COOPERATIVE LEARNING AS A TOOL FOR ENHANCING A WEB-BASED CALCULUS COURSE

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ABSTRACT

One aspect of concern when presenting a web-based course is the lack of personal contact. Group work or cooperative learning is a means of addressing this problem. We work with large groups of students of between one and two hundred, mostly residential students and mostly students who repeat the course. At present we present three such Calculus courses, on both first and second year level.

Our courses present a number of group-based activities such as assignments and projects. Students are divided into small groups of three or four and it is expected of them to get together to discuss the subject matter and work on assignments and projects as a group. The group is awarded a mark that contributes to their individual grading.

At the end of such a course a questionnaire was issued to establish the success of the cooperative part of the course. In this paper we discuss our findings on the successes and pitfalls of our model. We firstly discuss the process of forming groups. We then investigate how students experience the cooperation with fellow students, their work ethics and how trustworthy the cooperation between students is. We discuss our concerns and critically evaluate our model.

1. Background

Four semesters ago we started running our first web-based Calculus course at the University of Pretoria. The target market is the so-called anti-semester students, students who have failed first time round and need to repeat the course, although first-timers are also welcome. Our experiences and findings are reported in (Engelbrecht & Harding 2001(1) and (2)). Due to the success of the project we have expanded to presenting three successive web-based courses. We thus have students now that have completed three semesters of Calculus on the web. We work with large groups of students, between one and two hundred students per course.

One aspect of concern when presenting a web-based course is the lack of personal contact. It is often difficult for a student to stay committed and motivated when completely on his or her own, especially in a subject such as Calculus where discussion of the subject enhances understanding considerably. Group work or cooperative learning can be applied as a means of addressing this problem.

An important factor, that simplifies matters slightly, is that all our students are residential. Some of them share accommodation, others commute daily and attend some of the other courses together, but there is also group of students who have no real contact with any of their fellow students.

2. Cooperative learning

An extensive introduction on cooperative learning is presented in (Hagelgans et al 1995) and although this book was written in the pre-web era, anyone venturing this way would benefit from reading it. According to these authors, cooperative learning happens when a large group of students gets divided into small groups of say three or four students each, assigned for the duration of the course. Students then learn cooperatively as they perform activities such as homework assignments, computer assignments, etc as a group.

The value of having students learn mathematics in group regard through discussing mathematics with each other has been substantiated by many researchers (Arzt 1999), (Webb 1989) and positive teaching experiences using cooperative learning have been reported by various teachers e.g. (Qin et al 1995). In addition to this, a very important skill that we rarely include in our learning outcomes is the ability to get along with other people. Johnson & Johnson (1990) emphasize that "having a high degree of technical competence is not enough to ensure a successful career. A person also has to have a high degree of interpersonal competence."

To employ group work successfully is not an easy task. Even for students attending lectures, "cooperative learning, like most teaching techniques, is a complex strategy with no simple formulas for success" (Arzt 1999). In a distance learning situation, cooperative learning becomes even more difficult, mainly because of a lack of physical contact.

Kaufman et al (1997) identify six elements as essential to successful cooperative learning, namely

- positive interdependence
- social skills
- face-to-face verbal interaction
- individual accountability
- group processing, and
- appropriate grouping.

We have tried to accommodate as many of these elements in our web-based courses as possible, with varying success.

3. Course Description

All three our web-based Calculus courses are run along the same model. We prescribe a textbook (Stewart 1999) and guide the student through the course on a dynamical day-to-day basis. We provide for one discussion hour per week, a contact session, but this has, somewhat surprisingly, proved to be fairly poorly attended. We use WebCT as a platform, the reason being that our university subscribes to this software and they provide the necessary infrastructure and support. We break the study material down, firstly into themes and then into units, each of which provides for more or less a daily portion. For each of the units we provide study objectives, short lecture notes and problems of the day. None of these activities are monitored by us and therefore requires a fair amount of self-discipline from the student's side.

We do provide a number of activities that "assist" students in keeping up to date. One such activity is a weekly quiz, done on the web with immediate feedback. Students do these quizzes individually and we have had excellent response to this. Although there is no security check on this, we do let it contribute 10% to the semester aggregate and students soon get to use it as a fair judge of their progress. The quizzes also serve as a preparation for the two term exams and final exam, each of which consists of a written as well as a computer based section. The latter, again an individual activity, is done in a computer lab under supervision. Other activities are done cooperatively as explained subsequently.

