

Beyond the Numbers: A Deeper Look into the Retention of Female Engineering Students

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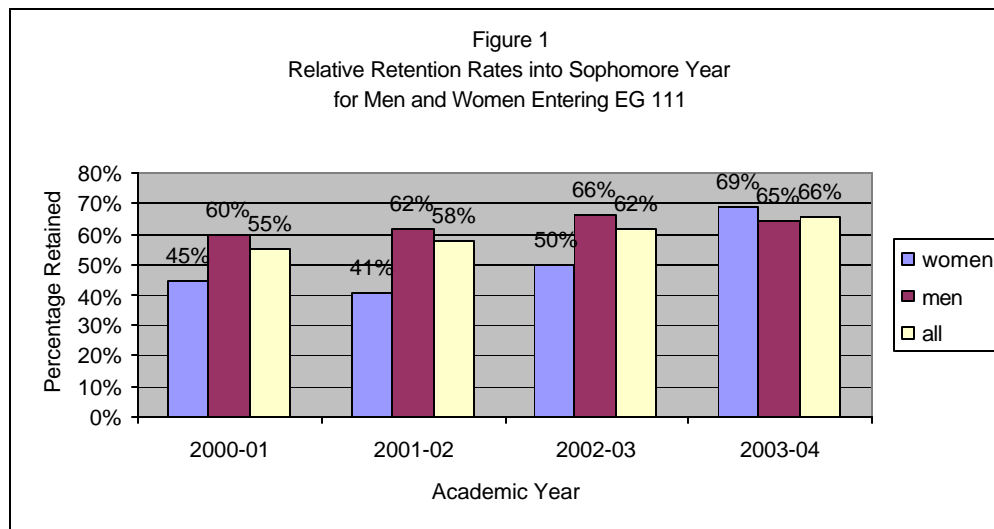
Abstract--Understanding the retention of women in engineering programs involves more than comparing how many women reach a particular milestone with how many began working toward that milestone. A complete picture of retention should also incorporate the factors that affect retention, examining how leavers and stayers differ on multiple levels: who, demographically, leaves and stays; when leavers make the decision to leave; why stayers make the decision to stay; and what programmatic factors most influence retention. At the University of Notre Dame's College of Engineering, the study of the retention of female engineering students uses information from a number of sources to understand the many and varied factors that influence retention: demographics, academic performance, experiential information reported on in-class surveys, a week-by-week review of retention and attrition in the first-year Introduction to Engineering Systems two-course sequence (EG 111/112), and anecdotal information obtained by talking with students. Coupling information gleaned from all of these factors has helped to understand the factors that impact whether a student who begins engineering as a first-year student will remain in engineering at the beginning of sophomore year.

For example, pre-college demographic information indicates that retention rates have historically differed between female students who select an engineering major on their application for admission (~60%) and those who select some other major but nonetheless begin the first-year enrolled as an engineering major (~30%). Multiple in-class surveys highlight experiential differences between female and male students. Week-by-week tracking of course drops help to pinpoint course events that discourage some students. Anecdotal information gleaned from interviews with stayers and leavers indicates that female students need to have more opportunities to interact with one another outside of class. Longitudinal comparisons from class to class enhance the understanding of how one class differs from the next in key characteristics.

This information has led to significant changes to the first-year engineering program that have improved retention of female students from less than 50 percent to nearly 70 percent in one year. This paper discusses these information-gathering efforts and shows how they led to real systemic changes that have positively impacted the retention of female engineering students.

Introduction

Beginning in the 2000-01 academic year, the College of Engineering at the University of Notre Dame offered a new two-semester, six-credit-hour Introduction to Engineering Systems course sequence (EG 111/112) (Brockman 2002), required of all first-year students intending to major in engineering as sophomores. Initial efforts to assess course effectiveness revealed a substantial difference between the retention rates of men and women. In the first three administrations of the course, 60 to 66 percent of men who started the course remained in engineering at the start of sophomore year, compared to only 41 to 50 percent of women (Fig. 1).



