THE EFFECT OF COURSE SEQUENCE ON THE RETENTION OF FRESHMEN ENGINEERING STUDENTS: WHEN SHOULD THE INTRO ENGINEERING COURSE BE OFFERRED?

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ABSTRACT

ECE 100, Introduction to Engineering Design, is required of all students in the College of Engineering and Applied Sciences (CEAS) students at Arizona State University (ASU). Due to space and staffing constraints, approximately half of the students entering in the fall take the course during their first semester and the other half does so during their second semester in the spring. Most of the students who take ECE 100 in the spring do not take any engineering course in their first semester.

Studies done when the introductory course was in a different format, suggested that if engineering students took the introductory engineering course during their first semester, their rate of retention was higher than for those who took the course in the spring. In a recent study, it was shown that the retention rate of the fall 95 first-time, full-time freshmen (FFF) in ECE 100 their first semester had a higher retention rate one year later than the average FFF in the CEAS. The question is, "Are new students retained at a higher percent if they take the ECE 100 in their first semester?"

ECE 100 students were surveyed in the fall 95 and spring 96 semesters. Surprisingly, for all groups: men, women, and minority students, retention was higher after two years for those students who took ECE 100 in the spring. This difference was significant for the male students. Among FFF students, while men did better taking ECE 100 in the spring, women and minority students showed a trend of higher retention by taking ECE 100 in the fall. This trend would suggest that special programs for FFF women and minority students, not in ECE 100 in the fall, might help increase retention.

Introduction

Much attention has been given in the last few years to the retention of freshman engineering students. For example, Besterfield-Sacre, Atman, and Shuman did an extensive study on models for determining student attrition in engineering [1]. They found that freshman engineering students who left the program in good standing had a lower appreciation of the engineering profession, had less confidence to succeed in engineering, had more confidence in their communication skills, and were a little more influenced by family to study engineering than those students who remained in the progam. Moller-Wong and Eide developed an engineering student retention model and urged other engineering schools to understand why some engineering students stay and some leave [2]. There are many factors to be considered that impact engineering student retention. The positive effects of a learning community program on first year engineering students have been studied [3]. The design of an Introductory Engineering Course is important not only for its engineering content [4], but also for its ability to retain the beginning engineering student [5].

An additional factor to retaining freshman engineering students is whether they are directly exposed to engineering only one or both semesters. Carnegie Mellon University, for instance, requires each student in the engineering college to complete introductory courses from two departments [6]. Theoretically, the freshman engineering student would be in an engineering course the first two semesters. A special course was designed by Porter and Fuller [7] to give first year students a taste of engineering thought processes and problem solving methods in the first semester on campus. An express purpose of their course is to make sure that students do not leave engineering without ever experiencing the challenge and reward of solving an engineering problem. Mix and Balda [8] developed a special introductory electrical engineering course to help create a sense of belonging for their freshman students in their first semester. Budny, Bjedov and LeBold [9] studied the direct correlation between graduation and the first semester GPA, as well as the impact on retention of when a student takes a particular math class.

ECE 100, Introduction to Engineering Design, a four credit hour semester course, is an introduction to engineering design philosophy and methodology. This course is required of all freshmen students in the College of Engineering and Applied Sciences (CEAS) at Arizona State University (ASU). Each semester it is taught in three large lecture sections of up to 160 students for two hours a week, then in a lab section of 80 students for two hours a week, and then in another lab section of 40 students for two hours a week. Due to space and staffing constraints, approximately half of the entering students in the CEAS take ECE 100 during the fall semester and the other half does so during the spring semester. The spring ECE 100 students are also joined by many students who have transferred to the CEAS in the spring. Most of the students who take ECE 100 in the

spring do not take any engineering course in their first semester.

In a previous study, it was shown that the retention rate of first-time, full-time freshmen (FFF) in ECE their first semester (fall 1995) had a higher retention rate one year later than the average FFF in the CEAS [10]. Studies done when the introductory engineering course was in a different format, suggested that if engineering students took the introductory course during their first (fall) semester, their rate of retention was higher than those who did not. The purpose of this paper then is to compare the retention rate of fall first-time freshmen taking the present ECE 100 course in the fall to those fall first-time freshmen who did not take ECE 100 until their spring semester. In addition, the retention of all students who took ECE 100 during the 95-96 academic year will be compared relative to the semester in which they took ECE 100.

