International Journal of
Engineering Education (IJEE)
e-ISSN : 2540-9808

EFFECT OF COLLABORATIVE LEARNING STRATEGIES ON STUDENT ACHIVEMEMENT IN VARIOUS ENGINEERING COURSES

Geraldine Gonzaga Nerona
Department of Industrial Engineering, Saint Louis University, Philippines

e-mail: geraldinegonzaga@yahoo.com

Abstract- *This study focused on determining the effectiveness of collaborative learning strategies in improving students' performance in three general engineering courses. The pretest-posttest control group experimental design was used in the study. From the results of the z-test, there were no significant differences in the pretest scores of the experimental and control groups. However, there were significant differences in the posttest scores of the respondents, with the experimental groups engaged in collaborative learning obtaining significantly higher posttest scores than their control group counterparts, who were exposed to the traditional lecture-discussion and individual learning methods. Effect sizes were also positive for the experimental groups, meaning, they were able to perform better in class compared to their control group counterparts.*

Keywords *– collaborative learning, achievement, engineering courses*

Submission: June 28, 2017 Correction: March 12, 2019 Accepted: April 17, 2019

Doi: http://dx.doi.org/10.14710/ijee.1.2.114-121

[How to cite this article: Nerona, G.G., [2019]. EFFECT OF COLLABORATIVE LEARNING STRATEGIES ON STUDENT ACHIVEMEMENT IN VARIOUS ENGINEERING COURSES, 1(2),114-121. doi: http://dx.doi.org/14710/ijee.1.2.114-121]

1. Introduction

Engineering education in the 21st century brings forth a multitude of challenges both in teaching and learning. Though many educators find the traditional lecture method effective in delivering lessons in the college level, it is still noteworthy to point out that teaching strategies must also evolve as the type of students in university change. A common observation is that attention span of students is just roughly 10 minutes (Izenberg, I., 2015), so engaging students in a 55-minute lecture by the professor is certainly futile in establishing retention and students' ability to think critically. To keep students engaged in learning throughout the hour, it is important to involve them in learning activities that allow them to participate in their own learning processes, thus allowing them to interact and communicate what they know at the moment and think of what they still want to know.

The Myers-Briggs Type Indicator has often been used to classify students' learning styles in different disciplines (Montgomery, S.M. and Groat, L. N., 1998). The first two dimensions, Orientation (Extrovert/Introvert) and Perception (Sensing and Intuitive), are the ones that appear to have an effect on learning (Montgomery, S.M. and Groat, L. N., 1998). Unfortunately, the learning styles of students do not match with the learning styles of faculty. Majority of the faculty (54%) are introverts while a greater proportion students (70%) are extroverts. Also, 70% of undergraduate students prefer active, sensing, verbal and logical learning styles, and prefer the role of faculty as "coach" rather than as "expert" (Montgomery, S.M. and Groat, L. N., 1998). This helps explain why engineering faculty often fail to "reach" those engineering students whose preferred modes of learning differ (Montgomery, S.M. and Groat, L. N., 1998; Morse, L. C. and Bobcock, D.L., 2015). This mismatch in learning styles of faculty and students prevents both from achieving their goals in the teaching-learning process. The implication of this is not being able to realize the outcomes that students need to demonstrate at the end of the course, and eventually at the end of the program. Hence it is a greater challenge for the faculty to move out of his comfort zone, and design learning activities to match the generally extrovert and sensing type of college students we have.

According to Albert Bandura's Social Learning Theory, people learn from one another, via observation, imitation and modelling. This theory has often been called a bridge between the behaviourist and cognitive learning theories since it involves attention, memory and motivation (retrieved from http://www.learning-theories.com/social-learning-theory-bandura.html, May 13, 2016). Through observation and interaction, better retention of learning is established, and the learner is motivated to continue discovering. In relation to this, Lev Vygotsky's Social Development Theory asserts that social interaction plays an important role in cognitive development; consciousness and cognition are the end product of socialization and social behaviour (retrieved from http://www.learning-theories.com/vygotskys-social-learning-theory.html, May 13, 2016). In line with these, Jean Lave's Situated Learning Theory argues that social interaction and collaboration are essential components of situated learning (retrieved from http://www.learning-theories.com/situated-learning-theory-lave.html, May 13, 2016). Situated learning occurs when a student is placed in a situation where he actively interacts and participates, analyses and makes decisions -- then learning comes naturally. From the progressivists' point of view, learning is an active process in which the learner himself/herself is involved. Learning affects the whole individual as an experiencing organism (Ornstein, A.C. and Levine, D.U., 1985). Therefore the student learns through interaction with his/her total environment and situation. Similarly, Gestaltists assert that learning is essentially experiencing, reacting, doing and understanding, through the interaction of the learner with his/her total environment or situation. These proponents of Education argue that, social interaction plays an important role in establishing the permanency of learning that later on translates into better academic performance, while realizing the learning outcomes that faculty aim for their students to attain.

