On teachers' involvement in design and evaluation of collaborative activities: Case studies in Secondary and Higher Education.

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Abstract
This paper discusses the role of teachers during design, implementation and evaluation of activities that involve computer mediated collaboration. The reported research is in the frame of a study of collaborative peer-learning, during teaching algorithms. In particular we focus on two case studies that involved students of different levels (secondary education and university level). We discuss the main characteristics of the two studies: interesting findings concern the learning impact of the instructional approach used, process of discovery of existing common misconceptions and collaboration attitude of different student groups.

Introduction

Computer-assisted collaborative learning has been increasingly considered an interesting area of research, as it is founded on socio-cultural theories that suggest that cognition and learning take place at the level of groups and communities (Stahl, 2005). Collaborative learning is believed to promote the active character of the learning process, as it is related to the deep level of information processing and the requirements of deep understanding from the students involved (Dillenbourg, 1999). Moreover collaboration is a fundamental prerequisite of *inquiry*, a cultural and biological process in which people collaboratively construct new meanings through participation in transforming problematic situations (Dewey, 1938).

In this context the role of the *teacher* needs to be reconsidered. In the various phases of design and implementation of activities involving computer-assisted collaborative learning, the teacher is believed to play a new crucial role that should be first identified in order to be technologically supported. According to (Petrou, Dimitracopoulou, 2003) an important aspect that needs more research in CSCL is the challenges of tutoring in synchronous computer mediated collaborative problem-solving, applied in real school environments. In order to contribute towards this objective, we need to study the role of the teacher during the lifecycle of collaborative activities, including the design, implementation and evaluation of new activities in different instructional contexts. The premise of our research is to define key requirements that may lead to a new generation of tools to support tutors. As the main emphasis of this research is in synchronous computer-assisted collaborative activities in school environments, in which specific tools may be needed most, we study, using ethnomethodological approaches a number of situations, out of which we attempt to derive key characteristics related to the learning outcome and the involvement of the tutors. There are some common elements in the studies reported in this paper, among which the subject matter and the collaborative technology used, while there are some distinct differences, like the instructional approach and the level of the educational institution.

The technological environment used is *Synergo* (Avouris et al. 2004), that has been already used successfully in various authentic synchronous collaborative learning settings, as it supports synchronous computer mediated collaboration while at the same time promotes analysis of trails of the activity that have been recorded by the environment itself.

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The subject domain of the activities is related to *development of algorithmic skills*, that may be associated to different cognitive levels (Bloom et al. 1964), starting from *knowledge* of key algorithmic structures, *comprehension* of their workings, *application* of them to simple problems, *analysis* of problems in order to identify the most appropriate use of algorithmic constructs to them, *synthesis* of a solution to the given problems and *evaluation* of correctness and completeness of the developed algorithmic solution. These cognitive skills, as in other design and engineering domains, are characteristic of inquiry approaches that involve negotiation and in general collaboration. In addition, this subject matter is introduced in various levels of education, with different instructional approaches and objectives, so it is considered suitable for studying teachers' role in everyday classroom, in alternative settings.

In general, algorithms are considered a fundamental concept in computer science teaching (Tucker et. al. 1995), where they are related to problem solving skills. Various approaches have been proposed to support teaching algorithms, including use of alternative representations, like graphical and verbal ones (Scanlan 1998). In the case of computer-supported collaboration, graphical representations are more effective due to their higher symbolic value and ease of manipulation in a shared workspace. So, representing algorithms through *flowcharts* has been considered to be effective in our context. Flowcharts, an easy to master diagramming language, is a common representation for many problems. At the same time flowcharts are included in many computer science curricula in secondary education as well as in some introductory to computing courses of higher education. So, in the reported here studies we suggested to the teachers involved to design new activities of exploration and building of algorithms expressed in the form of flowcharts, using a collaborative peer-learning approach and introduce these activities in the frame of their courses. At the same time we observed the process of the design of the new activities, testing them, implementing them in the classroom or the laboratory, assessing students' performance and evaluating the process.