4. Group Activities

Students are presented with two types of group activities - assignments and projects. Each assignment, at least four of which have to be handed in during the semester, comprises of problems, mainly selected from the textbook and requiring a substantial amount of work. It is expected of a group to get together to discuss the subject matter and then to work on the assignments. Each group hands in one copy and all members are awarded the same mark.

The projects, of which there is one or two per semester, normally consist of some related application that requires use of technology. The purpose of this is to familiarize students with graphical software and the use of computer algebra systems to broaden their knowledge laterally.

The non-stated implication with these cooperative activities is explained in (Hagelgans et al 1995): "The longer the students work within a cooperative group environment, the less dependent on the instructor they become. They become more willing to explore problems on their own - particularly to explore new, non-standard problems. And they become more willing to try to explain their ideas to others." For a course taught via the internet this is a crucial factor. Students necessarily need to be less dependent on the instructor and we feel that group work can be applied as a successful means to achieve this.

5. Group Selection

Leikin (1999) says that heterogeneity is one of the most important issues when planning a cooperative learning setting. It is recommended in (Hagelgans et al 1995) that instructors

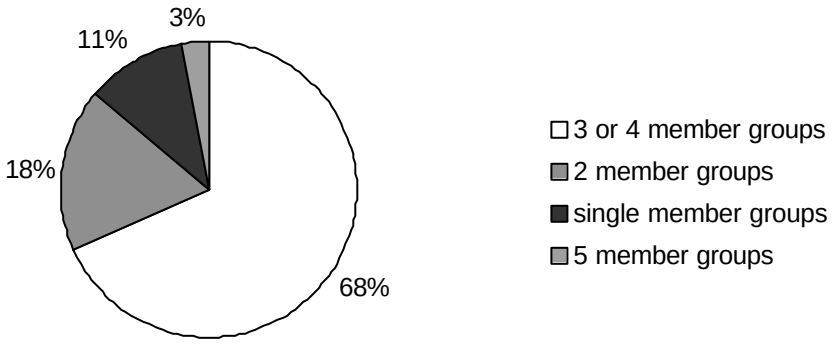
distribute the talent, expertise and various social characteristics represented in the class to form heterogeneous groups, mostly done with the aid of a questionnaire. It is also recommended to have permanent groups established by the end of the second week in class. In a distance learning model this is, unfortunately, not feasible. Just to have everyone in a group of close to two hundred accessing the web and familiarizing him or herself with the web environment in the first week or two is no mean achievement in itself, let alone have them fill in a questionnaire on the web.

Another option, that of involving student self-selection into groups, seems preferable in our case, especially because most students have no real contact. Students notify us, via the web, of their group members and they are then assigned a group number. For the students who do not know anyone at the onset there is the option of "advertising" on the website (in the Discussion Forum). Apart from a few "stragglers", the formation of groups takes about a week to ten days to be completed. It has to be added that because of experience in the early days we make a point of pressing the urgency of the matter upon them and we remind them daily. The group formation at the onset of the course is not cast in stone and, obviously, a few changes result during the semester.

In the recent semester we ran two web-based Calculus courses simultaneously, a first year single variable Calculus course and a second year course on multivariable Calculus, and issued a questionnaire towards the end. From the results of this questionnaire issued to students, a number of conclusions can be drawn on the selection process.

