Using Collaborative Concept Maps for Coordination and Knowledge-sharing in Learning Communities for Science

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Abstract—Concept maps are commonly used as knowledge representation mechanisms to classify a given domain in the scope of a constructivist knowledge building process. In this paper we carry out social constructivist learning experiences using concept maps as a collaborative knowledge-sharing tool with applications in the coordination of virtual communities for learning. In our experiment, the community studies an environmental area -theoretically and in-situ- collects data from a variety of experiments and makes a representation of it. Then, they build a common concept map representing their understanding of this area using a set of tools developed ad-hoc and integrated by a metamodel wrapping approach. Finally, they complete it linking their node with the collected information as a way to organize and to navigate through the different pieces of knowledge that they have been accumulating during several fieldtrips.

Keywords—collaborative concept mapping; sharing knowledge; learning communities

I. INTRODUCTION

Virtual Learning communities [1] are social structures that give a new perspective to studying in groups, more related to “doing and practicing” than to the traditional “listening and reading” seen in traditional classrooms. By means of an appropriate technology, students virtually meet in groups of different typologies; communicate with the community; search and share data from several sources and practice knowledge acquired in previous learning process.

The use of a shared representation for communication helps to improve coordination in groupware systems and it can also be applied to learning community platforms. A coordinated representation is easily adopted by users and coordinating representations have been proved to result in a better performance improvement within the study of a domain task, as it has been seen in [2].

Concept mapping [3] is a representational model that has been proved to be useful for science studies and more effectively if they work in groups [4]. The effectiveness of concept maps is well known and grounds on the constructivist theory providing a rich mechanism for knowledge building both individually and in a collaborative manner (collaborative concept mapping, or CCM), enhancing meaningful learning, promoting discussion and providing a social thinking tool [5] [6]. The resulting map is a final product that integrates a set of concepts and relationships, plus the process of elaborating it. Other studies [7] have found how collaborative concept mapping improves students’ interaction and allows them to know about their classmates’ strengths and weaknesses.

In this respect, the aim of the paper is on the one hand to illustrate a family of tools to generate collaborative concept maps when teaching practical science. On the other hand our intention is to explore how learning outputs within the virtual community are labeled as learning objects both as a knowledge-building process result and as a learning object itself to be potentially reused.

We set up experiments with a K-12 group in the scope of practical science, as an outer activity. In general, in science, a virtual community can collect different data about a subject, and build collaboratively a concept map relating all of them. CCMs have been used for teaching in several scientific scopes as electricity [8], human body [9], photosynthesis [10] or physics [11] [3] among others. There are also different ways to share information and to generate common knowledge, all of them depending on the learning domain, the collaborative learning techniques [12] implemented to organize the activities, the type of interaction (synchronous, asynchronous or both), how the organizations manage what they do and know [13], the places to share and interact [14] and finally, the available tools to work and collaborate.

In order to allow this scenario, interaction between tools is an important goal and we need flexible content aggregation systems, which permits to share, search and retrieve complex learning objects.

In summary, in this paper it is showed how to use concept maps as a representational mechanism to share and generate common knowledge for Science in Virtual Communities. The community studies an environmental area, collects data and makes a representation of it. Finally they build a common concept map representing their understanding of this area and complete it connecting each concept with the picked up data. This process generates a model of the region and a way to arrange the different pieces of knowledge collected during several fieldtrips.

The paper is organized as follows. Firstly, the context and motivation of the research is described. Secondly, the activities carried out in the learning community are listed along with their relation with the collaborative concept mapping. It is followed by the description of the concept mapping tool and the results of the experience with K-12 students. The paper finishes showing some possibilities for motivating collaboration in virtual communities.
II. CONTEXT OF THE RESEARCH AND MOTIVATION

ENLACE is a research project carried out in conjunction with teachers in a secondary school and SEO/Birdlife, an organization that strives to conserve birds along with their habitats and global biodiversity, by working with people to attain a sustainable use of natural resources.

The project approach is to create a leitmotif for students’ and teachers’ participation: The joint construction of a model for a very rich environmental area named El Pardo natural park. We aimed students and teachers to create learning designs to maximize technology-based opportunities around this central contextualized motivation. These can be applied to a diversity of subject matters in the curriculum such as math, natural sciences, geography, language, or social science topics.

Our proposal gives an educational network offering services that will provide ubiquitous web applications for learning activities, both inside and outside the classroom, in order to improve student learning and teachers’ work. It uses a technological platform to store and retrieve all the virtual community data. It consists on a Learning Object Repository (LOR). The users have access to the LOR by using a portal from the classroom, from home or from outside during the fieldtrip (Fig. 1). The LOR [15] stores data and artifacts created from heterogeneous resources. Artifacts, in this sense, are the products created by learners using certain tools on a diversity of devices.

