Collaborative Learning as a Tool for Retention of Engineering Students: An Update on the Success of Engineering 'Redshirt' Camps and Collaborative Learning Workshops at the University of Houston Cullen College of Engineering

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Abstract

Our experience at the University of Houston is similar to that of many engineering schools around the country: far too often, engineering students who thrive during their freshman experience do not pass essential sophomore engineering courses. In our Department of Electrical and Computer Engineering (ECE), the pass rates of courses such as Circuits and Electromagnetics have traditionally hovered between approximately 50 and 60%. These rigorous courses, which are the foundation for further work in the ECE curriculum, can be difficult even for the well-prepared student.

To better prepare eligible students for the challenging sophomore engineering curriculum, ECE faculty created Redshirt Camp, a weeklong interactive camp that uses collaborative learning pedagogy to teach critical engineering concepts. During the following semester, students continue to practice techniques learned at Redshirt Camp through weekly, course-specific Collaborative Learning Workshops.

Now in its fifth semester, this program has proven to be a valuable retention tool in our ECE curriculum. Since its inception in the summer of 2002, pass rates for the Circuits course have varied between 40 and 61% for students who did not complete the program. In contrast, students who completed both Redshirt Camp and the subsequent Collaborative Learning Workshops had pass rates between 62 and 75%. Success has been even greater in the Electromagnetics course: non-participant participation pass rates varied between 46 and 59%, while 78 to 91% of program participants successfully completed the course. As the popularity of the program with both ECE students and faculty has grown, college-wide support has increased. The programs have been expanded to include critical courses in Civil and Chemical Engineering.

Introduction

This paper serves as an update on a successful two-part program implemented in 2002 in the Department of Electrical and Computer Engineering at the University of Houston: "Redshirt" Camps and subsequent Collaborative Learning Workshops (CLW). This retention program was implemented with the goal of increasing the alarming pass rates (hovering in the 50-60% range for years) in two sophomore level Electrical and Computer Engineering (ECE) required courses, Electromagnetics (ECE 2317, officially titled "Applied Electricity an Magnetism") and ECE

2300, “Circuit Analysis”, referred to as simply “Circuits”. These two courses, the first in a series of rigorous technical classes, are pre-requisites for further ECE coursework, and were identified as significant obstacles in retaining ECE majors beyond their second year.

Previously reported results[1] of these programs at the 2003 ASEE Conference ended with our “cautiously optimistic” conclusion that the Redshirt Camps and Collaborative Learning Workshops are increasing the pass rates in these two challenging ECE sophomore courses. Since the last reporting in spring 2003, additional Camps and workshops have been held each semester, with even more promising results. In fact, the popularity and success of the program has spread to other departments within the Cullen College of Engineering. Breakout sessions of Redshirt Camp as well as Collaborative Learning Workshops are now offered for classes in Chemical Engineering and Civil Engineering sophomore-level courses.

Redshirt Camps: Description and Pedagogy

The first element in our retention curriculum, called Redshirt Camp, is a four day program held the week before classes start in both the fall and spring semesters. Sessions last approximately eight hours per day. The name is derived from the athletic meaning of “redshirt”- that is, to prepare and strengthen an athlete (*i.e.* student) for an upcoming season (*i.e.* semester) without losing eligibility. The key element of Redshirt Camp is the creation of a learning community in which students collaborate in small groups on challenging exercises. Topics are not only intended to strengthen students’ base knowledge in pertinent course-related content (*e.g.* units, vector calculus, and linear algebra), but are intended to help the students discover and practice effective learning strategies such as time management and reading comprehension, which they can apply to future coursework, research, and work projects.

All entering sophomores and incoming transfer students are invited to participate at no cost to the student. Since many of our students hold part time jobs and taking time off from work could pose a financial hardship, we offer a scholarship (currently $150) to active participants who complete the camp. A typical schedule is shown in Figure 1.

<table>
<tr><td></td><td>Monday</td><td>Tuesday</td><td>Wednesday</td><td>Thursday</td></tr>
<tr><td>9:00-9:30</td><td>Breakfast</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>9:30-10:00</td><td>Introductions/Contracts</td><td>Discuss Evening Problem #1</td><td>Discuss Evening Problem #2</td><td>Discuss Evening Problem #3</td></tr>
<tr><td>10:00-10:30</td><td rowspan="2">Engineering Problem Solving</td><td rowspan="2">Calculus</td><td rowspan="2">Simultaneous Equations on Calculators</td><td rowspan="2">Breakout Session: Circuit Analysis</td></tr>
<tr><td>10:30 - Noon</td></tr>
<tr><td>Noon - 1:30</td><td>Lunch</td><td>LunchCrunch#1-OfficeMaxCalculator</td><td>LunchCrunch#2-Hikers</td><td>Lunch</td></tr>
<tr><td>1:30-1:45</td><td rowspan="2">Collaborative Learning and Group Work</td><td>Discuss Lunch Problem #1</td><td>Discuss Lunch Problem #2</td><td rowspan="2">Developing a Plan for Fall 2005/Time Management</td></tr>
<tr><td>1:45-3:45</td><td rowspan="2">Vectors and Coordinate Systems</td><td rowspan="2">Word Problems, Reading for Clues</td></tr>
<tr><td>3:45-4:00</td><td rowspan="2">Evening Problem #1</td><td>Camp Evaluations</td></tr>
<tr><td>4:00-4:30</td><td>Eve Problem #2</td><td>Eve Problem #3</td><td></td></tr>
<tr><td></td><td>Groups work on Eve Prob #1 on their own</td><td>Groups work on Eve Prob #2 on their own</td><td>Groups work on Eve Prob #3 on their own</td><td></td></tr>
</table>

Figure 1. Typical Redshirt Camp Schedule. Note the mixture of lecture sessions and group work.

