Collaborative Learning in Computing Science: A CAUT Project

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Abstract

Learning to solve problems involving rapidly changing technology can prove to be very difficult, even for computing science students in their final years of study. Their previously-learnt problem-solving techniques, gained while studying programming in earlier years, are inappropriate in situations where solving problems is dependent upon information and documentation that is changing rapidly, even during the semester of study.

This paper describes a CAUT project for which the authors were granted funds in 1994. The project aimed to help students learn how to solve complex computing problems by developing more appropriate ways of thinking and better problem-solving techniques. It used collaborative learning activities, involving Computer-Mediated Communication (CMC), and a pilot study. The subject used for the pilot study was Computer Systems Architecture 3, a final-year bachelor's subject that contains a major topic strand on parallel processing. It was felt that learning would be improved in this topic, if students could learn new and more effective problem-solving strategies when seeking to build the programs that were very complex and involved dynamic information and documentation.

The outcomes of this pilot study suggest that, by providing innovative group learning experiences involving collaborative learning, especially computer conferencing, and by using technology to 'extend' the normal classroom, students can overcome their previously-learnt strategies faster and more successfully than when only experiencing traditional ways of learning.

Keywords

collaborative learning, computer-mediated communication, tertiary teaching, computing science

1. Context of the Project

Competing pressures for universities to reduce expenditure and improve the quality of students graduating from higher education combine with a need to provide teaching programmes that extend over more diverse sets of knowledge and skills than in previous decades. Today, academic staff are faced with the difficult task of creating new and better learning experiences for their students and at the same time incorporating a burgeoning amount of information and a greater variety of relevant information sources that are now available on electronic media. A reduction in resources for teaching and an increase in the number of students further exacerbate the learning / teaching situation.

A significant problem in student learning has been clearly identified over several years of teaching problem-solving in computing science. This paper describes a CAUT project that has sought to overcome this problem by taking advantage of collaborative learning techniques used in conjunction with Computer-Mediated Communication (CMC). A more general discussion of CAUT initiatives is to be found in Hammond (1994).

1.1 Student learning difficulties

In the advanced stages of computing science courses, students are required to learn how to solve highly technical computing problems by undertaking practical programming classes simulating real-world conditions. Some of this technical problem-solving deals with complex computing resources undergoing changes while the subject is being taught. These changes occur frequently and unpredictably, resulting in associated reference material, essential for successful problem-solving, being highly dynamic in nature. Teaching staff are concerned about the difficulties experienced by many students when attempting to deal with the mismatch between software versions and associated information and documentation. Parallel processing is particularly fraught with this problem.

Currently, students work with massive amounts of unstructured information and documentation that becomes rapidly outdated. Students are not accustomed to assembling, analysing and synthesizing all the information they need from such *changing* information and documentation. In addition, course materials require frequent updating (even during the course of the teaching semester), if they are to support student learning.

Not all student's past experiences of successful programming can be mapped directly across to the new learning situation. When computing science students learn programming in the early years of their computing degree, they develop group techniques to help them solve programming problems successfully. Students become skilled in working with their peers and teachers, often enabling them to develop successful intuitive approaches to problem-solving. Such sharing of ideas and group learning is generally most helpful in technical problem-solving. However, these group techniques do not always apply when trying to solve other types of problems. The usefulness of students' normal group learning techniques in the situation under discussion is confounded by the sheer volume of information and documentation available at any time and its dynamic nature. In addition, it is evident from current teaching that students have most difficulty in understanding and developing appropriate problem-solving skills for complex programming in the initial phases of learning how to program.

In essence, many of the students' problem-solving skills are inappropriate, and must be replaced by new learning techniques. 'Unlearning' old, successful techniques and replacing them with different techniques is particularly difficult to do and students need to be helped to 'get over this hump' as quickly as possible if they are to gain the required new problem-solving skills within the semester of study whilst still maintaining their enthusiasm for the subject content.

1.2 CMC as a collaborative learning tool

An expanding range of information technology tools is now available to support improved student learning and teaching. Teachers at all education levels now have opportunities to diversify their teaching styles and delivery modes and support better ways of disseminating information and exploring knowledge sources. One area of great potential is Computer-Mediated Communication (CMC). CMC is being used in many discipline areas in higher education in England, Europe and North America, and in a variety of forms, including computer conferencing. In Australian universities, the potential of using CMC for collaborative learning is greatly enhanced by its ability to be easily linked via AARNET to a wealth of electronic information services. When used to support collaborative learning environments, CMC is starting to show encouraging outcomes in terms of improved student learning.