In engineering education, professors are often focused on emphasizing science and mathematics skills. The US National Academy of Engineering Report in 2008 wrote that, in teaching engineering, vital characteristics of engineering such as creativity, teamwork and communication are often ignored. In a detailed survey following the publication of this report, it was found that academic engineers (engineers who teach) see engineering discipline as being about three things: applied science and mathematics; solving problems, and making things (Goodhew, P. J., 2010). But prior to achieving these skills, professors often neglect the processes involved to reaching these ends. Creativity, teamwork and communication are enhanced through social learning processes, as advocated by Bandura, Lave and Vygotsky. When a student is motivated to learn through observation, interaction and modelling, learning specific skills comes almost naturally.

In the engineering classroom, the professor is often observed to use teacher-centered approaches like lecture and demonstration, often using deductive processes in teaching technicalities. But no matter how well prepared or how well scripted, delivering lessons through teacher-centered approaches is not an effective way of developing either knowledge or understanding (Goodhew, P. J., 2010). Both active learners and reflective thinkers do not learn effectively in a class where students are passive recipients of knowledge. Unfortunately, most engineering classes fall into this category (Felder, R.M., 2002).

A study conducted in 2006 attempted to investigate more extensively, the factors that affect attrition rates in gateway courses or introductory courses leading to math, business and science (including engineering) degrees at the Northern Arizona University (NAU) (Benford, R. and Gess-Newsome, J., 2006). It was found out that academic success in gateway courses was affected both by student factors and non-student factors which include instructional methods of the professor. It was also stated that professors mostly use traditional and didactic methods in teaching the gateway courses, and a correlation seems to exist between teaching style and rate of student success in these courses. In this study, significant differences in success was found among students who do and do not discuss class materials with their peers. Students who discuss ideas with their associates are most likely to receive an A,B, or C, while students who never discuss class materials with their peers are most likely to receive a D,F, or W. Hence, the role of the professor in setting the conditions for learning is vital and cannot be taken for granted.

These prior studies have found that progressive teaching styles involving student interaction that encourages exchange of ideas help improve their understanding of ideas, and in turn, their success in the course (Benford, R. and Gess-Newsome, J., 2006). It is imperative therefore that engineering professors engage their students in active learning. There are indications that engineers are more likely to be active than reflective learners, with similar cognitive processes as extroverts and kinaesthetic learners (Felder, R.M., 2002). Active learners do not learn much in situations that require them to be passive (such as most lectures); active learners work well in groups, and tend to be experimentalists.

One effective learning strategy for active learners in the college level is collaborative learning. "Collaborative learning" is a collective term for various educational approaches involving joint intellectual effort by students, or students and teachers together, where students work in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product (Smith, B.L. and MacGregor, J.T., 1992). Aside from addressing the learning processes of engineering students, collaborative learning enables students to develop their abilities in working in teams. Now more than ever, engineers are expected to work in projects that put together a balanced use of technical, communication, and people skills. The idea of collaborative work is inseparable with engineering practice. In the natural practice of their profession, engineers are expected to collaborate with people as they work in accomplishing the complexities of every phase of their project- be it in line with construction, product, process or systems development, and most importantly, in the implementation of such. In this sense, collaborative learning improves not only academic performance of students, but also encourages attainment of goals through enhanced group processes (Gol, O. and Nafalski, A., 2007). Appeals for engineering educational reform assert that graduates lack the necessary training and experience in solving unstructured problems, working in teams, and communicating effectively with engineers and other professionals; hence collaborative learning is indispensable in preparing engineering students for their future careers (Macpherson, A., 2015) .

