Collaborative Activities and their Implementation in an Internet-Based Maths Course: A Case Study

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Abstract

The paper reports on the experience of the Centre Collégial de Formation à Distance, a post-secondary distance education located in Montréal, Québec, in introducing new courses over the Internet. Up until recently, the Center had followed the traditional distance learning model of providing its students with material for individualized home study. Consistent student reports of isolation and lack of peer interaction led it to explore the collaborative learning capacities of the Internet. First to be implemented is an existing maths course specifically redesigned for a field test. The first results show that, at least within small groups, the Internet does allow for synchronous collaborative activities. Students, both with each other and with a tutor, can share a white board around a common maths problem and discuss the various solutions in a live interactive way via Internet supported telephone and file sharing.

Introduction

As part of the RECTO project funded by the Quebec government information highway program ("Fonds québécois de l'autoroute de l'information"), the distance learning center (Centre collégial de formation à distance, or CCFD) of the Rosemont CEGEP (a post-secondary institution located in Montréal, Canada), was given the mandate to re-engineer a course for its implementation on the Internet.
The course chosen is a pre-university level mathematics course in integral and differential calculus. In its present form, this course uses new technologies in a limited way. It is mostly print-based, although it also uses mail, the telephone and interactive television modules."Re-engineering" in this context means redesigning a course already offered by the Center through distance learning to take advantage of the potential offered by the Internet.

The objective of the project is to facilitate the emergence of innovative learning and teaching models, based on new instructional approaches. It has raised several issues. One pertains to the organisation of collaborative work for designing a distance learning course via the Internet. Another regards the systematic coordination of the Internet environment relevant for educators (the designer and the tutor) and learners alike [Stahl et al., 1995]. There were both presented and discussed at Inet 96 last June [Chomienne and Potvin 1996]. The objective of the present communication is to go one step further, by presenting the first results from the pre-trial stage in the implemention process of the Center's distance collaborative learning project.

Because of the novelty of the medium (the Internet), an exploratory case study was chosen as a research strategy. The research question was: How can the Internet environment be used to offer collaborative learning activities to students remote from one another? The case concerns a maths course selected for its high attrition rate. Students had stressed isolation as a major difficulty in solving their maths problems.

The research team started the project with the following requisites: they were not supposed to develop new infrastructure material; they had to experiment with existing tools; and they had to design and implement collaborative activities and test them in naturalistic settings, that is with students at home, the usual learning environment of the CCFD client population.

The developing team also had to test the technologies available on the Internet so that collaborative activities could be designed in accordance with the real capabilities of these technologies.

What Is "Collaborative" Learning?: A Definition That Fits the Characteristics of the Maths Course Students

Collaborative Versus Cooperative Learning.

In educational sciences, the terms cooperative and collaborative often share the same meaning. We will follow this shortcut, and use both terms indistinctly. For a subtle distinction, see the study conducted by the Centre for the Study of Classroom Process [Abrami et al., 1993] and reported in [Ricciardi-Rigaud 1993].

Features of Cooperative Learning

[Slaving 1985] defines cooperative learning as an environment where students from different performance levels work together in small teams towards a common goal. This definition fits the target population of the course. Indeed, the target population consists of high school students in initial training, retraining adults or adults in permanent training. They all need to reach the same goal -- understanding concepts of integral and differential calculus -- but they don't share the same cognitive profile, or the same learning habits.

Following [Salomon 1992; Johnson and Johnson, 1984; and Slaving 1985] we chose the following constructs as essential characteristics of cooperative learning: interdependence among members, peer interaction, information sharing, and constructivist and humanistic approaches to learning.

An Empirical Process: The Analysis of Prior Experiments

Internet for collaborative learning is a relatively new field of study. As a starting point for our project, we chose to study the corpus of literature analysing concrete experiments. One recent concept of interest in the literature is that of "Computer Support for Cooperative Learning", or CSCL. It is derived by analogy from a previous concept, "Computer Support for Cooperative Work" (CSCW), which refers to the potential capabilities of technologies for teamwork processes. One example is group decision making, which is frequently found in business environments.

