Introduction of Synchronous Peer Collaboration Activities in a Distance Learning Course

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Abstract—This paper presents the main findings and lessons learned from introducing a synchronous peer collaboration activity in a distance learning computer science course. Synergo, a software that supports such an approach, was used in this activity. The organizational, technical and academic challenges of introducing this activity in the course are discussed. After analyzing the students' interaction and their opinions, and evaluating of the final results, it was found that this activity was received positively by the group of students concerned, who engaged in peer tutoring and used this as an opportunity to break the isolation of the distance learning setting and to forge links with each other.

Index Terms— Collaborative work, computer science education, educational technology.

I. INTRODUCTION

Synchronous peer collaborative activities are rarely part of distance learning courses. In the frame of a computer science course of the Hellenic Open University (HOU), Patra, Greece, such an activity was recently designed and implemented. The objective was to investigate the effectiveness of synchronous peer collaboration in such a context, to

Manuscript accepted for publication, to appear as: M. Xenos, N. Avouris, D. Stavrinoudis, M. Margaritis, Introduction of Synchronous Peer Collaboration Activities in a Distance Learning Course, IEEE Transactions on Education, (forthcoming 2009)

examine the feasibility of large-scale deployment of a synchronous collaboration facility and to identify the challenges of such an endeavor. The findings are discussed in this article.

The application of peer collaboration involved first setting up a technological infrastructure and then making it available to the students of the distance learning course. Through this facility, the students could interact synchronously, in pairs, in order to work on an assignment that involved collaboratively building an algorithmic solution to a given problem, using a flowchart representation. Analysis of the history of student interaction recorded in server logs has revealed interesting patterns in relation to peer learning, while study of the chat dialogues provided an insight into the social implications of this approach for the students of this distance-learning community.

In order to verify the effectiveness of synchronous peer collaboration, analysis of the activity can be performed using discourse analysis, task analysis, or even a combination of methods [1]–[3]. In the case presented here, a combination of the following evaluation methods was used: a) monitoring and analysis of interaction; b) evaluation of the students' academic achievement and c) inquiry on the subjective views of the students expressed through a post-study questionnaire. This analysis revealed students' collaboration patterns, while the post-activity questionnaire revealed their subjective view on this activity.

In order to verify the feasibility of implementation of the service, records were kept by the support team, indicating the effort required to set up and run the application and support tools, such as the help desk and the forum, the degree of possible automation, and so on. The aim of this record keeping was to predict potential problems, and to offer the best possible support to the students concerned.

II. LITERATURE REVIEW AND CONTRIBUTION OF THE STUDY

Synchronous interaction and collaboration of students in distance education has thus far not been considered a high priority, and of limited use for a number of technical, pedagogical and organizational reasons. However, new technological advances in network computing and theories of collaborative learning [4] suggest the use of a synchronous interaction approach, which, as argued in this paper, can feasibly be implemented and used with current commonly-available home computer equipment and connectivity. The approach used in the reported study is based on low-bandwidth text-based communication and shared workspace interaction. There are technical advantages to such an approach, from which new person-to-person interaction structures may emerge [5]. However, development of an effective peer interaction facility for open and distance learning (ODL) involves various technical, educational and social challenges, as has been discussed in other similar experiments [6]. Despite the difficulties of the endeavor, HOU supported the design of the activity and the deployment of the infrastructure, persuaded by the benefits that collaborative learning can bring in this context. This approach was expected to contribute through the creation of shared referent artifacts, for example flowcharts, increased community cohesion, and better learning [7].

A new activity was introduced as an optional assignment in the course, to be accomplished within a specified period of time by the students, working in pairs. A considerable number of students undertook this optional assignment, which represented a considerable deviation from normal way of studying. The activity was monitored, and questionnaires were then filled out by the participants to evaluate their experience. The reported study, in terms of the number of students involved, and the complexity of the infrastructure, is such that the findings may be considered applicable to many other similar situations. The lessons learned are presented in the following sections.

III. CONTEXT OF THE STUDY

A. The Computer Science Course at the HOU

The study presented here took place in a course at the HOU which is part of a 4-year degree program in Computer Science. Specifically, first-year students taking the module INF10 "Introduction to Computer Science" participated in the study during the winter semester of the academic year 2003-2004. In this particular course, the focus of the subject matter on design, and the use of web-based materials, provided favorable conditions for applying a synchronous distance collaboration approach.