Collaborative learning is a student-centered approach in that it allows the students to construct their own learning- through meaningful group processes, rather than just watching, listening and copying notes. In collaborative learning, the role of the teacher shifts from being "the sage on the stage" to "the guide on the side" (Macpherson, A., 2015), from being an expert to becoming a coach for learning. In collaborative learning, the instructor does not merely rehearse his lecture for the hour, but rather designs group activities that enable students to interact with each other to assess where they are in the learning process, be accountable for the material assigned to them, learn from the "more knowledgeable others" from the group, and further think of what they still want to know beyond the material. Furthermore, collaborative learning is firmly based on doing; as such, it constitutes active learning (Gol, O. and Nafalski, A., 2007).

In the engineering program, many opportunities arise for engaging students in active learning- since technical courses require complex thought processes to be able to translate content into learning outcomes. Extensive researches conducted in the past reveal that "whenever problem solving is desired, whenever divergent thinking or creativity is desired, whenever quality of performance is expected, whenever the task is complex, when the learning goals are highly important… when an instructor wishes to promote positive interaction among learners, a facilitative learning climate, a wide range of cognitive and affective outcomes, and positive relations between themselves and the learners" (Macpherson, A., 2015), learning cooperatively or collaboratively is as essential. The engineering program is rich with opportunities to provide learners with multiple avenues to engage in social learning processes, from content or concept-based courses- to mathematical or problem-solving courses- to laboratory courses – to capstone courses.

Few studies show evidence of collaborative learning in engineering education in the Philippines, although collaboration is an ABET accreditation required component of the engineering curriculum (Gol, O. and Nafalski, A., 2007); Stump, G.S., 2011; Terenzini, P.T., et. al, 2001). However, collaborative learning activities are viewed by some educators as impractical in the classroom or as an ABET accreditation requirement that must be superficially met (Stump, G.S. et.al., 2011). In line with these results, a study on the effectiveness of active learning found that there is broad but uneven support for the core elements of active, collaborative, cooperative and problem-based learning in engineering education (Prince, M., 20014). Indeed, ABET now requires institutions to demonstrate that their graduates have developed 11 competencies, including the abilities "d. to function on multidisciplinary teams", "e. to identify, formulate, and solve engineering problems", and "g. to communicate effectively."(Terenzini, P.T., et. al, 2001) Although academic institutions have a common understanding on the competencies that need to be achieved, still a vague consensus exists on how to enable students to achieve these competencies. It is a common belief however that active learner-centered strategies have the ability to produce better student outcomes than traditional teaching strategies (Goodhew, P. J.,2010; Macpherson, A., 2015; Terenzini, P.T., et. al, 2001).

It is the intention of this study to determine the effectiveness of collaborative learning in improving students' achievement, at the same time develop other competencies required in the ABET, at least for three general engineering courses namely- differential equations, engineering economy and engineering management. Of the numerous mathematics courses in engineering, Differential Equations is regarded as one of the prerequisites or "gateway courses" to engineering major courses in every field of specialization. However in a recent study conducted, it was revealed that Differential Equations has one of the highest attrition rates in engineering mathematics, having an average failure rate of 29.75% and dropout/withdrawal rate of 5% for the last five years (Author, 2016).

Engineering Economy is a general engineering course enrolled by all engineering students in their 4th or 5th years. This course has the objective of preparing future engineers in making decisions objectively that involve selection of projects or alternatives that produce the best benefits at a minimum cost. Lecture and drill are the usual methods that dominate teaching of the course, but attrition rates in engineering economy can go as high as 50%.

Similarly, Engineering Management is a general engineering course enrolled by students in their senior year. The course is essential in preparing the student for his future career not only as a technical expert but as a leader and initiator. In fact, even if young engineers start with non-supervisory jobs early in their careers, most engineers can expect a transition to management responsibilities at some point in their professional career (Morse, L. C. and Bobcock, D.L. , 2015). Engineers therefore are not only expected to manage projects, but people and other resources as well. In this course, the students' ability to apply social skills is important in the problem-solving process, since analysing problem situations include activities that involve coordinated effort- like brainstorming, communication, and decision-making, to name a few. In this course therefore, developing students' skills in collaborating effectively with their peers is a must, since interpersonal skills are of utmost importance in working effectively in teams.