The architecture also has functionalities to define different learning activities, contextual data, and connection to external tools that save their results in the LOR using the web services mechanism. Thus, the repository offers the interoperability mechanism to share and interchange data in this learning community.

III. ACTIVITIES IN THE LEARNING COMMUNITY

The activities in this learning community consist on observing a nature phenomenon in the countryside that has been studied in the classroom (for example, the river state and their link with their environment, animal trails, and the tropic change), collecting data and relating them. This relationship is not only about an individual understanding of the problem but a community one. Therefore, several tools should be available to join and share the information.

In this experiment, some activities are cognitive and other social. All of them offer different possibilities of combination, giving a rich variety of collaborative and social learning techniques to take full advance for exploring learning alternatives. The type of activities is described in the following section, while the tools are shown in next section.

A. Reflecting and modelling

Concept maps can be used as representation tool in the modelling process within the group, in order to obtain automatically a single and a group conceptual model. Pre-designed templates with the sub-domain concepts and relationships are used. So that, it is possible to delimit the elements of the domain in which the students work to build their model. These templates are a shared representation in the group that should guide the generation of a common model of the community.

In our experiment, we offered templates for flora, fauna, river flow, sun and shadows, distances, etc. with the concepts and relationships related with the animals, plants, trails and other observations that the children had to perceive in their trip. Relationships are generic and help to build and merge common models. To illustrate this, in the case of a Mediterranean ecosystem river trip, the concepts and relationships about fauna and flora that students could observe are showed in Table 1.

<table>
<thead>
<tr>
<th>TABLE I. CONCEPTS AND RELATIONSHIPS EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FAUNA</strong></td>
</tr>
<tr>
<td><strong>CONCEPTS</strong></td>
</tr>
<tr>
<td>Primary Consumers</td>
</tr>
<tr>
<td>Secondary Consumers</td>
</tr>
<tr>
<td>Tertiary Consumers</td>
</tr>
<tr>
<td>Vulture</td>
</tr>
<tr>
<td>Deer</td>
</tr>
<tr>
<td>Wild boar</td>
</tr>
<tr>
<td><strong>RELATIONSHIPS</strong></td>
</tr>
<tr>
<td>eat</td>
</tr>
<tr>
<td>compound of</td>
</tr>
<tr>
<td>is a</td>
</tr>
<tr>
<td><strong>FLORA</strong></td>
</tr>
<tr>
<td><strong>CONCEPTS</strong></td>
</tr>
<tr>
<td>Producers</td>
</tr>
<tr>
<td>Tree</td>
</tr>
<tr>
<td>Brush</td>
</tr>
<tr>
<td>Oak</td>
</tr>
<tr>
<td>Cork oak</td>
</tr>
<tr>
<td>Junk</td>
</tr>
<tr>
<td>compound of</td>
</tr>
<tr>
<td>is a</td>
</tr>
</tbody>
</table>

B. Observing and collecting data

Students have to collect data to share them afterwards. Long term activities involving several groups usually have to be divided in tasks performed by each of them. Overall knowledge about it should be obtained aggregating and sharing the observations in a posterior phase.
In this research, there was a community of students that went to the countryside to observe and reflect about different natural phenomena in more than a few moments of the year. Several trips were organized for groups of students each of them with 20-30 students of different K-12 courses. Because they did not attend to all the trips they do not see the same things (even in the same route because nature is always changing), so the aggregation of the different observations could form a more complete view of how the forest is. The observations were recorded in mobile devices and finally stored in a repository as learning objects.

C. Sharing

Sharing is a type of activity that could be tackled in two ways, accessing community data directly or situating them into a conceptual map. In the first case, the community framework has access to the repository and can get them using different search criteria. In the second case, users can connect their observations to a concept map.

In the case of sharing with conceptual maps, two options are available depending on how the conceptual map is created:

(i) First, a general concept map is designed (for example, as a first step of the experience, before the trip) and then automatically the observed data is automatically situated in the map with a relationship “is a”. This is a structured way of navigating in the observations of the students.

(ii) Second, each student creates a concept map with his personal point of view of the problem. Next, a common concept map is obtained in a merging process. The algorithm used to create the common concept map is based on [4]. Starting with a concept map produced by one group of students, we compare it with another map and change the first one in these ways:

- If a link and the concepts linked are the same in both maps, then add a number 2 in a bracket on the linking line. This means that two maps share the exact link.
- If they have the same concepts but different link, then write both linking words on the linking line and the number 2 in a bracket.
- If only one concept is the same, then add the different concept with the link.
- If both concepts in the second concept map are not found in the first map, then a separate new link is created.

