Using Collaborative Learning Techniques to Integrate Economics and Engineering Economy at the Freshman Level

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ABSTRACT

Mercer University's School of Engineering has taken the opportunity provided by the transition from the quarter system to the semester system to engage in a two-year-long curriculum renewal effort. As a result of this effort, the industrial engineering department is responsible for designing an integrated economics/engineering economy course to be taught at the freshman level. In keeping with the school's philosophy of an integrated curriculum, the course also emphasizes students' computer and communication skills. To teach such an integrated course, especially at the freshman level, we needed to redesign our traditional engineering economy course. We decided to incorporate collaborative learning strategies into our revised course; thus, the course features a mix of traditional lectures and group learning assignments. This paper describes the development of this new course.

INTRODUCTION

As part of the redesigned engineering core curriculum, the engineering economics course, traditionally taught at the junior level, has become a part of the freshman year curriculum. Furthermore, the microeconomics that had been a separate quarter-long required course taught by the business school has been integrated into the new semester-long course. These two changes in the engineering curriculum have led to the need to seriously reexamine the way the engineering economics course is taught.

We have made three major changes to the course structure. First, the new course is team-taught. Business school faculty teach the microeconomics portion and engineering school faculty teach the engineering economy portion. Second, the new semester-long course deals with subject matter previously included in two quarter-long courses; therefore we eliminated some topics that were included in the original courses. Third, we designed the new course around the needs of the typical college freshman. Many freshmen have not yet learned the benefits of studying together as a group. Unlike juniors, freshman students are typically still developing their time management and study habit skills. We believe that designing the course based on collaborative learning principles will increase the students' chances for success.

Studies conducted over a number of years have shown that the cooperative learning approach is very effective in a wide variety of educational environments. [1] A recent *Prism* article [2] describes the following benefits of cooperative learning at the higher education level:

- Higher levels of achievement
- Greater level of academic self-esteem
- Creation of more sophisticated solutions to complex problems
- More positive relationships

Two recent books discuss general ways to apply collaborative learning principles in the engineering classroom. [3,4] In addition, several authors have written articles which describe the use of collaborative learning principles in specific engineering courses. Felder's [5] articles detail his successful experiences over a number of years. Yokomoto and Ware [6] present data on the effective use of group quizzes in a sophomore level electronics course. Sears [7] gives a detailed description of the implementation of collaborative learning in a freshman level electronics class. Jones and Brickner [8] report on the use of cooperative learning in a large-enrollment statics class; Howell [9] gives a detailed description of the implementation of cooperative learning in a dynamics class.

However, there is some indication that a number of faculty members have not yet incorporated these active learning and group techniques in their engineering economy classrooms. In a recent survey, [10] fewer than half of the respondents indicated that they use groups (formal or informal) in their engineering economy classes. On the other hand, many of us have used some collaborative learning techniques in the engineering economy classroom and would like to spend time developing more such exercises. Since the literature indicates that the potential benefits of teaching in a cooperative learning environment are worth the substantial time investment, we will use these techniques extensively in our new course.

IMPLEMENTATION PLAN

Having decided to use cooperative techniques in this course, we needed an implementation plan; we adopted a three-phase implementation procedure.

Phase I

Develop a departmental library of collaborative learning books and articles
Motivate other instructors as to benefits of collaborative learning
Incorporate collaborative learning principles into the basic course structure
Prepare collaborative learning exercises for a small number of classes
Develop preliminary assessment/feedback forms for students and faculty
Develop a long-term assessment plan
Initiate documentation procedures
Explore possible funding sources for curricular development

Phase II

Continue assessment procedures
Continue documentation procedures
Analyze assessment/feedback forms
Analyze quizzes and exams to determine problem areas
Incorporate additional collaborative learning exercises
Develop funding for potential projects such as peer assisted learning groups

Phase III

Continue assessment procedures
Continue documentation procedures
Disseminate results (successes and failures) to colleagues
Develop and implement experimental designs to test efficacy of new methods

Work with others who want to use additional active learning techniques in their classes
Conduct workshops

PROGRESS IN PHASE I

The decision to design the course based on collaborative learning principles does not mean that we will abandon the lecture format altogether. The course will include a mixture of lecture and active learning exercises. We intend to start with short-term informal learning strategies. As course development continues, we will modify our strategies and incorporate more formal learning exercises.

During our initial course offering, we will implement both formal and informal cooperative learning activities. We will use informal cooperative learning groups to help students learn the principles of nominal and effective interest rates. In addition, we will develop lessons using formal cooperative learning groups for two areas that have been problematic in the past (e.g. taxation and replacement analysis). We will not attempt to use cooperative base groups during this phase of the curriculum development plan.

Much of the success of the active learning exercises will depend on how well the students prepare for class. In an attempt to encourage students to come to class prepared, we require students to use a word processor to answer homework questions. During the class period, they are allowed to write in additional information. Students who submit hand-written homework receive less credit than those who submit typed responses do; we hope that this will encourage students to become familiar with the material before class.