This study then is undertaken with the intention of improving student achievement in different engineering courses while realizing other learning outcomes, and developing students' ability to think critically, communicate effectively, and process team goals successfully.

Statement of the Problem

The intent of this paper therefore was to investigate further the effect of collaborative learning strategies on the achievement of students in various general engineering courses namely – differential equations, engineering economy and engineering management, with the purpose of at least recommending a method that enables engineering students to achieve success in their courses, while polishing the social skills that they need in the practice of their profession.

Specifically, three questions are addressed in this paper;

1. What is the level of performance of students in the experimental and control groups in their pretest for differential equations, engineering economy and engineering management?
2. What is the level of performance of students in the experimental and control groups in their posttest for differential equations, engineering economy and engineering management?
3. Is there a significant difference in the pretest and posttest scores of the students in the experimental and control groups for the three courses?

Some confusion has risen from the past on whether to use the term "cooperative learning" or "collaborative learning" for students in the college level. In essence, these two terms are not all different, which is why many educators use these terms interchangeably. Both stress the importance of active learning through social interaction. However it is said that collaborative learning more generally encompasses the group processes involved when college students work together unselfishly in small groups to achieve the best learning outcomes for their team (Gol, O. and Nafalski, A., 2007).

It has been suggested in numerous studies in the past that there are five elements of this team learning approach namely: positive interdependence; promotive interaction; individual accountability; use of interpersonal skills; monitoring of progress Gol, O. and Nafalski, A., 2007; Macpherson, A., 2015; .Johnson, D.W. and Johnson, R.T., 1979). Positive interdependence presupposes that the team can only succeed if all team members put their efforts together to achieve their common goals. Promotive interaction means that members encourage and support each other so that they move forward together. Individual accountability makes sure that each team member contributes equivalent effort and that each one is responsible and accountable to the group's outcomes. However to achieve all these, interpersonal skills must be polished; individualistic and competitive motives must be discouraged since they do not contribute to the team's success (Johnson, D.W. and Johnson, R.T., 1979). In order to determine success of the group processes, there must be an objective way of measuring the team's achievement - in terms of formative and summative evaluation (both individual and group) (Diaz, V. et. al., 2010). Feedback must be given often and immediately so that the students are aware if they are achieving the supposed learning outcomes, and the proper group processing. In essence therefore, in collaborative learning, the team functions as one unit with uniform goals, where competition and individualism do not have a place.

The activities used in engaging collaborative learning techniques in this study are based on the framework in "Learning Together and Alone" (Johnson, D.W. and Johnson, R.T., 1979).

1. Make a number of preinstructional decisions. Instructor has to decide on the objectives (academic and social skills) for the lesson, size of groups, the method of assigning students to groups, the roles students will be assigned, the materials needed to conduct the lesson, and the way the room will be arranged.
2. Explain the task and the positive interdependence. Instructor clearly defines the assigned task, teaches the required concepts and strategies, specifies the positive interdependence and individual accountability, gives the criteria for success, and explains the targeted social skills students are to engage in.
3. Monitor students' learning and intervene within the groups to provide task assistance or to increase students' interpersonal and group skills. Instructor systematically observes each group as it works. When it is needed, the instructor intervenes to assist students in completing the task accurately and in working together effectively.
4. Assess students' learning and help students process how well their groups functioned. Students' learning is carefully assessed and their performances are evaluated. Members of the learning groups then process how effectively they have been working together.

The results of this study will be useful in improving the overall quality of teaching and learning, since the university is now in the process of implementing an outcomes-based education. Moreover, collaboration is an ABET accreditation required component of the engineering curriculum. Collaborative learning is also identified as one of the educational principles in the recently released "Educational Principles and Strategic Directions" (Sales, G. B., 2016) of this author's university, emphasizing that the university encourages collaborative learning through creative pedagogical platforms as key to effective and meaningful education. In particular, this study will benefit school administrators and professors in their attempt to come up with learning materials focused on the educational objectives that need to be attained by students. Students in turn will have an opportunity to better understand and learn in a more functional, pleasurable and permanent way.

