Increasing the Use of Collaborative Learning Techniques in an Integrated Economics and Engineering Economy Course

Joan Burtner, Laura Moody
Mercer University

Abstract
As part of a three-year curriculum renewal effort, the authors were given the task of designing and implementing a semester-long integrated economics/engineering economy course to be taught at the freshman level. We have incorporated collaborative learning exercises into our revised course; thus, the course features a mix of traditional lectures and group learning assignments. This paper describes the implementation of this new course over the past two semesters as well as our progress toward increasing the use of active learning techniques in other School of Engineering courses.

I. Introduction

Mercer University's School of Engineering is currently in the third year of an intensive curriculum renewal effort. Several factors provided the impetus for this curriculum renewal effort. First, Mercer University switched from the quarter system to the semester system for AY 97-98. Second, a decision was made to reduce the number of credit hours required for the bachelor's degree. Third, the school plans to apply for program accreditation during our next ABET visit. (We currently offer an ABET-accredited BSE degree with specializations in biomedical, electrical, environmental, industrial, and mechanical engineering.) Fourth, we are modifying our course offerings in response to ABET's Engineering Criteria 2000.

As a result of the curriculum renewal effort, two different quarter-long courses were combined to create a semester-long integrated economics/engineering economy course. Thus, the engineering economy course, traditionally taught at the junior level, became a part of the freshman year curriculum. The new course, EGR 120, is required of all Mercer students who intend to graduate with the BSE degree. The authors, both members of the mechanical and industrial engineering department, were given the responsibility of designing and implementing this new course.

II. Teaching Philosophy and Course Development

The process of designing and implementing the new course offered both challenges and opportunities. The first challenge we faced was to integrate material from what is traditionally two separate courses (and in many places, including Mercer, taught by two separate schools) into a single course. The second challenge involved the requirement to

include the course as part of the freshman year curriculum, even though it is usually taught in the sophomore or (more often) junior year. However, the need to redesign the course for the semester system also provided us with an opportunity to "start over" in our approach to teaching the subject. Furthermore, we were able to design a course in which we could systematically integrate the innovative approaches we had been researching and implementing on a smaller scale in some of our other courses.

As a first step in developing the new course we engaged in discussions about teaching philosophy and learning styles. The initial focus of our discussions centered around developing and implementing methods of classroom instruction that would enhance the success of students in a course that is traditionally taught at a higher level. It was also clear to us, however, that we could use this course to help students develop problem solving and learning skills that would be useful to them throughout their careers.

This focus on developing student problem solving and learning skills is, of course, not unique. Educators frequently talk about the paradigm shift that is taking place in undergraduate education. As Barr and Tagg [1] express it, the shift is from the instruction paradigm to the learning paradigm. They state that in the new learning paradigm,

> "a college's purpose is not to transfer knowledge but to create environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of communities of learners that make discoveries and solve problems." (p.15)

Many engineering educators focus on approaches for developing these skills. Smith and Waller [2] call for a change from a competitive and individualistic learning environment to a cooperative learning environment in the classroom as well as the development of cooperative faculty teams. Guskin [3] observes,

> "to create learning environments focused directly on activities that enhance student learning, we must restructure the role of the faculty to maximize essential faculty-student interaction, integrate new technologies fully into the student learning process, and enhance student learning through peer interaction." (pp. 18-19)

Evidence of the paradigm shift appears elsewhere in the literature related to teaching engineering. ABET's Engineering Criteria 2000 is a reflection of the new philosophy. Participants at engineering education conferences deplore the excessive use of "chalk and talk" lectures and commend the use of active learning techniques in the classroom. Others [4] talk about the use of instructional strategies that place emphasis on the student as learner, and the teacher as facilitator. Books and articles [5,6,7] emphasize the need to be aware of teaching styles and learning styles.

When describing the development of new courses, many authors refer to Chickering and Gamson's seven principles for undergraduate education. As we developed the course, we were especially influenced by four of these principles. The specific principles that guided us stated that good practice in undergraduate education encourages contacts between

students and faculty, develops reciprocity and cooperation among students, uses active learning techniques, and respects diverse ways of learning. [8]

As we read the literature and talked about our goals for the new course, we agreed that the lecture-only approach to teaching would not give us the results we wanted. We wanted to develop a learning environment in which students were actively involved in the learning process. Both of us have had some successful experiences using active learning techniques in several of the courses we teach, and we decided to incorporate some of these activities into the new engineering economy course. Thus, the revised course would feature a mix of traditional lectures and group learning assignments.

