Summer Camp and Course Workshops for Sophomore Level Electrical and Computer Engineers

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Abstract

In response to a program supported by Texas engineering companies and the Texas state government, we have begun a project to attempt to increase the number of graduates in Electrical Engineering and Computer Engineering. We have chosen to work on two sophomore-level courses where the success rate in the past has been very low, specifically Circuit Analysis and Electromagnetics. The project has two parts. One part is a weeklong summer camp, called a Redshirt Camp. The students study topics that we believe will help them do better in these two courses in the coming semesters. Then, during the semester the students meet once a week in collaborative-learning sessions, called Workshops, where they work difficult problems in teams. Under the guidance of facilitators, they teach each other how to approach these problems effectively, and therefore learn more thoroughly. At the end of the first semester of this project, 73% of the students in Circuit Analysis who completed the workshop earned a high enough grade to move to the next course in the curriculum. This compares to 56% of the students taking the same exams who did not participate in or complete the workshop. For the students in Electromagnetics, 91% of the students who completed the workshop earned a high enough grade to move to the next course in the curriculum, compared to 51% of the students taking the same exams who did not participate in or complete the workshop. To compare the two groups, it was noted that the average GPA for students in the Circuits project group was only 3.2% higher than the average GPA for those who were not in the project. Similarly, the Electromagnetics students in the project had a 6.5% higher GPA than the other students in that class. With these early results, we are cautiously optimistic that we are making a difference for our students. Full results for two semesters of the project will be ready by the time of the presentation.

Introduction

This project began with the initiative of some engineering companies in the state of Texas, who approached the governor with a proposal to find ways to increase the number of graduates in electrical and computer engineering and computer science in the state. This resulted in a program called the Texas Workforce Development Act (TWDA). The TWDA created the Texas Engineering and Technical Consortium, which then sent out a request for proposals from the universities in the state, to allow the universities to explain how they would propose to meet this goal at each institution.

Here at the University of Houston in the Department of Electrical and Computer Engineering, we decided to attack two problems. One problem was the poor success rate in two key sophomore courses in our curriculum, Circuit Analysis, and Electromagnetics. The second problem was with misperceptions of female students in middle school and high school, concerning whether it would be appropriate to choose engineering as a major. We decided that we could try to do something about these problems, and have begun to work on both problems. This paper concerns only our efforts on the first problem; we will describe the steps we have taken to improve the pass rate in these two courses.

Our approach was adapted from, and largely copied from, a successful program here at the Cullen College of Engineering at the University of Houston, called the PROMES program. The word **PROMES** comes from **PRO**gram for **M**astery of **E**ngineering **S**tudies. When we wrote our proposal, we studied the techniques that this existing program already uses. That program involves a relatively small group of students from across the college of engineering. This program was one of the pioneering programs in the use of Collaborative Learning or Cooperative Learning, as described by Uri Treisman [1] and Paskusz and Foster [2]. Their emphasis is college wide, and is therefore somewhat more general, and is targeted more at the courses that our students take as freshmen. While the PROMES program does work with our two target courses, we felt that a new and additional effort could help our students even more.

We chose to concentrate our efforts on two required courses taken by our students in the second semester of their sophomore year. These two courses are Circuit Analysis, and Electromagnetics. (Their formal names and titles are ECE 2300 Circuit Analysis, and ECE 2317 Applied Electricity and Magnetism.) Both courses are standard three semester-credit-hour lecture courses, with three hours of lecture per week, and class sizes that vary from the low 20's to mid 50's. These courses were chosen because of the low success rate for the students. During the five years previous to the Fall 2002 semester, the average pass rate for Circuit Analysis was 52%, and the average pass rate for Electromagnetics was 57%. This pass rate is defined as the percentage of the students who officially attempt the course, who earn a high enough grade to get credit and move on in the curriculum. Therefore, to pass means that they have earned a "C-" or higher. An attempt includes the grade of W, the grade earned by those students who withdraw after being in the course for about a month or more. These pass rates are, of course, distressingly low, both for the students, and for the faculty involved in the course. While an exhaustive listing of the different changes that have been made to attempt to improve the pass rate in these courses would be too long for this paper, suffice it to say that many things have been tried to improve the success of the students, without substantial change. The pass rate has generally hovered in the 50% to 60% range for a number of years.