2. Methods

A. Respondents of the study. This study made use of the pretest-posttest control group experimental research design. The respondents of the study were two hundred eighty-seven students enrolled in the six classes of engineering economy, differential equations, and engineering management handled by this researcher. These three courses have been selected due to their varied content and multidisciplinary, heterogeneous grouping of students in each class. The experiment was conducted during the preliminary term of the first semester of AY 2016-17 for engineering economy and differential equations, and in the second semester of AY 2015-16 for engineering management, since this is a second-semester course in the engineering curriculum.

Table I. Respondents of the Study

Course	Experimental group		Control group		Total
	Schedule	n	Schedule	n	
Differential equations	1:00-2:00 MWF	50	2:00-3:00 MWF	50	100
Engineering economy	8:30-9:30 TTHS	49	3:00-4:00 MWF	49	98
Engineering management	9:30-10:30MWF	40	9:30-10:30 TTHS	49	89
Total		139		148	287

To rule out the effect of IQ, or general mental ability on the results of the study, a copy of the IQ test results of the respondents was requested from the SLU Psychological Testing Unit (2016). Following is the summary of the IQ test results:

Table 2. IQ of Respondents

IQ level	Differential equations Experimental Control group group	Engineering economy Experimental Control group group	Engineering management Experimental Control group group
Very high	3 2	5 4	2 4
High	7 9	10 11	10 11
Average	35 30	26 25	26 30
Low	5 9	8 9	2 4
Total	50 50	49 49	40 49

IQ of the control and experimental groups for the three courses have the same behavior, around 60% of the respondents have average IQ, around 26% have high or very high IQ, and around 14% have low IQ.

B. Data Gathering Method

The main instrument to measure performance of the students both in the pretest and posttest was an achievement test that covered all topics in the prelims. On the second week of classes, both the experimental and control groups were given the pretest to establish baseline data for the performance of both groups prior to the lessons and class activities. This was a problem-solving test for differential equations and engineering economy, while in engineering management, the test was a combination of identification, problem-solving and essay. Content validity was established by using a table of specifications, and constructed at a 50% level of difficulty. Reliability of the tests were computed using Kuder-Richardson 20, and revealed a 0.82, 0.76, and 0.89 reliability coefficient for differential equations, engineering economy, and engineering management, respectively.

After the pretest, the same prelim topics were taught to both the experimental and control groups. The control groups were taught using the traditional lecture-discussion method, and independent activities and assessments were given. However, in the experimental groups, the lecture was interspersed with collaborative learning strategies, and group assessments as well as individual assessments were given. Collaborative learning techniques used in the experimental groups are the following (adopted from "Learning together and alone" (Johnson, D.W. and Johnson, R.T., 1979).and "Cooperative learning strategies for college courses" (Macpherson, A., 2015): Paired focused discussion, turn-to-your-partner discussion, think-pair-share, jigsaw, small group discussion, modified pair-jigsaw, team competitions, brainstorming and mindmapping (for engineering management), and informal collaborative learning techniques such as focussed discussions and turn-to-your-partner discussions.

The experiment was carried out for approximately 4 weeks to give time to the students to adjust to a new learning process. The prelim exam was considered as the posttest of the experimental and control groups (same as the pretest), which covered topics in the prelim syllabus.

C. Treatment of Data

Both the pretest and posttest for differential equations were worth sixty points, for engineering economy- 100 points, and for engineering management-50 points. To determine the level of performance of the students in their pretest and posttest, the mean score of the students in each group was computed, and the following qualitative interpretation was made for the scores:

Table 3. Qualitative Interpretation For Pretest And Posttest Scores Of Differential Equations And Engineering Management

Differential equations	Engineering Economy	Engineering management	Interpretation
48 to 60	80 to 100	41 to 50	Excellent
36 to 47	60 to 79	31 to 40	Above average
24 to 35	40 to 59	21to 30	Average
12 to 23	20 to 41	11 to 20	Below average
0 to 11	0 to 19	0 to 10	Poor

To determine if there are significant differences between the pretest and posttest scores of the experimental and control groups, the z-test at the 5% level of significance (2-tailed) was used. Also, effect sizes were computed to determine the difference in percentile points between the mean of the experimental group and the mean of the control group (with this group's mean set at the 50th percentile). Effect sizes are calculated by taking the experimental group mean minus the control group mean divided by the average of the control and experimental

group's standard deviation (Springer, L. et.al., 1999). The resulting z-score is then used with a table of areas under the normal curve to estimate the percentile-point difference between the experimental and control group means with the control group mean defining the 50th percentile (Terenzini, P.T., et. al, 2001).