We have conducted two independent, self contained studies in order to involve the teacher in all these phases, in two distinct settings concerning two different ages of students in different levels of education: (a) a junior secondary school class[1] and (b) an Introductory to Computing University course[2]. In the context of these studies, activities suitable for collaborative learning, concerning exploitation and building of algorithms, represented in the form of flowcharts were designed.

In the following section, we discuss the context of the studies, the involvement of the teachers in their implementation and important outcomes that relate to the analysis of the activities performed by the teachers themselves.

The Studies

As already discussed, the main objective of the two studies was to involve the teacher during all main phases of introducing the collaborative activities: (a) *design* of the activity, (b) *implementation* of the activities in the class, (c) *analysis* of the collected data for assessment and evaluation of the learning process, in order to identify the corresponding needs. The teacher's motive for participation in the studies

[1] Vrachneika High School, Patras, Greece
[2] University of Patras, 1st Semester of Department of Electrical and Computer Engineering

was to use a new instructional approach for the students and a new environment that could support more effectively assessment of the learning process.

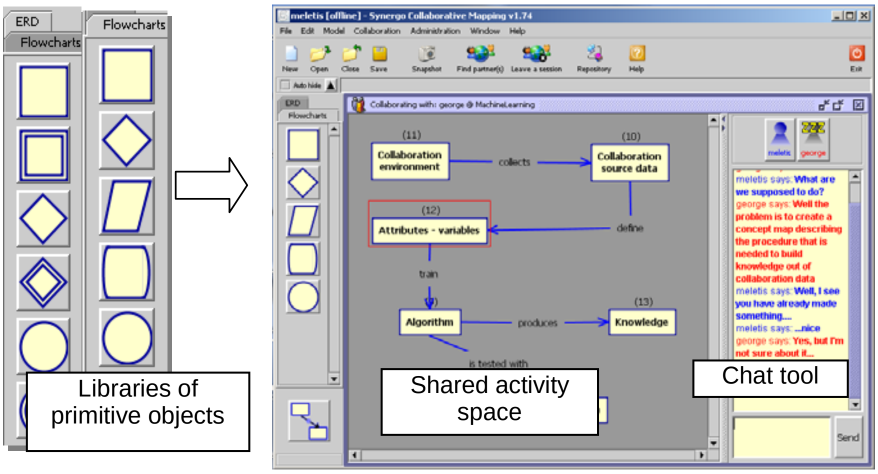

Figure1 . Typical screenshot of the Synergo synchronous collaboration environment, including a shared space, a chat tool for direct communication and libraries of primitive objects that can be dragged in the shared space.

The environment

We have used *Synergo*[3] as a collaborative environment and *Synergo Analysis Environment*, for the analysis of the collected data. Synergo comprises these two tools in a client-server distributed application, to support collaborative graph based activities. Synergo collaborative environment supports individual and collaborative building of various kinds of graphic representations of problems. It contains libraries for building flowcharts, entity-relationship diagrams, concept maps, data flow diagrams etc. data describing the activity can be produced in the form of logfiles and are available for inspection by the users or researchers. The main activity space of the Synergo modelling environment is shared by multiple actors, permitting collaborative problem solving activities of learning actors collocated (in a classroom) or at a distance, as in the case of the Hellenic Open University students (Xenos et al. 2004). Synchronous collaboration for problem solving is a case of computer-supported collaboration based on the concept of shared artefact/ work surface (Dix et al, 1998). As a result, one participant's manipulation of shared objects can be observed by the other participants. This communication through the artefact can be as important as direct communication between participants. A *dialogue tool* (chat) is integrated in Synergo, which is based on an instant messaging protocol, using the same point-to-point connection and protocol of the shared activity space. Through this, text messages are exchanged during collaborative problem solving. The chat tool, is activated from the collaboration panel. A typical view of the environment is shown in figure 1

Synergo Analysis environment permits presentation and processing of logfiles, which have been produced during Synergo activities. These logfiles contain in XML form description of users actions and exchanged text messages and are able to reproduce the activity for posterior inspection in playback mode, in a step-by-step or continuous way. Annotation of this logfile and statistical processing can also be done, as discussed in more detail in Avouris et al. (2004). While this analysis environment has been mainly used so far by researchers of computer-assisted collaboration studies

[3] Synergo is a freeware set of tools, developed by the Univ.Patars HCI group (www.synergo.gr).

who used Synergo, in our case we also investigated its effectiveness as a tool to support the tutors involved in their tasks.

