PALM-Peer Assisted Learning Methodology

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Abstract

Enrollments in engineering programs have not been keeping pace with expected job growth in industry. Administrators have been trying hard to increase enrollments, improve the retention rate of entering freshmen; and improve the percentage of engineering students completing an engineering program in a predetermined period. The attrition rate of students in engineering programs is typically high as compared to non-engineering programs.

Considering the group performance of students in an engineering class; a typical distribution of grades generally falls within the following percentages: 20%-25%-A students (Group I), 30% to 40%-B students(Group II), 20% to 25%-C students (Group III), and Group IV comprises those students who would need additional help to pass the course. In order to improve the passing percentage of students and subsequently their graduation rates, students in the last two groups normally need additional support and encouragement from their instructor. A preliminary research at the Engineering Technology Department, Texas Tech University Lubbock, TX, has been undertaken to address this issue.

The success of any program hinges on keeping interest alive in all participants. Surely, for students, the biggest incentives are to learn and improve their grades in the course. Students from three disciplines took part in the preliminary phase of this research: (1) electrical engineering technology, (2) mechanical engineering technology, and (3) construction engineering technology.

On a volunteer-basis, students from Group I were teamed with 2 to 3 students from Group III or Group IV. The students from Group I were appointed as a team leader with the task of organizing extra coaching session for their team members, minimum of 2 hours per week. The incentives for the participants are that leaders will get a bonus of 2.5% towards their final grade and-team members will have an opportunity to pass the class by improving their performance. The performance of leaders and team members was monitored and preliminary results of peer assisted learning methodology (PALM) will be discussed in this paper.

Introduction

The upward economic mobility of an individual and his levels of educational attainment have been well documented; individuals with higher levels of education (and more advanced credentials) enjoy higher income, better and more stable employment, and less dependency on public assistance. A high school diploma was generally considered as a respectable credential for securing a well-paying job until the late seventies. Rates of college graduates have increased considerably over the past 20 years, as have the economic returns to a bachelor's degree. Presently, it is considered that hiring decisions are influenced by having a college degree, a prerequisite for securing a decent and well-paying job[1].

Greene and Forester (2002) reported that every year about a million students fail to graduate from high school and are condemned to a lifetime of lower income and limited opportunities. However, more that 50% of these graduates don't meet the requirements of "college ready" students; consequently they can't enter college and have a lifelong barrier to higher incomes and better opportunities. The majority of these students belong to minority groups thereby burdening the initiatives sponsored by different government agencies to alleviate their social and economic hardships This study also reported that only 70% of all students in public high schools graduate, and that only 32% of all students leave high school qualified to attend a four-year college. Among minority groups, only 51% of all black students and 52% of all Hispanic students graduate from high school, and only 20% of all black students and 16% of all Hispanic students graduate college-ready.[2]

Enrollments in engineering programs have not been keeping pace with expected job growth in industry. Administrators have been trying hard to increase enrollments, improve the retention rate of entering freshmen, and improve the percentage of engineering students completing an engineering program in a predetermined period. The attrition rate of students in engineering programs is typically high as compared to non-engineering programs.

Scalise, et. al. (2000) had reported that performance of an entering freshman is crucial in determining his continuation in an engineering program or otherwise. They concluded that about 50% of students entering an engineering program leave before graduation with the majority of students leaving during the first year.[3] The following causes had been identified for this attrition: [4,5]

- Lost interest in engineering and increased interest in other majors.
- Poor teaching by engineering faculty.
- Overwhelming pace and load of engineering programs.
- Discouraging engineering grading systems.

Mentoring Scenarios

Originally, Mentor was a friend of Odysseus, entrusted with the education of Odysseus' son Telemachus. Today, a mentor is considered as a trusted counselor or guide[6]. Mentors can be divided in to many categories: well trained individual teaching less trained individuals; well trained capable individual teaching less well trained individuals; an untrained capable individual assisting another untrained capable individual in a synergistic fashion; untrained capable individual assisting an untrained less capable individual in a synergistic fashion, and other permutations of trained and untrained individuals.

