A Demographic Characterization of First-Year Engineering Students

Catherine Pieronek, John J. Uhran, Leo H. McWilliams, Stephen E. Silliman

University of Notre Dame

Abstract

The observation of substantially different retention rates of men versus women from initial enrollment as first-year engineering intents to enrollment as engineering majors at the beginning of the sophomore year at the University of Notre Dame has motivated an examination of demographic data to assess retention patterns. Based on the numbers of students enrolling in a required first-year engineering course, which has an initial population of approximately 360 students per year, women have exhibited a lower retention rate to the sophomore year (~50%) than have men (~65%). Demographic data discussed in the present manuscript include: gender; SAT scores; course grades; and intended major.

As evidenced by national studies on the retention of women in engineering programs, and as corroborated at Notre Dame, many demographic factors such as SAT scores and course grades do not accurately predict which students will remain in engineering. This necessitated a more thorough examination of student records to look for potential indicators of retention. Most interestingly, the student's "intended major," as indicated on the application for admission to Notre Dame, provides a significant indicator of retention. Students who, in their senior year of high school, had indicated an engineering discipline as their intended major on their application for admission remained in the program at a higher rate (~68%) than students who selected a non-engineering discipline as their intended major (~41%). While male students in each category remained in the program at a higher rate than female students in each category, the retention differential between male and female students who selected engineering as their intended was smaller (~9%) than the retention differential between male and female students who selected something other than engineering as their intended major (~20%).

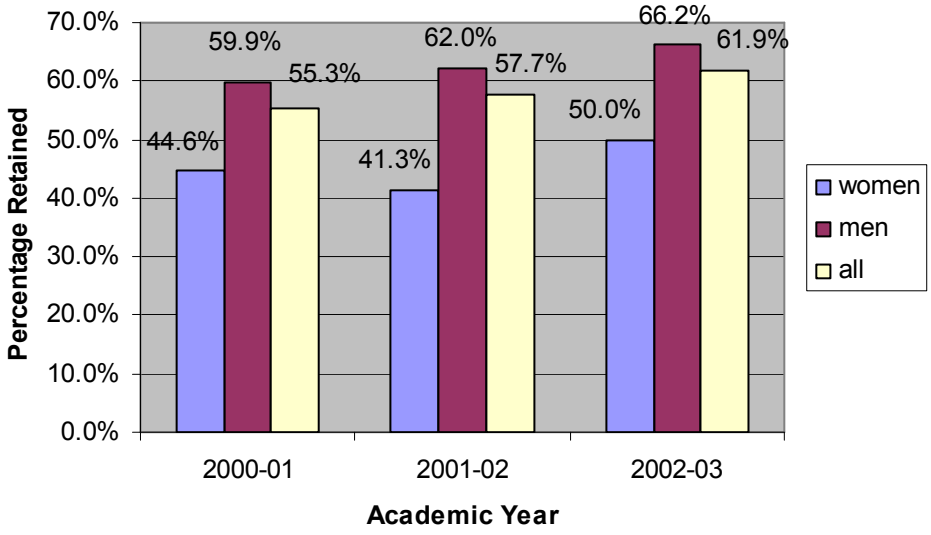
Since students who select a major other than engineering on their application for admission comprise approximately 25 percent of first-year students who initially enroll in engineering at Notre Dame, this information is influencing Notre Dame's efforts to increase retention, particularly among women. Of particular importance, the College now identifies the non-engineering admits, and particularly the women in this group, as at high risk for leaving engineering. The College is, therefore, designing special activities to increase communication with this group to aid them in making appropriate decisions regarding engineering as a potential major.

Introduction

The College of Engineering at the University of Notre Dame has devoted significant resources to developing and implementing a two-semester, six-credit-hour course sequence for first-year students who intend to major in engineering as sophomores (engineering intents). Brockman *et al.*[1] present the details of the motivation and development of this course. In addition, the course web site explains the basic structure and content of the course (www.nd.edu/~engintro). As part of the development of this course, the College has engaged in a thorough effort to evaluate the effectiveness of the new courses, identified in Notre Dame's system as EG 111/112.

One area of concern that has persisted through the first three administrations of the two-course sequence, in the academic years 2000-01, 2001-02 and 2002-03, involves the different retention rates for male and female students from the beginning of the first year to the beginning of the sophomore year. As illustrated in Figure 1, retention rates for women have ranged from 41 to 50 percent, while retention rates for men have ranged from 60 to 66 percent.