The *data collection technique* used in both cases involved the Synergo logfiles, as well as direct observation by teacher and researcher (ethnographic study), analysis and evaluation of the solutions produced by the students in electronic or paper form (the latter for the high school paper-pencil activity).

Context of Study S#1

The first study, reported in more detail in (Voyiatzaki et al., 2004), has taken place in a Junior High School (Gymnasio), in the suburbs of Patras, Greece, a school of a deprived area. Most children who participated in the study had little experience with computer technology outside the school environment. The activity took place in the computer laboratory and it was part of the introductory to computing course. The class teacher, a computer scientist with experience in technology mediated class activities, after an initial discussion on the possibilities of the technology and the characteristics of the class and the course, suggested an activity that involved exploring and testing by the pupils in dyads or triads of an algorithm. The algorithm was given in a form of a flowchart. The algorithm was in Synergo shared activity space accessed by collocated but dispersed partners who interacted mainly through this environment. Other students collaborated around a paper activity sheet. In either case, it was considered beneficial scaffolding of the problem solving by suggesting roles to the partners: one to be the algorithm executer, playing the role of the CPU, and the other to display the contents of memory, the role of RAM, and/ or of the Output Display.

All groups were given the same activity sheet, which contained the flowchart of an algorithm for finding the maximum of two integers, A and B. Next to the flowchart, a graphical presentation of corresponding memory cells and an output display was given. The students had to verify that the algorithm in the activity sheet solve correctly the "find the max of two numbers" problem, with completeness. To prove this they had to explore different pairs of A,B to verify the step by step execution of the algorithm and show the contents of the memory cells and the screen display in each case. The students were expected to test the algorithm for at least two different pairs of numbers (A>B, B>A), and assign correctly the values in the memory cells. This solution was considered acceptable, since this way they could demonstrate that they reached the first level of algorithm correctness check. However the completeness requirement was met only by students who also checked for the case of A=B. In total 30 students, 15 years old, participated in the study. Half of the students used Synergo tool for communication and collaboration, in teams made of two to three pupils each, while the other half of them used just a paper and pencil environment, in teams of three. In the latter case collaboration was effected in a face-to-face manner. This was an alternative approach; less demanding in terms of technology, since paper and pencil is the usual collaborative environment in the school practice, with different requirements from the tutor. The solutions and the problem solving approaches of the two groups were compared by the teacher with the help of the researchers who initiated the study.

Context of Study S#2

The second study was in the frame of an *Introductory in computing* first year course, part of a Computer Engineering University five year degree. The activity was designed by the teaching staff in the form of two hour lab session. The teaching staff was the faculty members responsible for the course and the teaching assistants who actually played the tutoring role during lab activities. The course content includes introduction in computer architecture, algorithms and data structures and operating systems. Since algorithmic constructs is part of the course curriculum, we discussed with the staff the idea of introducing for the first time collaborative algorithm building activities in one of the lab sessions. So a new activity was designed. This asked the students to express in the form of a flowchart, the algorithms that solve the following two problems: binary search in an ordered set of integer numbers and Russian multiplication of two integers. No specific roles were assigned to the students in this case.

Seventy-six (*76) students* of 18-19 years old, participated in the activity that lasted one lab session. The actual time allocated per task was around 40 min. Each student had to solve both problems, one working individually and one working collaboratively. The partners of collaborative sessions were collocated in the same lab area but distant enough to need to use the tool for communication. In either case the tool to draw the flowchart and collaborate was Synergo. The order of the tasks and the selection of the collaborative/individual task for each student was done in such way that all possible combinations were effected. The purpose of this design was to compare performance of students in the two settings, and measure learning impact of collaboration especially if peer teaching took place during collaborative activities. The assessment of the produced results was based both on the quality of the solutions and on the degree of collaboration for the group activities.

