Understanding Freshman Engineering Student Retention through a Survey

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Abstract

It is easier to retain a student than to recruit one. Yet, retention of engineering students is difficult. Although the retention rate of engineering students in the College of Engineering and Applied Sciences (CEAS) at Arizona State University (ASU) of beginning full-time, first-time freshman engineering is about the same as freshman in all units at ASU, some of the engineering freshman change to other disciplines in the university. Many beginning freshmen engineering students do not have much understanding of an engineering career. Engineering is not a topic taught in middle schools or high schools. Students may choose engineering because someone told them their good math skills qualified them for an engineering career or because they were aware that engineers make good salaries. Obviously engineering is not for everyone and there will always be some engineering students who determine that they really do not want to be an engineer. However, many other students may like the engineering curriculum, but because they do not see the relevance of the beginning engineering courses, may drop out during or after the first year.

A survey was made of freshman engineering students to enable us to better understand our students. The survey was given at the end of the semester to the students in the introductory engineering class. The students were asked to select and to rank the top three statements from a list that best described their reasons for choosing engineering or an applied science.

This paper includes an analysis of why our students chose to study engineering or construction and also a discussion on any correlations between the reasons that the students chose CEAS and their retention in CEAS or the university after one year. Of particular interest is how the results of the analysis can be used to guide recruitment and retention efforts of our engineering students, particularly women and underrepresented minorities. The surveys, although developed for ASU, can be customized for any individual institution.

Introduction

The retention of engineering students is a difficult problem. Of those that enter the curriculum, on average, only about half finish. Since engineering requirements for admission are often higher than average, more should be succeeding[1]. However, the engineering curriculum is very demanding and students may leave due to poor academic performance or conclude that the heavy demand of the curriculum is not worth a continued effort. Many beginning freshmen engineering students do not have much understanding of an engineering career. Engineering is not a topic taught in middle school or high school. Students may choose engineering because someone told them their good math skills qualified them for an engineering career or because they were aware

that engineers make good salaries. Obviously engineering is not for everyone and there will always be some engineering students who determine that they really do not want to be an engineer. However, many other students may like the engineering curriculum, but because they do not see the relevance of the beginning engineering courses, may drop out during or after the first year.

The retention rate (approximately 69%) of full-time, first-time freshman students in the College of Engineering and Applied Sciences (CEAS, consisting of the School of Engineering and the Del E. Webb School of Construction (DEWSC)) is about the same as freshman in all units at Arizona State University (ASU). However, some of the CEAS freshman (10%) change to other disciplines in the University during or just after the first year[2]. Therefore, in the CEAS, the freshman retention rate is about 60%. These rates are not inconsistent with those of other similar engineering schools, but represents a large loss of potential engineers. In addition, the 70% university retention rate is well below the ASU goal of 78% freshmen retention by the Fall of 1999. In this time of increased accountability for educational budgets, retention metrics, including freshman retention and graduation rates, are very important and are being monitored by our Board of Regents. Finally, as a college we are responsible for providing an adequate diverse engineering supply to our industry partners.

ASU is a commuter school of some 43,000 students. We have nearly 5,200 students in the CEAS[3]. There are many choices for a change of major in the university, including liberal arts, business, or some other college and to make such a change is quite easy. In many cases the student is switching from a highly structured and rigorous field to a field requiring less extensive prerequisite knowledge[4]. We take recruitment and retention activities seriously. An Associate Dean of Student Affairs and Special Programs has a major responsibility for the recruitment and retention of students, including support for student organizations. Very active recruitment and retention programs under this office include: Recruitment, Women in Applied Science and Engineering (WISE), and an Office of Minority Engineering Programs (OMEP), which includes an area director for a Mathematics, Engineering, and Science Achievement (MESA) Program at the pre-college level.

The high attrition rate in engineering is even more severe for women and underrepresented minorities. Although the enrollment of minority freshmen in engineering schools has increased more than six-fold during the last two decades, their attrition rate is still very high[5]. The most common metrics used for student retention are the freshman retention rate and graduation rates for a freshman class after five years. The graduation rate for underrepresented minority students, namely African Americans, Hispanics and Native Americans, is much lower than that of non-minorities. The average graduate rate of underrepresented minority students for the freshman classes that entered a sample of 112 institutions between 1986 and 1989 was 35.0 percent (all disciplines). ASU was not included in this sample because graduation rates are very sensitive to an influx of transfer students and ASU has a high percentage of transfer students. This rate has remained the same as for students graduating in the 1980's. However, during the same time period, the graduation rate of non-minority students declined 9.1 percent to 59.3 percent[5].