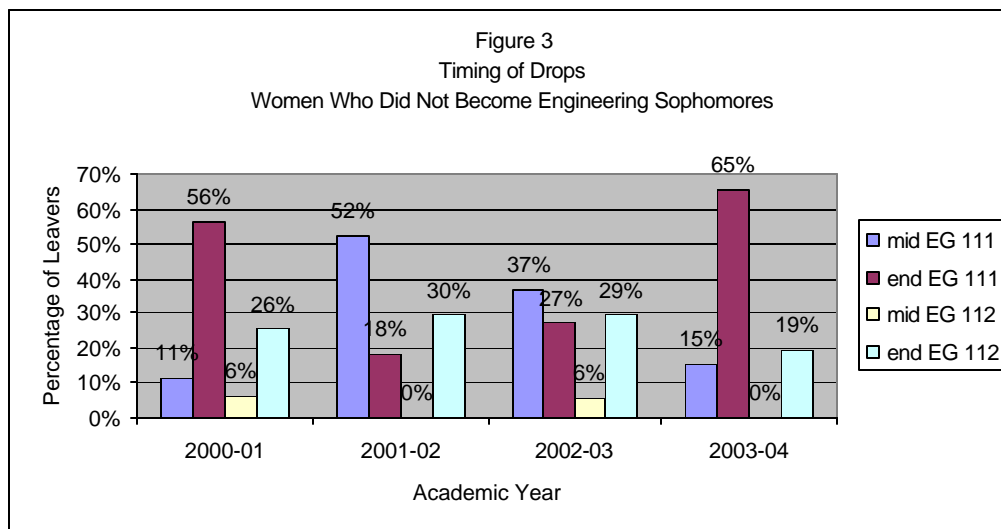
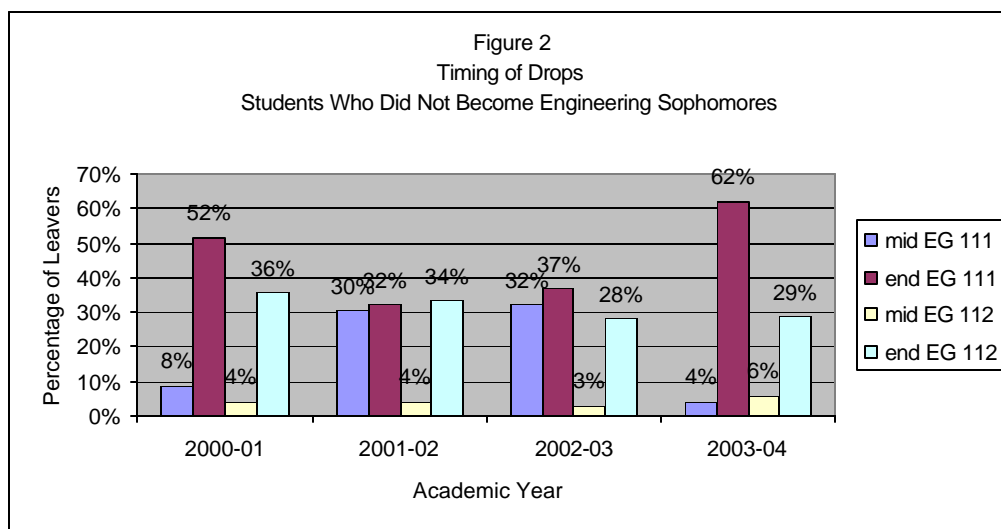
These differential retention rates prompted a more serious look at the factors that affect the retention of women. This paper looks at our approach to acquiring the information that prompted the changes to our program, including EG 111/112 surveys, interviews with departing students, demographic data and academic skills analysis. This paper also discusses briefly the actions taken in response to this information and the results from those actions.

EG 111/112 Surveys

Initially, EG 111/112 assessment consisted of two surveys, administered at the beginning and end of the academic year. The EG 111 Entry Survey, administered in the first two weeks of the fall semester, focuses on student characteristics – their interest in engineering, their engineering-related skills and their confidence in their abilities. This survey yielded predictable results. For example, when compared to men, women were more likely to have enrolled in EG 111 on the advice of others such as a parent or guidance counselor. Women also rated their skills lower than men rated theirs in areas such as computer programming and solving technical or mechanical problems. Women rated themselves higher than men only in the area of communications, particularly writing. (Pieronek 2003)

