AC 2011-1890: A LEARNING COMMUNITY FOR FIRST-YEAR ENGINEERING COURSES

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A Learning Community for First-Year Engineering Courses

Abstract

A learning community has been established for first-year students in the Department of Engineering at Colorado State University - Pueblo. Two engineering courses were linked by shared homework assignments, a robotics lab and periodical faculty meetings. A survey was developed and administered before and after the robotics lab to evaluate students' satisfaction and the knowledge gained. The results show an improvement in students' satisfaction of the overall experience. The effect of the learning community on students' learning and retention was also assessed. The positive effect of the established learning community was confirmed through higher passing rates and improved retention.

Introduction

It is well-known that the largest attrition in engineering programs in many institutions occurs during the first year of study[1-4], which impacts engineering departments in various ways, from academic performance to recruiting new students. Furthermore, as students leave an engineering program or even totally withdraw from a university, they will no longer contribute tuition and/or any other fees to the program or the university. Especially in the current economic environment, such a low retention rate will impact both the engineering program and the university on budget planning. Therefore, the high attrition rates in many undergraduate engineering programs represent a challenge for students, faculty, and administration alike. To meet this challenge, many universities and colleges in the U.S. have implemented learning communities[1] in various forms ranging from course material integration within linked courses[2, 5, 6] to fully integrated curricula for the first year students[7, 8] and living learning communities[9]. Most learning communities focus on the first-year cohorts where the attrition rates are the highest. A learning community can be functionally defined as "a broad structural innovation that can address a variety of issues from student retention to curriculum coherence, from faculty vitality to building a greater sense of community within our colleges."[1] Learning communities are more sustainable than many other educational reforms[10].

High attrition rates are even more pronounced among low-income, first-generation college students (which closely resemble the student demographics at Colorado State University - Pueblo). Engle and Tinto[11] address various obstacles to college success for low-income students. They state that "After six years, only 11 percent of low-income, first-generation students had earned bachelor's degrees compared to 55 percent of their more advantaged peers." One of their recommendations includes cohort development. Furthermore, the learning community model improves the persistence of the low-income and the first generation students[12].

A learning community is an environment that encourages student-student, and faculty-student interaction. At Colorado State University - Pueblo, a pilot learning community was initiated in the Department of Engineering in fall 2009. Two first-year courses were linked with shared homework assignments. In addition, a three-hour robotics lab was added to stimulate students' interest in engineering, to introduce students to team work, and to allow students to meet other faculty members in the program. These three items present known strategies for increasing retention.

Approach

The primary objective of the learning community at our engineering department is to improve the retention of the first-year engineering students. To fulfill such a goal, two first-year engineering courses (*Introduction to Engineering* and *Problem Solving for Engineers*) were linked. While the courses are different, both of them introduce programming concepts and programming languages to the learning community of the first-year students.

Colorado State University – Pueblo is a regional comprehensive university. All freshman students who are interested in engineering are welcomed to take a broad-based preliminary course *Introduction to Engineering* at the Department of Engineering. It was initially offered once a year in fall. Later, due to increasing enrollment, it has been offered in both fall and spring semesters since the 2009-2010 academic year. It meets for two 50-minute sessions each week during a 15-week semester. Roughly, the content is divided into two parts: lectures and labs. The primary goals of the course are fostering strong study skills, learning about the various engineering disciplines, and introducing the concepts of engineering ethics in the lecture section while introducing basic computer skills (e.g. Word, Excel and Access) and providing the students with first laboratory experience in engineering fields. Usually, about 20 to 30 percents of the students in this course are from non-engineering fields with various majors (see Table 1). The other linked course *Problem Solving for Engineers* is a more specific MATLAB-based programming course and requires an equivalent of 2 years of high school algebra as a pre-requisite. As a pilot learning community was initiated in fall 2009, the introductory course was selected as the key course due to its no-prerequisite feature.

Table 1: Students' information in the *Introduction to Engineering* course

Semester	No. of Students	No. of Engineering Students	Percentage	Non-engineering students majored in
Fall 2008	39	32	82.1%	History, Pre-Business, Business management, Sociology, Political Science, Athletic training, Physics, Chemistry, Civil Engineering Technology, Undeclared, Unclassified (Non-degree)
Fall 2009	26	19	73.1%	
Spring 2010	21	18	85.7%	
Fall 2010	39	28	71.8%	

The learning community was established first by having joint homework/lab assignments in both MATLAB and Excel. These two assignments consist of reading and manipulating data, applying formulas and then plotting the results. Both of them were engineering-related, but the difficulty levels were different. In such an arrangement, all students with various backgrounds can learn basic programming skills and understand simple engineering applications while capable students can still challenge themselves through a more difficult assignment. Second, the *Introduction to Engineering* course has a lab in which each group of students builds and programs a LEGO

Mindstorms NXT Robot to accomplish certain tasks by using the Mindstorms NXT graphical programming language (see Figure 1). In fall 2010, in the *Problem Solving for Engineers* course, a joint assignment was initially given to finish the same tasks by using MATLAB to help the students learn the differences between a text-based programming language like MATLAB and a graphical programming language like Mindstorms NXT. Furthermore, the robots built by the best team were displayed in cabinets near the classroom along with the group pictures. Third, the faculty who were involved in any of these activities met periodically to discuss the students' performance, class schedules and other related issues dealing with the learning community of first-year students.