Rather than providing remediation, Redshirt Camps initiate a novel academic program that promotes academic excellence and fosters leadership skills. The ultimate goal of the two-part program is to produce higher retention rates and fewer withdrawals or failures when the students subsequently enroll in sophomore level core engineering courses. An important goal in the Redshirt Camp portion of the program is to indoctrinate students into collaborative learning pedagogy in order to help them succeed in the subsequent Collaborative Learning Workshops held during the semester. Rather than creating a competitive environment similar to what students may experience in many engineering classrooms, Redshirt Camp emphasizes collaboration over competition. We believe that students often lose confidence in applying their math and science abilities due to the competitive nature of many engineering courses, and that they are much more likely to thrive in collaborative environments with social interaction. Instead of competing with each other to solve problems, Redshirt Camp provides students with tasks and projects that require teamwork. Another reason why many students struggle in core courses is that often they have difficulty relating course content to their own lives; the course seems "abstract" rather than practical. To this end, real-world examples are used in each of the modules in Redshirt Camp.

Workshops: Description and Pedagogy

To continue the general techniques and principles taught at Redshirt Camp and to apply these techniques to specific course content during the semester following camp, we offer Collaborative Learning Workshops, held for two hours once a week throughout the semester. Typically workshops are held on Fridays when our engineering students have few or no class conflicts. Because we feel that "buy in" of the collaborative learning pedagogy is critical to success in the Workshops, only students who successfully completed Redshirt Camp are eligible to participate in the Workshops.

The idea behind our workshop series is that, under the guidance of a trained facilitator, students can learn core principles more efficiently by working together with their peers. Once students embrace the notion of working together, forming groups outside of class to do homework problems and to prepare for examinations, they will discover that pooling their knowledge will result in the whole (a given group) being greater than the sum of the parts (individual students). In addition, group dynamics result in students encouraging one another and, in many instances, students finding some time in a hectic schedule to relax together socially. The workshop portion of the program is not simply remediation under a new name; on the contrary, it is an honors program where the pace is challenging and students tackle problems above and beyond than the ones they are exposed to in class. Workshop facilitators are in direct communication with the faculty of the corresponding course lecture sections throughout the semester, so that continuity with the lecture material is ensured. Assignments from the course itself are not discussed in the workshops, however, and workshop facilitators do not lecture on course material. Instead, emphasis is placed on guiding students through solving advanced problems in a collaborative environment. Students are also given clear guidelines about the ethics of completing tests and graded assignments individually.

The main purpose of each workshop session is not only to reinforce core concepts, but also to guide students to teach each other and gain big-picture knowledge in the process. As students learn to incorporate collaborative learning techniques to solve challenging problems and apply them to the rest of their undergraduate coursework, they are more likely to progress to the next semester and ultimately graduate. During the collaborative learning process, students are responsible for critiquing one another's work. To do this, they must become more articulate critics than they are usually accustomed to being; they must refuse to accept an answer unless they can see why it is correct. It is not unusual at the first sessions for the students in a group to be impressed by one member who is particularly assertive, even when wrong. Nor is it atypical for several students to insist they have the same answer when they are patently at odds. The desire to agree and to be agreeable overrides their critical perceptions. As they continue, however, they learn to question and to demand explanations; then they are nearly ready to defend their own ideas.

Students are required to take responsibility for their own educational enrichment and are held accountable. Workshop attendance and promptness is required, as sporadic attendance would not only diminish the absent student's opportunity to profit from the workshop, but would also undermine the sense of community that the workshop is intended to encourage. If a student misses more than one workshop, they are not allowed to continue in the program that semester.

Results

To date, Redshirt Camps and Collaborative Learning Workshops have been held during five semesters. Data from four semesters has been compiled, and it is anticipated that data from Fall 2004 will be available by conference time. During the first four semesters (Fall 2002, Spring 2003, Fall 2003, and Spring 2004), 194 students have completed Redshirt Camps. Subsequent Collaborative Learning Workshops have had 192 successful participants (some students have completed both workshops). As a group, we have seen enhanced pass rates for our Redshirt Camp and Collaborative Learning Workshop participants in the targeted Circuits and Electromagnetics courses. Students have given overwhelmingly positive feedback about the worthiness and need of such retention programs.