First Year Engineering Student Survey

Beginning in fall 1995, a First Year Engineering Student Survey has been given to the ECE 100 class each semester late fall and early spring. This survey queried basic demographics, such as gender, ethnicity, age, and whether the student was a community college or university transfer. In addition, the survey queried when the student decided on engineering, why he/she chose engineering, why ASU was chosen, and several predictions. The students were asked to predict: graduation from the CEAS, graduation from ASU (not the CEAS), a change of major within the CEAS, failure of one or more classes, receiving tutoring help for a specific course, requiring more than four years to graduate, and transfer to another college or university. Some results of the survey given in the fall 95 were reported in previous papers [10], [11]. Note that the size of survey samples vary since not all students responded to each question.

The survey results were compared each semester between those who gave their id (optional) and those who did not (70% did each semester). Although there were a few differences in the predictions to seek tutoring help, to change majors within the CEAS, and to fail one or more classes; there was no difference in their prediction of graduation from the CEAS. The confidence level of graduation has been positively correlated with retention in previous studies [12]. Therefore it is reasonable to assume, in general, that the retention of the no id students would be approximately the same as the good id students.

Throughout this paper, p-values will be given so that the reader can determine how significant the data are without imposing a preselected level of significance. In general, we are testing to see if the means of two populations are the same or, in other cases, if the category breakdown of two populations is the same. A p=.05 indicates that there is only a 5% chance that the two populations are the same based on the sample data [13].

Demographic Comparison

The question is, "Are new students retained at a higher percent if they take ECE in their first semester?" Since enrollment in the ECE 100 course is on a first-come, first-served basis, the demographics of the two student groups will be examined for differences. The gender, ethnicity, age, and source of transfer of all students who took ECE 100 in the fall of 1995 were compared with those who took the course in the spring of 1996.

There is no statistical difference between the two semesters with regard to gender distribution. The ethnic breakdown differs between the two semesters at a level of p=.065. The percentage of underrepresented minority (African American, Hispanic, and Native American) students is significant at the p=.151 level. Between the two semesters, the average age of the men is insignificant, while the women in the spring class are younger (p=.062: t-test, unequal variances). The distribution of ECE 100 students each semester who came to the CEAS from high school, a community college, a university, or both is statistically significant with p=.017.

The percentage of transfer students from the community college in the spring survey is slightly lower than in the fall (p=.156). However, in the spring, the percentage of transfer students from a university is very significantly higher than in the fall (p=.002). Although the percentage of community college male transfers is not significantly different in the two semesters, the increase in percentage of male transfers from a university during the spring semester is highly significant (p=.008). There is a lower percentage of women transfers from a community college (p=.027) and a higher percentage from a university (p=.149) for the spring semester.

The grade points and number of transfer hours were self-reported. Although the number of transfer hours is approximately the same for the two semesters, the GPA average for community college transfers is very significantly (p=.005) lower in the spring. There is no significant difference in the average grades for the two semesters among the university transfers. Significantly lower transfer grades in the spring semester were reported by men from community colleges (p=.048) and nearly significantly lower transfer grades were reported by underrepresented minority students who had transferred from a university (p=.057).

Among the 146 fall survey CEAS students with good ids, 64 (43.84%) are FFF. Among the 126 spring survey students with good ids, only 45 (36.6%) are CEAS FFF. Among the 176 spring students, 119 (67.61%) are new students to ASU that semester.