(a) Finding parts


(b) Building a LEGO robot


(c) Programming


(d) Asking for help


(e) Testing


(f) Demo

Figure 1: Students in the robotics lab

Observations and Results

The courses *Introduction to Engineering* and *Problem Solving for Engineers* are two of the first-year engineering courses. Most students in these courses were new to each other, to the faculty and to the campus. According to the Tinto model[13], the more they interacted with their classmates and the faculty, the higher the probability they will succeed in their college study. The idea of assigning shared homework is to encourage them to communicate with other students and/or the engineering faculty members. The periodic meetings among the professors involved in the learning community also help to monitor the students' progress and offer them further assistance if necessary. About 95% of all students in these two courses took the *Introduction to Engineering* course first or during the same semester as they took the *Problem Solving for Engineers* course. The passing rate of the *Introduction to Engineering* course was used to evaluate the effects of the learning community on students' performance. Table 2 lists the passing rate information through three semesters, which shows a positive effect of the learning community on the passing rate. No other changes were made to the courses during this time period.

Table 2: The Passing Rate Comparison

	Semester	Passing rate in percentage	
		For students taking the two courses in the same semester	For students NOT taking the two courses in the same semester
Before	Fall 2008	80%	67%
After	Fall 2009	92%	92%
	Spring 2010	83%	80%
	Fall 2010	89%	80%

A survey was developed and administered before and after the robotics lab to evaluate students' satisfaction and the knowledge gained. The survey questions are listed in Table 3 and the results are shown in Figure 2 – 6 and Table 4 (1 being the lowest and 5 being the highest rating). The symbols Q1 – Q5 represent the corresponding questions listed in Table 3. Most of the average rating data in Table 4 showed the improvement except the rating for Question 1 and 2 in fall 2010 semester. Such a drop in rating may be due to a couple of reasons: a lower percentage of engineering students (see Table 1), and more students taking the post survey than the pre-survey. In any case, the overall average ratings through three semesters (listed in the last column of Table 1) for all five questions were improved.

Table 3: Survey Questions

No.	Questions
1	How excited are you about engineering?
2	How excited are you about robots?
3	How confident are you in designing robots with LEGOs?
4	How confident are you in programming robots to accomplish a given task?
5	How comfortable are you with working in a team?

In order to evaluate the variations on average ratings from a statistical point of view, five histograms were plotted in Figure 2 – 6 which show the change on each of the five questions, pooling the data from the three semesters. In Figure 2, while the histogram shows some shift to the right, indicating some increase in excitement about engineering, the difference is not statistically significant. In Figure 3, the histogram shows some shift to the right, indicating some increase in excitement about robots; however, the difference is not statistically significant. In fact, one student was unexcited about robots after the exercise. In Figure 4, the students' confidence in designing robots with LEGOs increased, and the difference is statistically significant (P=0.000). In Figure 5, the students' confidence in programming robots also increased, and the difference is again statistically significant (P=0.000). Finally the students' comfort in working in a team shows a shift to the right (see Figure 6), and the difference is significant at the 0.05 level, but not at the 0.10 level (P=0.078). The corresponding statistical results are shown in Table 4. All statistical tests were one-sided, that is, tested for an increase in average response.

