a collaborative learning scenario - in which the proposal presented in this paper could be useful. Finally, Section 5 presents the conclusions as well as some future works.

2. Case Study and Its Evaluation

In order to collect data in a case study, a prototype – based on the architecture proposed at [Oliveira et al 2008a] – was used in a class of the "Fundamentals of Information

Systems" Course – in the Federal University of the State of Rio de Janeiro. Twenty-four learners participated of the study and were distributed in eight groups (A, B, C, D, E, F, G and H) - each one with three members. The number of groups and members were defined based on the infrastructure available to carry out the study and the desired investigation scenarios. Twenty-three videos, related to "Strategic Planning" or "Object-Oriented Programming" topics were selected from the Web. These topics were chosen because both of them are subjects of the course. The case study was configured to be performed in four stages. In each one, the groups should execute a specific task. After some of these tasks, evaluation questionnaires were applied.

In order to evaluate the approach for structuring information, it was important that the learners could experience segmenting a LO, by selecting and structuring specific parts of its content. So, the learners executed the segmentation process, but without using any structure that could support it – in other words, without using a content model. So, in the first stage, the groups E, F, G and H created, each one, segments – through the segmentation process. These segments were created using the videos related to the "Strategic Planning" topic. These groups should access the available videos and choose - according to their interest – the ones that would be segmented.

At the same way, thinking of evaluating the approach for structuring information, it was important that the learners could experience the challenge of choosing, grouping and sequencing segments in order to create a new instructional material, which could support the learners in accomplishing the purpose of some educational task. However, the learners should use segments created without the structure provide by a content model. So, in the second stage, groups A, B, C and D created, each one, a presentation related to "Strategic Planning" in video format using the segments created by groups E, F, G and H during the first stage. In addition, during the second stage, groups E, F, G and H shared the segments created during the first stage and analyzed each other's segments. The objective was to verify if the sharing of segments could promote the exchange of ideas as well as allow the development of critical thinking skills while considering different points of view. Then, the experience of sharing learning content using segments created by other learners was evaluated.

In the third stage, the groups E, F, G and H created, each one, segments. However, they used videos related to the "Object-Oriented Programming" topic and used a content model in order to structure the segments. Therefore, these learners could analyze the differences between the segmentation process with and without a content model to complement the description/structuring of the segments. Finally, in the forth stage, the groups A, B, C and D created, each one, a presentation related to "Object-Oriented Programming" in video format using the segments created by the other groups during the third stage (segments structured through a content model). So, it was possible to evaluate if the use of a content model could improve the creation and sharing of segments as well as the creation of the presentations. Moreover, it was also possible to evaluate if the use of a content model could improve the description and understanding of the segments.

2.1. Evaluation of the Interest on the Collaborative Learning Approach

The collaborative learning was evaluated based on the approach of sharing segments. It was analyzed the learners' view on using segments created by other learners for learning

a specific subject. The idea was to verify if there was an interest on behalf of learners in promoting a collaboration environment and if it could promote advantages to learning.

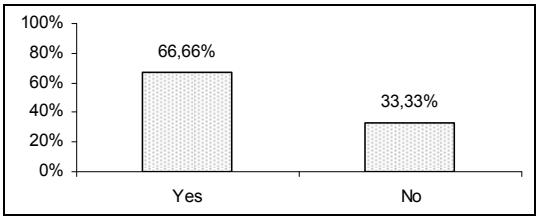

Figure 1. Segments were useful in learning the subject

According to Figure 1, the segments created by colleagues were useful in learning the subject for 66.66% of learners because they provide an overview of the subject. In addition, they explained and exemplified concepts and definitions, facilitating the understanding. However, they did not help learning for 33.33% of learners because their duration was too short to enable a good understanding of the subject. This is understandable because there was a time restriction on the tasks of the case study. According to answers on the questionnaires, all the learners agreed that sharing segments improves the exchange of ideas and it is an interesting approach. In fact, according to the learners, there is a motivation regarding the possibility of considering different points of view by analyzing segments created by others learners. These different segments complemented their understanding on the content as well as enabled looking the same subject according to other perspectives.

