E-learning meets the Social Semantic Web

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Abstract

The Social Semantic Web has recently emerged as a paradigm in which ontologies (aimed at defining, structuring and sharing information) and collaborative software (used for creating and sharing knowledge) have been merged together. Ontologies provide an effective means of capturing and integrating knowledge for feedback provisioning, while using collaborative activities can support pedagogical theories, such as social constructivism. Both technologies have developed separately in the e-learning domain; representing respectively a teacher-centered and a learner–centered approach for learning environments. In this paper we bridge the gap between these two approaches by leveraging the Social Semantic Web paradigm, and propose a collaborative semantic-rich learning environment in which folksonomies created from students’ collaborative tags contribute to ontology maintenance, and teacher-directed feedback.

1. Introduction

The Social Semantic Web has emerged recently as a new paradigm for creating, managing and sharing information through combining the technologies and approaches from the Web 2.0 [1] and the Semantic Web. While the Semantic Web aims at giving information a “well-defined meaning, better enabling computers and people to work in cooperation” [2] through the definition of ontologies, the Social Web transforms the “old” model of the Web – a container of information accessed passively by users – into a platform for social and collaborative exchange; in which users meet, collaborate, interact and most importantly create content and share knowledge through wikis, blogs, photos and videos sharing services; and activities such as collaborative tagging.

The idea of merging the best of both worlds (namely, through combining the common formats to define and structure information with the social mechanisms to create and share this knowledge) has converged in the concept of the Social Semantic Web, in which socially created and shared knowledge leads to the creation of explicit and semantically-rich knowledge representations. The Social Semantic Web can be seen as a Web of collective knowledge systems, which are able to provide useful information that is based on human contributions, and which improves as more people participate [3].

Adoption of the Semantic Web has already been shown to be beneficial for learning environments, in so far as ontologies can effectively model and interrelate information describing learning content, learning activities and learners; and thus improving content personalization and feedback provisioning [4].

However, despite the many promising aspects that stem from having structured information with well-defined meaning (intelligent search engines, content correlation according to semantic annotation, etc.), the Semantic Web is still not widely adopted. This is mainly due to the difficulties in ontology creation and maintenance, and the process of semantic annotation.

The Social Semantic Web paradigm can play a crucial role in the context of e-learning: on one hand, facilitating a larger adoption of ontology-based e-learning systems (overcoming the difficulties related to domain ontologies creation and update) and on the other hand, providing enhanced feedback based on collaborative activities. Moreover, e-learning systems can evolve according to the new forms of creation, exchange and fruition of knowledge offered by the Social Web paradigm (e.g., wikis, blogs, and social networks). We envision, as such, the possibility of the
birth of the “Education Social Semantic Web”, where pedagogically focused learning materials and activities are easily created, shared, and used by students and teachers; without the need for detailed knowledge engineering skills or know-how of advanced technologies. Along the lines of this vision, in this paper, we present an integrated framework that leverages the Social Semantic Web paradigm to enable folksonomy-driven ontology maintenance and feedback provisioning, based on students collaborative activities.

2. Collaborative Semantic-rich Learning Environment

In our previous work, we have demonstrated that semantic rich e-learning systems – in which ontologies interrelate information about learning content, learning activities and learners – can improve the current state-of-practice in generating feedback for online educators [4]. In particular, we have developed the LOCO-Analyst tool, which provides online educators with appropriate and reliable feedback about student-interactions with learning materials, as well as their mutual interactions during the learning process. The main motivation for developing LOCO-Analyst was to inform online educators about behavior and performance of their students, and help them rethink the content and learning design of the courses they teach. The initial evaluation of LOCO-Analyst showed that teachers perceived and appreciated the qualitative improvements it achieves in providing feedback.

LOCO-Analyst is based on Semantic Web technologies. It is built on top of the LOCO (Learning Object Context Ontologies) ontological framework [5], which we have developed to enable a formal representation of contextual learning object data. The LOCO ontologies enable unambiguous representation and integration of contextual learning data from the different e-learning systems and tools that students use during the learning process. Furthermore, LOCO-Analyst exploits semantic annotation (i.e. annotation with ontological concepts) to interrelate the diverse learning artifacts used, or produced, during the learning process (such as lessons, tests, messages exchanged during online interactions). Finally, LOCO-Analyst leverages reasoning to derive meaningful insight about the learning object context data.

LOCO-Analyst was developed as a generic feedback provision tool, which is easily adaptable for the use with diverse e-learning environments. This is made possible by implementing feedback functionalities that link with the ontologies of the LOCO framework. However, the major obstacle for the wider adoption of LOCO-Analyst lies in the difficulties of creating and maintaining domain ontologies upon which the tool depends.

