Session 2230

Measuring Improvement Due to the Implementation of Active and Collaborative Teaching Techniques

Kenneth J. Reid
Indiana University Purdue University Indianapolis - IUPUI

Abstract:

There are many teaching techniques that can make engineering and technology instruction more effective, more interesting, and more enjoyable for both the instructor and the students. These techniques include active and cooperative learning, which get the students involved in the classroom experience. These techniques can also help students understand difficult concepts, since they hear these explained by their peers in many cases.

This paper will report on one study involving two sections of a freshman introductory course. The course is Digital Circuits I in an Electrical Engineering Technology program, consisting of two sections of approximately 35 students in each section. Both sections went through half of the semester (including two exams) with a classroom format that was about 90% traditional and 10% active/collaborative, with 100% traditional laboratory experiments: student pairs working through a weekly laboratory experiment. At the midpoint of the semester, the format of one section continued (although a group design project was introduced), while the other lecture and laboratory changed. The new lecture format was mini-lectures with collaborative learning activities between, and a less structured, more team-oriented laboratory. Both sections covered the same material, and both had one exam and the final exam remaining.

The results to be presented in this paper include how the classes were structured, and an analysis of exam scores to measure any improvement which may be attributed to the different class structure.

I. Goal of the study:

The overall goal of this study was limited to determining any measurable short-term gain in exam scores by introducing collaborative learning techniques in the classroom. This study does not measure any improvement in long term learning or attitudes towards the subject matter or classwork in general. Also, only one metric is examined: short-term improvement in exam scores through one semester. There are a number of studies showing long-term improvement in learning for students with various learning styles when using different teaching techniques. In fact, there are literally hundreds of references dealing with issues such as using active and/or collaborative techniques in the classroom, measuring long term success using these techniques, and implementing these techniques in specific curricula.. [1, 2]

II. Collaborative and/or active learning:

There are many references which have been published describing collaborative and/or active teaching and/or learning techniques, and workshops are available with conferences such as the American Association for Engineering Education Annual Conference and Frontiers in Education, including the three-day long National Effective Teaching Institute held prior to the ASEE National Conference.[3, 4] The basic idea is to involve students in the learning process by having them take an active role in the learning process. Many of these techniques involve working in groups of two or more students - a skill that is very much in demand in industry, but seldom taught within the engineering or engineering technology curriculum.

There are also studies to describe why students work and learn better under different circumstances: typically based on different learning styles. Students that appreciate individual, written instruction may prefer the typical lecture format; however, some students prefer visual instruction or working within groups. The introduction of active learning techniques or collaborative exercises will appeal to those students who do not learn most effectively within the typical lecture. This can also explain why some students find working within a group setting to be difficult. Again, there are many publications which discuss different models of learning styles and effective teaching techniques to address these differences. [5, 6]

Rather than an exhaustive description of these techniques, those techniques specifically employed for this study are described below.

III. Course description

This study was performed in two sections of an introductory Electrical Engineering Technology course: EET 105, Digital Circuits I. Each lecture period was 50 minutes with one three-hour laboratory section. One section was during the day, with one in the evening. Lectures were “typical” through the first half of the semester - these were “chalk and talk”. Laboratories were also typical: the same groups of two students were given a new assignment each week. Through the second half of the semester, one section (daytime) kept the same lecture and lab format, while the other (evening) section switched quite abruptly to more of a collaborative and active learning environment. Approximately half of one lecture period was devoted to a lecture on the upcoming changes and benefits for the students.

Since IUPUI is an inner-city University, the makeup of the student body is composed of a large number of adult learners in the same classroom setting as younger students. The makeup of the student body introduced one variable into a study: many of the adult learners already had an appreciation for the value of teaming, and had started to work in teams prior to the emphasis in class. One additional variable was that seven (~20%) of the daytime students were enrolled in a mandatory “Learning Community” class which covered many of the aspects presented to the evening section, such as the value of teaming and assuming an active role in the classroom.

While these students were encouraged to work in a team environment, their scores appear in the data for the students in the typical lecture. Both sections were similar in number of adult learners (approximately 30-40%), minority students (~12%) and female students (~9%).

Specific changes to the lecture that were used included:

Mini-lecture technique: Each lecture period was strictly limited to a maximum of 15 minutes, followed by an activity. A typical lecture would have three mini-lecture sessions of approximately 10-12 minutes.

