Chapter 15. Computer Supported Teamwork: Evaluating Cooperative Learning in a Scaffolded Online Environment

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1. Introduction

Existing teaching-learning arrangements in many online courses do not offer sufficient scope for external students to work collaboratively. To prepare students for the IT profession, it is necessary to foster collaborative skills that are needed in the workplace. To provide an authentic context for learning, working collaborative in a technology-supported environment provides students with an authentic experience, replicating how they work when they have completed their university study and enter their profession. In addition, students need to become aware of their own skills in organising tasks, planning, testing and revising possible designs.

This study describes an online environment that provides learners with tools and scaffolds that can be applied in building a team and effectively managing tasks. Students used these tools and developed the skills they needed in order to complete the set task. Self-monitoring and self-assessment of skills were an integral part of the learning environment.

The use of online technology in this unit actualised learning in a number of ways:

- Students were learning computer-programming skills in an environment that was authentic, ie. that approximated the real world contexts of their future profession;
- Learning tasks made use of the technology in ways that fostered collaboration, problem solving and independent learning;
- Students communicated and networked in order to create programs, using bulletin boards and other online technologies;
- Teamwork and interaction were fostered by setting a collaborative task for students.

2. Teamwork and Collaboration Defined

One of the characteristics of being considered professional is having the capacity for self-direction and being able to apply practical strategies and skills in contexts that require them. Professionals have a body of expertise and, in addition, have lifelong learning skills and self-knowledge. Boud (1988) suggests that the capacity for self-direction includes elements of independence, dependence and interdependence and proposes that these form a continuum whereby the learner progresses from dependence, to independence and then to interdependence (Figure 15.1). Each of these stages requires learners who are able to reflect on and assess their own skills and capacities.

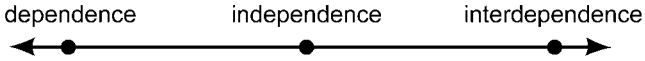

Figure 15.1. Continuum showing progress from dependent to interdependent learning.

It is widely accepted that graduates should not only be technically competent but they should also be skilled in communication and teamwork, have social and global awareness, be self-directed and be prepared for life-long learning. However it is much less clear how these "soft skills" are best developed in undergraduate students in the context of their studies. One recommendation is that pedagogy needs to change from transmissive, didactic approaches towards transformative, student-centred approaches (McLoughlin & Luca, 2000). In the present study, this has been achieved in the context of a project-based unit of study, involving both individual and group work, located within a Web-based learning environment.

The design and evaluation of the environment was informed by the notion of holistic, learner centred evaluation on ICT based innovations, as described by Alexander & Hedberg (1994) and later applied by Phillips et al. (2000) in the CUTSD *Project Handbook for learner centred evaluation of computer-facilitated learning projects in higher education*. This approach commences with analysis of the curriculum and the need for intervention, then progresses through formative monitoring of the learning environment, implementation and institutionalisation. This project was concerned with analysis and design evaluation and with summative evaluation of the learning process. The holistic approach of Bain (1999) was applied to the evaluation from inception to completion. Table 15.1 shows the application of the learner-centred framework to the design and evaluation of the study. Each of these stages is described in detail.

2.1 Phase 1: Analysis and Design of the Learning Environment

Programming in industry is often a team effort. However, for distance students studying online, opportunities for teamwork are often limited to peer interaction via bulletin boards which may be unstructured or lacking direction. It is good programming practice to create and share code that will form a part of cohesive applications through the use of abstraction and information hiding. These are achieved through separate compilation, the preparation of machine instructions in separate parts that are brought together by a team to form a single application. This practice also facilitates code re-use. Students are taught how to write code modules, and how to compile them together. In order to demonstrate their new skills, a constructivist assessment task and collaborative environment was created, which forms the basis of data reported in this study. The educational rationale for designing the philosophy whereby students engage in collaborative environments to actively increase their knowledge and understanding by articulating and revising their views and concepts. The constructivist notion is also extended by the idea of shared thinking and collaboration. McLoughlin & Oliver (1998) argue that participation in learning hinges on communication and dialogue between teacher and student or among peers. This communication serves both social and cognitive function and assists learners to become part of a community of learners (McLoughlin, 1999). Thus, the environment was designed in order to assist learners to communicate effectively online.