Educators experienced in CMC often comment on its ability to promote active participation in learning activities and to increase levels of peer interaction. This led to the CAUT project team's decision to use CMC. As our objective was to help students to discard their previously-learnt, inappropriate problem-solving skills and build on their successful intuitive problem-solving approaches, we decided to focus on the computer conferencing aspects of CMC, and use it as an adjunct to normal teaching . Key elements in our decision were CMC's ability to provide:

- group collaborative learning experiences
- direct and personal access to all required activities at times and places that were appropriate for individual learners
- a collaborative learning environment that supported students in expanding their ability to think and solve problems by taking in the views expressed by others
- support for academic staff and students to encourage reflection, using written text to interpret and understand.

The CMC tool we chose was CoSy, a computer conferencing system (1989), originally developed at the University of Guelph and used by a number of universities that are particularly concerned with open and distance learning environments (including The Open University, UK). CoSy can be used in small classroom environments or university-wide, depending on the teaching / learning requirements.

When the learning environment is careful planned, CMC can be used to help students build up their knowledge collectively as well as separately, and to guide students towards exploring many different pathways to acquire knowledge. CMC facilitates the sharing of knowledge and understanding among students studying a subject together, although they do not necessarily work together at the same time or in the same place. It is particularly conducive to augmenting the generation and collection of group input, to information sharing, brainstorming and group problem-solving. These elements were of particular importance for our teaching development.

2. Project Aims

Currently, students have to rely on paper documentation and an often incomplete set of information to solve their problems. Their main source of assistance is the teacher. Help may only be available in the scheduled teaching sessions. Students' current problem-solving strategies do not involve sharing acquired knowledge or the notion of extracting knowledge from a knowledge pool that encompasses the knowledge of lecturers, tutors, on-line information and other students' experience of experimental results.

The CAUT project aimed to provide new group learning experiences that would enable students to become aware that a much larger catchment area of knowledge was available than they had previously experienced and that they could tap into this by developing a collaborative approach to problem-solving. Thus, by introducing collaborative learning using CMC, we aimed to help students develop more appropriate ways of thinking and better problem-solving techniques, when faced with problems involving rapidly changing technology and dependent on dynamic information and documentation.

Our objectives were to create a learning situation that provided students with far greater freedom to choose a time and place that suited their needs, when studying and seeking answers to their queries, and that improved their ways of sharing their knowledge with other students and staff over the period of study. It was hoped that this would give them a significant advantage in terms of an increase in the range of possible responses to queries and a reduction in time taken to achieve successful solutions to their problems.

The aim of this project was felt to be best achieved by 'extending' the normal classroom and conducting a pilot study in a final year B. Sc. (Computing) subject, Computer Systems Architecture 3, in which Parallel Processing is a major topic.

3. Project Description

The Project consisted of several parts: an assessment of CMC resources that were available for use in higher education; the development of student activities in CMC mode; a pilot study involving a class of computing science students who were studying in the area of concern; and an analysis and evaluation of pilot study results.

This paper concentrates mainly on the collaborative learning aspects of the pilot study. Further information about innovations in the Parallel Processing course may be found in Hintz, Szewcow and Hammond (1994), Hintz, Hammond, and Szewcow (1995), and Hintz (1993).

Before the project began, one member of the team, Judy Hammond, completed a course of study on On-line Education & Teaching conducted jointly by the Institute of Education, University of London and The Open University, Milton Keynes, UK. Other members of the project team were new to collaborative learning and CMC, and had not used specific CMC tools before the project started.

The first task was to identify appropriate CMC resources. This would ensure that the curriculum materials and activities developed would provide the best fit in terms of developing collaborative learning techniques suitable for this student environment. These CMC resources became part of the normal computer resources available to students studying in the School of Computing Sciences.

3.1 Development of student activities for the Pilot Study

When planning to use collaborative learning techniques based on CMC, the types of activities one chooses are dependent on such factors as whether students are co-located or distributed in various physical locations, departments or universities, whether activities can be online or offline, stand alone or as an adjunct to normal classroom teaching.