Group quizzes: Between lecture segments, students were assembled into groups varying in size from two to six students and given a quiz. The quiz question was typically the sample problem which was done on the board in the daytime class to maintain consistency. When most of the groups had completed their answer, the correct answer was demonstrated by the instructor or a student group. These quizzes were sometimes presented as ‘contests’ or ‘one minute assignments’ for a change of pace. One advantage to this structure is that it provides for a break for the students where they could move around - increasing the likelihood that students will remain attentive through the remainder of the lecture.

Group homework assignments: Students were assigned the same homework for each section, but the students in the evening class were given the “strong suggestion” to do homework assignments in groups outside of class. They were encouraged to make a note of the person(s) they worked with on their assignment. This was not a requirement since 80 - 90% of our students at the freshman level are employed for a significant number of hours outside of school.

Additional group interaction activities also included one-minute papers (list the clearest answer, most confusing topic, etc.) and a number of chances to ‘vote’ in the classroom. Close votes were sometimes followed by a quick (and sometimes lively) ‘debate’ where students could defend their opinions.

The laboratory experiments were not significantly changed; however, the format of the lab teams was changed weekly. A variety of lab partner arrangements were made, including self-selection of partners, instructor assigned partners, and teams of two through four students to allow the students to work with varying groups. Both sections had a two-week large design task working in groups of two to three students at the end of the course.

IV. Specific advantages and disadvantages to these techniques:

Since this is a beginning class, one of the main advantages is to allow, or ‘force’ the students get to know other students. If they don’t know each other, it isn’t likely that they will work with each other. Another advantage is peer-to-peer instruction, which helps to clear up difficult concepts. An advantage (and possible disadvantage) is that presenting the material in a different way opens that material to students with different learning styles. This can be a disadvantage to students that prefer the straightforward lecture format (although there is no shortage of that style in Engineering and Engineering Technology).

The main disadvantage is to the instructor, at least initially. It can be difficult to adjust to a mini-lecture format (50 minutes is a short lecture - but 12 minutes?). There is more class preparation time required, although this didn't turn out to be a significant amount of time in this situation.

One myth that is usually considered a disadvantage is that less material can be covered in lecture when active learning techniques are employed. In this case, the amount of time explaining a problem on the board was roughly equivalent to administering a short group assignment or quiz. If this was not the case, the group quiz can be made to include a number of points in one quiz. The amount of material covered was basically the same in both sections.

V. Results

This comparison looks at the differences between the sections in exam scores before and after the changes. Students had two exams prior to the changes in the evening section, with one exam and the final afterwards. Students who dropped the course or 'disappeared' earlier in the semester were not included in any of the averages, and one student who did not attend lecture (essentially auditing the course) was not included. The sample size includes 34 students in the daytime section and 35 students in the evening section prior to the point of implementation of the new techniques. The number of students in the evening section was reduced to 31 for the second half of the semester to account for four students with abnormally high rate of absences (absent > 50% of lectures and labs), which would exclude them from receiving any benefit from collaborative/cooperative techniques. An important point in this analysis is that, while the material was presented in an active and collaborative mode, the exam as an assessment tool is an assessment of an individual, not a team. A different metric may reveal a more significant difference.

The averages and standard deviations are shown in Table 1. Sample size, or number of students is also presented, as is the P-value resulting from a t-test to judge the significance of the differences in the scores. A small P-value can indicate that two means which appear to be different are in fact statistically different (a widely accepted value of 0.05 or less indicates that this is the case). The P-value is obtained via running an unpaired t-test (independent samples, two-tailed P-value):

Table 1.

		Exam 1	Exam 2		Exam 3	Final: overall	final: new materia l	final: new materia l
		100	*100*		*100*	*% (100)*	*60*	*% (100)*
daytime	*n=34*	**85.2**	**84.9**	*n=34*	**61.6**	**71.5**	**38.5**	**64.2**
(stdev)		10.6	11.6		21.1	16.8	9.9	
evening	*n=35*	**84.5**	**79.6**	*n=31*	**64.8**	**74.3**	**41.2**	**68.7**
(stdev)		9.6	11.5		17.1	16.6	11.6	
P-value		0.78	0.06		0.64		0.51	

As shown in Table 1, the differences between the daytime and evening sections were not significant with the exception of a 5 point difference in Exam 2, which was prior to any changes in the course. A small P-value for exam 2 indicates that the difference is statistically significant, while the large P-values for the other scores indicate that the means are not significantly different between the morning and evening sections.[7]

Combining scores prior to and after the changes in instructional methods results in the summary below (Table 2). The score for the material on the final exam was converted to a percentage; material on the final exam covering topics from exams 1 and 2 are included in the totals under exam 1 and 2, while new material is included under Exam 3:

Table 2.