B. The "Introduction to Computer Science" Module

The INF10 module is one of the three first-year modules that students of the Computer Science course have to complete. During the academic year during which the study took place, 896 students were registered in the INF10 module; 69% of the students were male and 31% female, their average age was 31.1 years and most of them (98%) worked full time.

It should be noted that only half of the registered students manage to complete this module successfully, and not always at their first attempt. In general, the Computer Science program registers a relatively high dropout rate of 28% to 40% [8] for students of the INF10 module who fail to complete the module and drop out from the entire program. In 2003-2004, of the 896 students registered for this module, just 570 (63.6%)

– those who did not drop out during the first three months after registration – were considered as the ‘active’ course population.

C. Students’ Profile of the Computer Science Course

With respect to participation in first year modules, 55% of the students take only one module (INF10), and only 15% take all three available modules, i.e. considered full-time students. This is typical for a university that allows students to set their own pace of study.

The students in the module were allocated to tutoring groups, each coordinated by a tutor that met about five times per year at a location near the students’ place of residence. A variety of educational material was used, which was sent to the students or made available via the web. The tutor–student communication was based on e-mail and a forum, with the web site playing an important part in the process.

Each student attending the module had to submit four assignments, followed by two written examinations. In order to assist students in achieving these goals, the five face-to-face tutoring group meetings were supplemented by a number of informal face-to-face meetings or distant virtual classroom meetings. All these collaboration channels, in place before the start of the work presented here, were based on asynchronous technologies (e-mail and fora). In general, the students interacted mainly with the tutors and very rarely with each other, as often is the case in distance learning courses.

IV. METHODOLOGY AND TOOLS

This section outlines the methodology and tools used in the study. First, the technological infrastructure is briefly presented, followed by the basic phases and principal organizational tasks related to supporting this activity.

A. Outline of the Technological Environment

To allow synchronous peer interaction, new infrastructure needed to be established and organizational adjustments to be effected. Important considerations for technology deployment concerned constraints on bandwidth, and restrictions on p2p protocols imposed by firewalls and proxy servers. In the context of the reported study, the authors attempted to address these problems, and to setup and use a facility that built on the existing infrastructure at the University. It must be noted that students' Internet access at the time was mostly based on dial-up modem connections (73%), therefore the adoption of technology with low bandwidth requirements was considered appropriate.

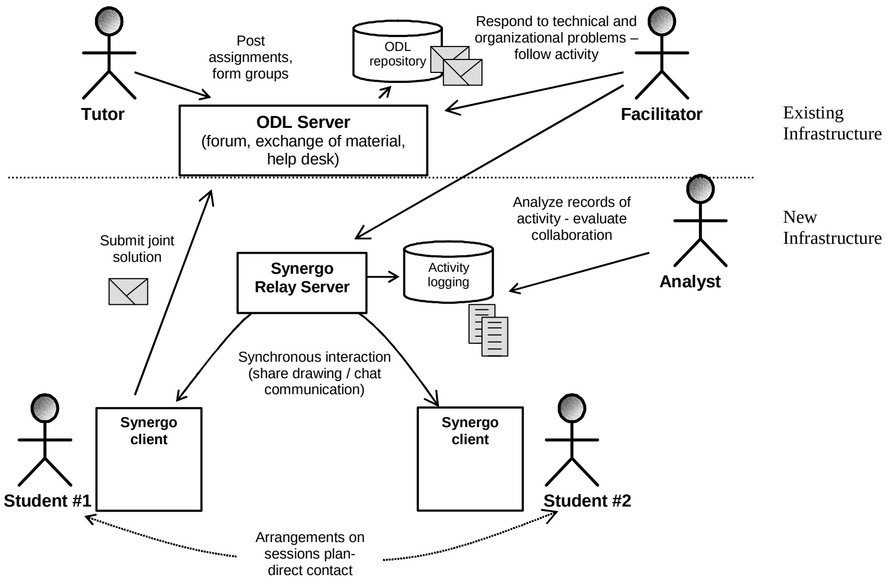

Fig. 1 The structure of the collaborative activity

The structure of this activity is described in Fig. 1, where the main components are shown together with the main actors who took part in the reported study (tutor, facilitator, analysts and students organized in pairs). The technological framework used was Synergo[1], a tool that permits the building and exploring of flowcharts by distant partners who can manipulate the developed diagrams in a shared activity space and communicate directly through a chat tool. In Fig. 2 the typical client environment is shown: flow chart on the left and chat tool on the right. In addition, Synergo integrates analysis tools that can automatically extract useful statistics of usage data.