One of the reasons we felt confident in approaching new techniques, and assessing the effects of these new techniques, in these courses is that the courses do not assign grades using the statistical performance of the students that semester. Course-average to letter-grade conversions are not set in stone, but they are not based on the performance of the students in that semester. Generally, the grades are adjusted slightly for the difficulty of the exams in that semester. Still, for the Circuits course we publish a minimum guarantee for each grade. For example, if a student earns a course average of at least 66% in Circuit Analysis, the student is guaranteed to earn at least a "C-" in that course. The algorithm followed in the Electromagnetics course is slightly different, but the grades are not assigned based on the class average or other statistical measures. This means that if we are able to improve the performance of the students on the exams, which are designed in the same style each semester, there should be an improvement in the grades in that course.

Approach Taken: Summer Camp and Workshops

We decided to take a two-step process for the students in this project. For the first step, the students attended a one-week camp, to be taken in the weeks before a semester starts, conceptually in the summer, to prepare the students for the two courses, Circuit Analysis and Electromagnetics. Students were recruited for this camp by advertising around the engineering building, and in the courses that are prerequisites for these two courses. In addition, we used some of the money from the TWDA program to offer $250 scholarships to any student who attended and actively participated in the camps. The philosophy here was that our students work between semesters (and during semesters!) to support themselves, and they needed something to offset their loss of income for the week.

The students met for four days, about eight hours per day, with assignments in the camp, over lunch, and overnight, to be completed in teams. A typical weekly schedule is given in Figure 1. The original intention of these camps, which we called Redshirt Camps, was to give the students insights into the courses before they began. We wanted to help the students shore up, review, and practice some of the mathematical skills that would be used in the courses. These skills included the use of different coordinate systems, and the review of some calculus concepts such as the choices of the limits of definite integrals. However, as our planning moved forward, the emphasis of the Redshirt Camps shifted more towards the preparation for the workshops that would be taken during the semester, as well.

	Monday		*Tuesday*		*Wednesday*		*Thursday*	
9:00-9:30	Breakfast	Anyone who wants juice & doughnuts	---		---		---	
9:30-10:00	Introductions/ Scholarship Contracts	BB, BF, DS, FC, JR, LB, MK, SL, SS, & WL	Discuss Evening Problem #1	BB, DS or LB	Discuss Evening Problem #2	DS or LB	Discuss Evening Problem #3	DS or LB
10:00-10:30	Engineering Problem Solving	FC, MK, & BF	Calculus and Integration	BB, MK, & BF	Complex Numbers	DS, MK, & WL	Circuit Analysis	DS, MK, & SS
10:30 - Noon	Engineering Problem Solving - Group Work		Calculus and Integration - Group Work		Complex Numbers - Group Work		Circuit Analysis - Group Work	
Noon - 1:30	*LunchCrunch#1-OfficeMaxCalculator*	*no facilitators*	*LunchCrunch#2-Hikers*	*no facilitators*	*LunchCrunch#3-ComplexNumber*	*no facilitators*	*LunchCrunch#4-BilliardBalls*	*no facilitators*
1:30-1:45	Discuss Lunch Problem #1	DS or LB	Discuss Lunch Problem #2	DS or LB	Discuss Lunch Problem #3	DS or LB	Discuss Lunch Problem #4	DS or LB
1:45-2:15	Coordinate Systems	SL, LB, WL, & BF	Word Problems, Reading for Clues	DS, LB, & WL	Simultaneous Equations on Calculators	BB, LB, & WL	Developing a Plan for Fall 2002/ Time Management	JR, LB, & BF
2:15-4:00	Coordinate Systems - Group Work		Word Problems, Reading for Clues - Group Work		Problems Using Simultaneous Complex Equations		Time Mgmt - Individual & Group Work	
4:00-4:30	Evening Problem #1 (in room)		Eve Problem #2 (in room)		Eve Problem #3 (in room)		Camp Evaluations	
	Groups work on Eve Prob #1 on their own		**Groups work on Eve Prob #2 on their own**		**Groups work on Eve Prob #3 on their own**			

Figure 1. Typical Redshirt camp schedule. This is a listing of a typical week of Redshirt camp. Note that it includes assignments to facilitators, and a mixture of lecture and group work.