	Exam 1, Exam 2 + older material on final exam	Exam 3 + new material on Final Exam
daytime	81.2	62.9
evening	79.7	66.7*
P-value	0.20	0.34

* = after incorporating active/collaborative techniques

While the P-value indicates that there did not appear to be a statistically significant difference between the exam scores of the morning and evening sections, the data shows that the evening section "gained" over 5 points after the new instructional methods were introduced. It is expected that further benefits to incorporating active/collaborative techniques would appear in a long term study.

Two additional improvements that were observed, although not measured, included:

1) The students with more collaborative techniques were generally faster & much more efficient in lab: they were more willing to work in a team environment. This is quite promising looking towards graduation (although this is admittedly down the road), and

2) These students generally exhibited a more participatory attitude in the classroom: they were ready to speak out in classroom discussions. In fact, this was evident on the first meeting of EET 155, Digital Circuits II, when the students from last semester were readily participating, while other students sat with (what has to be called) a surprised expression.

Course evaluations were not available at the time of writing this paper; however, students typically rate classes with an active component higher than courses with a straight lecture and lab format. [8, 9,10]

VI. Conclusion

Why go to the effort to incorporate these techniques if little improvement was measured in this study? It must be noted that this improvement, while small, was very short-term improvement (one-half of one semester). A number of other advantages are evident: first, these students now should have a learning community of their peers - a valuable asset when the explanation from the instructor doesn't "click". Also, it is anticipated that students who were involved in the active classroom will perform better in class and in the future. There have been many publications on active and/or collaborative teaching techniques, which have payoffs that occur more long-term.[11] Further data will be collected to verify this hypothesis.

Other improvements may be difficult to measure, such as attitudes towards classroom participation, addressing different learning styles through different methods of presentation of material. Although short term improvement may be small and/or difficult to document, long term improvements have been well documented. Furthermore, improvements in classroom participation and peer-to-peer instruction are also evident, although not necessarily measurable.

Bibliography

1. Smith, K.A., “Cooperative Learning”, *Proceedings of the1998 American Society for Engineering Education National Conference,* Session 2230, 1998.

2. Dyrud, M.A., “Getting a Grip on Groups”, *Proceedings of the1999 American Society for Engineering Education National Conference*, Session 3230, 1999.

3. URL: http://www2.ncsu.edu/unity/lockers/users/f/felder/public/NETI.html

4. Reid, K.J., “More Effective Teaching: One Year After the National Effective Teaching Institute”, *Proceedings of Frontiers in Education Conference*, Session 12d7, 1999

5. Felder, R.M., “Reaching the Second Tier - Learning and Teaching Styles in College Science Education”, *Journal of College Science Teaching*, 23 (5), 1993, p. 286-290.

6. Felder, R.M., J.E. Stice and R. Brent, Course Notes, *1998 National Effective Teaching Institute*, 1998, section A.

7. URL: http://www.graphpad.com/www.pvalue.htm

8. Goodwin C. and R. Wolter, “Student Work Group/Teams: Current Practices in an Engineering and Technology Curriculum Compared to Models Found in Team Development Literature”, *Proceedings of the 1998 American Society for Engineering Education National Conference*, Session 1547, 1998.

9. Koehn, E., “Collaborative Learning in Engineering Classrooms”, *Proceedings of the2000 American Society for Engineering Education National Conference*, Session 1621, 2000.

10. Finelli, C.J., “A Team-Oriented, Project-Based Freshman Problem Solving Course: Benefits of Early Exposure”, *Proceedings of Frontiers in Education Conference*, Session 11a2, 1999.

11. Johnson, D.W., R.T. Johnson and K.A. Smith, *Active Learning: Cooperation in the College Classroom*, Edina, MN, Interaction Book Co., 1991.

KENNETH J. REID
Kenneth Reid is an Assistant Professor in Electrical Engineering. He has a BS degree in Computer and Electrical Engineering from Purdue University, and an MSEE from Rose-Hulman Institute of Technology. He is currently working to implement advanced digital design techniques into early digital courses, electronics manufacturing, and implementing different learning and teaching styles in the classroom.