Cooperative Learning Homework Teams in a Materials Science Lecture Course

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Abstract

In an effort to enhance student learning, cooperative learning teams were incorporated into a junior-level required introductory Materials Science course for all engineering majors at the University of San Diego (USD) in Fall 1999 and 2000. The instructor assigned all students to teams during the first week of class. The teams were designed to be heterogeneous with respect to GPA and engineering major. Students were required to complete their homework assignments as a team turning in one solution set per team. They rotated playing the roles of coordinator, recorder, checker, and monitor. In each semester, over seventy-five percent of the students reported that cooperative learning teams had enhanced the course. About eighty percent of the students in each semester recommended that cooperative learning homework teams be used again in the next offering of this course. More than eighty percent of the students reported that their skills at problem solving, written communication, and teamwork had improved as a result of this course. This paper discusses the motivation for introducing these teams, the students' response, and the instructor's experiences with these teams over two semesters.

Introduction

Working in teams, improving communication skills, and enhancing problem solving are all key objectives for ABET 2000[1] as well as for most engineering courses. One way to address all of these is to have students work in cooperative learning homework teams. Cooperative learning[2,3] has been shown to have beneficial effects on student learning and benefits for the instructor including fewer and better papers to grade. Organizing the teams requires some work by the instructor at the beginning of the semester as well as continual monitoring throughout the course. To teach the students about teamwork, it is important that they be provided with a structure for the roles they are to play rather than just assigning them to groups. It is also important to provide opportunities to evaluate their teams. The National Effective Teaching Institute (NETI) provides excellent resources for organizing, facilitating, and evaluating teams that were used in the course described in this paper. [4]

Course Structure and Logistics

Cooperative learning homework teams were incorporated into a required junior-level Materials Science course for all engineering majors at the University of San Diego (USD). At USD, this includes Electrical and Industrial and Systems Engineering. In Fall 1999, there were 27 students in the class while in Fall 2000, there were 18. All of these students were full time engineering students and these are typical enrollments for the entire junior class of engineers at USD. The class meets for three fifty-five minute periods per week and uses William D. Callister's

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textbook.[5] The course covers materials fundamentals, electrical, magnetic, and mechanical properties. Some active learning exercises are included during the lecture. Although no lab is scheduled, during the past three years, the instructor has included one laboratory experiment.[6] Formal course objectives were also incorporated for the first time in 1999 and included on the syllabus. In addition, in Fall 2000 a mapping showing how the course objectives meet the USD Program Outcomes was also included to address ABET 2000 requirements. One of these program objectives is to "Have shown the capacity to work effectively on teams." For this course, this program objective is addressed by the cooperative learning teams.

Homework assignments were given weekly. The first assignment of the semester was done individually. By the second assignment, the instructor had assigned all students to teams of three or four based on their responses to a first-day survey. This survey collected information on their major, GPA, grades in Chemistry (a prerequisite for the course) and Circuits (their most recent engineering course), and hours unavailable. Students were asked to list others that they would not want to work with to avoid any serious personality clashes. In Fall 1999, the instructor also asked who they would like to work with. This caused problems, however, when students were not assigned to work with those they listed. The teams were designed to be heterogeneous with respect to GPA and engineering major. When possible, women and minorities were not placed in isolation on teams and attempts were made to find compatible schedules. The students were not allowed to self-select their teams because of reports in the literature advising against this.[2]

For team homework assignments, students turned in one solution per team. They rotated playing the roles of coordinator, recorder, checker, and monitor. Information on these roles was provided on the first day of class in the syllabus and is summarized in Table 1. They were patterned after materials from the NETI.[4] The instructor assigned the roles for each assignment to insure that students would rotate roles. In a team of three, the monitor and checker roles were combined. In Fall 1999, students were required to complete all but that first homework assignment as a team while in Fall 2000, students had one more individual assignment. This was in response to student comments in Fall 1999 that more individual assignments would improve their experience of working in teams in the course.

Table 1 Cooperative Learning Team Roles (from Ref. 4)

Role	**Responsibilities**
Coordinator	organizes work sessions, makes sure everyone knows when and where to meet and what they are supposed to do, keeps everyone on task and makes sure everyone is involved during the meeting
Recorder	prepares final solution to be turned in
Monitor	checks to make sure all team members understand both the solution and the strategy used to get it
Checker	double-checks and submits the final solution

Some changes were made to the assignments for the cooperative learning homework teams compared to assignments that students had done individually in previous years. The instructor added more problems to the assignments and included more design problems. Students were

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required to include a cover sheet listing the roles each team member played. A higher standard for completeness and presentation of solutions was used in the grading.

Evaluation

An anonymous mid-course and a final evaluation of the cooperative learning teams were conducted. In addition, students were required to evaluate each member of their team at the end of the semester according to a scale ranging from *Excellent* to *No Show*.[7] These responses were converted to a numerical value and adjustments made to individual team members grades for exceptional contributions.