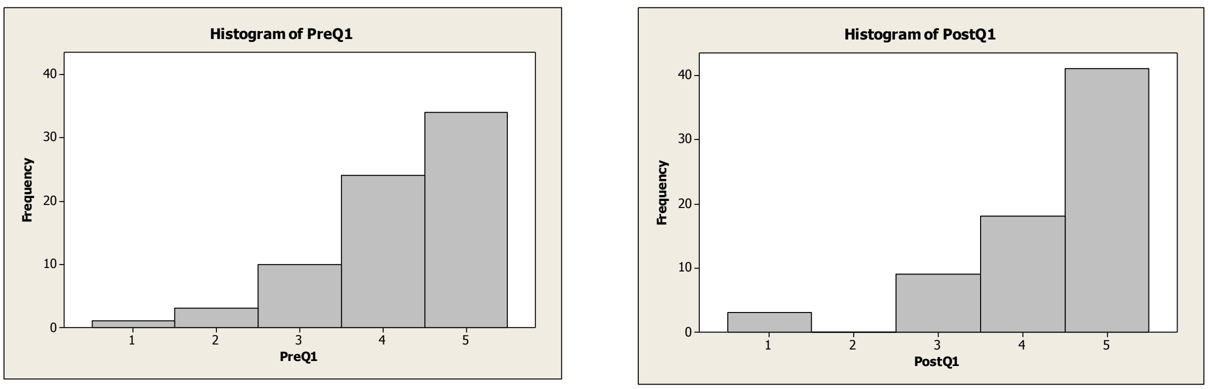

Figure 2: The histograms of Q1. Left: Pre-lab results; Right: Post-lab results.

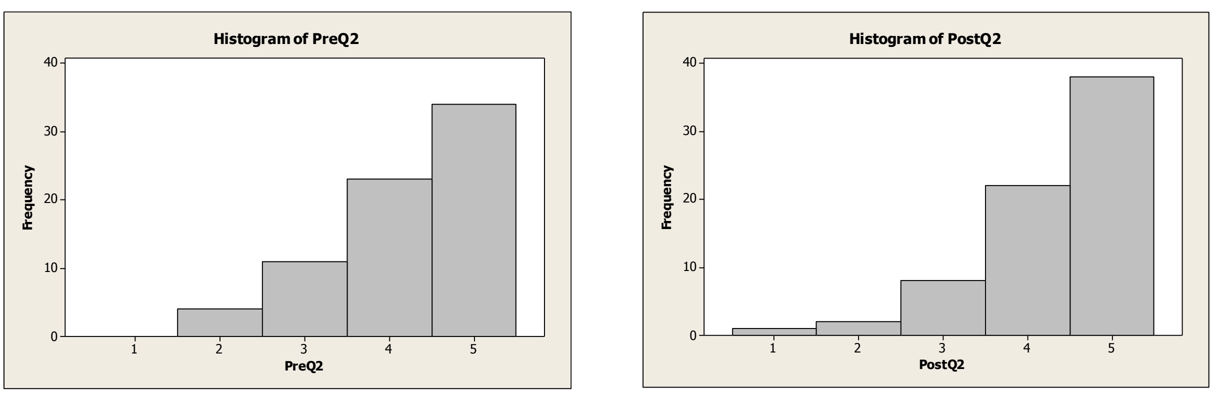

Figure 3: The histograms of Q2. Left: Pre-lab results; Right: Post-lab results.

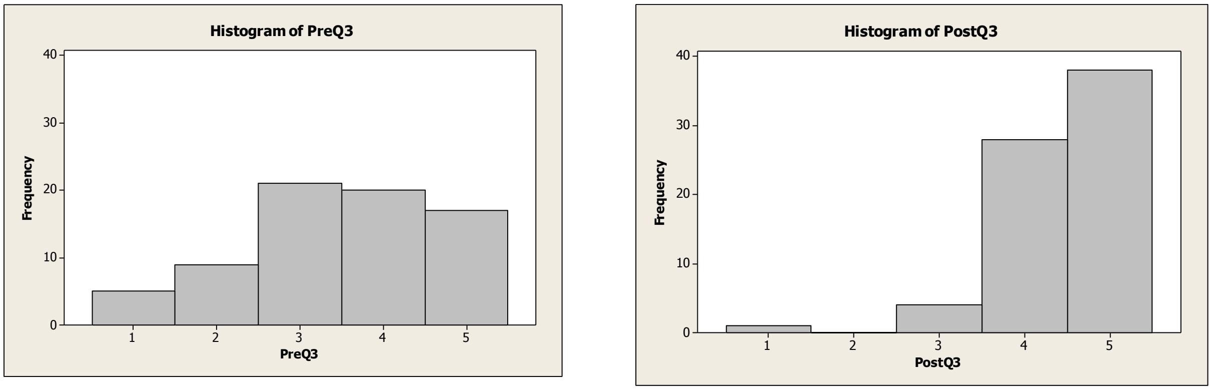

Figure 4: The histograms of Q3. Left: Pre-lab results; Right: Post-lab results.