Prediction of Graduation

Confidence in graduating is considered to be an indicator of retention [12]. This was shown in both the fall and spring surveys. Those students who were retained to fall 96 had a

	FALL 1995		SPRING 1996		p
	QUANTITY	% OF ALL	QUANTITY	% OF ALL	
ALL RECORDS	251	100.00%	263	100.00%	
Men	196	78.09%	205	77.95%	1.00[a]
Women	55	21.91%	58	22.05%	
ETHNICITY					
Asian	20	7.97%	29	11.03%	0.065
African American	5	1.99%	10	3.80%	
Hispanic	26	10.36%	27	10.27%	
Native American	5	1.99%	13	4.94%	
White	190	75.70%	172	65.40%	
Other			7	2.66%	
Blank	5	1.99%	5	1.90%	
Underrepresented Minorities.	36	14.34%	50	19.01%	0.151
AVERAGE AGE**					
Men	20.38		20.35		0.935
Women	20.81		19.43		0.062
TRANSFER FROM					
HS: <12 TRANSFER HRS	156	62.15%	166	63.12%	0.017[b]
Comm. College Only	74	29.48%	51	19.39%	
University Only	21	8.67%	34	12.93%	
Both CC and Univ.	0	0%	12	4.56%	

Table 1. - Demographic Data on Gender, Ethnicity, and Transfer Source Summary for Survey Students in Fall 1995 and Spring 1996
a - With Yates' correction
b - 3x2 table with "Both CC and University" distributed between "CC only" and "University only"

higher confidence in graduation than those students who had left the CEAS by fall 96. The differences are significant with p=.001 in the fall and p=.0004 in the spring survey. See Table 2. The most significant difference in confidence in graduation in the spring survey is shown by the women who were still enrolled in fall 96 and those women who were not (p=.077 with Yates' correction). In addition, the confidence in graduation breakdown by category is not significantly different between the two semesters for any group including all, men, women, minority, and non-minority students.

If we examine the graduation predictions for fall FFF only, we find that they are not significantly different between the students who were still enrolled in the CEAS in fall 96 and those who had left. This is true whether the fall FFF took ECE 100 in the fall or in the spring. Confidence in graduation from the CEAS is more of an indicator of one year retention (p=.198) for the fall ECE 100 students than the spring ECE 100 students (p=1.00).

If we consider just women, men, or minority students, there is no statistical difference in the predictions by those who stayed or left in each category. Those groups with a trend are women in the fall survey (p=.182) and minority students in the spring survey (p=.170). The statistical difference in the prediction of graduation between women and men in fall 95 is nearly significant (p=.059). If we consider the predictions of all FFF women versus men (fall and spring), the difference is significant at the p=.054 level. Consistent with previous research, the women were not as confident as the men in graduating from the CEAS. However, there is little difference between the predictions of men and women in the spring (p=.422). Although there is no difference in the predictions between minority and non-minority students in the fall (p=1.0), there is a near significant difference in the spring (p=.055). While the confidence level in CEAS graduation is the same for women in the fall and in the spring (p=1.0), the confidence level for minority students is lower in the spring (p=.170). There is no significant difference in the confidence of the men between semesters (p=.310).

Grades in ECE 100 and the First Math Class

The grades earned in ECE 100 by the students who were retained in the CEAS to fall 96 are very significantly different from the students who left the CEAS by fall 96. The difference is p=.0003 for the fall semester and p=.0006 for the spring semester. There is no significant difference (p=.367) in the ECE 100 grade distribution for fall and spring for those students who left the CEAS by fall 96. However, there is a near significant difference (p=.066) in the grade distribution for the two semesters for those students still in the CEAS in fall 96. See Table 3. Nearly 92% of the fall students received an A or a B, while only 83.2% of the spring students did. If we consider only the fall FFF who took ECE 100 in the fall, the ECE 100 grades are significantly different between those who stayed in the CEAS for fall 96 and those who left (p=.0047). See Table 4.

Graduation from CEAS: Id Students	Fall 95 All			Spring 96 All		
	Still CEAS (n=112)	Left CEAS (n=32)	p	Still CEAS (n=105)	Left CEAS (n=18)	p
Very good chance	82.1%	50.0%	0.001[a]	81.0%	50.0%	0.0004[a]
Some chance	14.3%	37.5%		17.1%	27.8%	
Very little chance	2.7%	9.4%		1.0%	5.6%	
No chance	0.9%	3.13%		1.0%	5.6%	
Really Don't Know				0.0%	5.6%	

Table 2. Prediction of Graduation by ID students Still CEAS (F96) vs. Left CEAS (F96) based on F95 CEAS status
a – with categories pooled