Our initial planning suggested that collaborative learning would be particularly useful in the initial exploration / design phases of student problem-solving activities, but that other 'traditional' ways of teaching were still necessary to ensure that the total body of knowledge was covered in the course. We decided to use collaborative learning as an *adjunct* to normal classroom teaching.

A set of student activities was prepared before the beginning of semester. These activities needed to be adjusted after the pilot study in light of what we had learnt.

The development of student activities involved analysing current student activities, deciding what activities would be best suited to the new collaborative learning approach, and then revising and creating new exercises and assignments suitable for students to develop the required problem-solving skills using collaborative learning. Activities were designed to help students assemble and analyse dynamic information and documentation in ways that would ensure that their levels of successful problem-solving were improved. Self-assessment tasks relating to the concepts to be learned were an integral part of the learning activities.

3.2 The Pilot Study

The collaborative learning activities were fully integrated into the Parallel Processing topic in the subject, Computer Systems Architecture 3, a third-year subject studied by students in the School of Computing Sciences B.Sc (Computing) degree. Students met face-to-face for lectures and some tutorial sessions as normal. The remainder of student activity centred on using the computer conferencing system, CoSy, available on terminals in the School of Computing Sciences.

CoSy supported a virtual learning community created by the students, lecturer, tutors and technical support and was available at any place and any time (not just designated tutorial times). Communication was many-to-many in that all participants saw and could respond to all messages placed in the conference. This allowed individuals and groups of students to learn from their peers and encouraged learning to be distributed amongst all knowledge sources, rather than being centralised on the lecturer. One-to one communication was also available *within* the conferencing system (in the form of electronic mail) so any student or staff member could send messages to any other individual member of the group including another lecturer, tutor, or a particular student. Students could also discuss their work face-to-face with staff, if they wished.

Student learning activities were undertaken on a series of exercises and assignments that had been developed by the project team before the course began. All the computer activities were text-based and included exchanging ideas, short messages, questions and answers, and analysing and summarising articles and papers of importance to the understanding of the subject. The first exercise was aimed at helping students become familiar with the technology and teaching them about the range of facilities available in the computer conferencing system. This was completed within the first two weeks of the course and enabled students to feel comfortable and confident about using CoSy.

Tutors interacted with students in a less formal way than when presenting formal classroom tutorials. Instead, staff provided exercises on CoSy requiring student responses. This enabled staff to provide student guidance and direction by responding to student messages placed on the conferencing system. Staff (as well as other students) could create, view and comment on CoSy messages at any time during the semester.

Students' progress was monitored by tracking their work as they progressed through their exercises and assignments on CoSy.

Students were encouraged to hand in their completed assignments in a specially designated part of the conferencing system (read-only and not able to be altered once the assignment was entered). This was a useful feature from both student and staff perspectives, as students could hand their work in at any time without having to physically find the lecturer / tutor concerned or be at the university. Staff found it useful to have a record of the time and date assignments were handed in for marking, enabling them to know how quickly students were able to complete the required work.

Evaluation was a very important part of the pilot study. The University of Technology, Sydney's Ethics Committee's approval for the evaluation procedures was sought and granted before the pilot study started. A range of formative and summative evaluation tools, similar to ones described in Alexander and Hedberg (1994), were developed for use in the pilot study. They included individual interviews with staff and students participating in the pilot study to identify strengths and weakness, pre- and post-course questionnaires and reflective diaries being kept by both staff and students throughout the pilot study. A content analysis of the interactions occurring between students and staff during the collaborative learning sessions was also undertaken to monitor the problem-solving skills that students were developing.

4. Project outcomes

Outcomes from the project were many and varied. We had expected that the outcomes would relate solely to improved student learning, but found that there were equally significant outcomes for academic staff in terms of their understanding about teaching the subject content and of the increased range of options for presentation and delivery of their curriculum.