In order for an individual to be mentored, the individual must first trust the counselor or guide. It is clear that anyone who has something to teach can be a mentor and any student may be mentored. For a learning situation to occur, the mentored student needs to be attentive and needs to study the mentor's material in order to acquire capability from the mentor's expertise. The capable student in the mentoring process exercises almost complete control over the mentor learning process. A less capable student may have great desire to learn a subject but can be limited in the level of expertise they can obtain.

A Student Organization Environment-Student-Student Interaction

Over the past several years at Texas Tech, we have had a tradition of upper class students from student organizations mentoring freshmen in a variety of engineering subjects. The subjects are usually fundamental engineering subjects, and the upper class students are capable in their subjects of interest. The upper classmen usually have very recent experience in learning the subject and knowing the difficulties encountered in the process.

The initial enthusiasm of the mentoring students and the mentored students is high. Attendance at study sessions is high. As the semester progresses, the attendance of the mentored students usually begins to drop, with spikes in attendance shortly before a test. As the response of the mentored students begins to decrease, the enthusiasm of the mentors begins to decline. With reduced attendance of the mentored student, many of the mentors begin to miss the study sessions.

A Lab Course Environment

In Engineering Technology Department, most of the classes have an associated one credit -hour lab component. For seniors, there is a three credit-hour independent design lab and a three credit-hour capstone lab project. The senior lab and capstone design project are student design and construction projects of increasing difficulty to test the students design capability. Before graduation the student is required to have an equivalent of at least three months of field work in their area of study. The three month full-time experience is called internship and is mandatory for graduation.

Student Choice with Professor Consent

In the one credit-hour lab associated with a class, the students are usually allowed to select their own lab partner. The laboratories are usually conducted with two-person teams. The lab experiments are relatively simple, open-ended projects related to the associated class. The students research the scope of the project, design a prototype device, and construct the prototype device. The prototype device is demonstrated and compared to the students' design specifications for the project. The students then write a formal written report associated with the project detailing the project design process, the prototyping process, the project hardware operation, and a comparison between their expected result and the actual experimental result.

The students have usually had previous classes together and have become acquainted in an academic setting and many times in a social setting as well. When the students are given the opportunity to select their own lab partner for a semester, they generally choose a familiar student. In the event that the students do not choose their own partner the instructor will assign a partner form the remaining available pool of lab students.

If the students have been acquainted for some time from a previous class, they will have had an opportunity to estimate their classmate's capability in the academic environment. Given a choice of lab partners, the students who are acquainted usually gravitate into groups. The students who have no acquaintances in a new class tend to be assigned a lab partner.

Many times the students' vested self-interest tends to make the students choose a partner who is similarly motivated and academically equivalent; these students are relatively well matched. The non-acquainted students suffer a random chance pairing. The random parings sometimes are well matched and sometimes highly mismatched.

The highly mismatched students may be mismatched in personality or in academic standing. A personality mismatch generates a great deal of friction, and the partnership generally fails. If the mismatch is academic, then mentoring sometimes follows and the more scholastically advanced students tends to bring the less scholastic student along and carry him through the lab hardware experience. The less scholastic student, however, must still produce formal written project reports. The difference in the lab partners' report quality can be large, but the quality of the less scholastic student tends to improve over time.

In all these cases it is assumed that the students are motivated to learn new material and attempt to achieve scholastic excellence. Some of the students do not appear motivated to learn new material and do not attempt to achieve scholastic excellence. A non-motivated student can damage the lab experience, and the learning experience of motivated students, so it may be necessary to reassign the motivated student to preserve his morale.

Gender-Based Interaction

Male-Male

Given the opportunity to choose a lab partner, the male student generally chooses a male partner with whom he is acquainted and who, from his perspective, has similar capabilities as himself. An unspoken bargain is struck between the equal partners that they will equally share the work load in the lab hardware design and construction. The bargain may mean sharing all tasks equally in order to check each partner's work, or it can mean unequal sharing of designated tasks. Unequal sharing can mean the partners are complementary rather than identical. Complementary partners experience a synergistic use of their skills to fill gaps in each partner's expertise. An example is one student attacking the majority of the design process and the partner attacking the majority of the construction process.