Technologies Used for CSCL: Limited Variety and Lack of Integration

CSCL is based on a rather limited variety of experiments. Most of them are related to the use of a computer mediated communication, or CMC [Ahern et al., 1992; Batson 1992; Feenberg 1987; Harasim 1990; Hawisher 1992; Henri 1992; Hiltz 1988a; Hiltz 1998b; Kemp 1992; Mason and Kaye, 1990; Ricciardi-Rigault 1993; Lohuis, 1996]. Usually it consists of written and asynchronous communication. If synchronous, it still runs on print based communication with the use of a chat function. Sometimes, CSCL is limited to an analysis of the use by the participants of a mere e-mail system [Newman 1992]. CSCL has also been studied in cases when students working in teams use an educational software. It is usually a simulation and the team is composed of two or three persons [Geban et al., 1992; Kneedler 1993; Resnick 1992; Roschelle 1992]. In such a situation, the learners are all present in the same location, and are therefore not separated by distance, but their interactions are mediated through a computer.

The use of more advanced technologies is seldom reported in the literature (for example, hypertext or hypermedias, videoconference desktop systems or groupware software allowing the synchronous transfer of graphics, animated pictures, or application sharing). Advanced technologies have rarely been tested for educational purposes because of their high costs as well as their still scarce availability [Collectif 1993]. Literature about these newer technologies is more abundant when CSCW is the issue [Schweitzer et al., 1993; Walther 1996; Dix 1996; Appelt 1996].

However, as [Dybvik and Lie, 1996] found, combining the Web with realtime multimedia communication, could provide a rich, distributed collaborative environment. As these tools are progressively integrated into the Internet network, they will increasingly be seen as a promising source for inexpensive collaborative work in distance education.

Yet, they will still need to be tested [Fetterman 1996]. Another issue is also the lack of a bandwith large enough for graphic or animated information to travel within reasonable time limits.

Six Lessons from the Literature

Our analysis of the literature on prior experiments allowed us to focus on six issues.

Involvement of Students

The involvement of students and the interaction between peers in a CMC are issues related to the definition of the role of the teacher. One of the teacher's main roles is to facilitate the participation of the students by diminishing their anxiety caused by the lack of direct contacts among peers [Feenberg 1987]. The teacher is then called a "moderator". His or her job is then to frequently synthesize the contents of the conference, to clarify key points in order to reassure the participants individually and collectivly about the value of their contribution to the task to be achieved.

The form of the discourse used by the moderator to stimulate discussion influences the degree of involvement of the students. [Ahern et al. 1992] found that an informal and conversation-like discourse, as compared to a formal discourse where the moderator asks questions, generates more elaborate answers from the students and more interaction among each other. Moreover, to have them learn how computer-mediated communication works, the moderator must engage the participants in a reflection on their own behavior as well as on the problems they face [Feenberg 1987]. [Henri 1992] even suggests that the animator be chosen among the working group members.

Level of Task Complexity.

The level of complexity of the activities to which the participants commit themselves is also a factor influencing the success of teleconferencing. For several authors, among which [Harasim 1990; Hiltz 1988b; Hooper and Hannafin 1991], teleconferencing is well adapted to activities involving mental processes of a superior order, among them the learning of scientific concepts [Goldman, 1992], or training for critical reading [Goodrum and Knuth, 1991]. Based on these findings, we believe that the resolution of maths problems like those accompanying the maths course under development is an activity which we can consider a good candidate for work in small remote teams.

Working Team Composition

The composition of working teams [Hooper et Hannafin, 1988; 1991], or the number of participants, are issues directly relevant for collaborative learning methods, which some authors have discussed in relation with experiments with NTI's. Student matching is another point of interest. For example, [Hooper and Hannafin 1991] found that in a computer based collaborative work environment, the weaker students were those who benefitted most from heterogeneous groupings. [Gail and Rein 1995] have addressed the question of pairing the partners.