Students reported that their skills in key ABET-identified areas had improved as seen in Table 2. Lower scores indicate more improvement in that skill. Note that the least improvement in each year was for oral communication which seems reasonable since this was not stressed in the course. Problem solving and working in teams were the areas where students reported the most improvement which demonstrates that they believe they are meeting some of the objectives of the course. In both semesters, no student reported that their skills had been adversely affected in any of the areas as a result of taking the course. The last two columns in Table 2 show the results of a similar analysis included in Ref. 8 for students in a materials science course at Worcester Polytechnic Institute (WPI). The first column was for a course that included cooperative and active learning activities while the second column is for a traditional lecture course. The USD students reported more improvement in their perception of each skill than either the WPI students in either cooperative learning or traditional lecture. This data supports the idea that cooperative learning is beneficial. However, no data exists on students' self-perceptions of these skills before the introduction of cooperative learning teams at USD and the courses at WPI had significantly larger enrollments. Also the USD course included other active learning activities besides the cooperative learning homework teams. It is interesting to note that, as shown in Table 3, the great majority of students at USD agreed or strongly agreed that cooperative learning homework teams enhanced the course. In Fall 1999, 79% of the students recommended that cooperative learning homework teams be used in Fall 2000. Eleven percent of the students recommended that they not be used and another eleven percent did not answer. In Fall 2000, 81% of the students recommended that cooperative learning homework teams be used in Fall 2001. None of the students recommended that they not be used and twenty percent did not answer.

Table 2 Average of student responses to "How were your skills in each of these areas affected as a result of taking Engr 114 this semester?" Scale was 1 = much improved, 2 = somewhat improved, 3 = unchanged, 4 = adversely affected. The last two columns are from Ref. 8.

	USD 1999	**USD 2000**	**WPI Cooperative Learning**	**WPI Traditional**
Working in teams	1.79	2.19	2.26	2.71
Written communication	2.00	2.19	2.67	2.86
Oral communication	2.11	2.38	2.58	2.97
Problem solving	1.86	2.00	2.34	2.56

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Table 3 Students' response at the end of the semester to "Cooperative learning homework teams enhanced Engr 114."

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**No Answer**
Fall 1999	32.1	53.6	7.1	3.6	3.6
Fall 2000	25.0	50.0	12.5	0.0	12.5

At the end of the semester, students were also asked to state their team's biggest difficulty. In Fall 1999, 70% (19 out of 28) and in Fall 2000, 90%, (14 out of 16) of the students reported that scheduling a time for the entire group to meet was the biggest difficulty. There was much more variety in their responses to "What was the most important thing you learned about working in teams from Engr 114?" Items which more than one student mentioned include communication (4 in 2000, 1 in 1999), different perspectives help you learn (3 in 1999, 3 in 2000), and tolerance (2 in 1999). Other responses included

- *It is an effective way to learn, if we actually meet.*
- *You need participation from everyone in order to be a successful team*
- *Sharing of responsibilities and commitment to work as a team*
- *Meeting on [night before the assignment is due] is not a good way to do an assignment when no one knows how to do something.*
- *It helps take off some of the load.*
- *They are more time consuming than working alone.*

Instructor's Experience

Overall, the experience of using cooperative learning teams in this materials science course went well. The instructor had expected resistance from some students at the idea of being required to work in teams. However, despite some complaints about specific team assignments in Fall 1999, complaints were minimal and no one argued that they did not want to work in teams at all. In the syllabus, procedures were given for firing a team member or quitting a team. No student took either option in either semester. To use these teams effectively, the instructor needs to be willing to talk with students about team assignments. In both semesters, the instructor spent some time on the first day of class explaining the benefits of cooperative learning and the relevance of teamwork to becoming an effective engineer. Sharing this motivation with the students helped them understand the motivation for using cooperative learning homework teams. Throughout the semester, the instructor had some interesting discussions about teamwork with the students. For example, one group included a student whose handwriting was messy due to a physical disability and solutions disorganized. The other two students on that team took pride in having excellently presented written work. These two students requested that they take turns writing up the assignments since it would be easier. The instructor discussed how it is important for all students to learn to present their work well and encouraged these two students to use this forum for helping the third student learn how to present more effectively which they did.

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The instructor certainly enjoyed having fewer papers to grade and agrees with other reports that the papers were of better overall quality than individual assignments. Another benefit of the smaller numbers of papers to grade is that homework assignments could be returned more quickly to provide useful feedback to the students. In addition, students were often able to answer each other's questions on the homework assignments. The questions that students did come to the instructor with were generally more thoughtful. Students were exposed to more problems, which is beneficial for their learning. Although it is difficult to assess their individual learning through performance on exams where no significant difference was seen, the instructor's perception is that students have a more positive attitude toward the class and the cooperative learning is probably helping and not detracting from learning. The instructor would recommend that others adopt such teams as long as the structure and logistics of the teams are well organized at the beginning of the semester. Giving the students some opportunities for individual homework assignments is also important. The biggest hurdle continues to be scheduling. Since students schedules do not stay constant in a given semester with work and other outside obligations including athletics, it is not clear how much can be done about this problem. However, this is representative of what students will face later in their careers as engineers.

Summary

Cooperative learning homework teams were included as a required part of a junior level Materials Science course in Fall 1999 and Fall 2000. Students worked throughout the semester in a team that was assigned by the instructor. Overall, students reported that the cooperative learning teams enhanced the course and should be continued. The largest number of reported problems had to do with scheduling conflicts making group work difficult. Students reported that their skills at problem solving, written communication, and working in teams improved as a result of taking this course.

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