Formula 2.1

Z-test (Mendenhall, W., et. al., 1999)

Critical value for z at 0.05 (2-tailed) = 1.96

A number from 1 to 4 was assigned to each of the points, considered as part of the paths in a sequential fashion: 1 at the starting point, 2 and 3 at the nodes and 4 at the last point of the sequence ([17]; see Figure 1).

$$z = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Formula 2.2

Effect size (Springer, L.et.al., 1999)

$$Effect\ size = area\ between\ z^* = \frac{\overline{x_1} - \overline{x_2}}{(s_1 + s_{2)/2}}\ and\ 0.50$$

3. Results

A. Performance Of Students In The Pretest

The performance in the pretest of the experimental and control groups for the three courses is summarized in the table below:

Table 4. Performance Of Students In The Pretest

Respondents		Mean	Standard deviation	Interpretation Of Mean	Z	Difference
Differential Equations	Experimental group	3.20	5.78	Poor		NOT SIGNIFICANT
	Control group	2.35	5.31	Poor	0.77	
Engineering economy	Experimental group	1.30	2.43	Poor		NOT SIGNFICANT
	Control group	1.50	2.90	Poor	-0.37	
Engineering management	Experimental group	2.90	2.31	Poor		NOT SIGNIFICANT
	Control group	3.25	3.15	Poor	0.86	

As seen in the results of the pretest, the performance of students both in the experimental and control groups is "Poor", which shows that all groups had very little base knowledge on the topics before the conduct of the experiment. Only a few students were able to answer one or two questions from the test either by guessing (for engineering management) or by applying a formula recalled from basic engineering (for differential equations and engineering economy). In experimental studies, the presence of a pretest and control group are necessary to serve as control for all sources of internal validity (Sevilla, C.G., et.al., 2000). In this sense, whatever scores gained in the posttest can be attributed to the treatment, which is in this case, the method of teaching.

Table 5. Performance Of Students In The Posttest

Respondents		Mean	Standard Deviation	Interpretation Of Mean	Z	Difference
Differential equations	Experimental group	40.00	15.76	Above average	4.54	SIGNIFICANT
	Control group	26.64	13.52	Average		
Engineering economy	Experimental group	60.08	18.56	Above average	2.42	SIGNIFICANT
	Control group	50.43	20.69	Average		
Engineering management	Experimental group	38.95	5.70	Above average	4.60	SIGNIFICANT
	Control group	30.94	10.40	Average		

The post test scores revealed an improvement in the performance of the control groups, from "poor" in the pretest to "average" in the post test. The teacher's use of the lecture method was effective in helping the students increase their performance up to the "average" level only, as revealed in the post test mean scores of the three experimental groups. Students from the experimental groups were able to improve their performance from "poor" in the pretest, to "above average" in the post test. All differences in the post test scores of the experimental and control groups for the three courses are significant. This is an indication that collaborative learning strategies were able to contribute to the bigger gain scores of the students from the pretest to the post test for the experimental groups.

These results are backed-up by several researches that were conducted in engineering education. A study on collaborative learning in engineering students confirmed that collaborative learning positively influences student achievement [10]. In this study, students' reported use of collaborative learning strategies and reported self-efficacy for learning course material showed positive correlation with their course grade. A series of researches conducted by Johnson and Johnson [21] have consistently reported that cooperation has favorable effects on achievement and productivity, psychological health and self-esteem, inter-group attitudes, and attitudes toward learning.