Form of Participants' Interaction

Interactivity can take the form of a unilateral imposition of procedures. [Hoyles et al. 1992] have observed that the interactivity among members of different teams in computer-based tasks on science problems was limited to a demand for technical help from some students and to the imposition of procedural directives from some others. There was no discussion of contentious points likely to lead to the learning of new notions.

Affective and Social Value

Several authors, among which [Gray and O'Grady 1993] or [Riel 1992] and [Rojo 1991], have highlighted the affective value and the social aspects of collaborative learning when it is assisted by a new information technology. [Rojo 1991] even reports that in a computer-based teleconferencing session at the Ontario Institute of Science Education (OISE), the participants she interviewed had mostly used the system to send messages to one another and to socialize.

The Lack of Message Filing Tools

In experiments designed to achieve group activities like writing essays or syntheses, participants complain they frequently experience difficulties to retrieve the messages that would be useful to them.

It is based on their knowledge of the potential, problems and limits of the previous experiments, that the maths course "re-engineering" team set out to achieve its mandate.

The CCFD Experiment: The Case Of Maths 103

As previously mentioned, this mandate was to use an existing maths course, already offered by the CCFD in distance education, to develop and test the design of new collaborative activities taking into account the capabilities of the Internet. The choice of the course was oriented by the constant report of the difficulties experienced by the students in solving maths problems individually. Students had been complaining that they wanted to work with their peers and discuss with them the steps (correct or incorrect) they were following while solving problems.

A Team Working Testing Process

The team consists of two content specialists, assisted by an educational technologist and occasionally by a computer analyst and a programmer. The members have been interacting on a weekly base for several months to develop scenarios involving collaborative activities assisted by tools and technologies avalaible on the Internet.

The team built upon its analysis of the literature on previous experiments. It also performed abundant testing of the technologies it was planning for student use. For example, it simulated collaborative learning situations (teams varying from two to five persons) using the tools avalaible. Content specialists thus became aware of the technical capabilities of these tools. They were then able to extrapolate the pedagogical potential of the technologies tested, and to select the most appropriate technologies and activities to further design.

Results

The development team tested a great variety of tools and technologies. The test conditions were intentionally those that were supposed to prevail in real-life situation, the home of the students. Hardware and software were those that the team could expect to find in the students' homes. The team assumed that students would have a PC-computer with a Pentium micro processor, 16 meg of RAM and a modem 28 800 bauds. Connection to the Internet would be obtained from a private provider.

The team came to a classification of the technologies and tools relative to the size of the student groups. It also wound up with principles for matching technologies with activities. For example, the Internet vidoconferencing CUSEEMe was found to be able to assume only a social function and to work with groups of no more than 4-5 persons. The high demand in the bandwith made the quality of image and sound very poor and unsuitable for didactic purposes.

It also appeared that students could not solve maths problems on a common whiteboard, shared with another student, without a graphic tablet. The problem of writing mathematic equations was solved by having students handwrite with a pen on the tablet, as on a regular piece of paper.

Table 1 shows which collaborative activities were designed, the fonctions they were given and the tools and technologies they were using.

Table 1. Collaborative activities, functions and technologies

Group Size	Technologies and Tools
- Large group (entire class) Functions : *social* ("nice to meet you", chatting, jokes,	Teleconferencing (asynchronous and synchronous, chat), type Exchange server

etc.). No moderator, leave the group to animate this forum. *technical troubleshooting*. No animator but a respondent for technical questions *providing answers* to self-learning exercices *about the content*. Tutor course introduction, live presentation *to fix meetings*	Asynchronous Teleconferencing (Exchange server) FAQ in a forum, read-only mode Audioconferencing (TeleVox) Distributed agenda (available with Exchange server)
- Medium groups : sub-groups of the entire class (4 to 5 persons) Functions : *social* *about the content*. Tutor remedial lectures to a group of students with similar maths understanding difficulties *to fix meetings*	Videoconferencing (CUSEEme) Audioconferencing Distributed agenda (avalaible with Exchange server)
- Teams of two Functions : *tutor advice* *problem solving* (exercices resolved by two students.) *to fix meetings*	White board and application sharing(InternetConference) and graphic tablet Idem Distributed agenda (available with Exchange server)

The team also designed, on a more detailed level, the activities that the tutor-animator must accomplish to animate the teleconferences. Guidelines include techniques for stimulating active participation, student matching, group formation, and other activities.

