Lessons Learned by a Novice Engineering Educator: Introducing a Cooperative Learning Technique to an Introductory Engineering Class

Deborah M. Mechtel
United States Naval Academy
Annapolis, Maryland

ABSTRACT

One challenge novice engineering educators face is teaching students who have varying levels of prior engineering experience or ability. A new variation of cooperative learning was introduced to meet this challenge. Cooperative learning techniques and lessons learned from this class may be extended to other courses with students of varying levels of preparation.

INTRODUCTION

Objective and Goals: One of the challenges of the Introductory Electrical Engineering course at the United States Naval Academy is teaching students who have varying levels of prior engineering experience. Prior experience includes: no exposure, electrical engineering courses at other institutions, or military technical courses. This experience mix further diminishes the efficacy of the traditional passive-student listening/active-instructor lecturing format, that has been shown to be the least effective teaching methodology [1]. Therefore, a new variant of the cooperative learning technique was used in two sections of this course to accomplish several goals. First, to support students with no experience while challenging experienced students. Second, to improve the leadership and teaming skills encouraged by the Accreditation Board for Engineering Technology (ABET) and to establish a foundation for future classroom/laboratory team design efforts. Third, to establish a professional, cooperative classroom atmosphere. Finally, this first semester's trial use of cooperative learning has been used to identify improvements in classroom techniques and procedures for future classes.

Initial Criteria For Determination Of Project Success: It has been shown that some uses of cooperative learning improve student performance [2]. Within the constraints of the limited number of total students (24) in two sections of the class, this initial evaluation provides results of both the students' and instructor's perception of the effectiveness of the teaching techniques in meeting the stated objectives. The initial criteria established for project success were as follows:
(1) Did students with different levels of preparation and ability perceive that they were supported or challenged beyond the level provided by a traditional lecture course?
(2) Did the instructor perceive that students with different levels of preparation and ability were supported or challenged beyond the level provided by a traditional lecture course?
(3) Did the students perceive that student performance improved over that expected from a classic lecture format?
(4) Did the instructor perceive that student performance improved over that expected from a classic lecture format?
(5) Did the students perceive an improvement in teamwork/leadership skills?
(6) Did the instructor perceive an improvement in teamwork/leadership skills?
(7) Did the instructor observe a cooperative, professional class atmosphere?

Using the listed criteria, this paper describes how cooperative learning was implemented, the evaluation techniques used to determine project success, student and instructor evaluations of goal accomplishment, the instructor evaluation of the implementation strategy, and conclusions and future plans.

IMPLEMENTATION STRATEGY AND PHILOSOPY

In prior courses, using the classic teaching methodology, the instructor typically worked at least two examples on the board for each new concept introduced to students. Student participation was generally passive and students were only actively engaged when compelled to respond to instructor questions. In contrast, the technique introduced in this class used cooperative learning groups of three or four students to work at least one example in class with the instructor acting as a resource for each group. At the beginning of the semester, the instructor assigned students to cooperative learning groups based on prior experience and GPA. Mid-semester, the groups were reassigned according to student preference and student performance on the first two exams. Overall, the students spent approximately 20% of their classroom time in cooperative learning groups.

Initially, the groups were required to hand in one problem solution per group and the students were also individually quizzed on the concepts introduced.   Dual grade quizzing was used, where students received two grades for each quiz - one grade was for their individual performance, the other grade was the lowest grade received by a member of their group. The intent of this strategy was to encourage students to take responsibility for group performance. A collateral purpose was to use group dynamics to stimulate active student participation, thereby enhancing both speaker and listener understanding while exposing students to peer explanations of concepts. Mid-semester, the dual grade quiz policy was replaced by a traditional quiz policy (only a single, individual grade); however the students were now required to hand in individual problem solutions after solving the problem in the cooperative learning groups.

Evaluation Tools: Given that each student participated in two cooperative learning groups during the semester, each student completed assessments of their own performance and the other group members' performance for each group.   In addition, the students assessed the cooperative learning process using mid-semester and end-of-semester questionnaires.   Other evaluation tools included student evaluations of the class and instructor, plus instructor assessment of student performance.

STUDENT EVALUTIONS

Evaluation Results: The mid-semester cooperative learning assessments by students indicated an overall positive response to this teaching technique. Mid-semester evaluation results are shown in Table 1.

