

Engineering Education Utilizing Collaborative Learning

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Abstract: Recently, employers have indicated that they are not totally satisfied with the individualistic approach of the average engineering graduate. This may be due to the fact that, today, in many companies team goals, team contributions, and team rewards often supersede individual actions. In fact, some authorities believe that the development of critical thinking, collaborative learning, communication, and leadership skills is vital for engineering programs as well as for students. The finding of this study suggest that students have accepted the concept of collaborative teaching and learning. As an example, the evaluation of student-teaching presentations was found to be above average with scores greater than “B” for all categories. In addition, comments indicate that a course utilizing the concepts of collaborative learning and teamwork was interesting and informative and could be of assistance to respondents in future endeavors.

1. Introduction

In the past, engineering faculty have often utilized the lecture method for classroom instruction [1]. However, this approach is generally not the best method to be used if the development of critical thinking, communications, and leadership skills is to be developed in engineering students. In particular, classroom discussion, collaborative learning/teaching, and team experiences are usually required for the enhancement of these techniques. Nevertheless, the concept of group learning and especially discussion may, at time, be difficult to initiate since students have generally competed against each other since the first grade. However, today, teamwork often is more important than individual actions in many companies [2]. In fact, faculties are being requested to work as teams and place less stress on individual efforts [3].

This paper reviews the concept of collaborative learning/teaching and presents the results of an investigation of the perceptions of a group of undergraduate and graduate students. The data for the study was obtained from a survey instrument which was distributed to students enrolled in a civil/construction engineering course that utilized, in part, collaborative learning and was taught for a number of years using this technique. The respondents were requested to rate, on a scale from “A” to “F”, various classroom effectiveness techniques that were used by students during their oral teaching presentations. The methods are those that are thought to enhance the development of critical thinking, communication, and leadership skills in engineering students.

2. Collaborative Learning

Collaborative learning may be described as an intellectual endeavor in which individuals act jointly with others in order to become knowledgeable of some particular subject matter. It is generally know, unfortunately, that from kindergarten through a Ph.D. program students are usually not encouraged to collaborate. In fact, collaboration may sometimes be called cheating. However, upon graduation most individuals become part of an industrial or university team and are required to collaborate with the members of the group. In fact, project Web sites may enhance collaborative design and collaborative learning [4]. Since the Web is probably going to become increasingly more important in the future, it appears reasonable that students should be taught to collaborate during their formal education.

Today, teamwork is especially important to engineering students. One way to encourage teamwork is to emphasize interpersonal and communication skills through collaborative learning. This approach uses small groups to solve problems and enhance learning by engaging students in the collaborative process and with one another [5]. The finding of a recent study, illustrated in Table 1, suggest that students prefer the use of thought-

Table 1 – Teaching Methods and Techniques: Undergraduate Perceptions

<u>Student Perception of Teaching Techniques</u>	<u>Preference for Teaching Method</u> 1=Strongly Agree; 7=Strongly Disagree		
	<u>Mean Value</u>	<u>Standard Deviation</u>	<u>Median</u>
Formal lectures	3.2	1.9	3.0
Lecture/discussion/problem solving	1.2	.6	1.0
Thought-provoking questions & discussion	2.3	1.1	2.0
Opportunity for student input	1.8	.6	2.0
Challenged by the subject matter	2.0	1.1	2.0
Group interaction	1.8	.6	2.0
Working in teams	1.4	.7	1.0
Exploring alternatives (brain storming)	2.3	1.3	2.0
Homework assigned, not collected	3.4	2.0	4.0
Homework collected, graded and returned	3.3	2.3	2.0
Take-home examinations	2.1	1.2	2.0
Field-trips	1.9	1.0	2.0
Outside speakers and/or visual aids	1.6	.7	1.0
Computer assignments	1.8	1.6	1.0

