Designing and Supporting Collaborative Activities

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Abstract. Collaborative Learning techniques could achieve a high impact on education if good enough tools were designed, implemented and utilized in classrooms. In this paper we describe the design of a collaborative learning activity for teaching Chemistry in Chilean schools. We describe a PDA-based software tool that allows teachers to create workgroups in their classrooms in order to work on the designed activity. The software tool has two separate modules: One module is used for supporting the teachers, which runs on a conventional PC and lets them create learning material and setting groups. The second module runs on PDAs and can be used by students in order to complete the group activity.

Keywords: Collaborative Learning, CSCL, PDA-based Groupware.

1 Introduction

Group work has been successfully used as a learning practice for many years, taking advantage over individual learning in several social and superior order factors, for example critical, creative, and meta-cognitive thinking skills [1]. Groups of various apprentices are the focus of the Collaborative Learning approach.

Collaborative learning can be defined as the united work of a group of apprentices in search of an academic goal, through tasks or activities, which must be developed by both a cognitive mediator and the group of apprentices [2]. However, this definition does not reflect one of the issues we consider more relevant in this kind of activities: the social interrelations within the group. These desired group interrelations can be expressed though social interdependences. A social interdependence is given when one person's results are affected by the other person's action [3]. Social interdependences can be either positive or negative. Positive interdependences (collaboration) are achieved when the individuals work together to achieve a common goal. Negative interdependences (i.e., competition) shows when individuals work against each other to achieve a goal that only one or few of them can reach [4].

It is important to remark that group work does not enhance learning by itself. Just putting a group of students around a task does not guarantee a real collaboration. Only through interrelations between the participants, and also through certain conditions, collaboration and hence learning can be achieved. This kind of learning not only teaches academic objectives, but also it can teach transversal abilities.

Recently, collaborative learning has acquired a great relevance in educational reforms of some Latin-American countries, managing to be included in most curricular setups. There is also a focus on teaching transversal abilities that has given reason for these reforms, precisely through inclusion of collaborative learning activities in the classroom.

These last years, there has been a great interest in using technology in order to support collaborative learning. In the majority of the Latin-American countries, the use of Information Technologies (IT) for supporting Collaborative Learning could represent a possible way for science to contribute directly to a better society, in particular in educational system enhancement. Computers Supported Collaborative Learning (CSCL) is a research area that studies the technological support (software and/or hardware) for groups of people who work towards a common goal or task and also provide a shared environment [5].

Using concepts as collaboration and team work, and also trying to distribute tasks in an optimal manner, it is possible to develop appropriated technology-supported collaborative learning tools. These tools should use positive interdependences, which allow creating dependences between students that participate in a collaborative learning activity. This allows team members to learn the same concepts through an equitable participation. It is very important to mention that it is not about students learning an academic objective, but also about them learning abilities such as team work, and responsibility delegation.

Collaborative learning activities development, and their technological support, requires a thoughtful analysis and design. According to our experience, great tools are not achieved by making learning easier to students, but by helping the teacher to monitor and evaluate activities [6]. The objective user of a CSCL application should be the teacher, because he/she knows what should be taught to students, and which the best way to do it is. It is very important to show that collaborative learning should be seen as a complementary part of traditional learning. In an integrated learning system, students should be able to perform collaborative activities, both individually and competitive, because after school life, they will be confronted to this kind of situations. On the other hand, it is very hard to measure the real value of IT supporting collaborative learning.

This paper presents a computer tool that supports collaborative learning, which helps teaching Chemistry contents for high school. In the next section the design of the collaborative activity created - which will be supported by IT - is shown. In section 3 we present the developed tool. Finally in section 4 we present the conclusions and our proposals of future work and extensions.

2 Collaborative Learning Activity Design

The collaborative activity design was defined in the particular field of study of Chemistry, particularly taking into consideration concepts such as molecular construction and representation through covalent links. This educational content is presented as an official content in the educational system of some of Latin-American countries. It is also important for students to gain some transversal abilities such as team work and individual responsibility. In order to achieve these goals, we propose groups formed by 3 to 5 students that correspond to the proposed size of groups in the actual literature [7]. Grouped students must perceive that they "sink or swim" together, which means, each member is responsible to and dependent on all the others, and that one cannot succeed unless all in the group succeed. Knowing that peers are relying on you is a powerful motivator for group work [8]. Strategies for promoting interdependence include specifying common rewards for the group, encouraging students to divide up the labor, and formulating tasks that compel students to reach a consensus [9]. The design of the collaborative learning includes positive interdependences that allow the group activity to be performed following certain rules that encourage real collaboration within group. The positive interdependences are explained as followed.