The grades in the math classes taken in fall 95 are significantly different for those fall 95 FFF students that stayed and those who left the CEAS by fall 96. The difference is significant with p=.014 for the fall survey students and p=.141 for the spring survey students. See Table 5. If we consider the first math class taken by females in ECE 100 in the fall, of those who stayed in the CEAS, 70% received A's, while no females that left the CEAS got an A. Similarly for males, over 60% of the students who stayed earned an A in their math class, while only 21% of those who left earned an A. Nearly 78% of the minority students who stayed received an A, while the one minority student that left received a D. Among the fall FFF females who took ECE 100 in the spring, 10 out of 11 received an A or a B in their first math class, while only one of the three females who left the CEAS had an A or a B. For minority

students, 5 of 9 students had an A or B, while the two minority students who left the CEAS had a C and an E.

Fall versus Spring Retention

The basic question is, "Do students who take ECE 100 in the fall retain at a higher rate than students who take ECE 100 in the spring?" This study of retention was limited to students who gave a good id on each survey. There is a difference between the retention of the two groups. However, contrary to previous studies, the retention rate was higher for the students who took ECE 100 in the spring than for those who took ECE 100 in the fall. The retention rate of the spring men after two years was 72.3% versus 53.7% for men who took ECE 100 in the fall (p=.004). It should be noted that the retention rates are higher for those students who took ECE 100 in the spring for all groups: all, men, women, minority, and non-minority students. See Table 6.

The retention rate after one year for fall 95 FFF was 71.9% for those students who took ECE 100 in the fall and 77.8% for the spring students (p=.481). This gap widened by the end of the second year to only 53.1% retention for the fall students and 64.4% for the spring students (p=.233). This difference is again most significant among the male students. The men who took ECE 100 in the spring were retained at a higher rate than those who took the course in the fall (p=.172 after one year and p=.041 after two years). However, it is very interesting to note that for FFF women the retention rate is higher after one and two years for the students who took ECE 100 in the fall. Minority students were retained at a slightly higher percent after one year if ECE 100 was taken in the fall. However, after two years, the retention rate was higher for those minority students who took ECE 100 in the fall. These differences are not significant for women or minority students, primarily due to the small sample sizes, but there is a trend that is worth watching in future studies. For example, after one year, the retention of FFF women was 76.9% for fall semester students and only 60.0% for spring students. The gap widened after two years, when fall FFF women were retained at 76.9% and the spring women at 50%. To obtain a perspective on the percentages, if the sample sizes had

Grade Earned	ECE 100: Introduction to Engineering					
	Fall 95			Spring 96		
	Still CEAS (n=112)	Left CEAS (n=32)	p	Still CEAS (n=108)	Left CEAS (n=18)	p
A	43.8%	34.4%	0.0003[a]	35.2%	33.3%	0.0006[a]
B	48.8%	28.1%		48.0%	11.1%	
C	6.3%	21.9%		14.8%	22.2%	
D	0.9%	12.5%		0.9%	5.6%	
E	0.9%	3.1%		2.8%	16.7%	
W	0.0%	0.0%		1.9%	11.1%	

Table 3. Comparison of F95 & SP96 ECE 100 Grades for Good IDS/CEAS (F95) Still CEAS (F96) vs. Left CEAS (F96)
a– last three categories pooled

Grade Earned	ECE 100 Grades for First Time Full Time Freshman					
	Fall 95			Spring 96		
	Still CEAS (n= 46)	Left CEAS (n=18)	p	Still CEAS (n=35)	Left CEAS (n = 10)	p
A	47.83%	38.89%	0.0047[a]	40.00%	50.00%	0.0678[a]
B	45.65%	22.22%		45.71%	10.00%	
C	6.52%	16.67%		11.43%	20.00%	
D	0.00%	16.67%		0.00%	0.00%	
E	0.00%	5.56%		2.86%	20.00%	
W	0.00%	0.00%		0.00%	0.00%	

Table 4. Comparison of F95 & SP96 ECE 100 grades for Good IDS/CEAS (F95)/FFF Still CEAS (F96) vs. Left CEAS (F96)
a – last four categories pooled