The EG 112 Exit Survey, administered near the end of the spring semester, focuses on how well

the two-course sequence met defined course objectives, but it also provides some macro level of assessment to determine whether the course affected student interests and skills. The EG 112 Exit Survey has been used since the initial administration of the course to identify those aspects of the four project modules that need modification. The survey has had little utility in assessing the issues that affect retention, however, because 60 to 70 percent of all students, and 70 to 80 percent of women, who opt out of engineering prior to the start of sophomore year actually leave before the end of the spring (EG 112) semester (Figs. 2, 3). Thus, this survey did not capture responses of the majority of those who left and, consequently, it provided a skewed picture of course success. For example, if student skills had improved over those reported in the EG 111 Entry Survey, we could not determine whether that improvement resulted from the course or because those who self-reported lower skill levels on the EG 111 Entry Survey had left the program prior to the administration of the EG 112 Exit Survey.



In 2003-04, we added an EG 111 Exit Survey, administered near the end of the fall semester, which enabled us to survey the students who ultimately left engineering prior to the end of EG 112 (~80 percent of ultimate leavers). This survey has provided some interesting information regarding the differences between leavers (those who left engineering prior to the start of sophomore year) and stayers (those who remained in engineering at the start of sophomore year). For example, first-semester leavers (those who before the end of EG 112) reported a higher rate of negative experiences in the first semester than either second-semester leavers (those who left after the end of EG 112) or stayers: they felt “overwhelmed by the intelligence of fellow students” and “intimidated by the engineering environment,” reported a low rate of forming relationships with fellow students, and did not engage in the group projects to the same extent as other students. On the other hand, second-semester leavers and stayers resembled each other in every single survey category, except that second-semester leavers felt “overwhelmed by the intelligence of fellow students” to a higher degree than stayers. (McWilliams 2005)

Among women, first-semester leavers and stayers differed in interesting ways as well. Stayers reported more positive experiences than leavers in EG 111, calculus and chemistry; stayers indicated a higher skill and comfort level with regard to computer programming; and leavers more often felt intimidated by the engineering environment. We could not perform any similar comparisons with second-semester leavers, however, because the population was too small for meaningful analysis. Nevertheless, this information has helped us to understand that first-semester leavers differ significantly from other students in a number of ways. (Pieronek 2005)

Student Interviews and Week-by-Week Course Drop Tracking

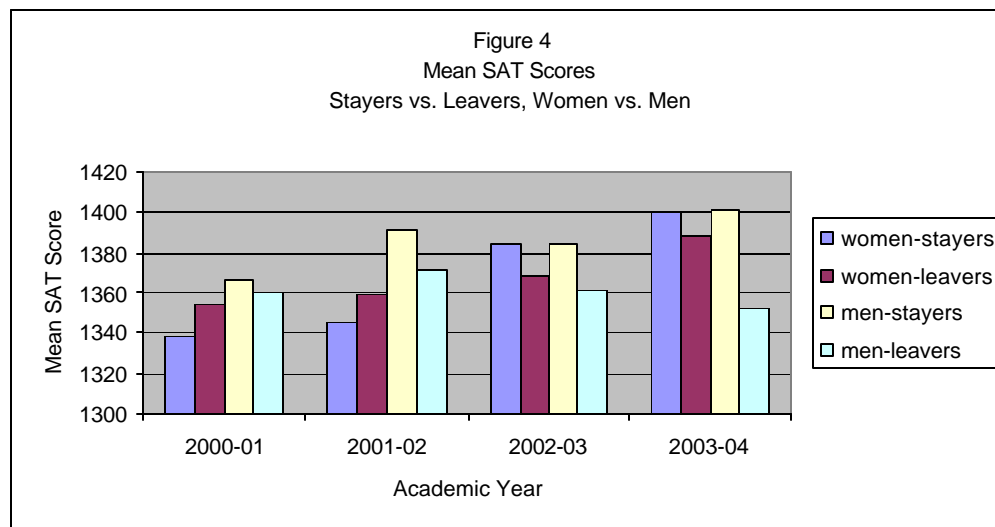
Prior to including the EG 111 Exit Survey in the assessment process, we interviewed students who had decided to drop EG 111, either in person or by e-mail, about their decisions to leave. Some of the students indicated that they had enrolled in EG 111 to satisfy someone else, such as a parent or counselor, and had decided that the course did not meet their needs. Others indicated, simply, that they did not like the class. A sizeable group, however, indicated that computer programming in some way affected their decision: some did not like programming; others felt frustrated with their inability to grasp basic programming concepts; still others decided that they did not want to major in engineering because they did not want to “spend the rest of their lives in front of a computer.” We also learned that, for most of these students, computer programming was entirely new to learn. At the same time, we tracked course drops on a weekly basis. We noted that two-thirds of all students who dropped EG 111 during the semester discontinued the course in October, coincident with the introduction of programming into the course. We surmised that the topic presented too great a challenge for first-semester, first-year students who had no previous exposure to the topic.

