USING COMPUTER-BASED PROJECTS WITH COOPERATIVE LEARNING IN FIRST-YEAR MATHEMATICS

Martin Rosenzweig
Bryant College, Smithfield, RI 02917, USA

ABSTRACT

As part of a continuing 10-year, classroom research project to the effective use of cooperative learning in first-year mathematics, the use of computer-based projects has been investigated. The Maple Computer Algebra System (U of Waterloo) was adopted and the impact of various strategies has been investigated. The points discussed are: elaboration vs discovery, degree of complexity (difficulty and length), frequency of assignment, and the assessment of the teamwork.

This report discusses the impact of the various choices and suggests possible alternatives to be considered in the context of one's own institution and students. Student reactions to various choices are also discussed.

1. Introduction

This paper, which discusses the use of computer-based projects in first-year mathematics classes, consists of four parts. The next part gives the context, that is, describes the organization and operation of these classes. The succeeding parts discuss the use of projects and some conclusions about their use.

Following attendance at the now defunct “Problem Solving Across the Curriculum” at Wells College in 1992, the author undertook to revise his teaching methods and began what has evolved into a ten-year project (Rosenzweig 1994, 1995, 1998, 2001, Rosenzweig and Segovis, 1996).

About five years into this evolution, the use of computer-based projects using Maple V, a computer algebra system (CAS) that was developed at the University of Waterloo, Canada. Student reaction was not positive and the nature of these projects has been modified during successive classes.

However since the **purpose** of this course is to use the language of the course, mathematics, to have the students learn something of small group interactions and a systematic approach to problem solving, it is clear that the projects play an important role. They provide an opportunity for the student members of each team to work together to produce work that has value for their learning and their class standing. Moreover, although these are business students and not mathematics majors, nevertheless the goal of imparting a modest level of mathematical knowledge has not been ignored. In that regard, these projects make a contribution to their learning. Some students have reported that these projects, not required by every instructor, are unduly burdensome. This is due to the frustrations associated with computer use in general. Other student responses have been more positive and suggest an appreciation of the clarification of some of the ideas from the class.

2. Organization and Structure of the Class: the context

The class operates on the basis of group-work. The students are assigned to 3- or 4-person teams by the instruction. The assignments are based on a dozen-question assessment of algebra skills taken on the first day of class, gender, and living arrangement (on-campus, or not). Experience has shown that single gender groups do not do as well as mixed groups, indicating that there is a social component to group-work. In addition, each group had a student with a good score on the initial assessment, one who scored poorly, and the other one or two average scorers. It also seemed useful to associate students by living arrangement to facilitate out-of-class meetings that were expected as part of the course-work.

Each team elects a team leader whose responsibilities include: meeting with the instructor to discuss questions related to leadership and also mathematical and other questions, particularly regarding the projects. In the current iteration of this scheme, team leaders rotate among the members of the team, changing with each new project.

Generally, the class period is divided into three sections: a 15 to 20 minute introduction of new material through lecture and discussion, a 25-, or so, minute period in which the team members work together on problems, usually in the text, relating to the new material, and finally, a one or two question quiz closes every class session.

The quiz serves three purposes: it informs the instructor about the ability of the class to absorb the new material, it informs the student on his/her understanding of this material, and it is a convenient way to track attendance.

The fundamental operating principle in the class is to create a "learning organization" in the sense that "A learning organization is an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights (Garvin, 1993, p.80 – quoted in Rosenzweig and Segovis, 1996). In terms of this class, the goal is to look not only at what students were learning, but also *how* they were learning.

To this end, at bi-weekly "course evaluation" is distributed to determine what the instructor might do to be more effective and to ask the students to assess their level of participation and learning, These evaluations, or reviews, serve as the core of the "process evaluation" that help guide delivery of the course. They also give students a sense of control over the operation of the class that tends to reduce the anxiety that many students feel in mathematics classes.

This assessment of the process is somewhat novel in mathematics classes where traditionally only the content is assessed (Rosenzweig and Segovis, 1996), and is called "double-loop" learning in the management literature (Argyris and Schon, 1978, Bolman and Deal, 1991, Senge, 1990). Here, we examine as we go, how successful the delivery of instruction is. The advantage of this approach is to provide information in a timely way for the improvement of the class. Simple questions as, "Are the blackboards visible to everyone?", "Can everyone hear the speaker?", "Is the writing clear?", can provide surprising encouragement to students attempting to understand what is being offered. Of course, the instructor runs some risk in seeking this kind of feed-back from his/her students, however the rewards can be quite substantial.

3. The Use of Computer-based Projects

The issues relating to the use of computer-based projects that are discussed here are: investigation versus clarification, frequency and complexity, and assessment.