We assessed pass rates (C- or better in a course) following the first four semesters Redshirt Camps and Collaborative Learning Workshops were held. Results are shown in Figure 2:

	Electromagnetics		Circuits	
	No Intervention	Intervention	No Intervention	Intervention
Fall 2002	74%	91%	61%	82%
Spring 2003	45%	77%	40%	61%
Fall 2003	Not offered		59%	75%
Spring 2004	65%	83%	58%	69%

Figure 2. Pass rates for Electromagnetics and Circuits Courses for students who did not complete the Workshops (No Intervention) and students who completed corresponding Collaborative Learning Workshops (Intervention).

We are pleased by the percentages of Workshop participants who have earned passing scores in the corresponding ECE course. Since its inception in the summer of 2002, pass rates for the Circuits course have varied between 40 and 61% for students who did not complete the program. In contrast, students who completed both Redshirt Camp and the subsequent Collaborative Learning Workshops had pass rates between 62 and 75%. The difference in pass rates has been even greater in the Electromagnetics course: non-participant participation pass rates varied between 46 and 59%, while 78 to 91% of program participants successfully completed the course.

Final course averages for students enrolled in Electromagnetics and Circuits varied depending on Workshop participation. In each semester that a Workshop was offered, Course averages for those students completing the Workshops were higher than overall the class average and the final course average of students not completing Workshops. Statistical analysis of these results is in progress, and will be presented at conference time.

Acknowledging that some bias may occur as a result of self-selection of workshop participants in these results, we turned to students' cumulative grade point averages (GPAs) prior to the semester in which they were enrolled in Electromagnetics or Circuits as a quantitative measure of their academic strength. Statistical analysis of students' cumulative GPAs was performed using a Student's T-test to compare mean GPAs of those students completing the Workshops (Intervention) to those not participating in the Workshops (No Intervention). Results are shown in Figure 3.

	Electromagnetics		Circuits	
	No Intervention	Intervention	No Intervention	Intervention
Fall 2002	2.95 (74%)	2.96 (91%)	2.88 (61%)	2.90 (82%)
Spring 2003	2.86 (45%)	3.24* (77%)	2.90 (40%)	3.07 (61%)
Fall 2003	Not offered		2.76 (59%)	3.00 (75%)
Spring 2004	2.90 (65%)	3.08 (83%)	2.88 (58%)	2.96 (69%)

Figure 3. Cumulative grade point averages of students enrolled in Electromagnetics and Circuits courses. Cumulative GPAs are shown for non-Workshop participants and those students enrolled in Workshops. Pass rates presented in Figure 2 are repeated in parentheses for clarity. GPAs are calculated on a 4.0 scale. Statistical significance of the means of students experiencing No Intervention and Intervention as determined by T-test at 95% confidence intervals are indicated with an asterisk (*).

Statistical analysis indicates that students who completed the Electromagnetics Workshop in the Spring of 2003 had significantly higher GPAs than the rest of the students enrolled in the Electromagnetics course that semester (GPAs of 3.24 vs. 2.86 on a 4.0 scale). For every other semester the Workshops were offered, no statistically significant difference was found in cumulative GPAs for students who completed the Collaborative Learning Workshop for the respective course vs. students who did not elect Workshop participation. While we remain cautious about drawing conclusions given the feasibility that the better students would generally be more inclined to seek out extracurricular opportunities and sign up for the Workshops, we are heartened by this result. We are optimistic that while in some cases "better" students (*i.e.* those with higher cumulative GPAs) may elect to participate in our retention program, the overall difference between participants and non-participants to date has not been considerable.

Conclusions

Our confidence in the success of our Redshirt Camps and subsequent Collaborative learning Workshops has grown since our last reporting[1]. With data from four semesters now available, we are in the process of evaluating final course averages to determine statistically significant differences, if they exist, between students who have completed our retention program and those who have not. Since our last reporting, we have been able to further address the issue of a possible bias resulting from the self-selection of participants by comparing the cumulative grade point averages of students who completed the Workshops to those students enrolled in the corresponding course but who did not participate in the Workshops. With the exception of students enrolled in the Electromagnetics course in the Spring of 2003, we feel confident reporting that the group electing Redshirt Camp and subsequent Workshop participation is on average no different than the rest of the students enrolled in the particular course.

While the results our retention program has produced regarding the pass rates of the sophomore level Electromagnetics and Circuits courses are encouraging, we await more rigorous statistical analysis. We also recognize that perhaps an even greater success is to be found in the change this program has effected in many participants' view of learning. Many students who have participated in Redshirt Camp have commented during exit evaluations that the techniques learned in the Camps changed their view and approach to learning not only material pertinent to electrical and computer engineering, but their education as a whole. One student commented, "I've never enjoyed learning this much before in my life." The introduction of the collaborative

learning pedagogy in the Redshirt Camps and its subsequent implementation in the Collaborative Learning Workshops may prove to have far-reaching implications beyond success in passing a particular course or obtaining an undergraduate engineering degree. We look forward to continuing program evaluation in future semesters, for students in the Department of Electrical and Computer Engineering as well Chemical Engineering and Civil Engineering majors.

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