The term “Redshirt” is intended to draw allusions to the “redshirting” of college athletes. For these athletes, this gives them a year to practice their sport without losing a year of eligibility in that sport. Athletes, who take a “Redshirt” year, spend that year growing in skills needed for that sport. This was our corresponding goal for these students. We wanted them to have some time to grow their mathematical skills in preparation for the semester. However, as we moved forward in the design of the camps, we began to perceive the need for more than just more instruction. Generally, the things that we would tell them in the Redshirt Camp had been told to them before, and would be told to them again as they took their engineering courses. One more repetition might help a bit, but it would not likely change the situation dramatically. We decided to move the emphasis and goals of the camp more in the direction of preparation for success in the workshops, the second part of the two-step process.

The workshops were intended to be an opportunity to encourage the students to use “collaborative learning” or “cooperative learning”. The terminology seems to vary somewhat, but the common principle involved is that students learn best when they study together appropriately. In particular, the students seem to learn best when they have the opportunity to explain the difficult concepts and techniques to peers. Although it seems to be a paradox that you learn something by teaching it to someone else, it has been demonstrated that the process of explaining something to another student is an excellent tool for learning that thing well. This is the principle that has been advocated and practiced for years in programs such as the PROMES program at our college. Adopting this, we made the workshops the centerpiece of our project to help students in these two key courses.

Thus, the Redshirt Camps were intended, in part, to sell the students on the benefits of collaborative learning. The selling was to be accomplished by having them learn to solve problems in groups, and hopefully finding that they can solve more problems and understand the solutions better. We had been told by the leaders of the PROMES program that the facilitators who assist the students in learning in groups are important to the process. These facilitators need to be trained, and so one of the associated goals of the Redshirt Camps was to train the facilitators who would be working in the workshops during the semester.

The workshops were set up to be two hours in length, once a week on Fridays. Again, we offered a scholarship of $125 for each student who successfully completed each workshop. This was intended to be an incentive to take part actively, and to offset the loss of income from outside jobs, which most of the students in our college have. There was no grade or credit earned for the workshop, at least at this time. There was one workshop for the Circuit Analysis course in the late morning, and one workshop for the Electromagnetics course in the mid afternoon, an hour after the Circuit Analysis workshop ended. Most of our students have few or no classes on Fridays, so doing this minimized the conflict with course lectures for other courses. We had been told that longer sessions, more than once a week, would be better. However, we wanted to try out the approach as soon as possible, and this choice allowed us to begin offering workshops almost immediately without adjusting course schedules.

The structure of the workshops was set to maximize time spent in collaborative learning. There was relatively little lecture, and most of that was aimed at addressing the structure of the workshop itself, and not to lectures on course materials. Then, a set of problems was handed out, to be worked on by the students in their groups. The sets of problems were developed by the facilitators, with input and oversight by the instructors from the course. Many of the problems were taken from old examinations. Upon the advice of others who had conducted such workshops, we specifically prohibited the students from working on problems from the homework assigned in the lecture courses. After a period of time to complete problems, representatives from the groups were sent to the boards in the workshop room, to work the problems for all the members of the workshop. This added an extra incentive to concentrate on the problems and to work in groups. The facilitators in the Circuit Analysis workshop noted that the Electromagnetics workshop seemed to be getting better results about halfway through the semester, and adopted this approach, and had better engagement from the students after that. Early in the semester, the

Circuit Analysis workshop facilitators developed a practice examination for their students to take individually, shortly before the first examination in the lecture course. However, the students found this to be of little benefit, and after that the workshops stayed with the practice of emphasizing the collaborative learning process as much as possible.