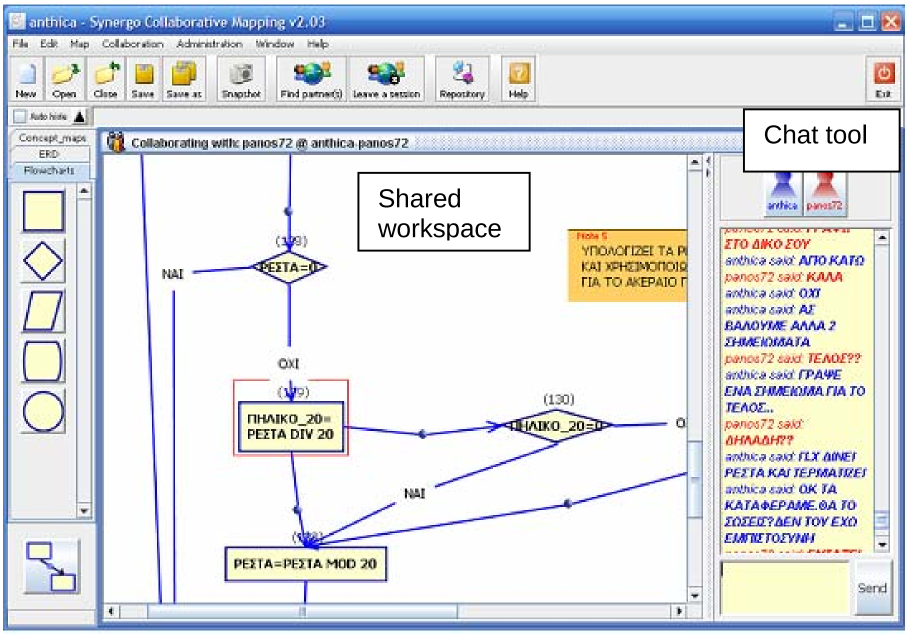

Fig. 2 The client view of the Synergo application

B. Setting up the Infrastructure and the Service

The objective was to enable the students, at remote locations, to practice the design of algorithms exclusively through computer-mediated collaboration.

The setting up of the activity involved the following phases:

Preparation: This phase included the feasibility study, ensuring the availability of the required resources (human and infrastructure), and the adaptation of the Synergo tool to

[1]http://hci.ece.upatras.gr/synergo

meet the specific requirements. Preparation also included the related administrative work, approval and funding.

Task Design: The new assignment involved the building of an algorithm for a bus ticket-vending machine using a flowchart representation. According to the project specifications, the vending machine could accept different types of coins and issue tickets of different values. The machine should return change and reject invalid coins.

Setting up the infrastructure: This phase included setting up a Communication Relay Server and a Database Server, linking with the University infrastructure, development of the user support material, running a number of pilot scenarios of use and finally arranging student access.

Student registration: The outline of the task was posted on the module site for two weeks. 150 students registered.

Creation of student pairs: The 150 registered students were matched into 75 pairs, so that pair members were from distant geographical areas. Next, Synergo software and the task description were made available to the students. CDs were mailed to the participating students, in case they could not download the files from the server, due to bandwidth restrictions.

Task execution phase: 30 days were allocated to complete the activity. A helpdesk service run by four persons handled problems and queries during this time. Two helpdesk members were responsible for technical problems, one for organizational issues (such as the mailing of CDs, reassignment of some pairs, etc.) and one for academic questions on the task itself. Responses to student queries were published and recorded in the forum, or handled by phone and e-mail. An indication of the level of support required is the fact that 527 messages were created in the forum, in 96 threads.

Project Completion: After submission, a sample solution was posted on the web site, the solution submitted by each pair was marked, and the results were sent back to the students. Subsequently, selected solutions were published at the INF10 web site and all students were requested to participate in a questionnaire-based survey about the project. The number of pairs who reached a solution was 65 out of 75, i.e., 130 students (87% of the students initially registered). This rate of participation was considered satisfactory for an optional assignment, since one of the major problems facing these students are the many demands upon their time.

V. COLLABORATION RESULTS, ANALYSIS AND DISCUSSION

A. An Overview of Students' Participation

There were 570 active students in the INF10 module, out of 896 registered students. 130 students (65 pairs) finally submitted a solution to the assignment, i.e., 22.8% of the active students. Although this number may appear to be low, it is representative of the behavior of students in distance learning who have to deal with work and family responsibilities, and thus face additional time limitations compared to students pursuing full-time education.