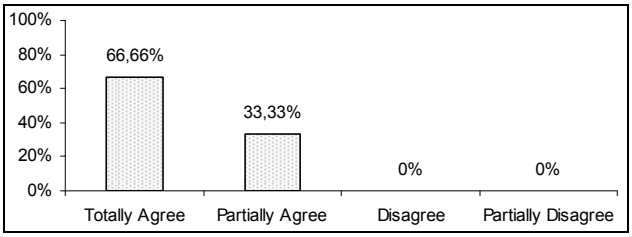

Figure 2. Sharing segments improves critical thinking and noticing different points of view

As presented in Figure 2, most learners (66.66%) totally agreed that sharing segments can be seen as an approach for promoting critical thinking and for considering different points of view. According to the learners, such strategy allows improving the understanding of the subject. A great advantage that was mentioned is the possibility of analyzing information that would not have been taken into account at first but that was brought to consideration by considering the critical thinking provided by other learners. Also, new points of view can be considered, making it possible to review personal opinion. However, for 33.33% of learners, this capability is possible, but depends on how the learning content created for other learners was structured. Therefore, it was possible to conclude that there is dependence between the efficiency of the collaboration process and the learning content being shared.

The collaboration process is an interesting approach, which could promote improvements in learning processes. However, considering an environment where this collaboration is regarding sharing learning content, this work argues that the success of the collaboration depends on how this learning content is well structured. So, if there is

an interest in promoting collaboration between learners through sharing learning content, it is essential to structure this content in order to facilitate its understanding.

2.2. Evaluation of the Structuring of Learning Content

The content structuring was evaluated based on both creation and sharing of segments. The goal was to know the advantages regarding the use of a content model to structure instructional content, mainly considering a collaborative scenario – in other words, whether the collaborative process could be improved by using structured segments.

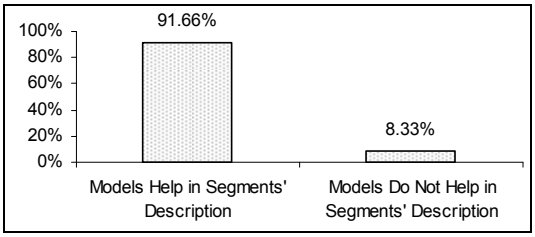

Figure 3. Using content model in segments' description

According to Figure 3, most learners (91.66%) affirmed that using a content model helped in the segments' description, complementing it. In fact, using the model introduces a meaning to the segment, facilitating its understanding. This is particularly important by considering a collaboration environment. Only 8.33% of the learners affirmed that content models did not help in segments description. Particularly, this could be influenced by the content model itself, which could not be totally appropriated to describe the segments according to the students' mental model.

This research argues that the better the understanding regarding the content being shared is, the easier it is its use. So, it is essential to think on the knowledge structure, making it easy to be understood. According to all the learners, it was easier to create the presentation using segments structured by a content model. The learners explained the better the segment's description is, the easier it is to find a more appropriated segment, specific to a particular need or interest, mainly considering using segments structured by others learners. So, there is an improvement in the collaborative process by improving the understanding of the segment being shared. However, although most learners considered useful to use content models to complement the segments description, a considerable portion of these students (37.50%), as shown in Figure 4, considered interesting the possibility of performing the so called categorization, using elements (categories) defined by themselves. On the other hand, 62.50% of them considered the choice to use a pre-defined content model to segments' categorization.

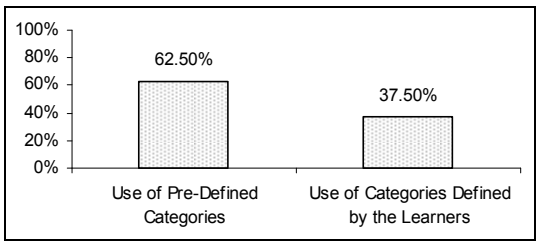

Figure 4. Preference regarding to the categorization of segments

The result presented in Figure 4 regarding to the definition of categories by the learners shows that it is necessary, during the segments' description, to use a model related to the educational context in which the participants are inserted. Otherwise, it is natural that they feel the need to define the segments according to their needs (not fully supported by the pre-defined content model used). It is important to emphasize that the pre-defined content model used during the case study did not aim at being exhaustive regarding to the number of categories.

3. Structuring Information Using RDF

Nowadays, the need to reuse and share information has become an imperative necessity. However, there is a difficulty in integrating information that was developed using different vocabularies and different perspectives on the data. The value of information increases as it becomes accessible to more applications across the entire Internet. Thus, there is a need regarding to provide a standardized way to represent information in a minimally constraining and flexible way.

With regard to this issue, the work described in this paper focuses on RDF (Resource Description Framework), which is a general-purpose language for representing information in the Web. It is particularly intended for representing metadata about Web resources, but it can also be used to represent information about objects that can be identified on the Web, even when they cannot be directly retrieved from the Web. To some extent, RDF is a lightweight ontology language to support interoperability between applications that exchange machine-understandable information on the Web. Moreover, it provides description facilities for knowledge pieces through triples that denote relations between pairs of objects. RDF is currently defined by a set of W3C recommendations [Manola and Miller 2004].