In a study on effects of small-group learning on undergraduates in science, mathematics, engineering, and technology (SMET), results revealed that the main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET was significant and positive (Springer, L., et.al., 1999). Another study which compared student outcomes of lecture-based and collaborative learning confirmed the same results. Results indicate that active or collaborative methods produce both statistically significant and substantially greater gains in student learning than those associated with more traditional instructional methods (Terenzini, P.T., et. al, 2001).

Table 6. Summary of Results For Effect Sizes

Respondents		Mean score	Standard deviation	Z*	Effect Size	Interpretation
Differential equations	Experimental group	40.00	15.76	0.91	+32	INCREASE
	Control group	26.64	13.52			
Engineering economy	Experimental group	60.08	18.56	0.49	+19	INCREASE
	Control group	50.43	20.69			
Engineering management	Experimental group	38.95	5.70	1.00	+34	INCREASE
	Control group	30.94	10.40			

The effect size indicates the number of percentile points that the experimental group is above (+) or below (-) the control group, with the mean of the control group at the 50th percentile (Springer, L., et.al., 1999). This means that the students of the experimental group for differential equations were able to increase their performance by 32% more than their control group counterpart. In the same way, the experimental groups of engineering economy and engineering management were able to increase their performance by 19% and 34% more than their respective control groups. Some researches also made use of effect sizes as a way to compare results of groups exposed to different methods of teaching. Positive effect sizes (increases) have been reported for teaching methods that use collaborative learning strategies as part of their class activities (Springer, L. et.al., 1999; Terenzini, P.T., et. al, 2001; Johnson, D.W. and Johnson, R.T., 1979

5. Conclusions and recommendations

From the results of the study, the following conclusions are put forward:

1. There was an improvement in the level of performance of the students exposed to the lecture method from poor in the pretest, to average in the posttest.

2. There was a greater improvement in the level of performance of the students exposed to collaborative learning strategies from poor in the pretest, to above average in the posttest.

3. Students from both groups had the same base knowledge on the lesson before the conduct of the experiment. Students engaged in collaborative learning strategies however were able to obtain a significantly higher level of performance in the posttest as compared to the lecture group. Students engaged in collaborative learning were able to perform better in class compared to the lecture group, as evidenced by the positive effect sizes.

From the aforesaid results and conclusions, the following recommendations are put forward:

1. Teachers/Professors should engage their students in varied learning activities that actively involve them in their own learning process, thereby motivating them not only to successfully accomplish the present lesson, but encourage them to look forward to the next lessons ahead.

2. The use of collaborative learning strategies is highly effective in teaching selected topics in various engineering courses regardless of content and nature of the course, as proven from the results of this study.

3. School administrators are encouraged to train their teachers/professors using collaborative learning techniques and other activities to help students achieve the competencies they are expected to have upon graduation. Validated and well-prepared learning activities will be instrumental in realizing the objectives of the outcomes-based education.

4. Students are encouraged to evaluate and improve their study skills and habits by maximizing their participation in classroom activities, as well as studying collaboratively with peers beyond class hours to supplement their learning in the classroom.

5. It is recommended to include collaborative learning as Teaching-Learning-Activities in the outcomes-based syllabus to enable the graduates of the engineering programs (as specified in the ABET) to function on

multidisciplinary teams, to identify, formulate, and solve engineering problems and to communicate effectively.

References

[1] Benford R. and Gess-Newsome, J. (May 2006) Factors Affecting Student Academic Success in Gateway Courses at Northern Arizona University; Center for Science Teaching and Learning Northern Arizona University Flagstaff, AZ 86011-5697 http://www2.nau.edu/~facdev-p/TR/Factors.pdf

[2] Diaz, V. et. al. (2010) Assessment of collaborative learning outcomes; Educause learning initiative

[3] www.educause.edu/eli/collaborativelearning

[4] Felder, R.M. (June 2002) Learning and teaching styles in engineering education, Engineering Education, 78(7), 674–681 (1988) Author's Preface — June 2002

[5] http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/LS-1988.pdf

[6] Göl, O. and Nafalski, A (2007), Collaborative Learning in Engineering Education, Global Journal of Engineering Education, Vol.11, No.2 © 2007 UICEE Published in Australia http://www.wiete.com.au/journals/GJEE/Publish/Vol.11,No.2/GolNafalski.pdf

