IMPLEMENTATION OF COOPERATIVE LEARNING IN A LARGE-ENROLLMENT BASIC MECHANICS COURSE

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ABSTRACT

The primary objective of this investigation was to explore methods of implementing cooperative learning in a large-enrollment, sophomore-level basic mechanics course. Time in class- was generally allocated as follows: questions on past homework, 5 minutes; lecture on new material, 10 minutes; example problem, 15 minutes; and collaborative group quiz, 20 minutes. To facilitate this schedule, brief *lecture summaries* and *group quizzes* were developed for each class period. Lecture summaries minimize the time students need to copy class notes and permit the instructor to focus attention on known areas of weakness. Group quizzes allow students to *"actively"* reinforce the material presented so that they can identify any *"gaps"* in their understanding and seek immediate assistance from group members and/or the instructor. Cooperative learning groups are formed by *randomly* dividing the class into groups of four students. In-class group quizzes help students develop personal relationships with fellow classmates that can serve as the foundation of a support network outside of class. To further enhance this objective, student groups were *randomly* rearranged about one-third and two-thirds of the way through the semester. Thus, each student had the opportunity to work closely with three different groups (or nine students) in the class over the course of the semester. The effectiveness of cooperative learning was evaluated based on *academic performance* and *attitudinal changes* of students. Academic performance of the cooperative learning section shows a consistent and measurable improvement in comparison to students in a traditional lecture section of the course. Attitudinal changes were dramatic but difficult to quantify. Overall, more than 90% of the students in the cooperative learning class expressed positive comments towards this approach and many indicated that this course was among the best courses that they have had in their career at Purdue.

INTRODUCTION

Basic Mechanics I (ME270 - Statics) is an introductory, sophomore-level engineering course designed to 1) introduce students to the fundamental principles of mechanics and 2) develop the basic problem solving skills necessary to model and analyze complex engineering problems.

Because of the large number of students enrolled in the course, class sizes exceeding 100 students are common. Large class sizes coupled with the amount of course material to be covered have forced most faculty to rely exclusively on deductive (lecture-based) teaching methods. However, past research [Felder and Silverman 1988] has shown that the deductive teaching style is inadequate for many students because of its incompatibility with their innate learning style. Consequently, engineering students often experience a loss of interest, motivation, and enthusiasm early in their academic career due to the impersonal, competitive, and passive nature of large-enrollment, introductory-level courses. This can frequently lead to attendance problems, poor student performance, and substantial student attrition.

In the traditional lecture-style engineering mechanics classroom environment, students rarely exchange information and ideas, and often see each other as *competitors* rather than *colleagues.* In fact, engineering students who switched to other majors were almost *four times* more likely than science or math students to indicate *"failure to form collaborative and supportive working peer-groups"* as a primary reason for switching [Hewitt and Seymour 1994]. In contrast, a recent meta-analysis comparing cooperative and competitive learning methods [Johnson and Johnson 1993] showed that cooperative learning promotes higher individual knowledge and proficiency y than does competitive or individualistic learning. Cooperative learning also increased interpersonal interaction among students, promoted greater social support, and improved student self esteem.

The objective of the current work was to explore methods to implement cooperative learning in a large-enrollment course. This document is based on three years of experience in implementing cooperative learning in ME270 Basic Mechanics I. During the 1994-95 academic year, the authors embarked on a one-year evaluation study to document the *academic* and *attitudinal* benefits of cooperative learning in ME270. Details of the evaluation study, along with the personal experiences of the instructor in implementing cooperative learning in ME270, are presented below.

INSTRUCTIONAL METHODS

In-Class Time Management

One of the biggest challenges to implementing cooperative learning in any classroom is *time!* Time in class was generally allocated as follows: questions on past homework, 5 minutes; lecture on new material, 10 minutes: example problem, 15 minutes; and collaborative group quiz, 20 minutes. In reviewing the previous days homework, only conceptual questions were addressed in class. Questions judged to be of minimal benefit to the entire class ‘were addressed on an individual basis outside of class. To further facilitate this schedule, *instructional materials* (lecture summaries and group quizzes) were developed for each class period. Past experience in Statics has demonstrated that lecture summaries serve to minimize student’s need to copy class notes and allow the instructor to focus the lecture time on known areas of weakness. Initially many students are uncomfortable with such a brief lecture, but after awhile students appreciate the fast-moving pace of the class. Selection of a suitable example problem served to illustrate and reinforce the lecture component of the class. The 20-minute time period at the end of each class was essential for effective collaborative group work.