Grade Earned Fall 1995	Math Grades for First Time Full Time Freshman					
	Fall 95			Spring 96		
	Still CEAS (n= 43)	Left CEAS (n=17)	p	Still CEAS (n=35)	Left CEAS (n = 8)	p
A	39.53%	5.88%	0.014[a]	48.57%	12.50%	0.141[a]
B	25.58%	17.65%		28.57%	37.50%	
C	18.60%	23.53%		14.29%	25.00%	
D	4.65%	17.65%		8.57%	12.50%	
E	4.65%	17.65%		0.00%	12.50%	
W	6.98%	17.65%		0.00%	0.00%	

Table 5. Comparison of F95 & SP96 Math Grades for Good IDS/CEAS (F95)/FFF Still CEAS (F96) vs. Left CEAS (F96)
a – categories pooled, some cells were less than 5 Note: These students took only one math class during the F95 semester

ENROLLED	ALL			MEN			WOMEN			MINORITY			NON-MINORITY		
	F95 (n=144)	SP96 (n=126)	p	F95 (n=108)	SP96 (n=101)	p	F95 n(n=36)	SP96 (n=25)	p	F95 (n=21)	SP96 (n=29)	p	F95 (n=123)	SP96 (n=97)	p
SPRING 96	88.9%	96.0%		90.7%	96.0%		83.3%	96.0%		95.2%	96.6%		87.8%	95.9%	
FALL 96	77.8%	85.7%	0.090	76.9%	87.1%	0.052	80.6%	80.0%	0.954	81.0%	89.7%	0.396	77.2%	84.5%	0.166
SPRING 97	60.4%	75.4%		57.4%	75.2%		69.4%	76.0%		52.4%	75.9%		61.8%	75.3%	
FALL 97	57.6%	72.2%	0.011	53.7%	72.3%	0.004	69.4%	72.0%	0.826	57.1%	75.9%	0.161	57.7%	71.1%	0.036

Table 6. Comparison of One and Two Year Retention Rates of students by ECE 100 semester and by gender and ethnicity

ENROLLED	FFF ALL			FFF MEN			FFF WOMEN			FFF MINORITY			FFF NON-MINORITY		
	F95 (n=64)	SP96 (n=45)	p	F95 (n=51)	SP96 (n=35)	p	F95n (n=13)	SP96 (n=10)	p	F95 (n=9)	SP96 (n=11)	p	F95 (n=55)	SP96 (n=34)	p
SPRING 96	93.8%	95.6%		96.1%	97.1%		84.6%	90.0%		100.0%	100.0%		92.7%	94.1%	
FALL 96	71.9%	77.8%	0.481	70.6%	82.9%	0.172	76.9%	60.0%	0.374	88.9%	81.8%	0.650	69.1%	76.5%	0.440
SPRING 97	56.3%	64.4%		51.0%	68.6%		76.9%	50.0%		55.6%	54.5%		56.4%	67.6%	
FALL 97	53.1%	64.4%	0.233	47.1%	68.6%	0.041	76.9%	50.0%	0.171	66.7%	54.5%	0.575	50.9%	67.6%	0.111

Table 7. Comparison of One and Two Year Retention Rates of FFF by ECE 100 semester and by gender and ethnicity

been 50 for each group, we would have p=.064 and p=.0036 for the one and two year significance. If the sample sizes has been 100, we would have p=.0089 and p=.00004. Similarly, with the minority students, although there was not a significant difference between the two survey groups in retention after one year, the difference of 88.9% and 81.8% would have been significant at p=.154 after one year for samples of size 100. The difference of 66.7% and 54.5% retention after two years is not significant at the p=.545 level. After two years, for samples of size 100, the significance level would be p=.075. See Table 7.

Discussion

The purpose of this study was to determine if new CEAS students were retained differentially by their enrollment in ECE 100 in the fall or in the spring. Since enrollment in the fall ECE 100 course is on a first-come, first-served basis, the demographics of the two student groups were analyzed to determine if they were indeed different.