The first choice to be made is whether the projects are to provide opportunities for students to explore new ideas, perhaps to demonstrate or prove basic theorems, to examine material not covered in the classroom, or to explicate classroom material, perhaps at greater length or from a different perspective. This is choice is in large measure driven by the preparation of the students in the class. Students with stronger mathematics backgrounds are more likely to be capable of investigating new ideas on their own, or with limited oversight. For classes of weaker students, this approach tends to be frustrating – asking of the students more than they are able to do. In this situation, using projects to introduce new material discourages students and is likely to cause them to withdraw from the course either formally, or tacitly. This was our experience with attempting "learning by discovery".

Effective use of the projects to expand on material from the class offers interesting opportunities also. Students can demonstrate ideas graphically, taking advantage of the facility of the Maple CAS to draw graphs. It becomes a simple matter to repeat graphs any number of times. This means the limits of a graph can be changed as desired. And one can, for example, have students demonstrate for themselves local linearity, and beyond these simple situations where local linearity cannot be obtained. The library package, "Student", offers many routines useful in first-year calculus. It is a simple matter to represent Riemann sums graphically as rectangles draw between a function and the axis. It also a simple matter to change the number of terms in the sum. Therefore, students can see the convergence of upper and lower sums and make conclusions about this fact.

The frequency and complexity of projects are naturally related. For more capable students, more reliance can be placed on the computer projects to substitute for lecture time. Also, the projects should be sufficiently demanding so that the effort of the entire team is necessary. Otherwise, the stronger students tend to take over to the detriment of the others.

Projects in the context of group-work. Cooperative learning is a particular case of the kinds of group-work that may be used in mathematics classes (Davidson, 1990, Cooper, et al, 1990, Johnson and Johnson, 1991). It is highly structured, and in the classes being reported on, the students are assigned to teams that are called “base groups” in the literature. These are groups that stay together for the entire term. This is not the only alternative that is available, but has certain efficiencies, as well as, drawbacks.

Allowing the students to remain together for the entire term allows them to become comfortable with one another, and to develop a sense of teamwork. In the best cases, an esprit develops that brings the team members to class regularly in order to support their joint efforts. However, it is important to catch dysfunctional teams as early as possible in order to correct the situation. Otherwise, good students are condemned to an unpleasant experience with unproductive teammates.

In the case of group-work, questions of assessment become sensitive issues. Students can be extremely concerned on having their marks depend on the work of others, particularly more ambitious or competitive students. For projects, only one grade is awarded and each student receives it. Therefore, the incentive is for the better students to strive to take over the work, and for the others to accept “academic welfare”. This requires some attention from the instructor, however can be mitigated by having grades adjusted by the amount of effort contributed by each student, or by having the project grades matter less, or by other stratagems. In this class, students are required to sign their names to the project to indicated participation, and are penalized for false statements.

In the end, it must be said that group projects encourage group-work. By holding sessions in which the team leaders are given information about the project, expect outcomes, etc, empowers them and gives them more confidence in dealing with their teammates.

As a final comment on the use of teams in first-year classes, it is sometimes the case, perhaps more often that not, that students do not possess the skills to function effectively in teams. It is particularly difficult for first-year students to perform the difficult tasks of team leadership. It may prove necessary to provide some type of support for the teams and the team leaders. In the classes here, the student leaders are required to attend a weekly session outside of class for training in the skills that may be required of them (Rosenzweig and Segovis, 1996, Rosenzweig, 2001). This training has solved many of the problems the team leaders face, and provided platforms for the exchange of ideas and experiences among the students.

4. Conclusions

The use of computer-based projects in junction with cooperative learning has proved beneficial on two counts: it has led students to an understanding of mutual enterprise, and encouraged them to participate in team activities with the knowledge that when everyone gains then it is a tautology that each individual gains. As our politicians so mischievously say, a rising tide lifts all boats, except in this case it is in fact true. Also, the projects have enriched the understanding of students by providing alternative views of the classroom material. The opportunity to visualize mathematical ideas using the graphing capability of the computer package has proven helpful, and to interested students exciting.

In our experience, the Maple V Computer Algebra System is a convenient vehicle for executing these projects. It has a “user-friendly” interface, and requires a minimum of programming skill on the part of the student. It also has sufficient power to provide the instructor with a variety of options for presenting material in the classroom and in the laboratory. There are of course alternative packages available, and there may be institutional as well as instructional reasons for choosing one or another. This is less important that the decision whether or not to require projects at all.

Student response has been variable. The students expressing approval of the use of computer projects usually enjoyed the additional exposure to mathematical ideas from a different perspective. The students that disapproved usually objected to the additional work entailed in going to the computer labs and attempting to extract results from their sometimes difficult interactions with the computers. On balance, the contention is that these projects contribute to learning and are worth the relatively modest effort required of the students.

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