Selection of Cooperative Learning Groups

Cooperative learning groups were formed by *randomly* dividing the class into assigned groups of *four* students [Smith 1986, Smith 1989]. Other more sophisticated methods of group selection involving steps to ensure an *equal distribution of academic ability* and *different personality types in* each group have been utilized in past semesters. However, these methods proved time consuming and showed no significant advantage over random selection. (As an aside, it is interesting to note that when group assignment included an equal distribution of academic ability, it was primarily the students with average GPA who emerged as the group leaders. In fact, the top academic students often initially resisted the notion of group learning.)

One of the benefits of in-class collaborative group activities is the opportunity for students to develop personal relationships with their classmates; these relationships can serve as the foundation of a support network outside of class. Often students are hesitant to seek help from their instructor, but are open to seeking help from their classmates.

To further enhance this benefit, the groups were *randomly rearranged* approximately one-third (after the first exam) and two-thirds (after the second exam) through the semester. Thus, each student has the opportunity to work closely with three different groups (or nine other students) in the class over the course of the semester. Past experience has shown that initially students have mixed feelings about switching groups. Some students develop strong relationships with their original group members and thus are hesitant to switch to a new group. Other students struggle in their first group and thus look forward to working with other people. Nevertheless, most students eventually understand the value of switching groups and working with different people.

Attempts to require students to work in their assigned groups on homework was met with great resistance, primarily because of scheduling problems with teammates. While students are not required to work in their assigned groups outside of class, they are encouraged to work with other classmates on homework assignments. Student-formed “base groups” are naturally created by students as their need arises; such groups often stay intact over the entire semester.

Group Activities

Group activities come primarily in the form of a *collaborative group quiz* during the last 20 minutes of each class period. The main objective of the group quiz is to have students *"actively"* reinforce the material presented in lecture in order to help them identify if there are any concepts which they do not fully understand. Often students think they understand principles clearly after watching the instructor review one or two illustrative examples, only to get *"stuck"* later when working homework problems on their own outside of class. By identifying *gaps* in their understanding in-class, other group members and/or the instructor can immediately address their questions.

Another benefit of the group quiz is that it allows the instructor to *"eavesdrop"* on group discussions. Often simple principles which faculty assume students have grasped are actually misunderstood. The group activity provides an immediate feedback mechanism concerning the specific problems students are experiencing. If there are common mistakes occurring within several groups, these can be addressed with the entire class prior to the end of the period.

In addition to eavesdropping on group discussions, group activities provide time for the instructor to interact with the various groups in the class in an informal manner. This allows the instructor the opportunity to develop a *personal relationship* with each student in the class.

Group quizzes are designed to promote a *positive interdependence* between group members. Students applying new principles for the first time often lack speed and confidence in their solution procedure. By working as a team, the group can more quickly, effectively and confidently solve a problem and resolve any questions than can students working individually.

Results of this three-year study indicate that all students benefit from this group interaction. Academically weaker students benefit from the personal attention of group members. Academically stronger students benefit from the opportunity to explain the basic principles to other team members thereby reinforcing these concepts in their minds. Furthermore, the weaker students often come up with questions that the better students did not think to ask. Again, such discussion deepens the group learning process and promotes higher order thinking.

Learning Students Names

One of the things students seem to appreciate most is being *called by name. This* is a challenging task with class sizes of 100-120 students. To accomplish this, pictures of each group of four students are taken to aid me in putting names with faces. Past evaluations have indicated that students greatly appreciated this because they were tired of being an *anonymous face in* a crowd. Furthermore, several students indicated that because I knew them by name they felt more *accountable* to me and to the class to do their work and to attend class.