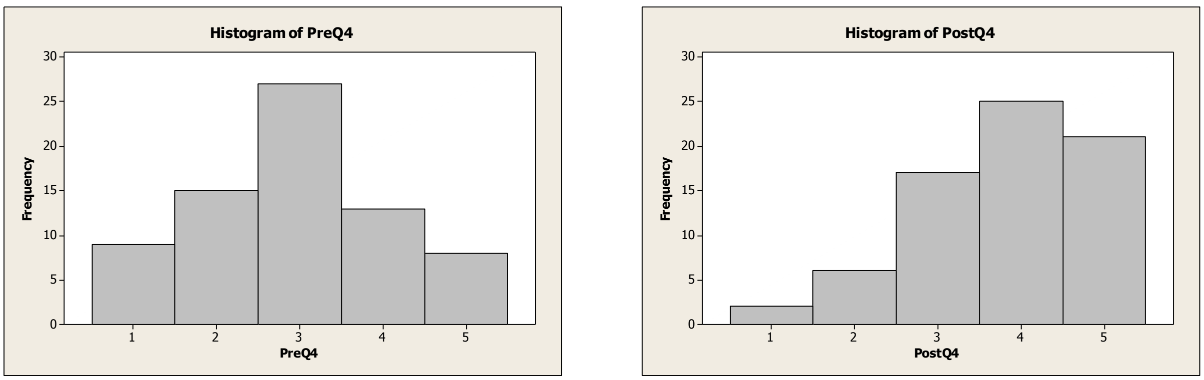

Figure 5: The histograms of Q4. Left: Pre-lab results; Right: Post-lab results.

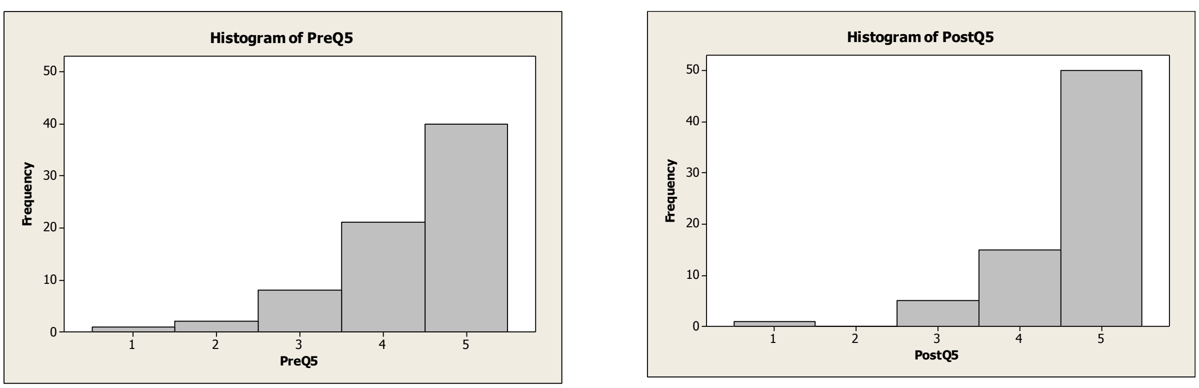

Figure 6: The histograms of Q5. Left: Pre-lab results; Right: Post-lab results.

Table 4: Survey results

	Total Students	EN Students	% in EN	Sample Size		Q1		Q2		Q3		Q4		Q5	
				Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Fall 2009	26	19	73.08%	19	16	3.58	4.13	3.89	4.19	3.37	4.38	2.95	3.94	4.21	4.44
P value							0.083		0.213		0.005		0.009		0.272
Spring 2010	21	18	85.71%	17	17	4.47	4.76	4.24	4.65	3.53	4.71	3.12	4.18	4.24	4.82
P value							0.098		0.034		0.001		0.002		0.025
Fall 2010	39	28	71.79%	36	38	4.42	4.21	4.36	4.24	3.53	4.34	2.86	3.58	4.47	4.55
P value							0.833		0.725		0.000		0.004		0.304
Pooled data	86	65		72	71	4.21	4.32	4.21	4.32	3.49	4.44	2.94	3.80	4.35	4.59
P value							0.475		0.442		0.000		0.000		0.078

Retention is another key issue that needs to be investigated. In this paper, the retention rate was calculated based on the numbers of engineering students in the *Introduction to Engineering* course, and their major changing information after one semester (see Table 5). Since the spring 2011 semester just began, the data for the retention rate related to the fall 2010 semester could not be collected and were not included in the table. The retention rates since launching the learning community in the fall 2009 semester have improved from 84% (fall 2008) to 89% (fall 2009) and 94% (spring 2010).

Table 5: Retention

	Semester	During the course		After one semester			
		No. of students	No. of EN students	Leave the Dept.	Leave the institution	Switch to EN majors	Retention (%)
Before	Fall 2008	39	32	3	3	1	84%
After	Fall 2009	26	19	2	0	0	89%
	Spring 2010	21	18	0	2	1	94%

Conclusion

A learning community was created by linking homework assignments of two first-year engineering courses, by introducing a robotics lab and by periodical faculty meetings. The survey results for the robotic lab showed an improvement in students' satisfaction of the overall experience. The passing rate in the *Introduction to Engineering* course was used to assess students' performance. The positive effect of the learning community was confirmed through the higher passing rates and the improved retention.

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