RDF is based on the idea of uniquely identifying things using Web identifiers (called Uniform Resource Identifiers, or URIs), and describing resources in terms of simple properties and property values. Through RDF, it is possible to have a homogeneous representation of information associated with resources identified on the Web. Particularly, RDF triples could be used not only to describe LOs segments, but also to specify relationships among them, which could be useful to promote a navigational exploration through segments. The benefits of this approach could be found in [Siqueira et al 2007] and [Oliveira et al 2008c]. However, RDF allows only solving the standardization description problem, leaving as a challenge to give meaning to a particular description.

While syntax interoperability could be resolved through a RDF description, the semantic interoperability could be resolved through vocabularies defined by the communities interested in describing resources. Each vocabulary - consisting of a set of elements, defined by a particular community addressing resources description - could be identified through a URI that defines it. Particularly, RDF does not stipulate semantics for each community to describe their resources. This lack of expressiveness of RDF was partly eased with the introduction of the RDF Vocabulary Description Language 1.0: RDF Schema (RDF Schema or RDFS) – currently defined by a W3C recommendation [Brickley and Guha 2004] –, which offers primitives to model hierarchies of classes and properties. In other words, it is possible to use RDF Schema to define a set of classes and properties for a document metadata catalogue.

So, the work presented in this paper proposes to represent content models using RDF Schema. In this way, each instructional designer, group of learners or institution could define which terms would be part of each particular content model. Obviously, once defined, a particular content model would be available on the Web and identified through a URI. So, this particular content model could be referenced by users interested in describing segments of LOs using the semantic embedded on it. In fact, a document with RDF description – describing a segment – can reference documents comprising RDF Schemas, importing the vocabularies comprised on them.

Moreover, once structured as RDF Schemas, different content models could be used in a schema matching process. Considering a collaborative scenario where groups of learners promote a sharing of LOs' segments structured through different content models (in this case, each group would have structured the segments using its own model of content), an interoperability problem could appear. In fact, the semantic related to the elements defined in a particular content model could be different from the semantic related to the segments defined in another content model. In this case, a schema matching is required.

Schema matching aims at discovering alignments (also named mappings, correspondences or matches) among semantically similar entities in different schemas. [Hu et al 2008] state that automatic matching algorithms and tools can automate 80% of the work, covering common cases and creating results that are close to correct. However, some manual work is also required. The complete automatic matching is a difficult task, which has been an issue of a lot of researches. In general, some interesting approaches could be considered in solving a matching regarding content models. One of them could be found in [Leme 2009], which – among others things - introduces a matching approach, based on the notion of similarity as well as some variations that explore certain heuristics.

4. An Informal Example of Semantic Interoperability

In order to facilitate understanding the interoperability problem, an example in a learning scenario is presented. Besides, it is discussed how the information structuring - mainly considering the proposal presented in this research - could be useful to, at least, minimize this problem. In this example, two groups are considered: A and B, both interested in creating (each one) segments of LOs, related to the subject "E-Learning" and in promoting a collaborative learning scenario by sharing these segments between each other. In order to structure the segments, it is considered to use content models, created through categories provided by ACM and Wikipedia environments.

Although Wikipedia offers a variety of features, one is particularly important for this example: categorization, which enables pages to be placed in categories – which can be used by readers to find sets of articles on related topics [Wikipedia 2009]. The categories allow easy navigation among connected subject areas via a tree-like structure. So, they could be used by a community in order to create a particular categorization schema - used to describe instructional materials (or, more precisely, segments of LOs). On the other hand, the ACM (Association for Computing Machinery) provides the ACM Computing Classification System [ACM CCS 1998] - a subject classification system for computer science used by the various ACM journals to organize subjects by area. The CCS involves a four-level tree of categories, which could be also considered to create a

categorization schema. Figure 5 presents an overview of categories provided by both ACM and Wikipedia – approximately related to the term “E-Learning”