Although percentage-wise more female first-time, full-time CEAS freshmen graduate from ASU, a smaller percent graduates from CEAS. For example, in seven years, 57.5% of the female first-

time, full-time freshman who entered in Fall 1988 had graduated from ASU, while only 46.8% of the men had graduated by that time. However, only 26.9% of the women had graduated from CEAS, while 28.9% of the men had. For the Fall 1987 freshman CEAS class, only 26.2% of the women had graduated from CEAS by Fall 1995 and 35.8% of the men had graduated[2].

Understanding the Retention Problem

A study on the retention of minority and non-minority students was conducted by the National Action Council for Minorities in Engineering, Inc. (NACME)[5]. The retention in engineering institutions was examined relative to five characteristics: (1) institutional control (public versus private); (2) college cost; (3) selectivity; (4) number of accredited engineering programs; and (5) number of student support programs. Selectivity was found to be the most important predictor of degree attainment for both minority and non-minority engineering students. Selectivity ratings are self assessments made by each college based on three criteria: percentage of applicants accepted, high school class rank and standardized test scores of freshmen who actually enrolled in the institution. The more selective the institution, the higher the graduation rate is for both minority and non-minority students[5]. For example, ASU accepts 80% of its applicants, has 23% of its freshman rank in the top 10% of their high school class, and the SAT 25th-75th percentile was 960-1200. These conclusions are backed by the U.S. News & World Report study of colleges. Schools with lower acceptance rates and larger percentages of top high school students than ASU have better retention rates, in general[6].

The NACME researchers interviewed the administrators at the most successful institutions to suggest other factors that impact retention. Six key actions were identified: (1) strong institutional commitment as measured by attitudes of faculty and staff, integral minority engineering programs, and allocation of resources; (2) focus on removing barriers to student success; (3) involvement of the corporate community; (4) precollege development of potential engineering students; (5) summer bridge programs; and (6) special attention to early success of freshmen[5]. In addition, exemplary schools attributed their success to specially designed programs. The institutions "looked inward to analyze and better understand their own culture, to focus on their undergraduate education mission, and to develop specific adaptations to make their institutions more effective with all students"[5]. The strongest models of retention efforts for minorities and women were found in schools of engineering. No specific retention efforts were identified for freshman and sophomore undergraduate students interested in science[7].

A study designed to determine the relative importance of factors contributing to career choice and persistence in undergraduate education surveyed students on seven college campuses. They included students in their study both that had switched out of Science, Mathematics, and Engineering (SME) and students who had not switched. The top five factors ranked by importance among students who switched majors were the same for men and women, although not in the same order of importance. The top five factors in decreasing order of importance for women were: (1) reasons for choice of SME major prove inappropriate; (2) poor teaching by SME faculty; (3) inadequate advising or help with academic problems; (4) non-SME major offers better education/more interest; and (5) lack of/loss of interest in SME: "turned off science." These same five factors were ranked by men in a 2, 1, 3, 5, and 4 order[8]. It is of value then to identify what the major reasons are for the choice of engineering by our students.

Designing the Survey

The research supports the importance of studying our students to better understand them and to design appropriate support and intervention programs to increase our retention and graduation rates. To better understand our freshman engineering students, a survey was made of freshman engineering students. The survey was given at the end of the Fall 1995 semester to the students in the introductory engineering core class. The survey was also given near the beginning of Spring 1996 semester to the students in the introductory engineering class. The survey captured some general demographics on the students, including work commitments, information about engineering role models, when engineering was chosen, why ASU was chosen, and recruitment participation and effectiveness. These topics are covered in another paper[3].

Of particular interest here is the survey question that asked the students to select and to rank the top three statements from a list that best described their reasons for choosing engineering or an applied science. The list of statements was compiled from a pilot survey in which students gave their main reasons for choosing engineering in answer to an open ended question[9]. To be able to conduct longitudinal retention studies on the students and to compare predictions with performance, the participating students were asked to volunteer their student ID. The question form used in the Fall 1995 survey was the most successful of three forms that had been used in a pilot survey[9].