A further dimension of the design process was to enable students to form teams, and this aspect was informed by the research literature on the qualities of effective teamwork.

The definition of *team* chosen by the researchers is that of Katzenbach & Smith (1993).

> *"A team is a temporary or an ongoing task group whose members are charged with working together to identify problems, form a consensus about what should be done, and implement necessary actions in relation to a particular task area".*

A team is different from a workgroup, members of which may or may not collaborate. While work groups often have individual

Table 15.1. Application of the learner centred-evaluation framework.

Phase	Focus	Application to this project
1. Analysis and design	Curriculum analysis Design of the collaborative learning interface and task to foster teamwork	The curriculum was analysed to determine the shortfall in support for team work and to provide a rationale for the design of the innovation
2. Development	Functionality and accessibility to students Formative monitoring of the environment and learning processes	Throughout the learning task, student usage of the bulletin board was observed and evaluated in order to establish how it supported teamwork
3. Implementation	Summative evaluation of learning process and learning outcome was carried out	Evidence was sought on the nature of learning processes and student perceptions of their learning

outcomes, the high performance team will work towards a collective and agreed goal. Thus, in addition to creating an environment conducive to team work, it was also essential to create a task that enabled group members to display team skills. Both of these stages informed the design of the environment.

2.2 Phase 2: Developing the environment to support group processes

Based on the literature, the researchers established eight group processes according to which they designed and assessed the Bulletin Board interaction. These processes were thought to be important in the development of effective team skills. In order to foster team skills, the environment had to *scaffold* or support teamwork processes. Scaffolding is a process through which efforts are supported while engaging in a learning or performance task (McLoughlin, Baird, & Pigdon, 2000). Students engaging in team work for the first time are often unaware of how to self-manage their own performance and that of others, while applying conceptual knowledge. In this environment, it was intended to provide metacognitive scaffolding in order to support self-management processes associated with effective teamwork. This was achieved by designing an interface where the supports for communication and on-task behaviour were built into the environment and the communication process. That is, for each teamwork process, a corresponding environmental scaffold was established. Figure 15.2 shows the interface that students used when communicating.

The online environment was designed along constructivist principles to enable communication, collaboration and negotiation of ideas. Each team used a bulletin board for exchange of information and social interaction. Students also used other online resources, but the emphasis was on the collective use of the provided bulletin board. The bulletin board was built on CGI forms which were handled by Perl scripts. Data from each team's bulletin