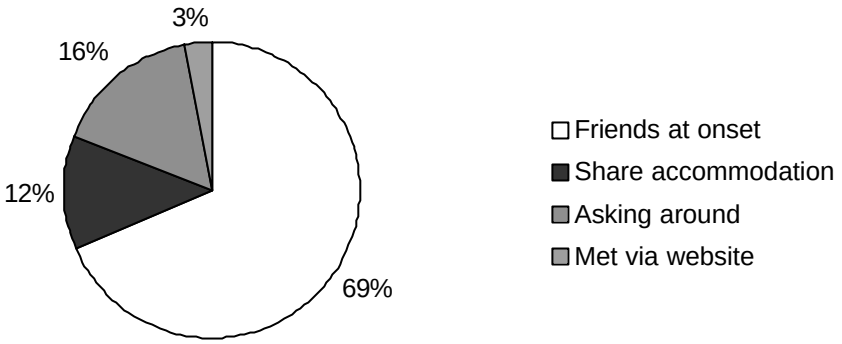
We were firstly curious as to how well this "natural" selection process works. The results are shown in Figure 1. It appears that just over two thirds of the students belonged to 3 or 4 member groups with the rest more or less evenly split between 2 member groups and single member groups and a very small percentage belonged to 5 member groups, mainly because of "orphans" (other members quitting) joining other groups.

Figure 1: Group sizes



As for how the groups got together, it seemed that convenience was the main factor here. The majority of students joined forces because they were friends at the onset, a much smaller percentage came together by simply asking around on campus for someone to work with and an even smaller percentage because they shared accommodation or lived close by. A surprisingly small group of students met via the website. See Figure 2.

Figure 2: Group selection



Although "single member groups" were discouraged at the onset and we required a motivation for every case, a bigger percentage than we had hoped for still worked on their own. Of the single member groups, 34% were left behind as "orphans" because of the higher than normal attrition rate (which was discussed in Engelbrecht & Harding (2001(2))) and 28% preferred to work alone. The latter group consists mainly of students who have no contact with fellow students because of their geographical location, a definite factor in a web-based model.

6. Students' Attitude to Group Work

In agreement with the findings of the survey done in (Hagelgans et al 1995), we generally experienced a positive feeling amongst students concerning their group activities; in fact, two thirds of all students expressed a positive feeling towards group work and the same percentage felt that their groups worked well together. Furthermore, 27% of the students were of the opinion that their positive feeling towards group work improved through the semester whereas a smaller percentage (17%) responded that this feeling deteriorated through the semester. We found this response encouraging in total, aided by the fact that only 4% reported that their groups did not work together "well at all".

Arzt (1999) reports that, "Although students are members of the same group, they may have different perceptions of how well they worked together and the solutions at which they arrived". We had the same experience and ascribe it to one of two reasons: on the one hand weaker students may have experienced the group collaboration more positively because they may feel that they have learned more, where this may not be the case with the better students; on the other hand lazy students that did not bring their side may feel that they scored in the sense that other students took over some of their responsibilities.

Listed amongst other activities they had done as a group during the semester were "revising past exam papers" and "consulting with senior students".

7. Work method

As to the procedure followed by the different groups when meeting, clearly one of three methods was followed, each with a more or less equal following.

The first method was to divide the assignment between the group members. Each had to take responsibility for his/her section of the assignment. In these cases they would have a group discussion on the inputs of the individual members before submitting the assignment.

The second work method was to split the work between the members and in these cases they simply "trusted the group member to be spot-on with his/her inputs". This, of course, was not exactly what we had in mind and these groups misused our intention, only to reduce the amount of work required by each individual.

The third procedure was that everybody tried everything before the meeting. At the meeting they would "compare notes". Normally one individual, sometimes called the "group leader" would then put everything together and finalise the assignment for submission. This was closer to our intention.

In a few cases there were complaints that "one person had to do all the work and the others had a free ride", but this was the exception rather than the rule. This is an important aspect, which leads us to the issue of assessment.

8. Assessment

The authors in (Hagelgans et al (1995)) are quite clear that group work should contribute to the evaluation of the student and recommend a contribution of 20-50% of the total grade. In our model we come in at the lower end of the scale with a contribution of 20% (assignments contributed 15% and projects 5%).

An issue not addressed in (Hagelgans et al (1995)) is whether some students do not benefit unfairly by being assigned the same mark as the rest of the group (or the reverse). Perhaps this is even more of an issue in a web-based environment where there is less control over the activities. To address this issue, we had all students attach a signed declaration with each group assignment, verifying equal (more or less) input by all group members. Afterwards we calculated the correlation between the marks that were allocated to students for group work activities and the combined mark for the two semester exams - done individually. There is strong positive correlation (Pearson correlation with 1% significance level) for both our first and second year groups of students. Not surprisingly the correlation was stronger for the second year group than for the first year students. As was feared, there were instances where students performed remarkably well in the group activities and poorly in the individual part of the assessment, in particular in the first year group. The second year students are probably a little more mature. Some consolation can be drawn from the fact that these cases were isolated and negligible percentage wise.