Results

At the time of the writing of this paper, we have completed a set of two weeklong Redshirt Camps in August 2002, and completed one full semester of workshops in both Circuit Analysis and Electromagnetics in the fall semester of 2002. While we have evaluations from the students on their sense of the value of the Redshirt Camps and the workshops, the key metric of interest here is the success of the students who took the two courses in the fall semester. Thus, in this paper, we will emphasize these results.

We present the grades in the Circuit Analysis course in Figure 2. In this figure we have shown the pass-rate in this course for the fall and spring semesters for the past five years. While this course is offered in the summer semester, the students in that semester are much more likely to have taken the course previously than in the fall and spring semesters. Thus, for the purposes of comparison the pass-rate in the summer can be so different that the comparisons are difficult. The pass-rate shown is the percentage of students who earn a passing grade of some kind, and are considered to have attempted the course. Thus, the total number of students includes those students who drop with a grade of W, which takes place after about a month of the semester, until about a month before the end of the semester. A passing grade in this course is considered to be a C- or better, since that is the grade needed as a prerequisite for the following courses. In the last semester shown, the fall of 2002, there are three points shown. As labeled, one of these points is the pass-rate for those students who completed the Circuit Analysis workshop (N = 30). One point is the pass-rate for all students in the course (N = 92), and the third point from the top is the pass-rate for the students who did not participate in the workshop, or did not complete the workshop (N = 62).

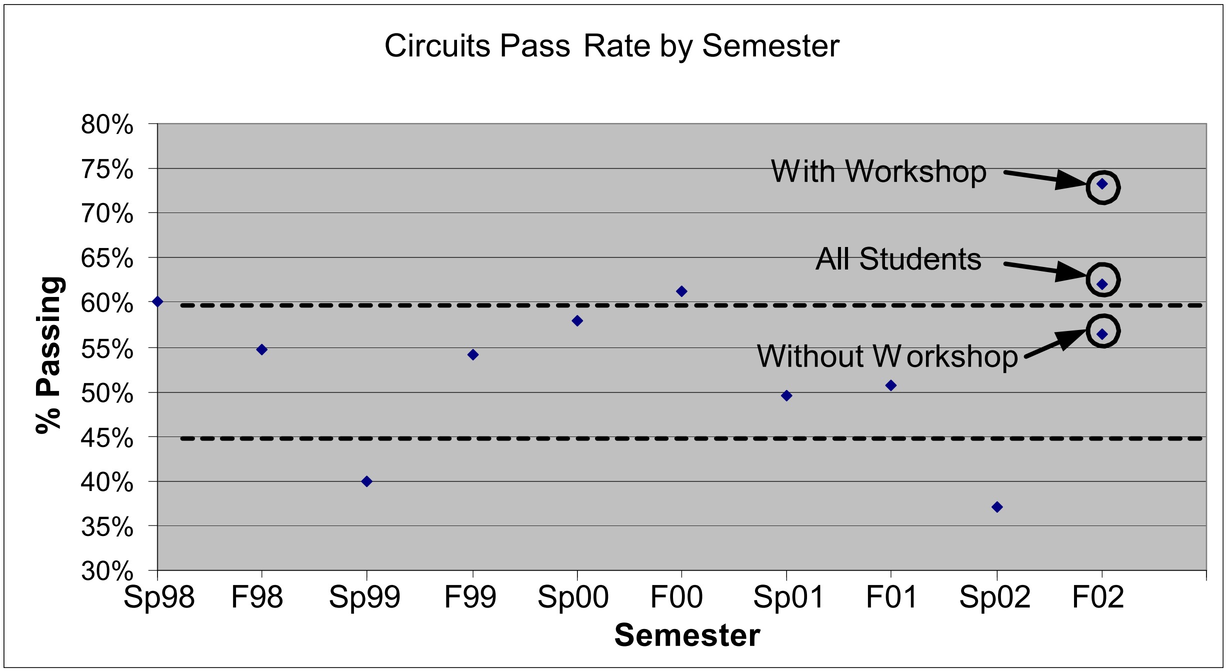

Figure 2. Pass Rate for Circuit Analysis, with and without workshops. This figure shows the percentage of students who satisfactorily passed Circuit Analysis in the fall and spring semesters for the last five years. Passing means that the students earned a grade of at least C-. The total number of students includes students who dropped and earned a W, which is counted as an attempt at the course. In the second semester of 2002, the pass rates are shown for students completing the workshops, the students who did not complete the workshop, and for all students. The dashed lines are about 7.5% above and below the average pass rate, and represents the expected course performance by semester.