In both the fall and spring surveys, the students who were retained to fall 96 had a higher confidence in graduation than those students who had left the CEAS by fall 96 (p=.001 and p=.0004, respectively). However, the graduation predictions of the FFF students who were still in the CEAS in fall 96 were no different than the predictions of those who had left the CEAS by fall 96. Consistent with previous research, the women were not as confident as the men in graduating from the CEAS. In the spring the minority students were less confident about graduation than the non-minorities (p=.055) and less confident than the minority students in the fall (p=.170).

The grades earned in ECE 100 were very significantly different for the students who were retained or not retained in the CEAS for fall 96. This is to be expected since the grading in the course is well spelled out as to what students need to do to "meet expectations" or "exceed expectations." There was a near significant difference (p=.066) in the grade distribution for the two semesters for those students still in the CEAS in fall 96. The grades were somewhat lower in the spring semester (less A's and more C's). The FFF who were retained had significantly or near significantly different ECE 100 grades than those of the FFF students who were not retained (p=.0047 for fall and p=.0678 for spring). Although some of the lab instructors changed in the spring semester, the same two professors coached the ECE 100 course in both fall and spring. Therefore, there is no reason to believe that the course demands were different in the two semesters.

The grades in the math classes taken in fall 95 were significantly different for those fall 95 FFF students that stayed and those who left the CEAS by fall 96. The difference was significant with p=.014 for the fall survey students and p=.141 for the spring survey students. In general, the students who stayed in the CEAS received A's or B's in their first math class, while those who left the CEAS received C's or lower. This was particularly true for the women and minority FFF students.

It was expected that the retention rate of students, in general, and FFF students, in particular, would be higher for those students who took ECE 100 in the fall. This expectation was based on past comparisons of ECE 100 students in the fall and spring semesters, lower GPA transfer grades for spring students, and the fact that most students in their second semester would have a harder academic load. However, this study showed that all students, and FFF freshmen, in particular, who took the course in the spring were retained at a higher rate than those students who took the course in the fall (77.8% for spring and 71.9% for fall). Both of these retention rates are considerably higher than the 54% retention rate reported by the University for the fall 95 FFF students in the CEAS. For an explanation of the higher spring retention rate, we note that since some students leave after one semester, there had already been some filtering of the students who took the ECE 100 in the spring. Also there were more transfer students in the spring survey. It is known that transfer students are retained at a higher percent than FFF since there has already been filtering before the student transfers. As noted before, the retention rate gap widened for the fall 95 FFF after two years: 53.1% for fall

ECE 100 students and 64.4% for the spring ECE 100 students.

An unexpected trend was shown in the retention rate for FFF women and underrepresented minority students. Contrary to the groups of "all" and "men," women and minority students were retained at a higher rate after both one year and two years, if they took the ECE 100 course in the fall. Since women and minority students tend to feel isolated in engineering due to their low numbers, perhaps not taking an engineering course during their first semester intensifies this problem. This suggests then, that special retention programs may be helpful especially for freshmen women and minority students who are not enrolled in ECE 100 in the fall. At the same time, men, taking ECE 100 in the fall, may be helped by additional mentoring or tutoring.

Conclusions and Future Research

The results of this analysis, loosely summarized, would suggest that the new men students take ECE in their second semester. However, if new women and minority students took ECE 100 in their first semester, they would have a better chance of retention. Alternatives to this decision would be to split ECE 100 into two semesters or to add an additional Introduction to Engineering course that would be available during their first year in the semester that a student is not taking ECE 100.

The retention rates of the survey students will be followed to graduation. In addition, surveys are being made of the ECE 100 course each semester. The trends indicated by the study of the 95-96 students, especially the women and minority FFF students, will be followed in the subsequent surveys. The trends indicated in this paper could be further validated or disproved by using historical records independent of the surveys.

This paper raises the question if the content and process by which the material in ECE is presented has a bias that favors one demographic group over others. Is the content in ECE 100 received more favorably by certain students at particular times in their academic careers? Are women and minority students better retained in engineering if they are exposed in their first semester to the teamwork and projects required in ECE 100 rather than experiencing a full semester of course work on non-engineering subjects taught by non-engineering faculty? Future research includes the formation of inclusive learning communities especially for freshman women and minority students who are not enrolled in ECE 100 their first semester. Their retention will be tracked and compared to control groups.

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