Common Goal Interdependence
To achieve a common goal positive interdependence, students must perceive that they can learn if and only if the other members of the group achieve their own goals. In our particular activity, students in each group are looking, as a team, to build a complex molecule representation. Without everyone’s participation it would (and should) be impossible to build the proposed molecules.

Resources Interdependence
In order to achieve a resources positive interdependence, each member of the group must have only a part of the necessary material required to complete the task. These resources must be combined in order to achieve the group’s common goal. In our activity, each group member is given just a fraction of the total molecules needed to build the complex molecule representation. They are also given some dummy molecules in order to give some difficulty to the exercise. With this way of distributing molecules, resource interdependence is generated between the members.

Environment Interdependence
Environment or surrounding positive interdependence is achieved when students work in the same physical space. The cognitive mediator must strive for the environment to be the optimal for the activity. During the execution of our activity, students can communicate face to face, because they are working in the same space. This face to face communication is possible mainly due to the use of Pocket PCs, which allow students to gather around in circles, or in a way that permits a fluent communication. This eventually allows students to generate simpler and more effective collaboration strategies, and encourages communication among them, which is a key instrument for groups to collaborate and learn.

Once the activity is set and defined, it is important to understand the best way to support it with technology. Designing a computer tool to support Collaborative Learning could include some restrictions for students strengthening the inclusion of positive interdependencies. Technology could also help the teacher with monitoring and evaluating these activities. In our activity, the chance of restraining resources through software could let us see a first analysis of the advantage of using CSCL tools. In the next section we will see how technology could effectively achieve to support the teacher in every step of the collaborative learning activity.

3 Technological supports for face-to-face activities

We have found certain points within the previously mentioned collaborative learning activity where technology could contribute effectively. This could apply to other similar collaborative activities (synchronic, in the class room, etc.). This support can be better explained by focusing on the main actors.

3.1 Supporting the Cognitive Mediator

The cognitive mediator (usually the teacher) [10], plays a key role within the collaborative learning because he/she is in charge of the design and execution of the activity. We have found some situations where technology could support this role:

Collaboration and academic objectives monitoring

In a synchronic collaborative learning session, the cognitive mediator could, through the use of software, monitor in real time the progress of collaboration and academic objective learning. He/She can achieve this by identifying participants and by viewing their participation in the activity. However, in sessions with a larger number of groups this information could be very hard to obtain without software tools. In software-less collaborative learning sessions, the cognitive mediator has to walk through the groups and observe who is doing what in each group. This can clearly make the cognitive mediator loose a large amount of information, and also intimidate the students, forcing them to act unnaturally. Using software, the teacher can monitor unobtrusively and in real time allowing him/her intervene in case he/she thinks is necessary.

Collaboration and academic objectives evaluation after the work session

In both synchronic and asynchronic learning sessions, the cognitive mediator could require, for a follow-up analysis, every step executed by students. The analysis of the student's strategies, particularly for collaboration, can be a key factor for redefining the activity in a better way, by creating better groups, assigning roles or focusing the activity in such a way that students learn in a better manner. Creating logs that record the actions executed in an activity, which also identify students, could be an excellent tool to improve work sessions in the future.

Learning Sessions Administration and Execution

The required time needed to execute a learning session could become a negative factor to include collaborative learning activities in a regular basis in the class room. An activity design implies defining groups, assigning students, defining roles and on top of it, the execution of the activity. Usually the teacher must distribute certain materials and also assign physical spaces amongst other things. This can make it harder to execute an activity in a short period of time. Technology could benefit most of these issues. For example, creating sessions where the amount of students changes dynamically. Software can be provided to automatically adjust the activity to the groups. The distribution of digital material will become a simple and dynamic step.