Course grades will reflect both the students' individual and team efforts. Homework, quizzes, exams, and class participation will all be part of the overall course grade. Grading for all cooperative learning exercises will be criterion-based.

We believe that freshman students need help in monitoring their course progress. Therefore, we will institute weekly quizzes. These quizzes will provide feedback to the students concerning their level of understanding and progress in the course. The quizzes, which require 10 minute or less to complete, consist of short answer questions and simple problems. Each question or problem will highlight a single important concept from the previous week that the students should have assimilated through their reading, classroom work, and homework. Patterns of success or failure on these quizzes may inform us of the effectiveness of various instructional methods used during the week.

On occasion, we will use a technique we call "pyramid quizzes" to enhance the learning experience of the weekly quiz. In a pyramid quiz, each student first answers the quiz question individually. After these solutions are turned in, students will pair up to solve the problem, and then two pairs will join together to solve the problem. Each student's final quiz grade will be a combination of their individual performance and their pair performance.

One decision made early in the design of the course was to focus on spreadsheet techniques, specifically Excel®, to solve engineering economics problems. This focus will allow us to accomplish two very important goals. First, we will be able to concentrate our efforts on developing students' understanding of the context of the problems rather than on the techniques used to solve them. In addition, we will need to teach students not only a knowledge base of

how to solve specific problems, but also to retain (or, if necessary, relearn) and use this knowledge base throughout their academic careers.

Since we are including spreadsheet techniques, class size is restricted by the number of computers available in the school of engineering's computer classrooms. Because of this restriction, there are six sections being taught by four instructors. In order to ensure a commonality of approach and focus, the four instructors meet weekly to discuss progress, problems, and suggested instructional techniques. We will use these weekly meetings to educate each other, evaluate our progress, and refine the course as we proceed. In addition, we will use these meetings to gather information for a course notebook that documents the results of our efforts. Ideally, these weekly meetings will allow us to function as a cooperative collegial teaching team as defined by Johnson, *et al*. [2]

ASSESSMENT/EVALUATION

The freshman engineering economics course is being designed to enhance the learning experience of the students, promote active and continuous learning strategies, and develop a specific skills and knowledge base on the part of the student. Because this is a "new" design, we need to develop and institute methods of continuous evaluation and improvement in the course. Furthermore, ABET 2000 criteria require that we develop methods of assessment throughout the curriculum. The assessment of the success of this course must complement the assessment of the curriculum's success.

The evaluation of the methods used in this course will be used as part of a program of continuous quality improvement. Ongoing evaluation will be accomplished through weekly instructor observation surveys, as well as statistics collected from weekly quizzes, homework assignments, and midterm exams. Weekly results may be used to identify and make small corrections during the course of the semester. Aggregate results will be compiled at the end of the semester and used to guide the design of future offerings of the course.

Comments from students are an important part of our assessment plan. After the term is over, we will analyze the course evaluation forms and use the results to modify the curriculum. During the term, we will periodically use "plus/delta" surveys . Plus/delta surveys have been used in several classes in the school of engineering since the fall semester of 1997 began. To conduct these surveys, students are given note cards at the end of the class period. They are asked to record on one note a positive comment concerning the class (a "plus") and on the other a specific aspect of the class they would like to change (a "delta"). The advantage of these types of surveys is that they give the instructor immediate feedback concerning students' impressions and opinions.

PHASE II AND BEYOND:

At the end of this semester, we will assess the results of the weekly and aggregate evaluations of the instructional techniques used in this course. We hope to be able to assess students' (and instructors') acceptance of various techniques, as well as identify lapses in students' performance with respect to the specific skills and knowledge requirements of engineering economics.

This semester's engineering economics course is a prototype for the type of course we would like to develop. Based on our experiences and the results of our informal and formal assessment procedures, we will develop a small set of more formal and elaborate collaborative learning

exercises targeted at specific problem areas. Some of the methodologies we will explore include 1) defining formal groups in which group goal-setting and topic verification [11] is an integral first step in the process, 2) peer review of group projects, 3) the institution of peer learning assistants, [12] or PLA's, 4) the use of a course web page to encourage interaction within and between groups and to share common questions and answers, and 5) the development of materials for a case study, appropriate for freshmen, which integrates microeconomic and engineering economics.

We will also explore alternative means of funding our development procedures. This funding will be essential to support adequate education and development activities, as well as to enable us to try out more costly alternatives such as paid peer learning assistants.

Finally, we intend to use our experiences in this course to help us educate our colleagues in the use and benefits of active and cooperative learning. This will require us to extensively document our procedures, experiences, and results and to disseminate this information to the faculty in the school of engineering, as well as to other interested groups and individuals. We have, like many others, encountered a certain amount of resistance on the part of faculty in our school to the idea of using cooperative learning techniques. We hope that, by demonstrating a certain amount of success and being able to give specific guidance, we will be able to overcome some of that resistance.

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