Figure 1
Relative Retention Rates into Sophomore Year for Men and Women Entering EG 111



In an effort to understand this gender differential, the College has studied a number of demographic factors that, hypothetically, could influence retention through the first year. These include performance on standardized entrance examinations (SAT/ACT), performance in the course and stated intended major on the student's original application for admission to Notre Dame, submitted by the students nearly a year before enrolling in first-year courses. This paper focuses on two of these demographics, SAT score and stated intended major, as demographic

information available prior to the arrival of the student at Notre Dame in the freshman year. As illustrated below, the student's intended major, as indicated on the application for admission to Notre Dame, proved significantly valuable in this study, providing insight both into the gender differential and into the groups of students most at risk for leaving engineering.

First-Year Engineering Intents at Notre Dame

Notre Dame is a highly selective doctoral research university that admits students on the basis of a number of factors, including standardized test scores, high school class rank, extracurricular activities and demonstrated leadership potential. While applicants must select only one intended major on the application, that information has little, if any, impact on the decision to admit a particular applicant. Rather, that information assists Notre Dame in planning course offerings for each first-year class and, in a broad sense, in aiming for a reasonable distribution of students among the four academic colleges (Arts & Letters, Business, Engineering and Science) and the School of Architecture. In recent years, engineering admits have consistently comprised approximately 17 percent of Notre Dame's first-year students, with women comprising 20 to 25 percent of this group.

Regardless of the intended major indicated on the application for admission, all first-year students at Notre Dame enroll in the First Year of Studies (FYS), an academic unit that facilitates the transition from high school to university life. The FYS web site explains the mission and goals of this program (www.nd.edu/~fys). Through the first-year program, Notre Dame students may select courses that meet university general education requirements, such as composition, math and science, and that expose them to potential courses of study. Upon completing the first year, students then select one of the four academic colleges or the School of Architecture. None of these academic units imposes any admission requirements beyond successful completion of the first year.

Students considering a major in engineering, however, must take certain courses in the first year in preparation for matriculating to the College of Engineering as sophomores. This schedule of courses includes particular levels of calculus, chemistry and physics, as well as the EG 111/112 sequence. Students who do not complete these courses may enter the College of Engineering only with special permission from the College, and might not graduate in the typical four years. Consequently, FYS encourages first-year students with even a slight interest in or potential for success in engineering to enroll in the engineering sequence of first-semester courses, so that these students may retain all of their options for future study as long as possible, while still working toward graduation within four years, regardless of the college they choose to enter as sophomores.

Over the past four years, a significant number of students who did not indicate engineering as their intended major on their application for admission to Notre Dame have enrolled in EG 111/112. As shown in Table 1, this demographic group comprises 20 to 25 percent of EG 111 enrollment each year and, consequently, is of particular interest in the analysis of student retention in engineering. The remainder of this paper will discuss two primary groups of

students: those students who indicated engineering as their intended major on their application to Notre Dame and who enroll in EG 111 (engineering admits); and those students who indicated something other than engineering as their intended major on their application to Notre Dame but who nevertheless enroll in EG 111 (non-engineering admits).

Table 2
Total Enrollment, Enrollment of Non-Engineering Admits and
Percentage of Non-Engineering Admits in EG111
in the Past Four Academic Years

	Total EG 111 Enrollment	Non-Engineering Admits Enrolled in EG 111	Non-Engineering Admits as a Percent of EG 111 Enrollment
2000-01	369	86	23.3%
2001-02	359	69	19.2%
2002-03	354	87	24.6%
2003-04	366	79	21.6%

SAT as a Differentiator Among Groups in EG 111

Although recognizing that standardized test scores used in isolation provide, at best, imperfect predictions of individual student performance in college (*e.g.* The College Board[2]), the College of Engineering analyzed standardized test scores (either actual SAT composite scores or the SAT equivalents of ACT composite scores) as one reasonable indicator of the relative academic strengths of different groups of students within the first-year class, and also as a possible indirect indicator of the probability of retention into the sophomore class. The choice to use standardized test scores resulted from two factors. First, as noted above, the score is available well in advance of student arrival at Notre Dame, thus allowing for some analysis prior to the start of the first-year fall semester. Second, this score is based on a common test given nationally and is available for all students, both present and past, thus enabling some comparison among successive first-year classes.