Material creation for the learning session

During an activity execution, the cost of acquiring the necessary material can become a real problem for the cognitive mediator. In particular, the need to recreate the activity with a new set of students or even the same set of students, but with a new level of difficulty is even harder. Digital material created through software, could be a simple and convenient replacement to physical material as paper. With this kind of solution, it is very easy to reuse the material or even use it as a base for new material. Therefore, the collaborative learning activity could be executed within the same group of students, with different levels of difficulty, with different objectives, or even with a new set of students. The material really takes a predominant role in the activities that require it. With this, the easy setup of the material and its reutilization can become a main factor. If it can be done in independent instances from the activity execution, it can become an efficient and comfortable process for the cognitive mediator. This ultimately decreases the needed time to execute the activity.

4 The developed tool

ColaboQuim is a software tool that intends to support the teaching of chemical molecules construction. This tool is divided in three modules which are designed for building material, executing the activity, and monitoring it. The collaborative activity consists, as previously mentioned, in having the students learn to build a predefined molecule using smaller and simpler molecules. The design of this activity consists of a synchronic work session where students have access to: a public space that is seen and shared by the whole group, and a private space that is different for every student, where the base molecules are stored. ColaboQuim is designed on top of a hardware architecture shown in figure 1.

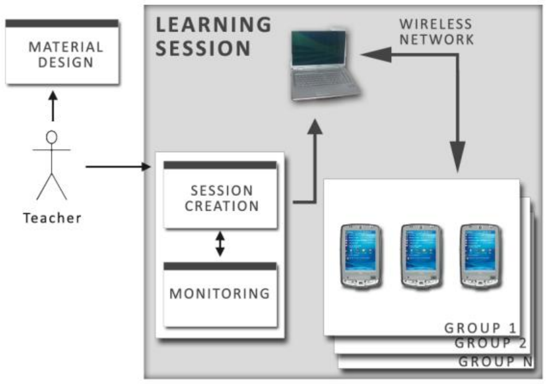

Fig. 1. Architectural diagram of the tool.

This architecture requires one Pocket PC for each student and a PC for the cognitive mediator, connected to a WiFi router that allows a simple wireless network. The material designer, session creator, and monitoring module are executed in the teacher computer. The use of Pocket PCs permits face to face communication within students, and also group forming in real spaces, as opposed to virtual groups occurring in e-learning networks. The use of desktop PCs requires an important restriction of mobility, which would restrain communication. Focusing in supporting mainly the teacher, our software is divided in 3 modules, explained in the following sections.

4.1 The Molecule Designer Module

The collaborative activity design is performed only once, however, several molecules must be created and designed for each executed activity. Material construction necessary for each activity can become a problem for teachers. It is very important to solve the teacher's need to rely on reusable material either for new learning sessions or for different groups of students. Due to this concern, a tool has been implemented to create material for these kinds of activities (creation of molecules). The cognitive mediator must build and save molecules before asking students to build their own. This helps to evaluate students' work, because it allows comparing, in real time, the result of each group. An application was created to design base molecules, which are intended to build bigger structural ones. Structural molecules can be used as objective molecules for groups.

We used XML standard for portability in the representation of the molecules, allowing this way letting the cognitive mediator create material in any computer with the software installed. The molecule designer module uses an interface to create base molecules, which are represented by a sphere containing the molecular representation, and links – single, double or triple links. These links can be associated to different angles of connection. This module also uses an interface similar to the one provided to the students' module that allows the teacher to build structural molecules in certain gridded space, by dragging and dropping molecules (see figure 2). These structural molecules will be used later in the collaborative learning activity.

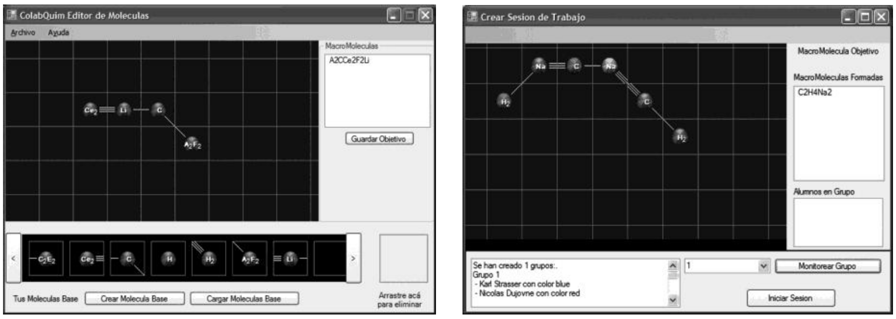

Fig. 2. Interface for creating macro-molecules and for monitoring the activity (in Spanish).