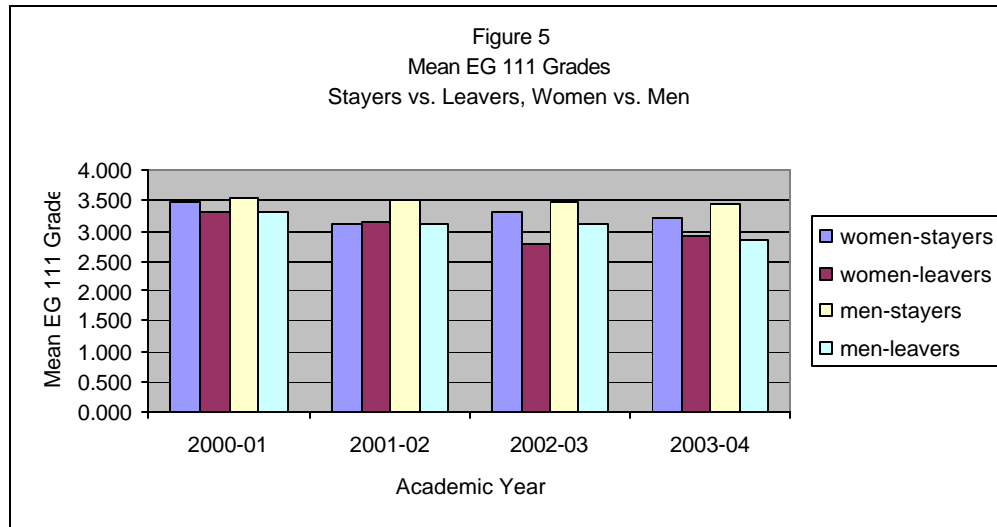
Finally, we got a general sense from female students that they felt isolated. They indicated that “no one else” in their residence halls worked as hard as they did, they had “no one” to study with in their residence halls, and they felt that, with the larger numbers of engineering students in men’s residence halls, male students had an easier time forming study groups, getting help from upper-class students and belonging to a group engaging in similarly demanding work. Conversations with upper-class women validated these beliefs.

From this aspect of our assessment process, we began to understand that the timing of certain course elements – that is, computer programming – might affect retention. We also learned that certain things outside of the course itself also had an impact on retention. A student’s prior exposure to computers and computer programming affected their comfort with learning a formal programming language. Additionally, certain aspects of our campus culture – most particularly, the distribution of female students among the women’s residence halls – had a negative impact on the persistence of female students. (Pieronek 2003)