LOCO-Analyst’s focus on providing feedback for teachers, classifies it as a teacher-centric environment. With the additional aim of improving the learners’ experiences in using learning environments, we have decided to make use of social constructivist theory by leveraging collaborative activities. Aiming to enable the use of this pedagogical theory, we have developed the Open Annotation and Tagging System (OATS), as an open-source tool that allows learners to collaboratively create and share knowledge, by adding highlights, tags and notes in HTML-based learning content [6]. OATS is a multi-purpose annotation tool that can be easily integrated into any e-learning system. For example, it has been integrated with the iHelp Courses Learning Content Management System (LCMS) [7], and used in several different e-learning courses deployed at the University of Saskatchewan.

Obviously, these two tools represent a teacher-centered (LOCO-Analyst) and learner-centered (OATS) approaches to learning environments. We have decided to integrate these tools in order to investigate the benefits that their synergy has to offer, which include:

i) the facilitation of ontology maintenance based on the results of learners’ collaborative activities;

ii) the provision of enhanced feedback for teachers describing students’ comprehension of the course content.

Accordingly, we have combined LOCO-Analyst, OATS, and the iHelp Courses LCMS, to create our collaborative semantic-rich learning framework depicted in Figure 1. This framework allows students to collaboratively tag the learning content in iHelp Courses LCMS using OATS. The results of their tagging activities are accessed by LOCO-Analyst which in turn analyzes them, and uses them to provide teachers with advanced feedback about students’ comprehension of course content (see Sect. 4).

LOCO-Analyst also provides interactive visualization of the course domain ontology aiming to facilitate the process of ontology maintenance (see Sect. 3). We have developed an algorithm for computing context-based relatedness between students’ tags and ontological concepts, which we use to further assist the teachers’ task of ontology maintenance, by suggesting the most relevant tags for a particular concept. The algorithm is based on the idea that the ontology itself defines a “context” for its concepts. So, when computing the relatedness between a concept and a tag, the surrounding concepts (forming the ‘context’ of the concept in question) must also be taken into account. To support this notion, we compute context-
based relatedness that contextualizes a semantic relatedness measure (e.g., NSS-Gwikipedia [8]) according to the domain ontology structure. This algorithm has been applied in two separate use-cases, described in the next two sections. These sections present, respectively, how we have implemented: folksonomy-driven ontology maintenance, and feedback provisioning based on students’ collaborative activities.

3. Folksonomy-driven Ontology Maintenance

Aiming to facilitate the educators’ task of maintaining domain ontologies, our framework leverages folksonomies generated out of the tags that students assigned to the learning content during the learning process.

Figure 2 presents the user interface of the LOCO-Analyst extension that enables teachers to refine the domain ontologies of their courses, which is based on students’ tagging activities, created with OATS. The extension consists of a tag cloud visualizing students’ tags (B) and a graph-based visual representation of the course domain ontology (C).

The domain ontology is presented using an interactive graph that we have implemented using Prefuse\(^1\) open-source Java visualization framework. A teacher can explore the ontology by zooming in and out and/or changing the focus of the graph view by clicking and dragging nodes.

The tag cloud employs the size and color of tags to convey to teachers information describing the tags popularity and relevancy, respectively. We have found these two feedback variables relevant for supporting teachers’ task of enriching domain ontologies. The size of a tag reflects its popularity, which is calculated by the number of times that tag was used to annotate a particular piece of learning content. The saturation of a tag’s color reflects its relatedness to the ontological concepts encapsulated in the content of the currently selected lesson (Figure 2A), as evaluated from our algorithm – darker colors denote more relevant tags.

A teacher’s interaction with the LOCO-Analyst’s extension for ontology maintenance can be described as follows: as the teacher selects a lesson (or a complete learning module) from the tree-like representation of the course structure (Figure 2A):

1. The visual representation of the ontology (Figure 2C) changes to emphasize the concepts relevant for the selection being made. The colors of relevant concepts become darker as the relevancy with explored content increases.
2. The tag cloud (Figure 2B) is populated with tags related to the selected lesson.

The teacher selects a tag (from the tag cloud view) that (s)he wants to add to the ontology and simply drags that tag towards the ontology view panel (Figure 2C). When the tag is ‘over’ the ontological concept it should be related to (according to the teacher’s opinion), the teacher ‘drops’ it. Instantly, a pop-up menu appears offering various options for establishing a connection between the selected concept and the tag (e.g., adding a tag as a sub-concept or as a related concept). As the teacher selects one of the available options for ontology enrichment, the ontology view gets updated to reflect the changes to the ontology. In addition, the teacher has an option to postpone the decision about the tag relation and note it for later consideration. LOCO-Analyst supports this by adding both the tag and the concept into the teacher’s notes, for later consideration.

4. Feedback Provisioning Based on Students Collaborative Activities

By leveraging data from OATS, our framework allows teachers to be informed about a student’s
comprehension of the course content based on their collaborative tagging activities.