In this case study, contrary to the first one, the diversity of observed groups behaviours was higher. Since no roles were assigned to the individual students, some partners produced a solution, while their partner was just observing, or just commenting. The ratio of instructors to students was around 10, so each instructor had to follow ten individuals, or five dyads working in parallel, depending on the specific task. Since the diversity of the approaches was higher, it was felt that the teacher could not cope with just going around the students during the activity, without the support of some aids. As Stahl (2005) has remarked, a group activity is based on a common ground and a shared meaning developed, while group cognition is developed beyond the situated and transient discourse itself. For an outsider, who has not taken part in the group activities even if it is an intervening experienced instructor, to manage to participate rapidly is a difficult task. This becomes even harder if the instructor has to follow a number of groups in parallel, as in the case of our case studies.

The involvement of the teacher

In this section we provide a brief summary of the tutors' roles during the discussed studies. The teacher was involved in each study during the *design* by setting the didactic goals according to the existing curriculum and the specific class characteristics and expectations, defining the activity, the problem solving task, the students task, defining the groups' structure and the evaluation criteria for the students

During the *implementation* of the designed activities the teacher was the observer of the process. In average there was 1 teacher (or teaching assistant) per 10 students in both studies. In one case of the high school activity, the teacher played the role of one peer. In this particular case patterns of peer learning were more clearly observed, as the teacher monitored and provided scaffolding to the collaboration and solution building process online, However this case, had an impact on the rest of the groups of that particular class. Therefore the new role of the teacher, who was expected to coordinate and mentor the collaborative process could not be effectively done through the collaborative environment itself.

At the *assessment* and evaluation phase, the tutors in either case first examined the produced outputs by the students. Subsequently they went further analysing the process, as it was played back by the environment itself. They also used the annotation tool, in certain occasions in order to identify using their experience, patterns of learning.

The analysis tool gave various graphical representations as results of statistical processing of the data gathered during the activity. Teachers have used these representations as a first level of assessment. Their interest was focused in particular on the content of dialogues that evolved during algorithm building, in parallel to student actions.

Discussion

In both presented studies we have assumed that the CSCL environment would provide the teacher with a better view of the algorithm building or algorithm exploring process, and of the reasoning of the partners. In the first case study where we had two approaches (collaboration face to face with paper-pencil vs collaboration with Synergo), the teacher using the logfiles and the playback tool confirmed our assumption.

High school study			***University study***		
Phase	***Outputs to evaluate***	***Comments on the outputs***	***Phase***	***Outputs to evaluate***	***Comments on the outputs***
Face to face collaboration use of paper – pencil	Activity sheets	Static outputs (no information on the development of the solution)	**Individual**	• Logfiles • Playback of the process (actions+chat) • Analysis of the solutions	Information on the development of the solution (from the playback) but none on reasoning
	Observation	Estimation on the process, and overview of the class		Observation	Estimation on the process, and overview of the class

Phase	***Outputs to evaluate***	***Comments on the outputs***
Collaboration using Synergo	• Logfiles • Playback of the process (actions +chat) • Analysis of the solutions	Information on the development of the solution, the reasoning through negotiation, and evidence on learning process
	• Observation • Monitoring	Group/ class Overview Scaffold the process

Table 1. The outputs for evaluation from the two studies

During the second study we were able to investigate how important is for the teacher the ‘playback’ of the development of the solution observing individuals working alone in comparison to the playback of the process in cases of collaborating partners, in which some of the reasoning could be derived from the dialogues. Comparing the two cases we have found that the ‘solution development including negotiation’ offers more complete view to the tutor on the learning process. In table 1 we are providing a structured description of the two studies, and comments on their outputs in each face.

On the other hand, analysing only the dialogue, without taking in consideration the actions in the shared activity space, prevents the analyst of interpreting effectively the discourse. In such context it was observed that the contextual information, in the form of the current state of the shared activity space, when a certain utterance was exchanged, was very important for interpreting the dialogue.