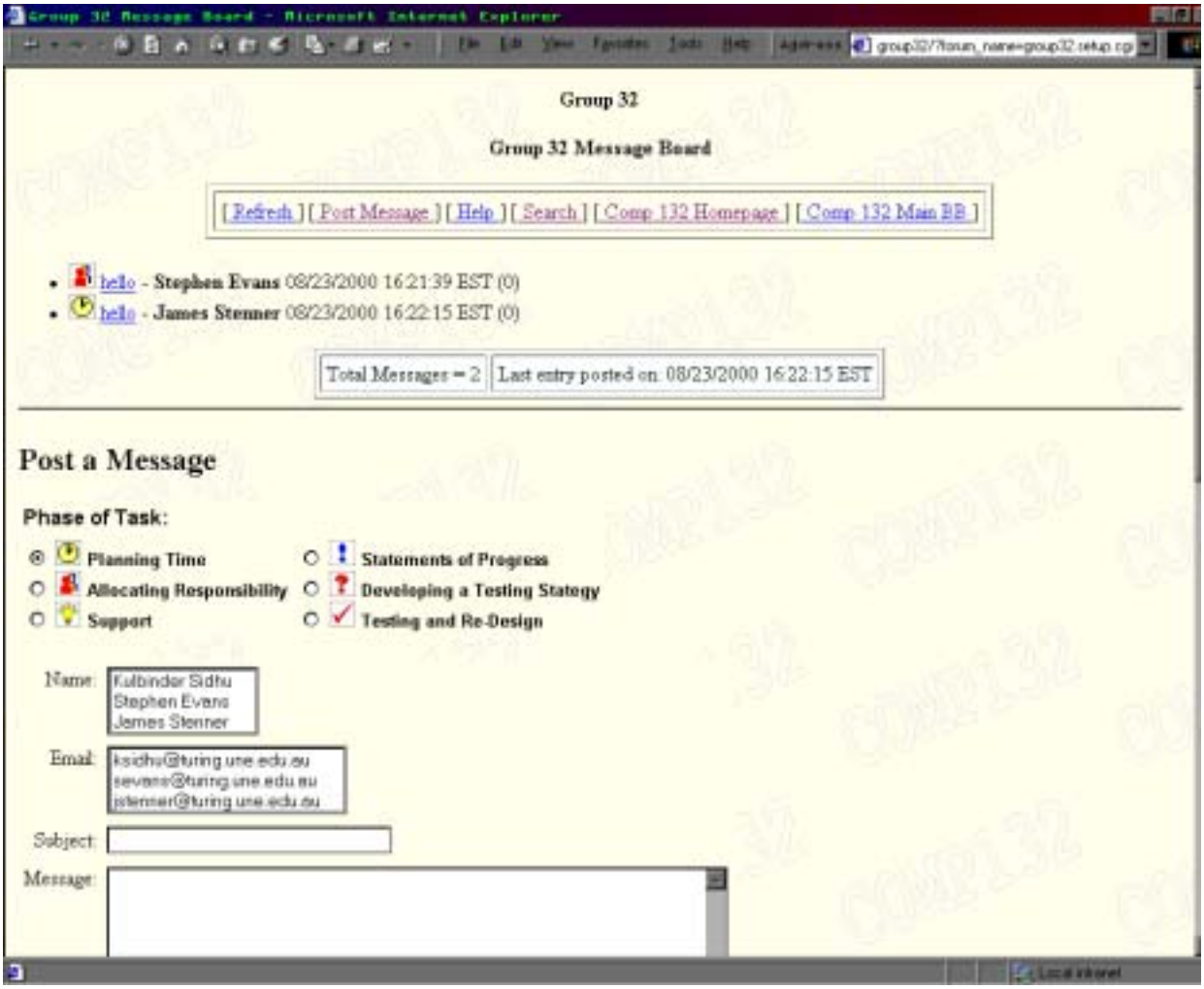

Figure 15.2. Bulletin board postings required students to identify the purpose of their communication.

board was stored in text data files. As all processing was handled at the server side, the bulletin boards were fast to assemble and download. Having all data files stored on the central server allowed for immediate analysis. The technology involved is freely available and not a commercial product, therefore involving no great costs.

While posting a message, the interface required students to identify the purpose of their communication. This form of metacognitive scaffolding was intended to prompt learners to reflect on the goal of communication. By specifying communicative goals that were supportive of team work, such as 'allocating responsibility' 'supporting peers' 'stating progress' it was anticipated that students would complete the task as a team and achieve the intended learning outcome.

Table 15.2 shows the linkage between the Bulletin Board (BB) scaffolds and teamwork processes, informed by the literature.

2.3 Phase 3: implementation

The task required the students to create three C++ classes that related to each other according to set specifications. The intended learning outcomes were not only the application of programming skills, but also the creation of a product that exhibited teamwork, thinking skills and problem solving. The three classes were a schedule keeping class, a birthday list class and a calendar class that integrated the other two classes in order to show which dates on a particular month had birthdays, and which had appointments from the schedule. In relation to other assessment tasks that are based on demonstration of programming skills alone, these sub-tasks were designed to be simpler, in order to allow a focus on the process of communicating with team mates and producing a collective result.

Collaborative learning was fostered by placing students in teams of three. Two of the three students were external students and the third was an internal. Primarily, this weighting was due to student numbers in the unit, but it also encouraged the use of online, more than personal, communication. The students had two weeks to complete the task, from when they were allocated into teams to when they were required to submit their part of the team's code.