Students were also asked what they liked least and best about cooperative learning and if they could recommend any ways to improve the implementation of cooperative learning in this class. 96% of the students felt their understanding of the material benefited from the different perspective peers offered, peer help on solving problems and the opportunity to explain concepts

2

to others. 37% of students disliked the dual grading policy for quizzes and some felt it was unfair. 21% of students indicated there were some interpersonal conflicts within the groups. 25% of students felt that cooperative learning would be improved by allotting more time for it in class.

Table 1. Mid-semester Student Evaluations of Cooperative Learning						
	Section 1			Section 2		
Student Response	Positive	Neutral	Negative	Positive	Neutral	Negative
Cooperative learning has helped me to understand course material more fully.	43%	43%	14%	67%	22%	11%
Cooperative learning has been a positive experience.	50%	43%	7%	78%	11%	11%
I would recommend cooperative learning to other students.	57%	29%	14%	78%	11%	11%

Results of student evaluation of their group members, including themselves, are shown in Table 2. Each section changed group membership mid-semester. The evaluation forms included a space for any additional comments students wanted to make. Students noted more interpersonal problems at the end of the semester than mid-semester. Most students justified their assignment of lower ratings of fellow group members based on group conflicts.

Table 2. Student self-examinations of their group members; for each section and as a function of first or second group (the students were reassigned into new groups after 8 weeks).							
Section	Group	Full participant, Did more than their fair share	Very cooperative	Acceptably cooperative	Minimally cooperative	Rarely cooperated	Did not participate
1	First	44 %	44 %	10 %		2 %	
1	Second	19 %	37 %	33 %	7 %	2 %	2 %
2	First	22 %	56 %	22 %			
2	Second	16 %	58 %	16 %	7 %		3 %

Goal Accomplishment: Student response to questions 1-3 in Table 3, and question 5 in Table 4 show that the majority of students perceived an improvement in their performance over the classic lecture format. The response to question 2 indicates that students felt more supported in deepening their understanding of material by discussing and explaining concepts to each other than learning in the all-lecture format. It is interesting to note that the majority of students felt that they gave and received equally in the learning process as shown in Table 5. Overall, students did not perceive a great improvement in leadership skills, although in response to question 4, 20% and 23% of students in sections 1 and 2 respectively commented that their teaming skills improved.

3

Table 3. Final Student Evaluations of Cooperative Learning : Part I						
Section	Section 1			Section 2		
Student Response	Agree	Neutral	Disagree	Agree	Neutral	Disagree
1. Compared to a normal lecture course, the use of cooperative learning groups improved my overall understanding of the course material.	46 %	46 %	8 %	50 %	20 %	30 %
2. Compared to a normal lecture course, having to discuss/explain concepts and ideas to other students deepened my understanding of the course material.	75 %	17 %	8 %	80 %	0 %	20 %
3. I would prefer that the professor do more examples on the board instead of doing examples in the cooperative learning groups.	23 %	38.5 %	38.5 %	40 %	10 %	50 %
4. Cooperative learning (dual grade) quizzes encouraged full participation in the cooperative learning groups more effectively than student assessments of other group members and handing in individual work for a grade.	0 %	46 %	54 %	30 %	20 %	50 %
5. Overall, cooperative learning was a positive experience for me	54 %	31 %	15 %	60 %	20 %	20 %

Table 4. Final Student Evaluations of Cooperative Learning: Part II				
Section	1		2	
Student response	Yes	No	Yes	No
1. Should group membership be switched more frequently than once a semester?	54 %	46 %	30 %	70 %
2. Should student assessments of other group members be done more frequently?	15 %	85 %	10 %	90 %
3. Should student assessments have a greater impact on the course grade?	15 %	85 %	0 %	100 %
4. Do you feel that the cooperative learning groups improved your leadership skills?	23 %	77 %	30 %	70 %
5. Overall, would you recommend a cooperative learning course format over a standard lecture course?	77 %	23 %	50 %	50 %

Table 5. Final Course Evaluation: Part III: Student Response to: "In the cooperative learning groups, did you feel that you received more or contributed more to the group?"			
Student Response:	Received more	Both equally	Contributed more
Section 1	18 %	55 %	27 %
Section 2	30 %	50 %	20 %

INSTRUCTOR EVALUATION

Goal Accomplishment: Based on exam and quiz results, it is unclear that this implementation of cooperative learning improved student performance on tests or their understanding of course material in general. However, the instructor perception is that this technique successfully helped to create a cooperative, professional class atmosphere, and that students with dissimilar backgrounds (both high and low degrees of expertise) were engaged in this program beyond that expected with an all-lecture format. In this sense, the learning process may have been eased for some of the students.