Pre-testing is in progress. Six students selected as volunteers have been participating for more than one month in bi-weekly synchronous tutoring sessions. In addition they have to individually learn the content of the course through HTML pages including text and Java applets. These pages are linked to Powerpoint lectures, on line exercises or Acrobat documents. Other exercises have to be solved. Some, solved individually first, are then commented and discussed with other students either in a computer mediated conference or in a synchronous activity where two partners share the same file. Audio communication or chat is available during the sharing. Data collection tools consist of structured questionnaires, semi-structured interviews and participant observation. Structured questionnaires are filled out by each student every time he or she starts a mathematical learning session. The time spent on the activity, the technical problems encountered, and the mathematical learning achieved are carefully noted by the students and the two tutors.

Notwithstanding the very real technical problems we have been faced with, the emerging results are encouraging. Technology exists that does allow synchronous activities. Cooperative activities are possible, and students even report that collaboration feels more real than in face to face situations. This positive result probably stems from the fact that the activities of the experiment were carefully prepared, protocols are clear and varied, each one being specifically adapted to the situation under consideration. Learning develops through the process of questions and comments that students address to their partners or to the tutor during the tutoring evening sessions.

We have found that the technologies employed are not without limits. One of them is their instability. For example, the audio has not been dependable at all times. Interestingly however, the students have quickly compensated by switching to the chat mode of communication. Ironically, this mode that we had originally tried to avoid, on the belief it could be tedious, turned out to be a substitute. In a number of cases, audio and chat were even both used at the same time.

More results related to the composition of the teams, the involvement of students and other issues are not yet available but will be presented at the Conference.

Conclusion: What Are The Problems We Were Faced With and Which Questions We Are Going to Answer?

During the development phase, the team encountered several difficulties. Mots of them were resolved by testing and evaluating the technologies.
As can be seen in table 1, we planned to use several tools and technologies. A major challenge turned up to be their integration in order to harmonize the learning environment for the students. Special programming had to be done to link the tools together. This effort of harmonization is also present at the level of the content of the course. A tutorial, presented as an introductory session, was designed to familiarize learners with their new technological environment. In addition, a study guide (hypertext document) including a calendar, will help students plan their activities. As the topic is mathematics, the progress of the learner is rather linear. We had to implement conceptual maps to which students can refer to re-orient themselves in the environment.

We were also aware of the rapid obsolescence of the tools, the systems and the technology we have chosen. Our choices however were made according not to one but to several factors, such as extensive testing, robutsness of the private providers, product evaluation and comparison across various specialized magazines.

We also encountered technical difficulties during the pre-testing. For the learner the variety of technologies available have been an obstacle. Interfaces varied from one to the next, and users had to learn myriads of commands. Fortunately, most of them had been using computers for a few years and were considered to be computer literate. A teleconference designed to report and solve technical problems has been set up for this purpose. Its content as well as reports in the interviews and questionnaires will allow us to classify and quantify kinds of problems and ways of avoiding them.

First results seem promising, and whathever they will turn up to be, we must emphasize that we have constantly had the preocupation of the learner during the entire development phase. Tools and technologies were tested to evaluate their pedagocial potential; learning activities were then designed to take the best part of the technologies.

Other questions will remain unanswered. For example, we didn't address the problem of learner interdependency when comes the time of assessment; other authors like [Brothen 1991] and [D'Souza 1992] have studied the effectiveness of evaluation quizzes via an E-mail system. However the assessment was always individual. We chose to treat the question of evaluation in a traditional mode. As with most courses offered by the CCFD, a few exams are take-home exams, except the final exam that is taken under class supervision. To address such issues, more experiments such as this one need to be conducted.

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