Survey Results

In the Fall of 1995, there were 444 first-time freshmen enrolled in the College of Engineering and 15 first-time freshmen enrolled in the DEWSC. There were also 106 new freshmen and sophomore transfers in Engineering and 8 in the DEWSC. In the Spring of 1996, additional new freshmen and sophomores entered CEAS. ECE 100, Introduction to Engineering Design, is a required engineering core course for all CEAS students. Although a few of the new students may have transferred in a core course equivalent to ECE 100, most of these new students would be required to take ECE 100 and would do so during their first two semesters in CEAS. Roughly half of these new students take the course in the fall and the other half in the spring. A total of 514 ECE 100 students were surveyed during the Fall 1995 and Spring 1996 semesters.

Our analysis and discussion in this paper focuses on the Fall 1995 surveys. In the Fall of 1995, there were 439 first-time, full-time freshmen (FFF) in CEAS, 424 in the College of Engineering and 15 in DEWSC. These students carried at least 12 semester hours of credit on the 21st day of the Fall semester and had transferred in with less than 12 semester hours of credit. These students form the freshman cohort of Fall 1995 students for which CEAS freshmen retention (still enrolled at ASU in Fall 1996) and graduation rates will be calculated. These rates are two of several metrics used by the University and our Board of Regents to evaluate the colleges. Therefore, an analysis of the data includes that of the FFF CEAS students, as well as the other students taking the ECE 100. The other major categories are freshman and sophomore transfer students and students enrolled in other colleges at the time they took the course.

Of the 251 Fall 1995 surveys, 220 were CEAS students, including 197 in the School of Engineering and 23 in the DEWSC. Of these CEAS students, 214 answered the question on why they were interested in engineering or an applied science. If we consider the percentage of students that ranked each reason either first, second, or third, then the reasons are in order of

importance are: (1) good potential salary (79.0 %); (2) do interesting work (71.5%); (3) many job opportunities (62.6%); (4) challenge of solving problems (25.2%); (5) profession transferable throughout the world (22.0%); (6) opportunities to solve societal problems (11.2%); and (7) the hardest possible undergraduate major to prove I can do it (6.5%).

If we compare the rank orders given by males (n=166) and females (n=48), only the difference on the seventh ranked reason, "I want to study the hardest possible undergraduate major to prove I can do it," was statistically significant (p=.019). Of the females, 16.7% ranked this as one of their top three reasons for an interest in engineering or an applied science, while only 3.6% of the men did so. However, another difference worth noting is that only 54.2% of the females chose CEAS because of "many job opportunities." Over 65% of the male students considered this to be an important reason for their choice of CEAS.

There was no statistically significant difference in the rankings between minority (n=32) and non-minority students (n=182). The most significant difference was with the same seventh ranked reason with a p=.207. However, the next most significant difference "challenge of solving problems" was an important factor for 34.4% of the minority students and only 23.6% of the non-minority students.

Of the 251 Fall 1995 surveys, there were 171 valid IDs given, 146 from CEAS (135 from the School of Engineering and 11 from DEWSC). Twelve IDs given by students proved to be incorrect. The transcripts and admission data for each of the students with a valid id were pulled and used to reconcile the survey data for accuracy. Each student was classified according to full or part-time status, class, and transfer status, that is, if the student had transferred in 12 or more hours. Of the 146, the largest subgroups were: FFF (n=65), first-time, full-time transfer freshman (n=31), and full-time non-transfer sophomores (n=13). Of the 11 Construction students with valid IDs, only two were FFF, one of whom was still at ASU in Fall 1996. Of the other nine, five were juniors, three were sophomores, and one was a transfer freshmen. A valid ID is necessary in order to do a longitudinal study on the correlation between retention and the reason that a student chose engineering. Therefore, it is important to know if the students who volunteered their ID number are representative of all the students in the survey with regard to any measure. There were no statistically significant differences in the percentages between those students with valid IDs and those without on why engineering was chosen. If we consider the percentage of students who chose each reason as either first, second, or third, then the most important reasons for choosing engineering in rank order for both groups are the same.

The data was next analyzed relative to retention. After one year (Fall 1996), 113 of the 146 CEAS students with a valid ID were still in CEAS and two more were still at ASU, although not in CEAS. This retention rate of 78.7% is statistically higher (p=.014) than the retention rate of 68.8% for all FFF CEAS students for the Fall 1995. However, FFF students only made up 44.5% of the sample. When the students were separated into those still in CEAS and those that have left ASU, there were no statistical differences in the percentages of students selecting each reason of why they choose engineering.