The new course was named EGR 120: Engineering Economy. The course was designed to emphasize active, collaborative learning and includes the following features:

Classroom equipped with a computer for each student
Lectures combined with in-class group activities
Informal cooperative learning exercises
Grades for participation
Weekly quizzes
Weekly instructor meetings
Common syllabus and common exam dates
Common final exam questions

III. Cooperative Learning Activities

Johnson, Johnson and Smith [9] define cooperative learning as the "instructional use of small groups so that students work together to maximize their own and each other's learning." (p. 10:2) Further, they divide cooperative learning groups into three categories: informal cooperative learning groups, formal cooperative learning groups, and cooperative base groups. During the two semesters that we have taught the integrated microeconomics/engineering economy course, we have used the following active learning techniques, many of which are based on the formation of informal cooperative learning groups.

<u>"Interactive use of technology in the classroom"</u> - Class was conducted in the computer lab. The room includes 22 student computers as well as one instructor's computer and projection system. During class, various solution methods were demonstrated on the board as well as on the instructor's computer and projector. Additionally, students were given an opportunity to work the examples themselves in class (by hand and on the computer.)

<u>"Concept questions"</u> - This idea was adapted from the ConcepTest which has been shown to be effective in college physics [10] and chemistry [11] courses. A very simple concept question might be, "If the advertised rate is listed as *nominal 10% per year, compounded quarterly*, would the effective annual rate be less than 10%, equal to 10 %, or greater than 10% per year? A more advanced concept question might relate to more complex issues

such as the assumptions inherent in incremental rate of return analysis. In EGR 120, the concept questions were used in the following manner. Often during the lecture the instructor would ask a question and offer several short answers. Class members were instructed to solve the problem individually. Students were then required to vote on the correct solution. If almost everyone gave the correct solution, the exercise was over. It was more likely, however that there would be a disagreement over the correct answer. In that case, students were given a brief amount of time to convince their classmates why their solution was correct. Students were given a chance to vote again and one student was given a chance to explain the correct answer.

"Multiple approaches" - Many instructors express concern that students use computer software programs such as Excel without understanding the underlying mathematical principles. To help students understand the relationship between Excel functions and factor calculations, students were divided into four-person teams. Each team was given a set of five problems. Two of the team members were required to solve the problems using equations or factor tables; the other two were required to use Excel. The team members then compared answers and, if necessary, taught the other members how to do the problems. Each team was required to submit one team solution sheet and was given a group grade for their work.

"Pyramid quizzes" - To enhance team learning, one of the authors administered pyramid quizzes. At the beginning of the pyramid quiz, students were given a quiz question to answer individually. After these solutions were turned in, the students paired up to solve the same problem. After a short time, two pairs joined together to solve the problem. The four-person group agreed on a solution and then submitted their solution for a group grade. Each student's final quiz grade was a combination of their individual performance and their group performance. In theory, strong students were able to convince others of the correctness of their answers, and weak students learned essential concepts by listening to the explanations of the strong students.

"Informal homework groups" - To reinforce the benefit of studying and working in groups, we occasionally gave students a brief amount of time to form teams of four to compare homework solutions at the beginning of the class session before turning in the homework. Since the course is offered in the computer lab, each student was allowed to use Excel or a calculator for problems that required calculations. When there was a difference of opinion, students were encouraged to justify their answers. This usually resulted in very lively discussions as well as better homework grades.

"Visual-verbal links" - During the 7th microeconomics class session, students were divided into groups. Each group was asked to "draw a market." In addition, each group was given a different scenario in which one or more of the determinants of demand or supply changed. The groups were asked to draw and explain to the class what happens to the market when this change occurs. This activity was rather effective, although more time should have been allotted. One unexpected benefit came about because the changes described in some of the scenarios were somewhat ambiguous, resulting in some lively discussion about the assumptions the groups made and what the effect would have been

under different assumptions. During the next offering of EGR 120, this same exercise was used as an out-of-class group homework assignment. This approach also worked well.

"Jigsaw groups" - During the 10th microeconomics class session one of the authors presented a "jigsaw exercise" using problems from the end of chapter 10. Students formed groups and answered two questions per group. Then the groups split up and formed different groups, in which there was one member from each of the original groups. These individuals then explained the answers to their problems to the new group.

"Integration of active learning and written team reports" - Students were required to bring in two car ads and two house ads with different stated interest rates. They worked in pairs to complete an in-class project in which they were asked to answer several questions using the costs and interest rates shown in the ads. The teams turned in a formal report on their findings. This exercise seemed beneficial both in terms of helping students understand the concepts and in solidifying their skills in working with interest rates and the time value of money.

IV. Course Evaluation

EGR 120 was different than the traditional engineering economy course in several ways, including: 1) large freshman enrollment, 2) increased emphasis on cooperative learning, and 3) integration of microeconomics and engineering economy. Our course evaluation dealt with these three topics.