Female-Female

There are many fewer female students than male students in the engineering lab class, however a female student will generally choose another female student as a lab partner. Due to the limited number of female students, equality between the female lab partners may be more difficult to achieve. However the female students are usually more motivated and more studious than the male students, so mismatches between partners appears to produce more mentoring situations in the female students than in the male students.

Male-Female

Male-female lab partners occur occasionally due to choice but most often due to lack of an even number of female students in the class. The male-female partnering does not provide the female partner a satisfying experience if the female does not have a strong assertive character. The males tend to dominate the partnership and in many, if not most cases, the female is more capable and does not use her full capability in the project design or hardware construction. The female may, however, excel in the formal written report phase of the lab project. The formal written report is relatively independent of the design and hardware results. The formal written report discusses the successes and failures of the project and the research and development necessary to accomplish the tasks in the lab experiments.

Present Study

In this study, three course were selected, one from each discipline in the Engineering Technology Department; Construction Engineering Technology (CTEC), Electrical Engineering Technology (ETEC), and Mechanical Engineering Technology (MTEC).

CTEC Course

The course is designed for junior students in the CTEC program. The course is considered tough from a student's perspective, as it involves extensive theoretical concepts and requires practice in solving problems. The course is designed to give students the fundamentals concepts of structural analysis dealing in determinate and indeterminate structures: trusses, beams, and frames.

- Number of Students: 42.
- Gender distribution: 41 Males & 1 Female.
- Ethnic Composition: 36 Whites, 5 Hispanics, 1 Black.

After the first test, it was possible to identify those students who needed additional help in passing the class. For peer mentoring, 9 mentors and 11 protégés were selected. Two protégés bailed out, claiming that they do not need additional help and would try to spend more time to improve their performance. For rest of the mentors and protégés, it was suggested that they should try to work out a schedule mutually convenient to both parties. As a minimum, 2 hours session per week was suggested.

During the course of semester, groups met at their own schedules, and the mentors helped their protégés in understanding the topics covered during class, as well as homework assignments. Special sessions were planned before tests. The performance of protégés improved over time and all of them were able to pass the course.

ETEC Course

This is a lab course designed for first-semester seniors in ETEC program. In the most recent senior lab project, the students were partnered in groups specifically to encourage mentoring. The senior lab was an all-male class having 16 students, with a wide variety of backgrounds. The majority of the students were traditional students; entering college directly from high school, but a sizeable percentage is non-traditional students; entering college at a later stage in their lives. Sixteen students were enrolled for this class; 13 White and 3 new Spanish students.

The 13 White students in this group had been together in previous lab courses; their partnerships remained relatively stable with few exceptions. As the students progressed from course to course, new students would join and familiar faces would fade away. The 3 new Spanish speaking students had very good English language skills, but they were a small percentage compared to rest of the group making up the class.

Four teams of four students each were assigned four separate but related tasks in a large scale project. Each team of four students had specific research and design tasks to perform. The tasks for each team overlapped and required inter-team coordination as well as inter-team cooperation and intra-team cooperation and mentoring.

The students were assigned into groups by the course instructor. The instructor attempted to take advantage of each student’s capability and expertise as much as possible. In each group, the instructor assigned a relatively high achieving student with three average achievers, where possible. Two of the three Mexican students were assigned one of the four-man lab teams along with two veteran lab students. The third Mexican student was assigned with three veteran lab students in a second four-man lab team. The ethnic composition of teams is as follows:

- Team-1 had two Mexican students and two Southwestern/Midwestern students.
- Team-2 had the student of Oriental decent and three Southwestern/Midwestern students.
- Team-3 had two Hispanic students and two Southwestern/Midwestern students.

- Team-4 had one Mexican student, one Hispanic student and two Southwestern/Midwestern students.

The project was (and is) a robotic vehicle project with a great deal of electro-mechanical work to accomplish. The project called for each team to design, using off-the-shelf parts, position sensors, obstacle avoidance sensors, vehicle actuators, vehicle control systems, vehicle data acquisition systems, and all of the devices necessary to outfit an autonomous robotic vehicle.

The lab project was a very open-ended project requiring a great deal of brainstorming and then a very diligent design process. Before any parts would be ordered or any real construction would be started, several designs needed to be processed and a single design needed to be selected to implement.