The 130 participating students were formed 65 pairs. 47 of these pairs used, in various degrees, the synchronous collaboration facility. The remaining 18 pairs collaborated mostly asynchronously. The reasons identified that eventually drove these students to work off-line were either technical or organizational. In some cases firewall or proxy restrictions did not allow collaborative sessions to be established. In some cases students tried to use Synergo from their place of work, where this kind of restriction is particularly common. In other cases, it was impossible for the two students to agree on a common time for online collaboration. For these 18 pairs their collaboration patterns could not be studied further.

The interaction of the 47 pairs who used Synergo was recorded. Of these 47 pairs, 17 submitted their joint solution through the Synergo facility, while the other 30 pairs submitted it in other ways, mainly via email.

By combining the Relay Server logs and the post-study questionnaires, it was found that combinations of synchronous and asynchronous interaction techniques were often used for collaboration. For instance, some pairs used the phone to communicate during some of their collaboration sessions, instead of the Synergo chat tool. Some other pairs worked individually before joining a collaboration session and used the online session to upload parts of the solution for comments by their peers. This behavior is not uncommon and cannot be avoided, since many people prefer voice-based communication to chat, or choose to work offline when they have some spare time available. The analysis presented below is based on data from all 47 pairs.

TABLE I

CHARACTERISTICS OF THE 130 PARTICIPANTS vs. THE ENTIRE POPULATION OF INF10 (896 STUDENTS)

	All students	**Participants Only**
Male / Female	69.0% / 31.0%	69.2% / 30.8%
Athens / Other regions	50.8% / 49.2%	43.1% / 56.9%
Average age	31.1	30.8

It is important to state that the 130 students who participated in this optional assignment had almost the same profile as that of the rest of the module students. Specifically, they have the same male/female ratio and average age, as illustrated in Table I. A minor deviation is observed with respect to the place of residence of the participating students. Although over half (50.8%) of the entire INF10 student population resides in the area of Athens, the largest urban area in Greece, only 43.1% of the students who participated in this experiment reside in this region. The explanation may be that students living in geographically remote or rural areas such as the Greek islands, are characterized by a much stronger desire for peer interaction than students living in urban areas, while in addition, students living in urban areas usually have much busier lives and can spare less time for optional tasks.

The 47 pairs who worked collaboratively using the provided chat tool each interacted for a number of consecutive sessions, in order to complete their task. In average 9.7 sessions were recorded per group. The average duration of a session was just over 21 min. A total of 163h 42min of interaction was recorded in 458 sessions, around 3h 29m of online activity per group. The group with the maximum interaction had an activity duration of 8h 41min, spread over 42 sessions of 12.4 min each on average. The frequency of the recorded sessions could be very high over a short period of time spanning just a couple of days, or could be much lower, with sessions occurring over a period of almost a month, an indication of the diversity of availability of the students of such distant courses. Most of the activity took place between 6pm and 1am, with the activity often lasting well into the early morning hours, while during working hours (9am to 6pm) the activity was very sporadic. Weekend days showed the most intensive activity.

A preliminary analysis of interaction characteristics for the 17 pairs who submitted solutions through Synergo was reported in [10]. It was found that the more balanced groups, in terms of student skills, were more active in terms of the density of their activity, measured as the number of events/min (correlation +0.44). The conclusion was drawn that it is important to encourage more balanced member interaction, either by ongoing tutor intervention or by building more balanced groups in the first place.

Another similar finding was related to the balance of the activity of the groups. It was discovered that shared workspace actions were more imbalanced than was the chat communication. The average ratio of partners' activity in the first case was 0.54 (stdev=0.32) while for the chat it was 0.76 (stdev=0.17). This difference is due to the different skills that these two activities require. Acting in the drawing space requires good knowledge of the task and of algorithm concepts, while chat was used for inquiring about the activity and for making remarks or even engaging in off-task conversation.

After the task was completed, a questionnaire was distributed to the students. 21 pairs (32%) completed it while, some of the students expressed their opinion in the forum. Responses to the questionnaire were not anonymous, in order to ensure the validity of the responses.

B. Findings Related to Synchronous Peer Collaboration and Learning

Through qualitative analysis of the interaction, selected activity episodes were identified and analyzed in order to identify typical patterns of peer support. It was found that the spirit in all groups was highly collaborative and supportive, to a much greater extent than in similar studies with secondary education students where conflicts occurred in peer collaboration experiments [11]. This high level of successful collaboration is due mainly to the voluntary nature of the participation in this experiment, and to the maturity of the participants who perhaps enjoyed this occasion of interaction with their peers as a rare opportunity for joint activity. A common pattern, especially at the beginning of a session, was for the partners to engage in off-task conversation about everyday matters in their lives.