The task drew on team-skills and content knowledge, and the underlying pedagogy was process–based and directed at encouraging interdependence among learners, with a large measure of autonomy (McLoughlin & Luca, 2000). As stated above, in order to support team skills, several support processes were provided to foster team building skills. Several phases and strategies were suggested to break down the task, encourage allocation of responsibility, maintain progress checks and foster team-supporting behaviours. The scaffolds and strategies were as follows:

Planning the team's time

Teams were filled with students from different locations, lifestyles and with different time commitments. It was suggested the students be up-front about their time and how much they could allow for the task over the two-week period. The students were also asked to suggest deadlines for completing the task.

Table 15.2. Bulletin board categories for teamwork development.

Environment (BB) Scaffolds	Teamwork Processes
– Planning the team's time	Schedule for task completion established or maintained
– Allocating responsibility	Roles established
– Supporting team members	Support sought from other members Problem solving strategies employed or solution suggested by team member
– Stating progress	Active participation towards project outcome Accountability and review of progress
– Developing a testing strategy – Testing and redesign of the program	Consultation Consensus building

Allocating responsibility within the team

With the three sub-tasks in mind, students were left the responsibility of dividing the task among the members of the team. Within each team there were differing perceptions of the difficulty of each sub-task and the students' own abilities. This forced the students to take part in discussions or be left with an undesirable responsibility.

Supporting (requesting support) team members

Once the students had been given some responsibility, it was time to go to work. Students were encouraged to offer assistance and advice to other team members, and to rely on their assistance when needed. Students were advised that seeking help from the unit's teachers should be a last resort, and should be approached as a communication that represented the whole team.

Stating progress

In order to keep team members informed, students were advised to state their progress in relation to the constraints that they had set themselves earlier.

Developing a testing strategy

In order to test the team's work, the students need to collect their code in one place and compile it together. This requires planning and negotiation. Students were also encouraged to anticipate how their code would be tested when marked, and discuss what the ambiguous aspects of the task were in order to create a reliable application.

Testing and re-design

Students were encouraged to discuss the success and failure of their testing, and prompted to determine changes required.

3. Evaluation Plan and Approach

It is important to emphasise that evaluation was part of the development phase of this project, and informed the design of the environment described above. The main focus of the evaluation was on the learning outcomes achieved, i.e. the development of team skills among students. A number of data sources were used to achieve triangulation. Following the completion of the task, students were requested to complete a survey which allowed us to gauge their perceptions of the task and the environment. As Alexander & McKenzie, (1998, p235) noted, " improved student learning using IT is dependent on appropriate learning design and students' perceptions and experience of the learning context." In order to obtain triangulated data, different forms of summative and formative evidence of learning was collected from the following sources:

1. Transcripts of the bulletin board were analysed to gather usage statistics in order to establish whether students have developed team-work and collaborative skills

2. Students completed an online survey which provided them with an opportunity to:
   a) Assess their own perceived performances
   b) Peer-Assess the effort of their team-mates
   c) Comment on effectiveness of the environment in supporting the learning task
   d) Describe their understanding of the collaborative approach to programming through a concept map

Success of the teams and individuals in completing the set programming task was evaluated for correctness, style and elegance.

To evaluate the success of the task and the environment, we set out to answer the following questions and to seek confirmatory evidence form student responses.

Does the learning task develop the desired social skills with regard to collaboration?

There was a significant correlation between the number of postings and the mark achieved for code written. The students posted, on average, over 4 messages on planning. Students were able to allocate tasks in their team rapidly; only 1-2 messages per student were recorded on average for this phase. Students were asked if they felt that the task had helped develop their skills as part of a team. Most students indicated that their team skills had developed as shown in Figure 15.3.