Linked to this is the common objection to group work that the workload is not shared equally between the group members. We asked the students whether each member of their group did his/her share in the group activities and by far the majority of the responses (73%) indicated that this happened "always" or "most of the time". This was encouraging and it confirms our belief that groups of students will spontaneously sort out issues like these themselves. Our experience is that in most cases a group tolerates a passenger perhaps once, but if on a second occasion a group member does not make his/her fair contribution, this student is either kicked out of the group or "disciplined" in some or other way.

9. Areas of Concern

The role of the instructor in a web-based course is distinctly different to that in a classroom situation, especially where group work is concerned. Quoting Hagelgans et al (1995) once again: "The instructor must play an active role in becoming aware of how the groups are operating. It can be expected that, left to their own devices, students may let their groups fall into non-productive modes of operation." In a web-based teaching it is not possible for lecturer to play such an active role. Luxuries such as " ... the instructor may move from one group to another to observe their progress and to provide assistance by giving hints, ..." are simply not possible. Yet, students do seem to find a framework for themselves within which they function fairly successfully. We also maintain that group work is probably more of a necessity than a nice-to-have when teaching web-based students compared to teaching classroom-based students. This is, in most cases, their only opportunity to verbalise mathematics and their only real contact with students doing the same course.

Other problems such as difficulties connected with modes of operation or with group dynamics, difficulties arising from organisational issues, and difficulties to do with individuals are even more distinct in a web-based than in a classroom-based course. In a web-based course it is also more difficult to deal with such problems since there is less contact between the instructor and the students. Students need to mature quicker and deal with these issues themselves. Our experience is that this happens indeed.

One disappointment was the fact that most groups met only before an assignment was due. We were hoping that the groups would progress to working together in other aspects of the course such as studying together, having more unforced discussions on the work, but unfortunately this was not the case. In a sense this was to be expected. Left entirely to his or her own initiative, the average student will follow the path of necessity, the path that leads to survival. The majority of groups (70%) would only meet when required - when an assignment was due.

10. Student Comments

In spite of a few reservations about group work expressed by students, it is significant to note that the majority (69%) testified to the importance of the group activities for the success of doing a web-based course in mathematics.

A few representative comments from students are:

"Group work is wonderful if every member does his share, otherwise it sucks."

"I was the driver and the rest were passengers."

"Those who understand the work help us a lot."

"It was the best way in which I fully tested my understanding of the material when explaining my method of solving a problem to my fellow students."

11. Conclusion

We have been experimenting with web-based courses for two years now and are convinced that this mode of teaching is here to stay and offers a fine alternative to the conventional model. However, in the absence of lectures there is a need amongst students to communicate in some way. The group work model that we introduced offers (part of) a solution to this need. Although it is clear from our research that students rate the importance of these collaborative activities as very high, not everything is working perfectly yet and we will have to build on the positive aspects of our experience in order to further develop this teaching model.

There is a need for monitoring the group activities from the instructor's side and better work ethic from the students' side. In a classroom situation the instructor has an ongoing opportunity to develop the dynamics of the collaborative learning process. In a web-based situation the instructor does not have the hands on opportunity to monitor the cooperative activities and therefore we need to provide better guidance on what the purpose of group work is and on how a group should function, perhaps in some handout in the beginning of the course.

We are convinced that collaborative learning is very important in a web-based mathematics course but more difficult to implement. Quoting Arzt (1999): "For teachers to use cooperative learning strategies effectively, they must become sensitised to the many complexities of the technique." In a web-based mathematics course it seems as if these "complexities" are even more complex.

In retrospect, it is clear that there are some important benefits that the student gains form this collaborative learning model:

- Learning a variety of approaches for solving a problem
- Opportunity to discuss and clarify ideas
- Improve communication and social skills
- More enjoyable teaching environment than conventional lectures
- Increasing confidence
- An opportunity to communicate, especially in this teaching model

These benefits correspond closely to those experienced by Kaufman et al (1997).

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