The building method uses simple interaction as double-click to rotate, and a context menu which allows deleting a molecule from the space.

Once the teacher creates a structural molecule, he can save it to be later used in the Session Manager module, where it will be assigned to a group and then compared to the group's result to see if students are doing things well.

4.2 Session Manager and Monitoring module

The collaborative activity allows students to create structural molecules in real time. Due to the fact that this activity is synchronic, it requires a tool that helps the teacher monitoring students' progress for each group. The tool must help the teacher to define groups and to assign learning objectives. The following application intends to solve these problems and also permits the teacher to evaluate the activity. Using a wizard-link interface, the teacher follows steps to complete these tasks.

The Session Manager tool obtains structural molecules previously created in the Material Designer module. This tool manages students, helping the teacher with a list of students available to create groups. This is helpful in situations where the number of students in a class room is dynamic. The amount of groups that will be participating in the learning activity is the first input the teacher must set when the session is starting. This number must be determined by the teacher depending on the complexity of the molecules, the difficulty of the problem or the amount of students available. It is not required for the groups to be the same size, but this is advisable.

The cognitive mediator must assign a structural molecule for each group. He/she also defines which structural molecule will be the current group objective molecule.

Once the groups are defined and the molecules are assigned, a learning session is started. The software waits for the groups to be gathered (and each student to activate the module in their respective Pocket PCs), and it monitors them. The learning session uses messaging through a simple wireless network. For this, a wireless router is required. The monitoring interface (see figure 2) allows the teacher watch in real time what each student in each group is doing in their public space.

The teacher can see in this interface exactly the same that the students are looking in their Pocket PCs. Each action a student performs in their module is registered and shown in this interface. Using a color system, the teacher can identify each student. This monitoring interface helps the teacher obtain the following information: state and progress; learning objectives; and collaborative work.

4.3 Students' Pocket PC Client module

In order to work in the collaborative activity, students uses a Pocket PC with the ColaboQuim client software installed. This software allows student to participate in a ColaboQuim learning session.

Through the use of the Pocket PCs, the student can gather with their partners in the group, and can communicate face-to-face with each other. The use of desktop PCs could obstruct the possibility of strategy creation. On the other hand, executing this activity with paper and pencil as material, could allow sharing the resources without restriction allowing one student to do all the work, therefore stopping collaboration by blocking the positive interdependences.

Initially, students receive their assigned molecules through the software tool, and those molecules are stored in their private space. The color of their molecules is a unique identifier for him within the group. This is very important since the action over the molecules, like move or rotate, are only available for the students own molecules. A student cannot change anything over their partners' molecules in the public space. This allows the Resources interdependence to be fulfilled.

Students can move or rotate their molecules through simple interactions like drag and drop and double-tap respectively. Each student must define a strategy to move their molecules from their private space to the group's public shared space. The public space is fully synchronized, so each action of students in their Pocket PC is shown in each teammate's interface. In the same manner, the teacher, through the monitoring module can observe in real time what is happening in the public space of each group.

The teacher can monitor how good the students are performing by checking how alike the objective molecule and the structural molecule created by each group are. The teacher can finish the activity when the objective is accomplished. With this, students loose the possibility of using a "trial and error" strategy, while reinforcing the collaboration strategy.

5 Conclusions and future work

The current paper shows the design of a collaborative learning activity to support Chemistry contents. Particularly it focuses on the building of structural molecules with covalent links. This is an academic content in the last years school curriculum in some Latin-American countries. We also present a tool, with modules both for PC and Pocket PC, to support the cognitive mediator's work and groups of student in order to participate in the previously mentioned learning activity.

The main value of the developed tool is that it shows a way to naturally include positive interdependences in a CSCL tool, and it also shows mechanisms to help the teacher to monitor the activity. Monitoring is of great value in collaborative learning, because it gives vital information for the cognitive mediator to evaluate students' work and allows him to take immediate corrective actions. With quick and precise interventions the teacher could create a real positive impact in students' learning, impact that could not be accomplished if the teacher did not have these kinds of tools. As a further work we are planning the use of different interaction devices for example Tablet PCs.

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