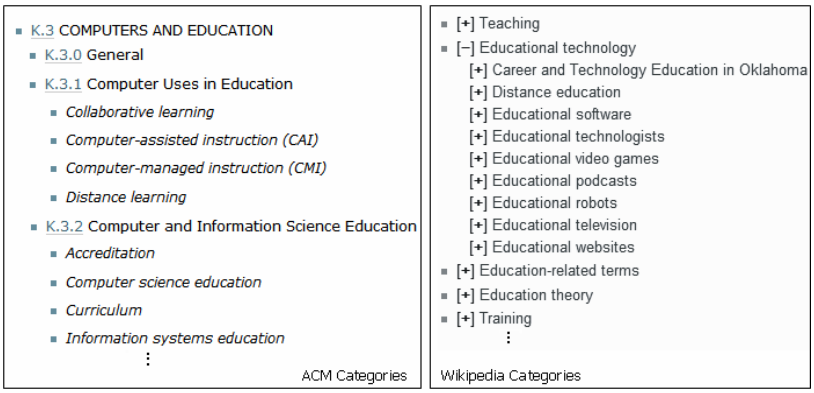

Figure 5. Part of ACM and Wikipedia categories

In the task of this example, group A could structure its segments using a schema created from ACM categories and group B could use a schema obtained from Wikipedia’s categories. Figure 6 presents, as example, part of a RDF schema created using the ACM categories presented in Figure 5.

```
<?xml version="1.0"?>

<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
              ⋮
<rdf:Description rdf:ID="Computer Uses in Education">
  <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
</rdf:Description>

<rdf:Description rdf:ID="horse">
  <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
  <rdfs:subClassOf rdf:resource="#Distance Learning"/>
</rdf:Description>
              ⋮
</rdf:RDF>
```

Figure 6. Part of ACM schema

As observed in Figure 5, both ACM and Wikipedia do not provide categories syntactically similar to “E-Learning”. So, it is necessary to analyze the possible categories, trying to find out the most suitable one to this particular need. Then, using the schema obtained from ACM, one possible category – to be chosen by a learner - related to the subject “E-L earning” could be “Distance Learning”. On the other hand, using the schema created from Wikipedia, one possible category could be “Distance Education”. Notice that they are not the same, but a student could believe they are the most adequate from those available. So, thinking in a scenario where groups A and B share their segments between each other, some considerable problems may appear. In fact, group A, for example, would search for segments from group B according to the terminology it (group A) is used to. In this case, the learners would waste time searching and analyzing segments in order to find those more related to their educational need - same for group B. This could hamper the learning process.

Therefore, it would be necessary to provide a matching between the schemas due to the difference regarding to their terms/categories. In other words, it would be necessary to find semantic correspondences/similarities between the schemas (more

precisely, between their elements), making it simpler for the groups to use segments from each other. So, using some schema matching technique it would be possible to match the terms “Distance Learning” and “Distance Education”. However, it is important to emphasize that, even when a matching does not provide a totally adequate correspondence, this matching could provide an idea of which categories, of a particular content model A, are related (have correspondences) to the categories of other particular content model B. So, from the provided suggestions, a learner could search for the segments which are more suitable to his/her needs.

It is important to consider a standard which allows using an automatic approach to find semantic correspondences among categories of different content models. That is the reason which makes RDF an important issue. In other words, considering available formal and pre-defined sets of categories, it is possible to apply approaches in order to find correspondences among entities comprised in these sets. Moreover, using RDF, any content model available on the Web could be referenced through an URI. This paper does not aim at discussing the various available approaches that could be considered to execute matching between RDF schemas, but it introduces the necessity of structuring information, mainly considering the possibility of sharing it. This is more important by considering a collaborative learning process, where the understanding of shared information is essential for the success of the educational process itself.

5. Conclusions

This paper discussed the importance of structured information considering a collaborative learning process. It was presented a case study where groups of students used a prototype in order to build new content by performing collaborative tasks. Some results obtained from this case study were presented and discussed. These results seem very encouraging as they have reinforced the idea that (i) collaborative learning is an interesting and simple technique that could improve the learning, (ii) the structuring of information is a necessary approach in order to perform collaborative learning scenarios and (iii) the semantic interoperability is a problem which could hamper this process, being necessary using some technique in order to minimize this problem.

It was shown that using RDF Schema is an interesting approach in order to structure content models. In fact, this proposal allows making available different content models through the Web, uniquely identified through a URI. Moreover, using RDF makes it possible to consider a schema matching approach during a scenario of sharing segments structured through different content models. In other words, RDF gives a necessary formality to enable to accomplish schema matching. Moreover, although there are several works on dealing with data heterogeneity, it is worthwhile to notice that treating content as a whole is different from dealing with segments of instructional content, and even more difficult when considering collaborative scenarios. So, it was important to discover how the learners deal with content segments and the problems related to the use of segments in collaborative learning. As future work, it is expected to extend the developed prototype in order to be able to deal with different media and apply it in different learning contexts supporting additional tasks. Besides, an ongoing work comprises to realize a case study in order to obtain results related – specifically - to schema matching approach according to the learners’ point of view.

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