Typical examples of peer tutoring are described below.

In one student group, Partner A introduced the conditional expression “Y DIV 50 > 0”. Partner B requests an explanation on the use of DIV and the meaning of this expression, partner A replies, explaining the use of this condition for calculating which coins the vending machine should give back as change. B requests further general explanation about the use of DIV, which is promptly provided by A. Subsequently, B admits that for the same part of the algorithm s/he had in mind a longer process, acknowledging the elegance of A’s suggestion.

In a dialogue episode of another student group, partner C attempts to create a conditional node using the wrong shape (barrel shape instead of diamond). In addition the text within this node is a full *if..then..else* expression. Partner D intervenes making a suggestion on the shape and the expression. C does not understand the suggestion and requests that D demonstrate it by acting in the shared space. D builds the conditional node of the flow chart and asks C to build the subsequent condition, since the algorithm involves a sequence of three conditions. C creates the second conditional node using the correct shape and wrong expression, D makes a new comment, in response C corrects the node and subsequently builds the third consecutive node correctly.

Both the above episodes demonstrate a highly supportive and collaborative attitude. In both, one of the two partners takes the tutoring role and the other one the inquiring role.

In both cases, the tutoring peer requests a demonstration of the acquired new knowledge by passing the initiative to the inquiring partner. This positive attitude and the beneficial use of this approach needs to be confirmed in cases of more extensive use of peer collaboration activities. In any case, it seems worthwhile to investigate further relevant pedagogical approaches and activities, as well as tools that further encourage the occurrence of such incidents in the context of distant synchronous collaborative activities.

With regard to students' performance, it was found that students who participated in this optional assignment had higher academic performance than those who did not. (Success 65% against 37%, drop out 23% against 39%, high score 14% against 4%). Furthermore, these students demonstrated better overall academic performance. From the students who registered in the program in 2003-2004, only 38 students managed to graduate by 2007. Among them 18 students had participated in the optional assignment, (13.8% of the participants) against 3.4% of the non-participants.

The implication is not that the participation in the assignment is the reason for the improved performance of these 130 students. Rather it can be seen as an indication that the students in question were more motivated and committed to their studies; thus the willingness of a student to participate in such assignments can be considered as an indicator of potential success.

Finally, with regard to students' perception and satisfaction from the synchronous peer collaboration, the findings are based on both students' responses to the questionnaire as well as student comments available in the forum. The comments received were, in general, enthusiastic; according to students' comments in the forum, participation in this assignment supported the learning process and –despite problems– students would participate again in similar activities. Some quotes from students' comments are:

"*…I believe that it is important to continue applying synchronous peer collaboration even without the grade bonus. It helped us to understand better what we have studied…*",

"*…This is something new helping us to correct our mistakes and the collaboration helps a lot. When one gets stuck, the other one helps and vice versa…*",

"*…The experience of collaborating with someone I have not met in person (yet), helped me very much. Please consider expanding this application to more modules of our curriculum…*",

According to the questionnaire-based survey, 85% of the students believe that the idea of engaging in synchronous peer collaboration activities is very good, and found the entire deployment well organized, while all of them (100%) declared that they would participate again in similar activities. Moreover, most of the students agreed that the main benefit from their participation in this exercise was the opportunity to collaborate with a fellow student (see Fig. 3, in which each student could choose more than one aspect).