Fig. 2 shows graphically the merging process. In the top, there are two concept maps, one about flora and the other about fauna. A new common map is generated with the merging process. As can be seen in the lower window, it has been created mixing both maps, linking them using the common concepts in the previous ones. Sometimes the resultant map is not very consistent, so a refining activity should be apply to it, what is another activity defined in our proposal.

D. Refining

The conceptual map generated after the sharing and the merging process may have inconsistencies or other problems, as non-connected nodes. For that reason, a refining activity could be necessary. This could be seen as a reflecting process in the community. For the system, it is a process that guarantees the quality of the knowledge stored in the repository, which is able to be reused in other learning experiences.

In our experiment, this activity was carried out by teachers along with students. Thus, another collaborative scenario was presented where students were interacting with each other, but under teachers’ guide. Collaboration could be both synchronous and asynchronous. The former was performed in the classroom, in a face-to-face scenario. The latter was supported by reusing learning objects mechanism (see Section IV).

The final concept map can be chosen from several proposals, so a polling activity can be helpful to stimulate collaboration and discussion between students.

IV. COMET: A TOOL FOR CONCEPT MAPPING IN THE LEARNING COMMUNITY

A new mapping tool, named COMET (Concept Maps for Enlace Tools), was designed to support the previous learning scenarios. It was developed on an existing concept mapping editor, called CM-ED [16]. There are other several mapping engines, like CmapTools [3], Inspiration [4] or Representation tool 2.0 [17], but we chose this one due to its intuitive and friendly interface and the ease of extending its functionalities.

The new modules added to CM-ED in the context of our research, which constitute COMET, allows interconnecting concept maps tools with learning object repositories. Students can build a map and associate its concepts or relationships with a Learning Object. To make easier this task, the application provides a repository searcher where it is possible to search objects according to different metadata criteria.

In order to show the learning object content, we use a metamodelling approach to wrap the outcomes of heterogeneous tools and present them in a similar way [18]. Now, we can integrate different tools, not only to share results, but also to link them semantically, combining wrapping technique with concept mapping knowledge representation.

Another feature of the tool is the possibility of saving the maps into the repository. Therefore, the creation of collaborative concept maps is allowed by providing asynchronous sharing map mechanism. Users can open a map from the repository, perform modifications, and finally save it again. Using this functionality, a map can contain other maps, independently whether the editor offers this feature or not. Since maps are also stored as learning objects, they can be linked to a node or relation of other map.
V. RESULTS

Our approach was tested in a science course involving two groups of twenty five K-12 students. The experimental group used COMET, and carried out field trips and modeling activities, producing data from several tools as learning objects and, by using our metamodel approach integration [18], linking those objects to collaborative concept maps. The control group did not use any experimental tool and they carried out the course using notebooks in a traditional way.

Final marks and several questionnaires were the methods used to perform the evaluation, including students and teachers opinion. The questionnaires followed a Spanish standard, named MISE [19], designed to evaluate the learning process.

In Fig. 3 we can observe an analysis of the assessment of groups about knowledge acquisition. “A” group represents the experimental group and “B” represents the control group.
Although most of the indicators that are related to knowledge acquisition are similar, there is a great difference in attentional processes and knowledge representation (Representation Systems). Looking at the figure, students using our proposal have a much better results (73%) than those using traditional representations (46%).

These results seem to point out that, learning objects linked to concepts, instead of plain digital resources, and sharing those representations, encourage students to focus their work on the learning activity. The sharing and refining activities also improve the representation skills of the students by checking their proposals with other ones. This is important, because the students had to share their observations with other classmates.

VI. CONCLUSION

This project was evolving K-12 students since the beginning. Several trips and experiences have been done outside and inside the classroom, in order to connect the theory with the practice. Hundreds of learning objects were stored in the repository to deal with. Students were also working with modelling tools and concept map tools.

The model of this research, combining different activities, offers many possibilities to explore different collaborative techniques [12] within the virtual learning communities. An example could be “working in teams”. In this example people are organized in teams, each one collecting data about a topic (trees, bushes, birds, etc.). Each team creates a concept map about a topic (the same or different). Then, a common concept map is created by merging and been populated with all collected information. Finally, it is refined in a brainstorming session. Another example is “working together”, similar to the previous one but everybody works separately in all topics, and at the end all the data is joined in a common concept map.

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Figure 3 Assessment of Groups. Knowledge Acquisition