4.1 Student outcomes

For students, the major outcome was that they had a greater sense of empowerment over their own learning and their ability to solve problems involving rapidly changing technology and dynamic information and documentation. We learnt that:

- nearly all students came to the new learning experience with little or no prior experience of online computer facilities, such as email, bulletin boards, World-Wide Web or other CMC technology

- students were positively disposed towards group-work as they had experienced it previously and enjoyed gaining new insights or points of view, refining ideas and gaining better directions by working with others

- after the pilot study, students viewed the CoSy conferencing system as being as easy to learn as they had anticipated, but more impersonal and not as productive as they expected. Nevertheless, all students were either still interested or somewhat excited about the potential for collaborative learning using CMC as a learning tool

- the reliability and 'ease of use' of the technology were very important factors in student satisfaction when learning collaboratively using CMC, suggesting that the provision of technical support throughout the course of study is essential

- the technical computer conferencing tool used in this pilot study, and particularly its interface, was out-of-date with modern 'windows-based' computing software (but it was all we could afford when we started on the project - a new improved version is available in 1995). This led to students feeling that they were limited in their ability to discuss as often and as widely as they would have liked. An up-to-date CMC system is essential, if the full potential of collaborative learning is to be reached.

4.2 Academic staff outcomes

For academic staff, we learnt that collaborative learning led to a more responsive learning situation that helped students develop more appropriate ways of learning. By providing tutorial and practical work in a computer conferencing environment, students' mode of learning became more 'distributed'. Learning moved from being completely centred on the lecturer, to include substantial interaction with peers over the period of computer conferencing. Questions raised by students at any time in the computer conferencing system were answered more timely and answers could come from one or more fellow students, technical support, tutors or lecturer. In this way, staff discovered what students' **REAL** learning problems were and were able to adjust their teaching accordingly whilst the learning was still in progress.

A major outcome was the reduction in time taken for students to learn the required body of knowledge in the course. This was unexpected and was due to:

- the need for staff to redesign the tutorial and practical parts of the course to create a new range of group learning experiences involving a collaborative approach

- more timely answering of student questions using online messages written by staff and / or other students
- the ability of lecturers and tutors to respond quickly to student needs whilst student activities were in progress.

In addition, academic staff gained new understanding that collaborative learning:

- requires detailed planning of all teaching / learning activities and materials used
- cannot be done ‘out of the blue’ or by a sole staff member. It necessitates teaching staff working as a group
- helps for better reflection by staff on teaching content and process, feedback on course content and delivery and more effective staff collaboration in course development
- requires a greater understanding of curriculum development principles, issues and techniques than academic staff often possess. Thus, training and staff development in this teaching mode is essential
- helps students share a good balance, variety and volume of information, thus leading to the extraction of required knowledge.

5. Conclusions

This paper has discussed a CAUT project about collaborative learning using computer-mediated communication. It was undertaken in 1994 by a group of Computing Science academics who wished to learn how to incorporate new information technologies into their teaching. Shirley Alexander, who worked in the Centre for Learning and Teaching at the time of the project, assisted us with the evaluation aspects of this technology-based learning development.

Reflections on the CAUT project have led us to make the following suggestions to assist other academics who may wish to apply similar techniques in their own curriculum.

If academic staff are to be encouraged to undertake collaborative learning in similar developments, then careful consideration must be given to supporting course development for collaborative learning in terms of :

- significant planning at strategic and detailed lesson preparation levels;
- training academic staff in course development to use these methods; and
- training academic staff to learn about appropriate CMC technology.

To use computer-mediated communication technology well in the delivery of new learning experiences requires :

- technical support throughout the course, so that students always have ‘good experiences’ when using the technology to ensure that they want to use it over the whole period of study and are not frustrated by computer failures and other technological problems.
- careful choice of technical tools. CMC software is now available with a variety of interfaces. These need to be assessed carefully before purchase to ensure they support student learning band are easy to learn and easy to use.

A sample of a typical student message written on CoSy during the latter part of the pilot study concludes this paper. A student wrote:

> *It wasn't until I came to type my answer to this question that I realised my original thoughts on this topic were incomplete. I had looked at the problem too much from a traditional programming point of view. My main problem was that I was tending to look at one entry going through the system to see what could be done in parallel, rather than at several numbers being in the system at the same time. My code reflects this strategy, rather than the following, as does my answer to question five. Using my new-found insight, my reasoning is like this......(followed by code he used to solve the problem)*

(Anon. student)

This message was available on CoSy for all students (and staff) to read and comment upon, and so learn from and build on this student's new-found strategy.

The message gives a clear indication of the level of reflective thinking achieved by one student when learning to solve problems collaboratively. What is important in this message is not just that the student realised what had occurred when he was learning how to solve a particular problem, but that he was willing and pleased to share his new-found understanding with other students in his class.

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