Academic Performance Information

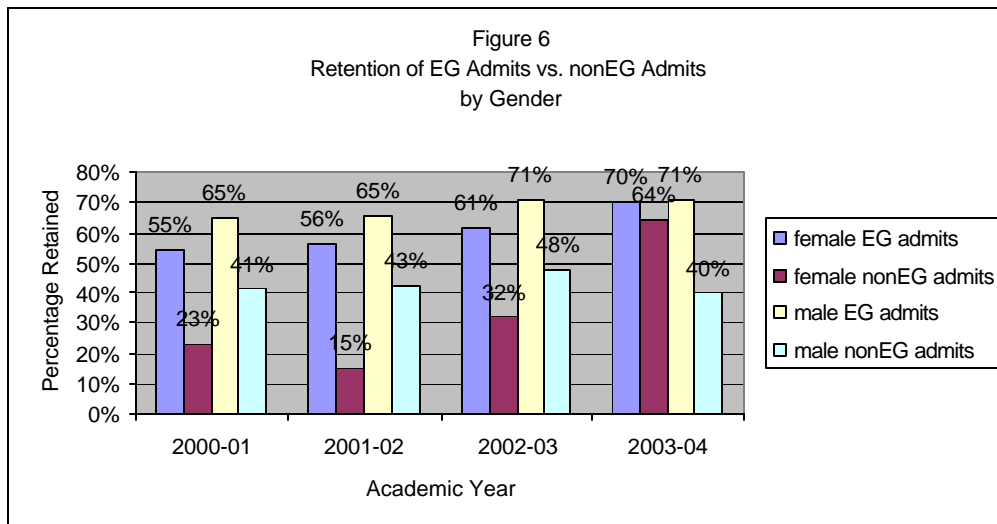
In an effort to understand any other differences between leavers and stayers, we engaged in a review of academic performance information. We looked at SAT scores as an indicator of the relative levels of pre-college academic aptitude among leavers and stayers, and we looked at EG 111 course grades as an indicator of engineering aptitude. Unfortunately, neither analysis yielded any useful information. With regard to SAT data, while men exhibit predictable behavior in that leavers have lower average SAT scores than stayers, women do not consistently exhibit similar behavior (Fig. 4). With regard to EG 111 grades, we noted a somewhat more predictable pattern of leavers having lower average course grades, but had some concerns that these lower grades might actually reflect a student’s interest in, rather than aptitude for, engineering (Fig. 5). (Pieronek 2004)





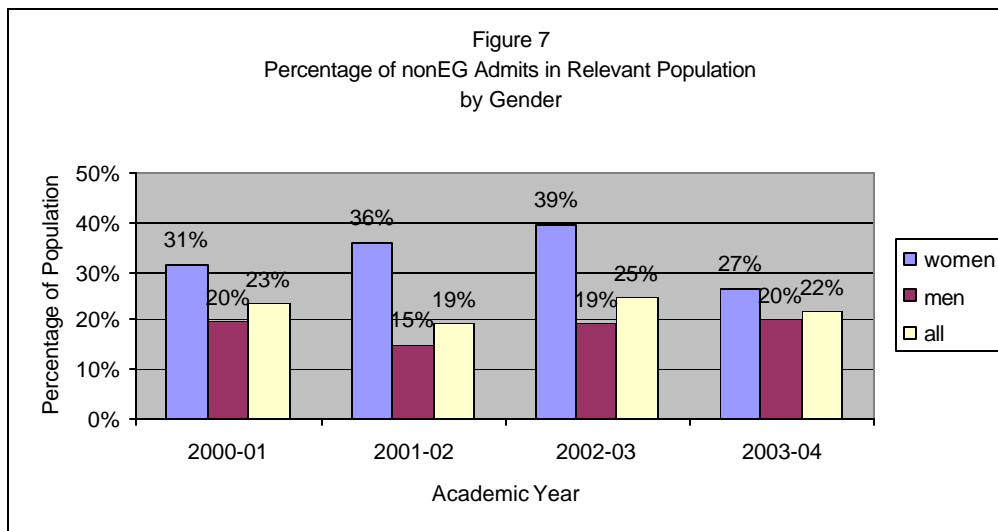
Demographic Information

Finally, we looked at demographic information in an attempt to identify anything in a student's background that could predict persistence in engineering. We found only that a student's "intended major" as selected on the application for admission seemed to correlate with persistence in engineering. Students who selected an engineering major (EG admits) on their application for admission to Notre Dame persisted at a much higher rate (~65 to 71 percent for males; ~55 to 61 percent for females) than students who selected some other major (nonEG admits) but nevertheless enrolled in EG 111 (~41 to 48 percent of males; 15 to 32 percent of females) (Fig. 6). (Pieronek 2004)



We also noted that, in EG 111, nonEG admits comprise a greater proportion of the female enrollment (over 30 percent) than of the male enrollment (20 percent or less) (Fig. 7). (Pieronek

2005) Thus, the extremely low persistence rate of a substantial segment of the female population contributed to the overall lower female retention numbers.