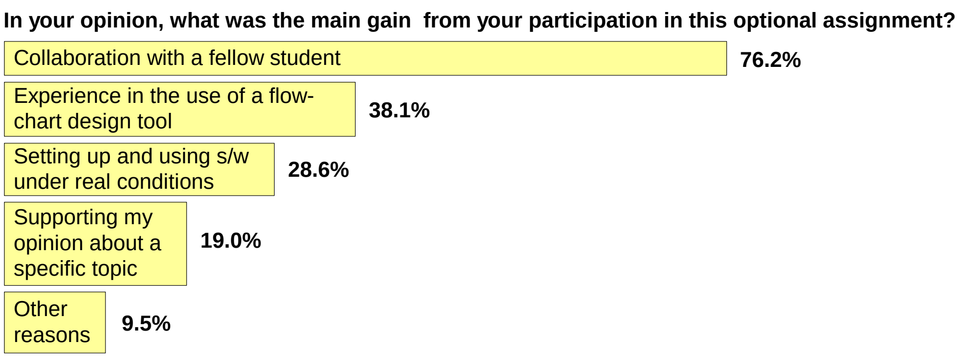

Fig.3 Students' views on the main benefit of the activity

To the question describing the collaboration with their partner, 85 % of the answers describe the collaboration as *very good*, while 52% claim that they continue to be in touch since the end of the assignment. On the other hand, only 10% describe the collaboration as *bad* or claim that there was no collaboration. In confirmation to this, after studying extracts of recorded dialogues, it was observed that often the partners were engaged in off-task social conversation, mostly about exchange of experience about other assignments and study work in the context of the same or other distance learning modules, but often extended to off-task matters. This is also confirmed by the finding that over 76% of the replies describe the main benefit from the activity as being the collaboration with fellow students instead of identifying academic or other gains (fig. 3).

Students' overall positive experience with the activity was also expressed in their responses to the open questions of the questionnaire.

C. Lessons Learned from the Deployment and Support

Despite the fact that the application proceeded as initially designed, a number of problems occurred. The problems reported and discussed in the forum, in 527 postings, were classified as a) organizational problems relating to the administration of the application, b) technical problems and c) academic problems related to the assigned task. The majority were technical problems (51%), while 40% were organizational and 9% academic.

Most of the organizational problems had been foreseen and had to do with inaccurate student details (incorrect postal address, or the like). In some cases, organizational problems prevented timely delivery of the software. Reassignment of student pairs proved to be quite time-consuming and caused a lot of frustration – and consequently a flow of messages – on the part of the ‘abandoned’ students.

As regards technical problems, some of these were quite complex and unforeseen. The majority of these complex problems were related to the variety of configurations of students’ workstations and the need of remote support. For instance, the Java VM cannot trace the proxy server settings, so users who use a proxy server had to reconfigure these parameters manually within Synergo. The screen resolution used by certain students also caused problems; the student with the low resolution could not see on the screen the part of the flow chart on which his partner was working, and thus sent a lot of requests for support, a well-known problem in shared screen applications.

Completely unforeseen were the technical problems related to an extensive power failure that occurred late on a Friday night at the server building. The duration of the power failure exceeded the UPS capacity, which caused the server to shut down. This affected many students who complained vehemently about it, as they often used to work late at night and in particular during the weekends.

As regards academic problems, very few student queries were received about the flowchart assignment specifications. Some of these queries were about the amount of comments required from students, the specifications for the vending machine return of change functionality, or the like.

Students’ satisfaction with the support that they received was measured through the questionnaire. The majority of students appeared to be very satisfied from the support that they received in relation to academic questions (very good 85%, no negative opinions), Satisfaction with organizational issues was somehow lower (70% very good, no negative opinions), and even lower with technical questions (35% very good, 50% good, 5% average and 10% poor), which is the only case in which students expressed a negative opinion relating to the support they received. This result clearly has to do with the nature and the complexity of the problems that the students faced.

In conclusion, the most important lesson learned is that in a large-scale deployment involving so many students with major time constraints and limited availability, and with such a diversity of technical equipment, and technical skills, the technical support and careful design of the infrastructure and helpdesk is crucial. The technical character of the problems is such that a range of expertise must be included in the support team, and 24 hour service is very important in real time synchronous collaboration conditions.

VI. CONCLUSIONS

This paper focused on the experience gained and lessons learned from the deployment of a synchronous collaborative problem solving activity in a distance learning computer science course. A major question that this study attempted to answer is whether, based on the reported experiment, it is worth pursuing the further introduction of synchronous collaboration activities in open and distance learning courses.

The answer to this question cannot be but multifaceted: in terms of organizational cost and technology requirements, a high level of commitment and human resources are needed to be able to support such an application,. The support team must be continuously available and be able to solve problems and offer solutions promptly. In terms of academic relevance, there have been interesting patterns of peer tutoring observed in the students' activities, which are conducive to learning and to development of critical thinking skills, especially in design courses like Algorithm Building. Finally in terms of social impact, it was found that the activity contributed towards the development and strengthening of the virtual student community. Many students who worked together for this assignment were reported to continue to communicate frequently, and collaborate in their studies. It seems that the co-presence of the partners and simultaneous engagement with the activity has lead to intense interaction between remote and isolated students that had an effect that exceeded the scope of the specific activity.

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