Freshman Performance in Engineering Economy

As noted earlier, the integrated course (EGR 120) is part of the standard curriculum for engineering freshmen. Part of the motivation for the revision in teaching techniques was a concern about how freshmen would perform in the course. We have offered the integrated course over a period of two semesters: Spring 1998 (6 sections), Fall 1998 (1 section). Thus, many of the students who enrolled in the course were second-term freshmen. Mercer's grading system is as follows: A, B+, B, C+, C, D, F. Using a four-point scale, A=4, B+=3.5, B=3, etc., we compared the final course grade for freshmen and non-freshmen. The results are listed in Table 1.

Student Level		***Course Section***						
		S001	**S002**	**S003**	**S004**	**S005**	**S006**	**F001**
Freshmen	**Grade**	2.38	3.30	3.00	2.38	3.27	2.59	2.00
	(n)	*(8)*	*(5)*	*(13)*	*(17)*	*(11)*	*(17)*	*(3)*
Non-freshmen	**Grade**	3.09	3.23	3.00	3.00	2.80	NA	2.97
	(n)	*(10)*	*(15)*	*(6)*	*(2)*	*(7)*	*(0)*	*(16)*

Table 1: Average final course grade and number of students per section

In three of the seven sections, the freshmen did not perform as well, on average, as the non-freshmen. However, in two of the sections, the average final grade for freshmen was higher than that of the non-freshmen. Overall, the freshman students earned a grade of

2.72 in the course, while non-freshman students earned a grade of 3.05. A studentized t-test of the results showed this difference to be significant ($p = 0.03$). Furthermore, the number of students who earned a D, an F, or withdrew from the course was much higher for the freshmen than for any of the other groups, as shown in Figure 1. These results, along with issues concerning where and when the students use the material in their curriculum, have led us to reevaluate the placement of this course in the freshman year.

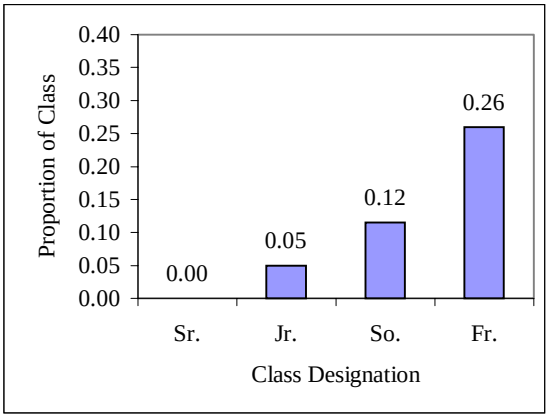

Figure 1. D, F, and Withdrawal Rates by Class Designation

Student Comments

Student evaluations are conducted for every course offered in the School of Engineering. These evaluations use a common form and are distributed during the last week of the term. The form includes a section of specific questions (value of text, pace of course, etc.) as well as a section in which students are allowed to write in comments.

There were no negative write-in comments about group activities; there were, however, some positive comments about the use of groups. Typical comments include:
"Working in groups was very helpful."
"The specific examples that we discussed in class and worked on together as a group helped a lot."

Students were much more concerned about the overall structure of the course. Many did not like having two different subjects taught out of two different books in the same course. For the most part, they did not see any connection between the microeconomics section and the engineering economy section. Typical comments include:
"Microeconomics and engineering economy should be taught as two separate courses."
"It was hard to switch gears in the middle of the course."
"We should have had the same teacher for both parts of the course."

The analysis of student comments on the standard evaluation form did not yield sufficient information concerning specific active learning activities. We are in the process of developing customized evaluation forms related to the specific active learning activities we use in the engineering economy course. We plan to distribute these forms during the spring 1999 semester.

V. Active Learning Throughout the School

The development and assessment of this course is part of an overall effort by the authors to use active learning techniques in the college-level engineering classroom as well as to encourage other professors to do so. In a previous paper [12] we outlined a long-range plan designed to increase the use of collaborative learning in the School of Engineering curriculum. We adopted a three-phase implementation procedure. The development and evaluation of this course is part of Phase I of that plan.

Other features of Phase I include:

Collegial Support Groups
In order to initiate and sustain significant changes in EGR 120 teaching techniques, we felt it was necessary to conduct weekly instructor meetings. During the spring semester, we offered six sections of the course. Four different instructors were assigned to teach the course. Weekly meetings were used to increase communication among the instructors. In essence, we developed into a collegial support group. We shared knowledge on active learning techniques; we reflected on what we had done in class; we talked about ways to modify the techniques that didn't work well.