In our analysis of the results of the Circuit Analysis workshop, we have added two dashed lines. These dashed lines are about 7.5% above and 7.5% below the average pass-rate for this course for the past five years. This defines a band, which is the range into which we expect the pass-rate to fall in any given semester. This expectation does not always come true, but is typical of what we have come to expect in this course for many years. If this expectation were a reasonable one, we would have expected that the students in the fall 2002 semester would end up in this range as well. This is a key in the analysis that follows.

We have been concerned that as we analyze our results there would be a bias that comes from the fact that our students self-select to take part in the camps and the workshops. One could imagine that the students who elected to spend this extra time would be the best students, and that the positive results from those students would follow whether the workshops and camps were effective, or not. However, one could also imagine that the students who elect to spend the time in these activities would be the students who perceived themselves as needing extra help; one could imagine that the confident student would not think that he or she needed to spend this extra time. We found that the Grade Point Average (GPA) of the students in the Circuit Analysis workshop was only 3.2% higher than the GPA for those who did not participate in the workshop. From this, we tentatively concluded that the quality of the students in the two groups, participating in the workshop and not participating the workshop, was about the same.

The results seem to confirm this conclusion. If we assume that the students in the workshop were not the better students, then the students who did not participate in the workshop should perform about as well as the students have done in previous semesters. In other words, the performance of the non-workshop students should be in the normal range for the course. Considering the other possibility, we would expect that the performance of the non-workshop students, as a group, would go down if we took the better students out of that group. Thus, if the better students opted into the workshops, the poorer students would be left, and the performance of the non-workshop students should be lower than the normal range for the course. That was not the case. The students who did not complete the workshop performed in the top part of the range of expected performance. From this, we tentatively conclude that the self-selection process did not result in significantly better students in the workshop. Therefore, we also tentatively conclude that the workshops do seem to dramatically improve the pass-rate of the students who take the workshop. We think that the workshops are helping the students perform better.

A similar situation occurred with the Electromagnetics workshop. We present the grades in the Electromagnetics course in Figure 3. Again we have shown the pass-rate in this course for the fall and spring semesters for the past five years. The summer semesters have been omitted, for the same reason as before. The pass-rate is also defined the same way. The pass-rate for those students who completed the Electromagnetics workshop (N = 22), for all students in the course (N = 83), and for the students who did not participate in the workshop, or did not complete the workshop (N = 61), are shown lined up vertically.