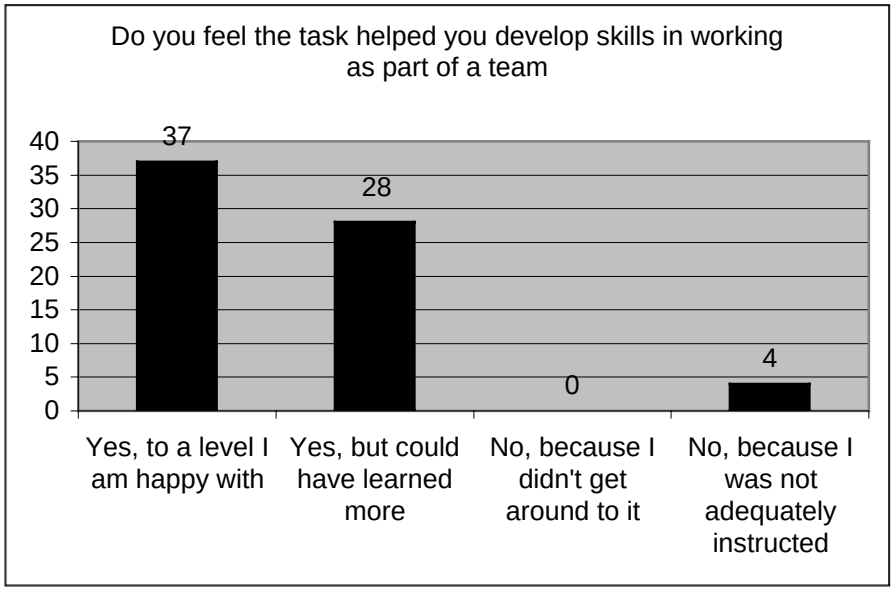

Figure 15.3. Students indicated that their team skills were improved.

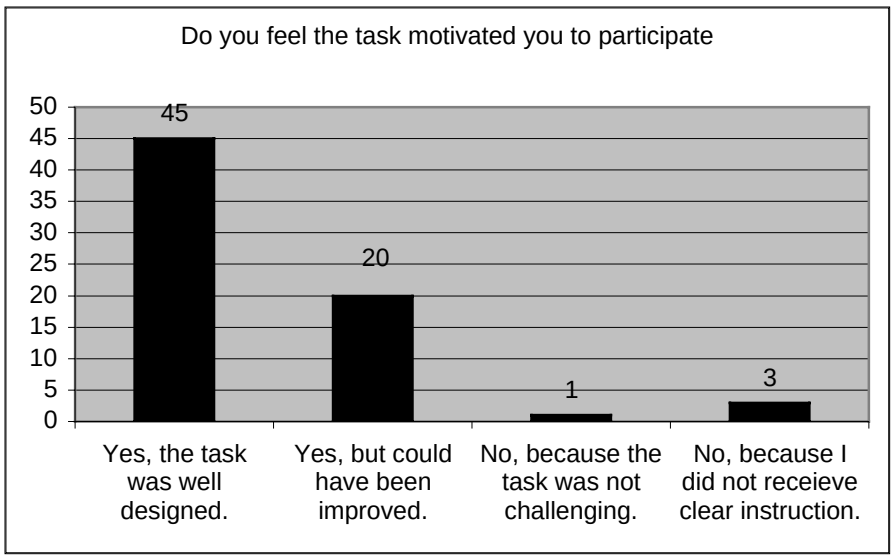

Figure 15.4. Student responses about motivation encouraged by the task.

Does the task motivate learning and development of the desired skills?

When presented with the question "Do you feel the task motivated you to participate", students responded unanimously in favour of the task, as shown in Figure 15.4. Some suggested that the task could be improved.

Results from assessment showed that the average mark for the assignment was a significant increase over results from previous assignments. A common problem with programming assignments is over-confidence which leads to leaving commencement of an assessment task to the last minute, which leads to panic, incomplete submissions and often plagiarism. None of these increased students' satisfaction in the course. Students were aware that the task required time and planning. It was a refreshing change to see that most students commenced communication with their team-mates almost immediately after being placed in teams.