Table 2 – Communications Requirement in an Undergraduate Program

<u>Communication Component</u>	<u>Assessment of Communication Component</u> 1= Strongly Agree; 7=Strongly Disagree		
	<u>Mean Value</u>	<u>Standard Deviation</u>	<u>Median</u>
Gained an understanding of how to communicate based upon the audience	1.8	.9	2
Learned to collect and use accurate data to support oral communication	1.8	.9	2
Learned to use visual aids to enhance a speech	1.3	.7	1
Learned to arrange a presentation into an introduction, body, conclusion etc.	1.9	1.0	2
Gained the ability to arrange a presentation in logical order which moves smoothly	1.9	.9	2
Learned to incorporate appropriate techniques (eye contact, posture, gestures, enthusiasm, etc.)	1.9	.9	2
Recognition that oral communication skills will be a benefit in future endeavors	1.7	.9	1

provoking questions and discussion in the classroom [6]. They also appreciate the opportunity for student input, like to be challenged by the subject matter, and enjoy group interaction. Undergraduates, in particular, perceive that working in groups and teams is an excellent learning experience. They also believe that the development of communication skills will be a benefit for them in their future endeavors. Students, therefore, appear to have accepted that collaborative learning, teamwork and communication skills are important aspects of the curriculum.

It is time for the faculty to utilize these concepts and enhance the collaborative learning process in engineering programs.

3. Communication Skills

It has been mentioned that the development of communication skills is important for engineering students. In fact, it has been written that engineers must become involved in broader issues and various non-technical groups [7]. This often requires the use of presentation and speaking skills. To assist in this effort, the Accreditation Board for Engineering and Technology requires that oral communication skills must be demonstrated within the curriculum by each student [8,9].

In order to assess the communications content of its program, the Department of Civil Engineering at Lamar University distributed a survey instrument to undergraduate students in the department. The questionnaire listed various communication components and requested respondents to indicate whether these components were satisfied in civil engineering courses [6].

The findings, as illustrated in Table 2, suggest that students have gained an understanding of how to plan a speech by collecting data, and using a variety of visual aids. In addition, they have learned to arrange a presentation into various sections and include eye-contact, etc. into their speeches. Students also strongly perceive that the communication skills they have mastered in their civil engineering course work will be a benefit for them in the future. Overall, the data indicates that the communications requirement in the department has been meeting its objective and has been well received by the civil engineering students.

4. Collaborative Teaching

In an effort to increase collaborative learning, the Civil Engineering Department of Lamar University has offered, for a number of years, an elective course designed to involve students in the teaching and learning process. The course is assigned a special topic number and usually has the title “Temporary Facilities and Hazardous Waste Design.” The class generally consists of the following four sections:

- 33% -- Lectures on temporary facilities required on a construction site
- 17% -- Lectures on general concepts of construction safety
- 34% -- Student seminars (oral collaborative teaching and written presentations) on hazardous waste site remediation
- 16% -- Comprehensive team design project

The grading is usually based on the following distribution:

- 20% -- Examination I
- 30% -- Examination II or Final
- 20 – 25% -- Seminar (oral collaborative teaching presentation and written report)
- 20 – 25% -- Collaborative team design project (oral and written report)
- 0 – 10% -- Homework

As shown above, roughly 50% of the class time and 50% of a student's grade is based on collaborative teaching and learning experiences.

In the seminar section of the course, one or two students are assigned a chapter to present from a hazardous waste safety or construction textbook. These collaborative oral teaching presentations are required to be informative, educational, and interesting (not boring). Handouts, overhead projectors, etc., and examples of personal protective equipment (PPE) are utilized. The hazardous materials team from the local fire department has also been invited to give a presentation. An attempt is made to conduct a lengthy discussion of the material under consideration. However, it has been found that the concept of collaborative learning and especially discussion can be difficult, at times, to initiate in engineering students [10]. In addition to the collaborative oral teaching presentation, a written report is required of each student.