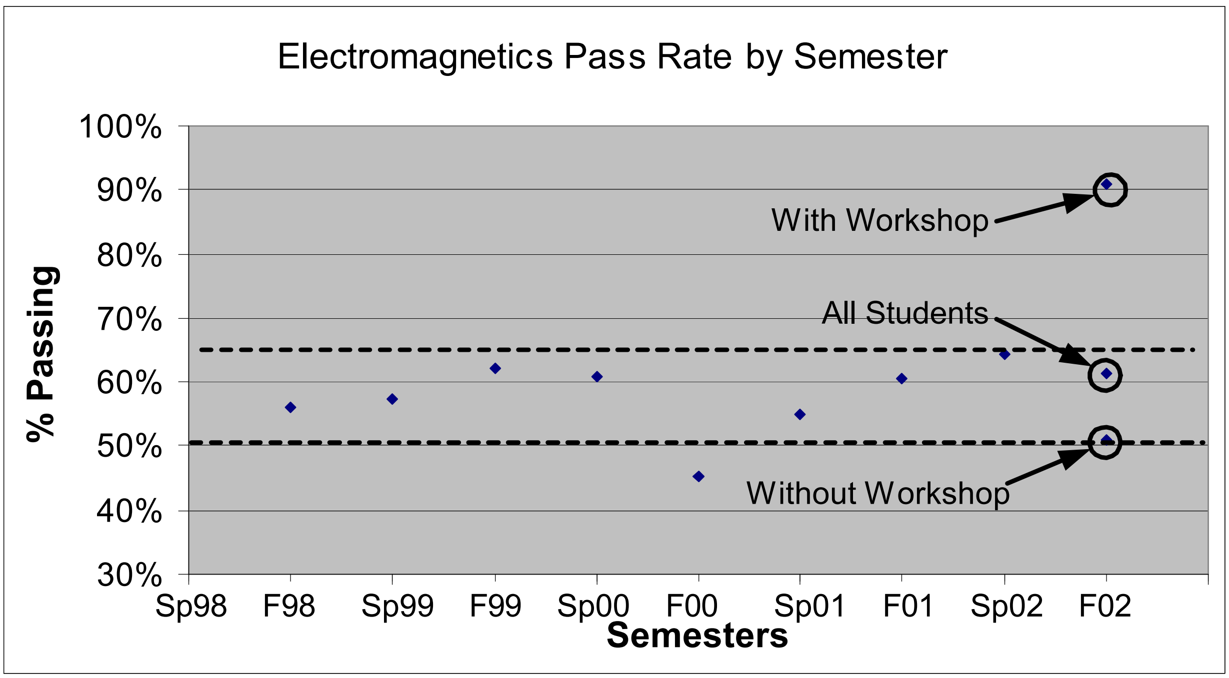

Figure 3. Pass Rate for Electromagnetics, with and without workshops. This figure shows the percentage of students who satisfactorily passed Electromagnetics in the fall and spring semesters for the last five years. This version of this course was offered for the first time in the fall of 1998. Passing means that the students earned a grade of at least C-. The total number of students includes students who dropped and earned a W, which is counted as an attempt at the course. In the second semester of 2002, the pass rates are shown for students completing the workshops, the students who did not complete the workshop, and for all students. The dashed lines are about 7.5% above and below the average pass rate, and represents the expected course performance by semester.

In our analysis of the results of the Electromagnetics workshop, we have added two dashed lines. Again, these dashed lines are about 7.5% above and 7.5% below the average pass-rate for this course for the past five years, to define the range into which we expect the pass-rate to fall in any given semester.

As we analyze our results to consider the possibility of a bias that comes from our students self-selecting to take part in the camps and the workshops, we found that the Grade Point Average (GPA) of the students in the Electromagnetics workshop was only 6.5% higher than those who did not participate in the workshop. This is somewhat more than the difference in the Circuit Analysis workshop group. Still, we believe, although with less confidence, that the quality of the students in the two groups, participating in the workshop and not participating the workshop, was about the same.

The results indicate that the students who did not complete the workshop performed in the range of expected performance, but in the lower part of this range. From this, we tentatively conclude that the self-selection process did not result in significantly better students in the workshop, but again with less confidence. On the other hand, we had to be heartened by the excellent performance of the students in the workshop. Of the 22 students in the workshop, 20 earned a passing grade, or 91% of the students. Therefore, we think that the workshops are helping the students perform better. In any case, we need more data to be reasonably certain of our results, both in the Electromagnetics workshop and in the Circuit Analysis workshop. We are encouraged by our results, and look forward to repeating the experiment in the coming semesters. In light of our increased experience, we are optimistic that we might improve the student success rate even further.

Conclusions

We have started a program where we have attempted to increase the pass-rate in two sophomore-level courses where the pass-rate has been discouragingly low for many semesters.

This program included a weeklong camp to give them skills for collaborative learning, and a brief refresher in mathematics skills and other tools to help them in these courses. Then, the students in the program participated in two-hour workshops once a week, where they were encouraged to use collaborative learning techniques to master the concepts more effectively. The results for the first semester seem to verify that this combination can improve the student performances.

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