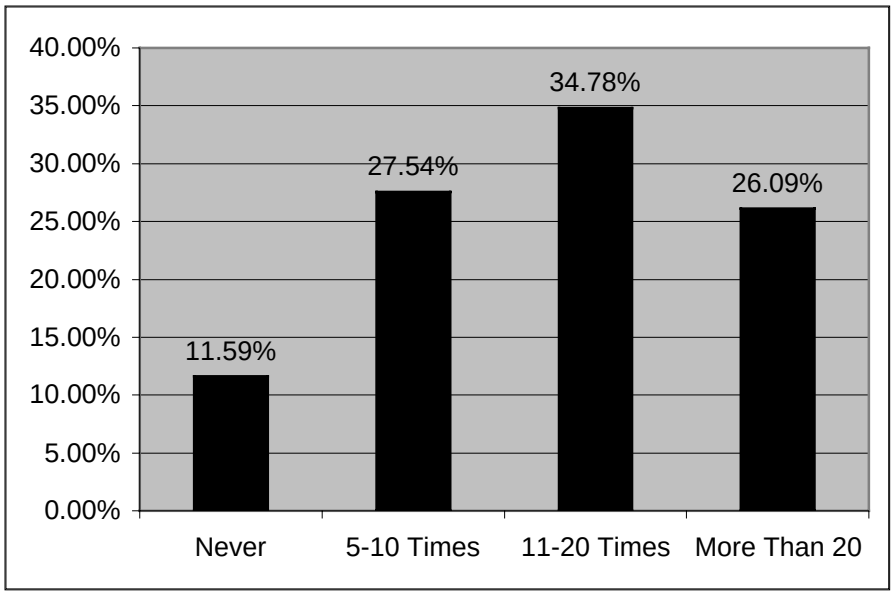

Figure 15.5. Distribution of total postings by individuals.

Do the students make use of the bulletin boards and other online technologies to develop team skills?

Each student who participated used the bulletin board, on average, over 15 times. The actual number of postings was distributed as in Figure 15.5. Although it was not possible to gain exact figures, students also indicated that they used e-mail (over 3 times per student on average) and most students also used the file sharing facilities available under Unix. Most students stated that they did not use other facilities, provided by the school (like Talk), or outside the school (like ICQ or chat). Interestingly, when asked if they thought the communication component of the task should have had more marks allocated to participation, almost all students said no.

Do the environment and learning tasks accurately promote professional teamwork skills?

Most teams that participated communicated an average of 46 times. Students were not placed in teams according to ability and students' code submissions were marked independently of the code of their team members. However, there was a very significant correlation between the total marks of the members of a team and the number of postings for that team. In fact the team who communicated the most with 118 postings in total, gained the highest mark overall, with all three team members gaining full marks.

Is the team working environment and task realistic to industry?

According to student replies, the students felt that the task and the environment and the task were realistic to what could be expected in industry. Students also reported that the experience had helped improve their programming abilities in terms of writing applications in separate files, compiling programs from separate files, testing programs and programming skills in general. These are all skills required in industry.

4. Analysis of Bulletin Board transcripts

An analysis of writings on 'high performance" teams (Johnson & Johnson, 2000; Katenbach & Smith, 1993) provide varying structures for analysis of the group processes used by effective teams. Chaousis (1996) suggests that key characteristics of effective teams are leadership, goals, decision-making, review, relationships and linkages. Katenbach & Smith (1993) focus on the triangulation of accountability, skills and commitment. Using these concepts and the ingredients for a successful team suggested by the researchers applied the list of group processes against which the Bulletin Board interaction for this authentic assessment task have been analysed. As shown in Table 15.3, these were establishing goals, supporting other team members, accountability and consensus building.

Methodology

Of the 35 groups who participated in the project, it was found that the number of postings varied considerably. The first step for the researchers was to identify broad categories in the data showing patterns in the number of postings. Table 15.4 displays four categories of postings as high, (H) medium (M) and low (L). Fewer postings than 20 were considered too few to analyse.

For the analysis, six groups of students were chosen from the thirty-five teams allocated the task. The groups were chosen according to the number of postings made on the Bulletin board. These six groups fell into three categories—postings above 75, between 50 and 74 and between 12 and 50. For the purposes of analysis, groups were categorised as having high (H), medium (M), or low postings (L), and the six groups were named 1L, 2L, 1M, 2M, 1H and 2H.