Group Representative Meetings

In order to give students a mechanism for input to the educational process, a biweekly group representative meeting was held. Each of the 25-30 groups would designate one member to represent their group at the meeting. The designated representative could change from week to week as determined by the group. The meetings were brief (typically 10-15 minutes) and were held immediately after class in an adjacent classroom. Feedback on workload, exams, quizzes, homework, etc. was solicited weekly. If group problems arose, the group representatives would brainstorm ideas to help address the problem. If a new idea was recommended, student input and feedback would be solicited from the group representatives before proceeding. The primary goal of the group representative meetings was to give the students a voice in what went on in the classroom and to let them know that their input was desired and valued.

EVALUATION RESULTS

There were three main tools used for evaluation of the cooperative learning approach: (1) *improvement in academic performance*, (2) *evaluation of a survey of study habits and attitudes (SSHA)*, and (3) *student response from course and instructor evaluations* and *focus group interviews.* Over the course of the past semester, comparisons were made between the *cooperative learning* section and a colleague's traditional lecture section.

This particular colleague was chosen because of his traditional approach to teaching and his award-winning excellence in engineering education. Several common themes have been identified and are summarized below.

Academic Performance Evaluation

Table 1 shows a comparison of the exam and course grades between the traditional lecture section and the cooperative learning section. In the Fall semester, the cooperative learning section consistently scored 7-10% better on exams; their course grade average was approximately half a letter grade higher than that of the traditional lecture section. In particular, the most significant difference between the two classes occurred in the middle and the lower segments of the performance range, where many students get discouraged and oftentimes give up. The cooperative learning approach seemed to help these students persevere and be more persistent in completing their studies without giving up. In the Spring semester the performance differences were less, perhaps partly due to the fact that the traditional lecture section was about 40% smaller in size; this permitted more faculty/student interaction in the classroom.

Evaluation of the Survey of Study Habits and Attitudes (SSHA)

A survey *of study habits and attitudes (SSHA) [The* Psychological Corporation 1967] was identified from the literature and adapted to the technical environment of engineering. This survey was given to the students as a *pre-* and *post-survey* to evaluate the impact of cooperative learning on the student population. The survey was designed to measure four primary quantities: *delay avoidance* (DA), *work methods* (WM), *teacher approval* (TA), and *educational acceptance* (EA). Three other measures, which are combinations of these basic four quantities were also evaluated: *study habits* (SH), study *attitudes* (SA), and study *orientation (SO).* Each of these quantities is briefly defined in Table 2.

Table 2 shows a comparison of the *pre-* and *post-survey* results for the cooperative learning section and the traditional lecture section. A comparison of the results for the Fall semester 1994 indicates that the cooperative learning section had slightly higher pre-survey scores but also experienced larger pre- to post- increases in all categories in comparison to the traditional lecture section. By far the most significant increase for both sections was in *teacher approval.*

For Spring semester 1995, both sections had virtually *identical pre-survey* scores for all categories. Again, the cooperative learning section consistently scored *higher pre- to post-survey* increases. Overall, the increases in the cooperative learning section were approximately double those of the traditional lecture section. Again, the most significant increases occurred in the *teacher approval* category followed by the *education acceptance.* Less significant increases were also measured in *delay avoidance* and *working methods.* Another interesting result to note is that the for both classes the pre-survey scores were significantly lower for the Spring semester in comparison to the Fall semester. This difference is most likely due to low SSHA scores from unsuccessful students during the Fall semester who were repeating the course in the Spring.

These results indicate that cooperative learning can have a significant positive influence on students' opinion of the classroom environment and their professors. Cooperative learning also has a positive influence on student study habits; it encourages students to begin assignments sooner and to utilize more effective study methods. However, for this influence to have a significant impact, cooperative learning would have to be implemented over several semesters.