4

Implementation Strategy: This cooperative learning technique requires different timing and implementation practices than an all-lecture format. More in-class time is needed to solve example problems. Students agreed with this assessment. Several students, when asked to make suggestions for improving the cooperative learning experience, recommended that groups be given more time to solve the example problems.

The percentage of students that considered cooperative learning a positive experience declined between the mid-semester and end-of-semester evaluation. Their mutual assessment results also declined as shown in Table 2. Some students noted that their experience was not positive largely because of interpersonal conflicts in the group. Optimizing the membership of all groups isn't possible. Still, mixing students with different levels of experience and GPA appeared to be effective. "B" students with prior experience worked well with "A" students that has no previous experience. It is interesting to note that some "A" students with and without experience had difficulty working together. "A" students with or without experience and "C –D" students with or with out experience also had difficulty working effectively with each other. There were less interpersonal conflicts in Section 1 than Section 2. These results correlate with the larger percentage of students who would have preferred group membership to change more frequently as shown in Table 4, question 1.

Students were uncomfortable with some of the implementation strategies that effected their course grade. Questions 2 and 3, Table 4, show that students prefer that mutual assessment use be minimized. As shown in Table 3, question 4, most students felt that the dual grade quiz policy used for the first part of the semester was largely ineffective. The dual grade quiz policy was eliminated in the second half of the semester because students were so uncomfortable with the process. Table 6 shows individual quiz grade averages using dual grade policy and the traditional single grade policy. No firm conclusions may be drawn from these results since the difference in quiz grades may be attributed to a number of factors. For example, course material becoming more difficult as the course progressed, diminishing enthusiasm for the course, and instructor choices for quiz problems. In addition instructor and/or student expectations can have subtle influences on performance.

Table 6. Dual and Single Grade Quiz Averages		
Section	Dual graded quizzes	Single graded quizzes
1	91%	73%
2	85%	71%

CONCLUSIONS AND FUTURE PLANS

It is known that students have different ways of learning new concepts. For example some students prefer active learning (doing) while others are passive learners (prefer to reflect before doing) [3]. Based on this premise, the instructor plans to continue incorporating cooperative learning techniques in the classroom; although in the subjective opinion of the instructor there was not an immediate measurable improvement in student test performance. To increase the effectiveness of the techniques described in this paper, the instructor plans to spend more time explaining the benefits of cooperative learning in order motivate the students to accept and

5

participate in the process. Cooperative learning benefits outlined will include: (1) a deeper understanding of course material acquired by explaining a new concept, (2) enhanced understanding from exposure to different problem solving techniques, and (3) the ability to work as an effective team member -- a necessary skill for most engineering projects.

As a result of student confusion over the difference between intelligence (or knowledge) and the ability to work effectively as a cooperating team member, a clearer explanation of the mutual assessment forms will be presented. Groups will be changed four times a semester to limit interpersonal conflicts. This is the first majors course in the electrical engineering curriculum at the USNA, and therefore provides an outstanding opportunity for the students to establish a solid foundation for teaming in future upper level courses.

This teaching technique can be improved by carefully selecting problems that can be solved in a reasonable amount of time. It has been decided to eliminate the dual grade quiz policy completely since students were uncomfortable with this quizzing strategy and because the utility of this grading technique does not justify the students' discomfort. Students will continue to do mutual assessments that will become part of their course grade, supported by instructor observations of group dynamics. The strategy of using group problems, where only one solution per group is used to establish a common grade for all the group members, will be continued.

Finally, although the instructor observed no measurable improvement in student test performance, it was clear that the attitude of most experienced students changed noticeably after the first cooperative learning session. Instead of creating conflict in the classroom, most took ownership of the teaching/learning process, and became an additional asset to the class. A professional classroom atmosphere resulted despite the wide disparity in ability, experience, and age.

Bibliography

[1] McKeachie, W.J., *Teaching Tips*, 8th Edn., D.C. Health & Co., Lexington MA (1986).

[2] Felder, R.M., and Brent, R., *Effective Teaching: Workshop Notebook*, presented USNA (1997).

[3] Felder, R.M., and Silverman, L.K., "Learning and Teaching Styles in Engineering Education," *Engineering Education*, 78(7), p. 674 (1978).

Biography

Deborah Mechtel completed her Ph.D. in 1994 at the Johns Hopkins University in Baltimore Maryland. She is currently an Assistant Professor at the United States Naval Academy in the Electrical Engineering Department. Her research focuses on electro-optics, testing of high speed circuits, and advanced packaging development.