To present the teacher with this kind of feedback, we have extended the dialog that is used in LOCO-Analyst for displaying feedback about one particular student (Figure 3). The dialog is based on tab panels, each one presenting a specific kind of information that LOCO-Analyst contains about the student (i.e., the information generated from the available data on the student's interaction with the LCMS). In particular, the dialog comprises four tabbed panels, labeled ‘Forums’, ‘Chats’, ‘Learning’ and ‘Annotations’. Whereas the former two panels are aimed at informing teachers about the student's online interactions (in discussion forums and chat rooms, respectively) with other participants in the learning process, the latter two are intended for presenting information regarding the student's interaction with the learning content (i.e., reading, annotating, and commenting).

Figure 3. A screenshot of the interface providing feedback based on students collaborative tagging

Figure 3 presents a screenshot of the Annotations panel, which provides feedback based on students collaborative tagging activities. On the left hand side of the dialog (Figure 3A), there is a tag cloud presenting tags that all students used for annotating the course content. We make a visual distinction between the tags that the selected student – let us call him Tom – used, and those that other students used but Tom did not. This distinction is visualized by making active (i.e., mouse pointer turns into a hand indicating a clickable tag) and blue only those tags that Tom has used; whereas other tags are not clickable and are painted in grey. This allows the teacher to easily identify to what extent Tom's perception of the course content overlaps with that of his fellow students. After the teacher selects one of Tom’s tags from the tag cloud, the course content annotated with that tag is presented in the form of a tree as shown in Figure 3B. The tree root represents the course, branches are lessons annotated with the selected tag and tree leaves are parts of the lesson’s content annotated with the selected tag. After the teacher selects one annotation (i.e., a tree leaf), the part of the lesson forming its ‘context’ is presented in the Annotation Preview panel and the student’s (i.e., Tom’s) notes related to that annotation are listed in the Notes Preview panel (Figure 3C).

The idea behind the suggested interaction is to help the teacher evaluate the student’s conceptualization of the course content. The assumption is that the tags that the student used for annotating the content reflect his perception (or even comprehension) of the content. The suggested visualization would also help teachers easily spot all parts of the course that the tags were used with, and thus help them reveal some of the students’ misconceptions.

We are currently working on some further visual indicators to be added to the content annotation tree (Figure 3B) to indicate the level of agreement between the teacher’s and the student’s conceptualization of the content. To accomplish this, we will make use of the (semantic) annotations of course content with concepts of the domain ontology: students’ tags and a context-based measure of relatedness between ontology concepts and tags (a variant of the one used for ontology maintenance). Since the domain ontology reflects (or at least should reflect) the teacher’s conceptualization of the course content, using our measure of relatedness between ontology concepts and tags we can identify where the teacher’s and the student’s conceptualizations overlap and where they diverge.

5. Related Work

There are many aspects of e-learning environments that are affecting the educational process, including (but not limited to) domain knowledge, knowledge artifacts, pedagogical models, user behavior and characteristics, social interactions, and the platforms for delivery (e.g., mobile phones, or a web-based LCMS). If advanced educational services are to be provided, all these e-learning aspects need to be captured and represented in an integrated way - in a unified knowledge space [9]. This is precisely the reason why Semantic Web technologies have been recognized as one of the major directions for the next-generation e-learning environments. There have been numerous proposals for leveraging ontologies in e-learning systems, which are aimed at covering some of the aforementioned aspects of e-learning environments [10] [11] [12].

On the other hand, Social Web (or Web 2.0) based approaches, such as collaborative tagging and social
bookmarking, have so far gained a high level of adoption even in every-day e-learning practice (e.g., Elgg is used in more than 170 online courses at the University of Brighton [13], and has even impacted the development of new pedagogical theories such as connectivism [14]. Combining the user-friendliness of collaborative activities with structured ontological definitions is starting to be seen as a solution for the convergence of these approaches into the new Social Semantic Web paradigm. An attempt at leveraging this paradigm in e-learning environments has been proposed in [15] where Westerski, et al. propose a method of assembling an on-demand curriculum from existing learning objects provided by e-learning services suppliers. Essentially, the proposed approach is based on gathering all student interactions and activities, representing them semantically, and exploiting this information together with (semantically represented) data of the student’s current course progression. This approach would allow for accurate selection and sequencing of learning objects that would best suit the student’s needs. This work is in its early stage, and for the moment, only the theoretical model has been developed.

6. Conclusion

In this paper, we have pointed out benefits that the Social Semantic Web paradigm can bring to e-learning environments. In particular, we have presented an integrated framework for the combined usage of folksonomies and ontologies. Our framework eases the process of ontology maintenance and enhances the feedback provisioning capabilities of semantic-rich learning environments. This contribution is an important step in the road of wider adoption of Semantic Web technologies in learning environments - enabled by leveraging Social Web approaches- as well as an improvement of educational process by better comprehension of students’ activities from which both learners and teachers will benefit.

Our future work will deal with the collection of data coming from a deployment of our framework in an actual e-learning setting. In this way, we will be able to perform an extensive evaluation of the proposed interfaces and gather feedback on what additional types of user interactions might be valuable, so that they can be added to the future releases of the framework. In addition, we intend to collect detailed usage data of students and teachers within our framework in order to evaluate the effectiveness of our approach.

7. References