Resource library of printed materials
We have built a small library of books and articles. Many are related to the general topic of improving college teaching. Others focus on collaborative learning; still others deal with the topic of organizational change. All of the references at the end of this paper are part of the library.

Active learning web page
We are developing an active learning web page which includes 1) descriptions of active learning exercises we've used 2) a list of active learning books and articles located in the industrial engineering suite 3) papers presented by Mercer faculty, and 4) links to other active learning resources.

VI. Conclusion

What lies ahead for the engineering economy course at Mercer? The course is influenced by various internal and external factors. At the current time it is part of the common engineering core required of all BSE students. As we move toward program accreditation, and as we modify our curriculum in response to ABET's Engineering Criteria 2000, we are reevaluating the content of many of our common core courses, including EGR 120. The result of this reevaluation has been twofold. First, we have changed the content of the course to include project management and cost estimation topics in place of microeconomics. Second, we have moved the course from the freshman year to its more traditional place in the sophomore year or higher (depending on the needs of the various programs.) We are, however, still committed to the classroom approach we have adopted for the course.

Our new focus this year is on curricular revision so that we may successfully achieve program accreditation under the new EC 2000 policy. There is little time left to focus on developing and refining changes in classroom teaching techniques. Nevertheless, we are convinced that we need to continue our efforts to vary the techniques we use in the classroom, even though our time constraints are causing us to temporarily scale down our approach.

Most importantly, we are committed to our long-term plan. We know that it takes a lot of hard work to effect a major change in teaching techniques; we know it is easy to revert to *"talk and chalk"* methods. However, we strongly believe that the adoption of collaborative learning methods is important to our students' success. We will continue to do what we can to promote the use of active learning in the classroom.

References

1. Barr, R. & Tagg, J. (1995, November/December). From teaching to learning: A new paradigm for undergraduate education. Change, 27 (6), 12-25.

2. Smith, K. & Waller, A. (1997). Afterword: New paradigms for college teaching. In W. Campbell & K. Smith (Eds.), New paradigms for college teaching. (pp. 269-281). Edina, MN: Interaction Book Company.

3. Guskin, A. (1994, September/October). Reducing student costs and enhancing student learning: Part II Restructuring the role of faculty. Change, 16-25.

4. Catalano, G.D. & Catalano, K. (1999). Transformation from teacher-centered to student-centered engineering education. Journal of Engineering Education, 88 (1), 59-64.

5. Felder, R.M., Felder,G.N. & Dietz, E.J. (1998). A longitudinal study of engineering student performance and retention: V. Comparisons with traditionally-taught students. Journal of Engineering Education, 87 (4), 469-480.

6. Campbell, W. & Smith, K. (Eds.). (1997). New paradigms for college teaching. Edina, MN: Interaction Book Company.

7. Rafe, G. & Manley, J. (1997). Learning style and instructional methods in a graduate level engineering program delivered by video teleconferencing technology. [On-line]. Available: http://fairway.ecn.purdue.edu/~fie/fie97/

8. Chickering, A.W. & Gamson, Z. (1987). Seven principles for good practice in undergraduate education. AAHE Bulletin, 39 (7), 3-7.

9. Johnson, D., Johnson, R., & Smith, K. (1991). Active learning: Cooperation in the college classroom. Edina, MN: Interaction Book Company.

10. Mazur, E. Peer instruction. (1999). [On-line]. Available: http://mazur-www.harvard.edu/Education/EducationMenu.html

11. NewTraditions Consortium. Chemistry Concept Tests (1999). [On-line]. Available: http://genchem.chem.wisc.edu/newtrad/

12. Moody, L. & Burtner, J. (1998). Using collaborative learning principles to integrate economics and engineering economy at the freshman level. American Society for Engineering Education 1998 Annual Conference Proceedings, Seattle, WA. June, 1998, CD-ROM.

JOAN BURTNER is an Assistant Professor of Industrial Engineering at Mercer University. She is the coordinator of the freshman design course, faculty advisor for the Society of Women Engineers, and the Director of Mercer's Summer Engineering Camp for Teens. She holds a BSE (Industrial Egr.) and an MSE (Egr. Management) from Mercer, as well as a BA (Psychology) and an Ed.S. (Guidance and Counseling) from the Univ. of Florida. She is currently working on a doctorate at Nova Southeastern University.

LAURA MOODY is an Associate Professor of Industrial Engineering at Mercer University. She is the Director of the Industrial and Systems Engineering program. She holds a BS (Electrical Engineering), MS, and Ph.D. (Human Factors Engineering), all from the Georgia Institute of Technology. She is the coordinator of the engineering economy course.