We used this information to re-analyze data from the EG 111/112 surveys to determine whether female EG admits and nonEG admits differed in any meaningful ways. The EG 111 Entry Survey revealed the following statistically significant differences between female EG admits and nonEG admits (Pieronek 2005):

- In identifying their primary reason for enrolling in EG 111, EG admits indicated that “engineering would make the best use of their skills, interests and abilities,” while nonEG admits enrolled in the course because it provided maximum flexibility in the choice of a major upon entering sophomore year.
- In identifying their secondary reason for enrolling in EG 111, EG admits indicated that “engineering would best enable me to serve my community,” while nonEG admits thought that engineering “would make the best use of their skills, interests and abilities.”
- 78 percent of EG admits, but only 50 percent of nonEG admits, either strongly agreed or agreed with the statement, “I expect to complete my engineering degree.”

This demographic information, coupled with survey results, indicated that female nonEG admits exhibit a lower level of commitment to engineering upon entry to the program.

Actions Taken in Response to Information Gathered

As a result of the information gleaned from the EG 111/112 surveys, the interviews and week-by-week tracking of course drops, the review of academic credentials and the review of demographic information, we made three changes prior to the start of the 2003-04 academic

year, each of which appears to have had a positive impact on retention.

First, in response to the survey information, the interviews and the week-by-week tracking of course drops, we moved the computer programming segment of the course into the second semester. This now gives students one semester to adjust to the rigors of a college engineering program without the frustration of mastering a completely new subject. We also changed the way in which we teach programming, shifting from merely including programming as an aspect of the engineering projects that students worked on during the semester to teaching programming as a separate course module and emphasizing the use of the computer as a tool in solving engineering problems. (Pieronek 2004, McWilliams 2004)

Second, also in response to the interviews, we worked with the University's Office of Residence Life to consolidate female engineering students into fewer than half of the women's residence halls on campus, which had the effect of doubling the concentration of female engineering students in those particular residence halls. We included all women enrolled in the course, whether EG or nonEG admit. (Pieronek 2004)

Third, to address the issue of the higher drop rate among nonEG admits, based on our understanding that these women, in particular, had different motivations from EG admits for enrolling in EG 111, we included two lectures at the beginning of EG 111 to describe the relevance of the engineering profession to society. (McWilliams 2004)

Results

We have seen a dramatic improvement in the retention of female students – both EG admits and nonEG admits alike. The retention rate of women overall improved from 50 percent in 2002-03 to 69 percent in 2003-04, and actually exceeded the retention rate of male students for the first time (Fig. 1). We also saw a dramatic improvement in the retention of female nonEG admits, from 32 percent in 2002-03 to 64 percent in 2003-04 (Fig. 6). Finally, we noticed an interesting shift in the timing of course drops (Fig. 3). In 2001-02, 52 percent of the women who ultimately left dropped engineering in the middle of the fall (EG 111) semester; in 2002-03, 37 percent left mid-semester; but in 2003-04, only 15 percent left mid-semester. (Pieronek 2005)

This dramatic shift in retention prompted us to re-visit our survey and demographic data to compare the classes entering in 2002-03 and 2003-04. While some traits differ between the two classes, none stands out as a good explanation for the different retention rates. (Pieronek 2005) As we begin to study the class entering in 2004-05, we see a similarly positive trend in retention, and will continue to analyze the survey and demographic data to ensure that nothing in those factors explains the retention shift better than the changes we make in a conscious effort to improve our program and, consequently, improve retention.

We feel confident in concluding that the changes we made enabled us to keep students in the program longer than we had in the past. We now have some level of confidence that the female students who ultimately drop engineering do so after having had some time to learn about the subject, rather than as a result of some mid-semester frustration.

Conclusion

For the last three academic years, the College of Engineering at the University of Notre Dame has engaged in a comprehensive assessment process to understand the factors that affect the retention of female engineering students. This multifaceted process has helped us to identify several specific changes to our course and to the campus environment that have led to improved retention of female students into the sophomore year. This process has also pointed out the value of using data from multiple sources, of looking for factors that explain not only why women historically exhibited a lower retention rate than men, but also explore the differences within the group of women that differently affect the retention rates of various segments of the female population. Importantly, we did not rely on one source of data to inform our efforts. Rather, we relied on different information from different sources, which we put together to create a more complete picture of the factors that affect the retention of female engineering students.

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