[7] Goodhew, P. J., (Sept.2010) Teaching Engineering All you need to know about engineering education but were afraid to ask Peter J Goodhew, Sept 2010 http://core.materials.ac.uk/repository/teaching-engineering/teaching_engineering_goodhew.pdf

[8] Izenberg, I.(Aug. 31, 2015) The Eight-Minute Lecture Keeps Students Engaged Faculty Focus, Higher Ed Teaching Strategies, Magna Publications (Aug 31, 2015) http://www.facultyfocus.com/articles/instructional-design/the-eight-minute-lecture-keeps-students-engaged/

[9] Johnson, D.W. and Johnson, R.T. (1979) Learning Together and Alone: Cooperative, Competitive, and Individualistic Learning https://www.nactateachers.org/attachments/article/1439/Smith_NACTA_Journal_Sept_1979-2.pdf

[10] https://www.researchgate.net/publication/31640337_Learning_Together_and_Alone_Cooperative_Competitive_and_Individualistic_Learning_DWJohnson_RT_Johnson

[11] Macpherson, Alice (2015) "Cooperative Learning Group Activities for College Courses" KORAFaculty Scholarship: Paper 14. http://kora.kpu.ca/facultypub/14

[12] Mendenhall, W., Beaver, R.J., Beaver, B.M. (1999) Introduction to probability and statistics, C&E Publishing, Inc., Books/Cole Publishing Company

[13] Montgomery, S.M. and Groat, L. N. (1998) CRLT Occasional Paper, no. 10 1998 http://www.crlt.umich.edu/sites/default/files/resource_files/CRLT_no10.pdf

[14] Morse, L. C. and Bobcock, D.L. (2015) Managing Engineering and Technology, 6th Ed., Pearson Education South Asia PTE. Ltd.

[15] Nerona, G. G. et.al. (May 2016) "A proposed forecasting method for course offerings in basic engineering"

[16] Ornstein, A.C. and Levine, D.U. (1985) An introduction to the foundations of education. Houton and Mifflin Co. Boston

[17] Prince, Michael (Jan. 2013) Does Active Learning Work? A Review of the Research

[18] Version of Record online: 2 JAN 2013
DOI: 10.1002/j.2168-9830.2004.tb00809.x
2004 American Society for Engineering Education
Journal of Engineering Education
Volume 93, Issue 3, pages 223–231, July 2004
http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2004.tb00809.x/abstract

[19] Sevilla, C.G., et.al. (2000) Research methods, revised edition. Rex Book Store

[20] Smith, B.L.and MacGregor, J.T. (1992) Washington Center for Improving the Quality of Undergraduate Education. http://evergreen.edu/facultydevelopment/docs/WhatisCollaborativeLearning.pdf

[21] Springer, L., Stanne, M.E., Donovan, S.: Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis Author(s): Leonard Springer, Mary Elizabeth Stanne and Samuel S. Donovan Reviewed work(s): Source: Review of Educational Research, Vol. 69, No. 1 (Spring, 1999), pp. 21-51 Published by: American Educational Research Association

[22] Stable URL: http://www.jstor.org/stable/1170643 or https://www.math.upenn.edu/~pemantle/active-papers/springer-stanne-donovan.pdf

[23] Stump, G.S; Hilpert, J.C; Husman, J. Chung; W, Kim, W. (Jul 2011) Collaborative Learning in Engineering Students: Gender and Achievement
Journal of Engineering Education 100.3 (Jul 2011): 475-497.
http://search.proquest.com/openview/9612304874453d1106c21a3080c5d84c/1?pq-origsite=gscholar

[24] TERENZINI, P.T., CABRERA, A.F. COLBECK C.L., PARENTE, J.M., BJORKLUND, S.A. (2001) Collaborative Learning vs. Lecture/Discussion: Students' Reported Learning Gains
Journal of Engineering Education (Jan 2001): 121-130.
http://barnard.edu/sites/default/files/inline/collaborative_learning_vs_lecture-discussion_student_reported_learning_gains.pdf

[25] What is collaborative learning?
http://evergreen.edu/facultydevelopment/docs/WhatisCollaborativeLearning.pdf

[26] Difference of cooperative from collaborative learning
http://cei.ust.hk/files/public/ccl_related_stories.pdf