4.1 Analysis of Bulletin Board Transcripts

For the highest performing team, clarifying when and how they would work together was more significant that with other groups (Table 15.4). The type of hardware and software available for communication as well as the legitimacy of using other forms of contact were the focus among the 1L, 2L, and 1M groups.

In contrast the timing of communication and contact was the main topic of conversation for the higher performing teams. Only the highest performing teams actively used the bulletin board to share code and discuss the specifics of their work progress. Table 15.4 shows that highest performing teams 1H and 2H and 2M used communication strategies and active participation to achieve task goals. Thus, the quality of bulletin board interaction and the degree to which team behaviours were demonstrated in bulletin board postings were related to overall success in the task.

5. Discussion of Results: Inclusion of Process and Product Skills

The use of online technology in this unit actualised team-based learning in a number of ways:

- Students developed cooperative skills in computer-programming tasks in an environment that was relatively authentic, i.e. that approximated the real world contexts of their future profession.
- Learning tasks made use of the technology in ways that foster collaboration, problem solving and independent learning.
- Students communicated and networked in order to create programs, using bulletin boards and other online technologies.
- Teamwork and interaction were fostered by integrating the task with assessment processes.

Table 15.3. Numbers of postings with groups N=35.

No of postings by category	0><11	12><50 Low (L)	50><75 Medium(M)	75><120 High(H)	Total
No of groups in each category	10	16	5	4	35

Table 15.4. Identification of communication strategies.

Team process	1L	2L	1M	2M	1H	2H
# postings by group	29	23	68	49	77	118
Communication strategies clarified and maintained	2 (7%)	4 (17%)	13 (19%)	4 (8%)	6 (8%)	29 (25%)
Active participation towards project outcome	8 (28%)	1 (4%)	7 (10%)	20 (41%)	18 (23%)	44 (37%)
Group Score	8	22	20	26	19	28

Without direct instruction on how to function as a team, most students seemed to enjoy the task and learn new skills. The scaffolding of team skills was achieved successfully though design of the interface and assisted team performance. Students were not completely convinced that working online was the most efficient means of completing a given task, and the objectives of the tasks needed to be made more explicit in order to focus students on both process and product outcomes of teamwork (Paloff & Pratt, 1999). This could have been more effectively achieved by posting guidelines for communication or allowing teams to formulate their own team rules. Another means of drawing attention to group building processes would be to allow students to work on tasks selected by a team, and to create their own criteria for evaluation. This sharing of responsibility is one way to stretch the facilitation skills of online teams. Again, virtual teamwork could have been enhanced by enabling intergroup collaboration and feedback, whereas this study provided opportunities only for small group discussion.

6. Conclusion and Recommendations

Further scaffolding of team processes would seem to be needed for distance learners to function effectively as teams. This can be achieved in online environments by task and assessment design and by creating intergroup interdependencies. In order to increase task realism, students need to be presented with some incentive to engage in dialogue with their team-mates, such as a structured task environment presented in this study (See Figure 15.1). If conflicts cannot be resolved within the team, the team should nominate a member who will formally approach an instructor and present a question. Instructors could be seen as consultants to the team, with advice coming at a cost.

The task was used to encourage students to collaborate through interdependencies in the tasks that had to be completed, but nevertheless 29% of students failed to do the task. Some teams either had a team member drop out or not participate, thus reducing the number of postings. In terms of testing, however, students were forced to find ways of compensating for the member lacking in their team. Reflections on these team processes might have elicited further data on interpersonal skills needed for effective groups.

The online environment could be improved by providing some additional facilities, for example, enabling intergroup comparison of results with discussion, a more immediate online communication medium (like chat) being available in the environment, and also some common area for storing and collaboratively testing the teams files. It was also suggested that students have a choice of a general category for postings to the bulletin board.

These suggestions have provided us with a rich source of data on the design features of effective online teams, together with an improved understanding of the importance of structured environments for students who are novices to virtual teamwork and peer partnerships. Ongoing research is intended to investigate and evaluate effective scaffolding processes for team building skills in other technology-supported environments.

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