The foregoing paragraph reviews the actions that have been taken to involve students in the teaching and learning process in a particular class. In addition to the above, a comprehensive team design project is required. The teams are composed of between three – five students. A topic involving the design of temporary facilities needed at a conventional construction site or a hazardous waste remediation project is assigned. An oral

Table 3. Course Evaluation

<u>Classroom Effectiveness</u>	<u>Effectiveness Rating Score*</u>	
	<u>Student Presentations</u>	<u>Faculty Lectures</u>
Makes course interesting	3.7	3.9
Conducts class for a reasonable length of time	3.6	3.9
Presents concepts in an understandable way	3.1	3.9
Presents carefully planned and helpful lectures	3.6	4.0
Makes attending class worthwhile	3.4	4.0
Answers students' questions effectively	3.5	3.9

* Based on 4=A, 3=B, 2=C, 1=D, 0=F

Table 4. Course Evaluation Comments

<u>Comment</u>	<u>Student Comment</u>
1 practical	I especially like the team project and oral presentations. The project was very but made me think.
2	Hazardous waste site design was my favorite course during my entire academic career. An oral seminar and written report was assigned to each student. In addition, a computer program and team design project was required. In brief, it covered many things with which an engineer should be involved.
3	This class gave me an understanding of temporary facilities and hazardous waste site remediation. It also gave me the chance to improve my public speaking skills.
4	I would prefer the department offer more such courses which are really interesting and could be quite helpful to me in the future.
5	The atmosphere in the class was relaxed, which helped me learn.
6	I appreciate the teaching techniques which produced a very interesting and informative course.
7	The student presentations were sometimes difficult to understand. However, some were much better than others.
8	I was not sure of taking this class when it was first described to me. However, the class was very interesting and educational and I'm glad I was enrolled in the course.

presentation with discussion and a written engineering design report is required. As in past studies, the students have expressed the belief that working in teams and group interaction are excellent learning experiences.

5. Class Evaluation

In order to evaluate the "Temporary Facilities and Hazardous Waste Design" course, evaluation forms were distributed to students enrolled in the class. The students were requested to evaluate the instructor in the course in addition to the various student teacher presentations. The results are illustrated in Table 3. As shown, the student presentations were rated less effective (3.1 – 3.7) than those of the faculty member teaching the class (3.9 – 4.0). This is to be expected since faculty members generally have considerable more teaching experience. The largest difference in scores was in the "presents concepts in an understandable way" category; 3.1 students versus 3.9 faculty. "Makes attending class worthwhile" posted the second greatest difference; 3.4 students versus 4.0 faculty.

Nevertheless, it should be mentioned that, overall, the student ratings were above average with an effectiveness score 3.1 or “B” for all categories.

The respondents were also requested to comment on the course. A representative sample of the comments is listed in Table 4. As shown, comments 1 – 6 and 8 generally state that the class was interesting and informative and could be of assistance to the respondents in the future. However, there may be a concern with comment 7 that reads as follows: “the student presentations were sometimes difficult to understand.” This reinforces the lowest rating score of 3.1 for the “presents concepts in an understandable way” category listed in Table 3. Nevertheless, 3.1, even if it is the lowest recorded score, may be considered to represent an above average ‘B’ rating. Therefore, the evaluations indicate that involving students in the collaborative teaching and learning process has been well received by those enrolled in the class.

6. Conclusions

It has been written that classroom discussion, collaborative teaching/learning, and cooperative team experiences are generally required to develop critical thinking, communications, and leadership skills in students. This investigation suggests that students accept the concept of collaborative learning and teaching in the classroom. As an example, the evaluation of student teaching presentations was above average for the various classroom effectiveness techniques measured, and taken under consideration. In addition, comments indicate that courses utilizing the concepts of collaborative learning and team design projects were interesting and informative and useful for the future. Also, the finding of a previous investigation suggests that students perceive that they have mastered communication skills in their civil engineering classwork.

These results indicate that students appear to have accepted the concept of collaborative teaching and learning, teamwork, and discussion in the classroom. They also perceive that the development of communication skills will be a benefit to them in future endeavors. It is time for the engineering faculty to utilize this resource and initiate the development of collaborative teaching/learning, teamwork, communication, and critical thinking skills in the courses under their direction. Practitioners must also recognize that future graduates may wish to apply these concepts in the work place.

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