For these lab students the design process was not very satisfying; they were all more interested in the construction and operation of a vehicle than in processing several design iterations that would not be implemented.

The lab was comprised of three modules for each of the students. The three portions were: hardware design and construction, formal and informal presentations of design results before an audience of their peers, and a formal written report on their individual and the team design process.

During the formal presentation, each student was given a task agreed upon by members of his respective team. They were allowed 15 minutes per team member. All the team members from a four-man team were allowed to contribute to any portion of their team mate's presentation before and during the formal presentation. In general one team member spoke at a time on a single portion of the team's project, and then the next team member would speak on another facet of the team's project. After all four team members had finished their respective presentation; they had an opportunity to fill in any missing gaps that might have been overlooked during the team presentation.

During the first formal presentation only 2 students out of 16 used more than 10 minutes of the allotted presentation time. The average for the rest of the 14 students was around 5 minutes each. Table 1 shows the results of first formal presentation and duration for each student. The average time of presentation for the class was about 6.6 minutes per student.

All presentations were well delivered but lacked details, probably the students were not sure what all to include in a 15-minutes presentation in order to make it meaningful and comprehensive.

The results of second formal presentation are shown in Table 2. As can be seen, students with longer oral presentations from the first presentation session had presentations of relatively the same length in the second session. Also, many of the students with shorter presentation in the first session remained relatively unchanged. But a few of the students learned from the students in their group and from the experiences around them and increased the length and content of their presentation. The average for the 15 presenting students is about 8.4 minutes, up from the pervious 6.6 minutes.

Table 1. Results of First Formal Oral Presentation

Task 1: Power Train		**Task 2: Mechanical to Electrical Interfacing**	
Team Member #	Presentation Time (minutes)	Team Member #	Presentation Time (minutes)
1	2	1	6
2	10	2	7
3	4	3	8
4	6	4	9
Task 3: Actuator Blazer		**Task 4: Sensors**	
Team Member #	Presentation Time (minutes)	**Team Member #**	**Presentation Time (minutes)**
1	8	1	8
2	2	2	3
3	6	3	15
4	5	4	6

Most of the presentations were computer slide presentation during the first session; some were overhead projections, and some teams did not use slides at all. During the second presentation all of the presentations were computer slide presentations. The slide presentations were of varying quality and detail, but the technology standard was set in the first set of presentations and all the teams adjusted their presentations.

Table 2. Results of Second Formal Oral Presentation

Task 1: Power Train		**Task 2: Mechanical to Electrical Interfacing**	
Team Member #	Presentation Time (minutes)	Team Member #	Presentation Time (minutes)
1	10	1	14
2	9	2	18
3	8	3	10
4	5	4	Absent-Test
Task 3: Actuator Blazer		**Task 4: Sensors**	
Team Member #	Presentation Time (minutes)	**Team Member #**	**Presentation Time (minutes)**
1	6	1	7
2	4	2	3
3	5	3	13
4	5	4	4

The end-of-semester formal written report was an individual effort. Each student was to produce a formal report containing their work for the semester. The contents of the report were a written summary of the student's effort for the semester, an appendix containing a photo copy of their lab notebook (LNB), and a photo copy of any *'relevant materials'* the student had discovered on the internet or elsewhere during the semester. The written report and the lab notebook are the student's original work and all the *'relevant material'* is someone else's work, e.g., sales brochure, equipment data or other found material generated by an outside source.

Table 3 shows the results of the formal written report with the number of written pages, the number of lab notebook pages, and a weighting factor for other material. It can be seen from Table 3 that many of the students relied heavily on outside material to pad their formal report. Some of the reports contained 10 times more supporting material. But in the scope of the design of the project, gathering the outside material was and is a critical factor in the successful completion of the project. The formal written portion of their reports on power train and mechanical to electrical interfacing teams shows a great deal of effort in both the written portion and in the lab notebook portion.