Of the 34 CEAS women with valid IDs, 28 were still in the CEAS after one year, one woman was at ASU but not in CEAS, and 6 women had left ASU by Fall 1996. There were no

statistically significant differences in the percentages of students selecting each reason, primarily because the samples are so small. However, there are several trends to consider in future studies. First, five of the 28 women (17.9%), who remained in CEAS, wanted to study the hardest possible undergraduate major to prove that they were capable. None of the six women who left ASU had that as a ranked reason for being in CEAS. While only one of the 28 women (3.6%) still in CEAS had checked that "a career that does not necessarily require graduate study" was important (actually ranked third), two of the 6 females (33.3%) that left ASU had chosen that reason as the most important. Last, 17 of the 28 remaining females (60.7%) "expected many job opportunities," while only two of the women (33.3%) who left ASU considered that an important reason to study engineering.

Of the 65 CEAS FFF students in the survey, 47 were still in CEAS in Fall 1996, one additional male was still at ASU but not CEAS, and 17 had left ASU. This 73.8% retention rate for the CEAS FFF in the survey is not statistically different from the 68.8% retention rate for the whole CEAS FFF cohort (p=.396). If we compare the CEAS FFF students who were still at ASU with those who had left ASU, the differences in the percentages of selecting each reason were not statistically significant. The largest differences occurred with "expect many job opportunities" (p=.274) and "expect to do interesting work" (p=.284). For the FFF students who were still at ASU, 68.1% expected many job opportunities, while only 52.9% did of the FFF students who left ASU. While 70.2% of the FFF students retained expected to do interesting work, 82.4% of the FFF students expected interesting work. Of the 17 FFF students who left ASU, 5 of them had a GPA of 3.0 or better. They may have continued their college work at another institution. Nine of the 17 students left the University with a GPA of less than 2.5, which is required for graduation. In fact, 7 of these students left ASU with a GPA of less than 2.0.

Discussion

As already mentioned, the most important factor contributing to undergraduate decisions to switch from Science, Mathematics, and Engineering (SME) majors by women was "reasons for choice of SME major prove inappropriate"[8]. This factor was cited by men as the second most important factor. Our survey showed that the major reasons for all of our students were good salary, interesting work, and many job opportunities. During the first year, when we lose approximately 40% of our CEAS students, the students will typically only take one engineering course (ECE 100). Therefore, the most probable source of any reinforcement to the student on why one should become an engineer is through the ECE 100 course. Therefore, to improve retention we should examine our presentations in ECE 100, in the Freshmen Orientation Program, in recruitment events, and in seminars aimed at freshmen to reinforce the students that the reasons they have used to choose engineering and construction are indeed good factors and are realizable.

The higher retention percentage of FFF students in the Fall ECE 100 course is worth noting. Their retention rate may be higher than the average Fall CEAS FFF student due to their enrollment in ECE 100 in the Fall. It may be that better students are more likely to be advised and be preregistered early, thus enabling them to secure a seat in ECE 100 for the fall semester. This hypothesis will be examined with the Spring 1996 survey results and other future surveys.

The only statistically significant difference of reasons among the student groups was that more females chose "the hardest undergraduate curriculum to see if they can do it" than did males. This may be a motivating factor to be successful in engineering. However, if during that first year they learn that the curriculum is indeed very difficult, they may decide that it is no longer worth it to prove they can do it. The only FFF female that was not retained left after the first semester with a 3.0 GPA and an "A" in ECE 100.

The reasons for choosing CEAS most often given in addition to the listed categories were "good pre-med preparation" and "I am good at math and science." These categories will be added in future surveys, along with "my counselor advised me to major in engineering" and "because a family member or a friend is an engineer."

Conclusions

This survey has given us a start at better understanding our students. I believe it would be helpful to the students to discuss the reasons why people choose engineering or construction during recruitment and orientation events, especially during their first year of college work. This information could be given to them through the ECE 100 class, faculty and staff advisors, WISE, and the OMEP. The students in the survey, with valid ids and who were not retained, will be surveyed for additional insights into their reasons for leaving the college and ASU.

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