Course and Instructor Evaluations and Focus Group Interviews

Course and instructor evaluations were conducted during the semester after each of the frost two exams and at the end of the semester in the final course evaluations typically done by the School. At the end of the semester, *focus group interviews* were also conducted with volunteers from the class. A review of the course and instructor evaluations and the focus group interview transcripts indicated that the *attitudinal change* in the students was dramatic. Their anecdotal response to the cooperative learning methods was extremely favorable. Over both semesters, approximately 90 to 95 percent of the students expressed positive comments towards this approach, and many of them indicated that this was the *best course* that they have had in their career at Purdue.

CONCLUDING REMARKS

Cooperative learning methods have been implemented in a large-enrollment, traditionally lecture-style, basic mechanics course. Evaluation of the effectiveness of cooperative learning indicates a significant improvement in students' *academic performance* and *attitude* and slight improvement in *study habits* in comparison to students in a traditional lecture section of the course. It is hoped that the results of this study will serve as a model and catalyst to encourage more faulty to consider how cooperative learning methods might be implemented in their courses.

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Table 1. Comparisons of Average Hourly Exam Grades and Course Grades Between the Traditional *Lecture* Section and the *Cooperative Learning* Section.

Fall Semester 1994

	Exam 1	Exam 2	Exam 3	Final Exam	Course Grade
Lecture (114 students)	76.0	63.8	72.0	61.3	2. 18/4.0
Cooperative Learning (118 students)	82.1	68.5	79.7	65.7	2.78/4.0

Spring Semester 1995

	Exam 1	Exam 2	Exam 3	Final Exam	Course Grade
Lecture (70 students)	70.7	69.1	66.7	60.3	1.91/4.0
Cooperative Learning (113 students)	71.3	69.4	69.2	57.6	2.06/4.0

Table 2.. A Comparison of the Pre- and Post-Survey of Study Habits and Attitudes (SSHA) Results for the Traditional *Lecture* Section and the *Cooperative Learning* Section.

	DA	WM	TA	EA	SH (DA+WM)	SA (TA+EA)	SO (SH+SA)
Fall 1994: Pre-Survey							
Lecture	22.12	22.76	24.83	26.20	44.88	51.04	95.92
coop. Learning	21.34	25.16	26.80	26.94	46.50	53.50	99.99
Fall 1994: Post-Survey							
Lecture	21.89	22.22	31.04	27.06	44.12	58.11	102.22
coop. Learning	22.76	25.59	34.71	28.05	48.35	62.76	111.12

	DA	WM	TA	EA	SH (DA+WM)	SA (TA+EA)	SO (SH+SA)
Spring 1995: Pre-Survey							
Lecture	19.06	21.71	24.14	23.21	40.77	47.36	88.13
coop. Learning	18.91	21.67	23.99	23.29	40.58	47.28	87.86
Spring 1995: Post-Survey							
Lecture	20.16	22.30	30.25	26.28	42.46	56.53	98.98
coop. Learning	20.23	23.98	35.11	28.51	44.21	63.62	107.83

Delay Avoidance (DA): promptness in completing academic assignments (50 points)

Work Methods (WM): effective study procedures and efficiency in doing academic assignments (50 points)

Teacher Approval (TA): a student's opinion of teachers and their classroom behavior and methods (50 points)

Education Acceptance (EA): a student's approval of educational objectives, practices and requirements (50 points)

Study Habits (SH): combines the DA and WM scores to provide a measure of academic behavior (100 points)

Study Orientation (SO): combines the SH and SA scores to provide an overall measure of study habits and attitudes (200 points)

BIOGRAPHICAL INFORMATION

Jim Jones is an Associate Professor in Mechanical Engineering at Purdue University. He is a member of ASEE and the faculty advisor for the Purdue Student ASEE Chapter. He received his B.S.M.E. from Tennessee Tech in 1981. He received both his M.S.M.E. and Ph. D. in Mechanical Engineering from Virginia Tech in 1982 and 1987, respectively.

Dianna Brickner is an independent instructional designer. She has been actively involved in the research design and development of instruction for the past 13 years. Her expertise in instructional theory and strategies and research practices complement her skills in the custom instructional design process. She completed her Ph.D. in Instructional Research and Development at Purdue University in May 1995.