Table 3. Results of Formal Final Report

Task: Power Train			
Student #	**Formal Report (pages)**	**LNB (pages)**	**Appendix Thickness (cm)**
1	22	22	1.5
2	12	40	3.5
3	28	10	1.2
4	33	15	1.1
Task: Mechanical to Electrical Interfacing			
Student #	**Formal Report (pages)**	**LNB (pages)**	**Appendix Thickness (cm)**
1	15	41	4.5
2	17	55	3
3	22	38	1.5
4	14	10	1.5
Task: Actuator Blazer			
Student #	Formal Report (pages)	LNB (pages)	Appendix Thickness (cm)
1	9	10	0.5
2	8	20	0.7
3	10	10	2.5
4	9	15	0.5
Task: Sensors			
Student #	**Formal Report (pages)**	**LNB (pages)**	**Appendix Thickness (cm)**
1	13	60	2.5
2	8	64	0.5
3	10	14	6.5
4	25	11	1.3

The actuator team was weak in nearly every respect, except for one student in his acquisition of relevant data. The actuator team did not appear to exert a great deal of effort on the project.

The sensors team excelled at retrieving relevant data and keeping extensive lab notes. One of the sensor team members wrote extensively on his portion of the project.

Some of the students chose to maximize their potential grade by presenting original material in their report and lab notebook. Some of the students chose to maximize their grade with outside relevant material. Some of the students chose to do both, and some of the students chose not to excel in either area.

The students in each group were chosen by the instructor to complement each of their respective talents. The Power Train, Mechanical, and sensors groups had complementary and mentoring student groups with a leader emerging in each group as the semester progressed. The leader was not necessarily the mentor. The actuator group was full of less than cooperative "lone rangers" students. The "lone rangers" were not the best students and in general did not benefit from the efforts or leadership of the better students on the team.

MTEC Course

The course is designed for juniors in MTEC program. Class consists of three hours lecture and three hours non-credit lab. The main objective of this course is to provide the fundamental knowledge to understand important concepts in materials engineering and their applications in engineering design and manufacturing process during hands-on practical sessions.

- Number of Students: 29 students were enrolled during last two semesters.
- Gender Distribution: 28 male and 1 female.
- Ethnic Composition: 27 White and 2 Hispanic.

Students are exposed to the use of experimental apparatus and state-of-the-art data-collection systems. Students are encouraged to use creativity in their learning and foster self-reliance required for open-ended experiments. This methodology discourages cook-book approach and promotes team work.

Main emphasis from the instructor's point of view is to teach students teambuilding skills. For each topic, basic information is provided in the classroom by the instructor; teams are assigned real-engineering case studies and realistic time is given to research background information related to the assigned problem. For each case study, one team leader is assigned to communicate with the instructor. Team leader is changed by assuring each student will share responsibility for providing leadership to their own group. Students are encouraged to contact related industrial companies and do research on scientific journals, or web based information collection. After completing their assignments, students present their work in a formal setting in front of their peers. Power point presentation provides public speaking practices. In this process, students are transformed from passive listeners to active learners and become an integral part of the teaching team.

These goals and objectives were achieved by implementation of active cooperative learning group method into regular lecture and lab sessions of the course. The following goals were achieved: (1) group goal of maximizing group learning; each group member worked beyond their individual effort, (2) group members helped each other for in time completion of assigned tasks, (3) group members work face-to face to produce joint work products, formal reports and, presentations and (4) group members worked in team environment and coordinate their efforts to achieve their objectives and goals.

Summary and Conclusions

Based on the limited data gathered during the course of this investigation, it is concluded that peer-assisted learning methodology is an effective technique for helping lower achieving students to understand and comprehend difficult concepts and improve their performance in the course.

This study showed that there was a positive out come for students as well as the instructor by providing closer collegian relationship between students and instructor. The instructor got a chance to share his/her engineering experience with the students. Students gained positive interdependence by believing that they are linked to each other in a way that if one fails, they all fail; therefore, they all must succeed in order for the group to succeed. Working face-to face provided a better way of interacting with each other since students were expected to explain verbally to each other, and to discuss the concepts and problem solving strategies. The students learned to support each other and promote an environment of learning and mentoring. Lower achieving students were provided with an opportunity to improve upon their performance during the course.

Acknowledgment

This paper was reviewed by Ms. Carolyn Kennedy, Senior Executive Associate, Office of the Provost, Texas Tech University. Her help is greatly appreciated.

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