As a summary, we have deduced from both studies that the analysis of the produced information, could provide the teacher with adequate evidence on the collaborative attitude and behaviour of the students, details on the algorithm building/exploring process and identify misconceptions on basic algorithmic structures. It was also observed that it was particularly difficult for the tutor to participate in multiple collaborative sessions at run time.

Discussion about the collaboration process

In either case, the students were motivated for working collaboratively. They were informed that special credit marks will be given for demonstrating collaborative attitude.

The High school students were active but they were not making any special attempt to collaborate as very limited negotiation took place beyond the pre-defined behaviour by the activity. The role playing that was used for scaffolding ration was effective in the sense that both peers were active. However evidence of real negotiation was missing.

The university students were very active during group activity. Almost 50% of them were negotiating or trying to explain their actions to their partners if asked. There were students however that were not negotiating systematically. These students when asked for explanations, they seemed that they were expecting their partners to be able to understand their own reasoning, by just observing their actions in the shared workspace, without considering necessary to give any additional explanations, as shown in dialogue extracts included in figure 2. These students seem to consider that the development of the solution was most important than working together. It is possible that this behaviour was a result of the limited time that was given for the collaborative activity.

Student A: What do I have to do ?
Student B: Just watch what I'm doing

Student C: What we are supposed to do during "collaboration"?
...after a long active session . . .

Student C: Well, Collaboration seems interesting

Figure 2. Two fragments of dialogues demonstrating students attitude towards collaboration

From the chat dialogues and the observation, in both studies, there were indications, that the students had difficulties to define 'collaboration', probably due to lack of previous similar experience (figure 2). From both case studies, it seems that there is lack of collaboration 'culture' in the students, in both levels of education.

Concerning the added value of group activity, in both studies there were examples of students 'teaching' their partners, correcting them, proposing correct actions, explaining and encouraging their partners to imitate their actions, using Synergo. The examples were very clear in the sessions of the university students. From the dialogues of university students, the teacher has outlined some examples that imply deep learning during the collaboration process.

Discussion about the algorithm building process

In both studies there were initial assumptions from the instructors involved. However even when it was requested by the activity sheet, the students, have not used a common strategy to approach the solution. They usually started without adequate negotiation on the strategy. However, in cases of later negotiation, in both studies, students used the graphic representation for grounding discussion. The university students had achieved a high level of negotiation, since according to the analysis; more than 60% had negotiation patterns in their activities.

Discussion on indications related to the learning process

In both studies the instructors have identified before the study their objectives on the learning outcome and anticipated possible difficulties in handling certain objects or abstract concepts (loop instructions, variables, algorithm verification through tracing the flowchart). In the first study, at the high school, there was evidence from the logfiles, that the students had difficulties in handling the '*variable*' concept. We have observed the same difficulty during the University activity where almost 25% of the students had misconceptions concerning this abstract concept. The misconceptions were thus similar despite the age difference.

Conclusion

In this paper we discussed the first findings of two independent studies involving design and implementation of computer-supported collaborative activities. The instructors played an important role in all phases of the reported studies. The ultimate objective of this research to define requirements for CSCL tools to support tutors, during such collaborative activities. It was discovered that scaffolding of collaboration can be important for effective development of common ground by all partners concerned. Role playing, that was used in one occasion, is an effective mechanism, however participation of the tutor in the process seems also very effective. It was shown that the tutor finds it difficult to follow and support many groups in parallel, while when in one occasion the tutor played the role of a student there were many patterns of peer tutoring observed in the particular group.

Concerning post-activity assessment of the result by the tutors, it was found that a record of *actions* (in the common workspace) and *dialogue events* seem to give powerful input to the tutor for diagnosing misconceptions and in general of the reasoning process.

A final remark on applicability of the reported findings is that since the reported studies concern so different settings, the reported observations can be generalized and we believe that the discussion included is relevant to many other computer-mediated collaborative problem solving situations and can lead to requirements for future tutor supporting technology.

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