Table 2 presents the mean SAT scores for Notre Dame's first-year class as a whole, and for various subgroups of students enrolled in EG 111 over the past four academic years. From this information, the College has made the following four observations. First, over the last four years, as a group, women and men who begin EG 111 have comparable mean SAT scores. Second, students enrolled in EG 111 have higher mean SAT scores than Notre Dame first-year students as a whole, in some cases by up to nearly 40 points (female engineering admits in 2003-04). Third, while the mean SAT scores for the men enrolled in EG 111 have remained relatively constant (~1380), the College has noted an increase each year in the mean SAT scores for the women enrolled in EG 111. In the most recent academic year, the mean for the women was significantly higher than the mean for the men. By this measure, then, it would appear that the

relative academic strength of the women entering the course (as measured by the SAT) is increasing over time. Fourth, despite this substantial increase in the mean score for the women, the retention rate for the women remains substantially below that observed for the men (Figure 1). Hence, the College has concluded that mean SAT score, in isolation, does not provide a good predictor of retention into the sophomore year.

Table 2
Mean SAT Scores of First-Year Students at Notre Dame as
Compared to First-Year Women and First-Year Men Enrolled in EG 111.

Year of Initial Enrollment	First-Year Students at Notre Dame	First-Years Enrolled in EG 111	Women Enrolled in EG 111	Men Enrolled in EG 111
2000-01	1341	1359	1347	1364
2001-02	1350	1377	1353	1384
2002-03	1350	1377	1377	1376
2003-04	1359	1387	1397	1384

The College also assessed the mean SAT score of the students who remained in engineering in the sophomore year versus the students who left engineering prior to the sophomore year, once again separated by gender. Table 3 shows these values for the past three academic years. Anomalous data exist in selected years (e.g., women in 2000-01; men in 2001-02), and no consistent pattern emerges. Once again, the mean SAT score, in isolation, does not appear to provide a strong indicator of probability of retention into the sophomore year.

Table 3
Mean SAT Scores for Students Retained into the Sophomore Year
versus Students who left Engineering Prior to the Sophomore Year

Year of Initial Enrollment		Students Retained into Sophomore Year	Students Leaving Engineering Prior to Start of Sophomore Year
2000-01	women	1338	1354
	men	1367	1360
2001-02	women	1345	1359
	men	1391	1372
2002-03	women	1385	1369
	men	1384	1361

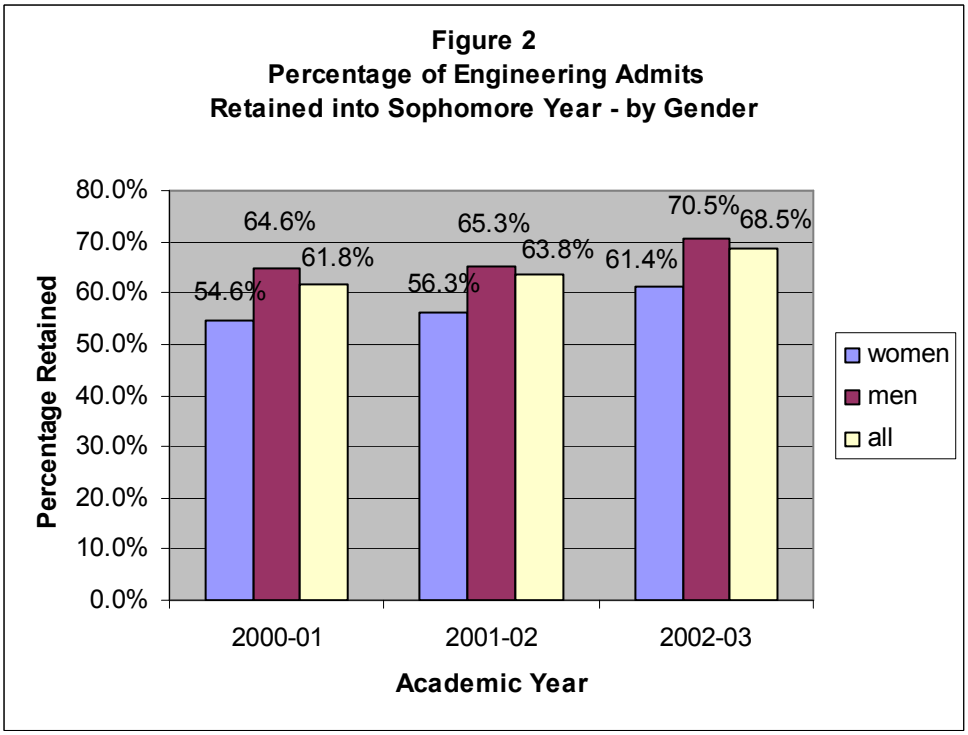
Intended Major on Application as a Differentiator among Groups in EG 111

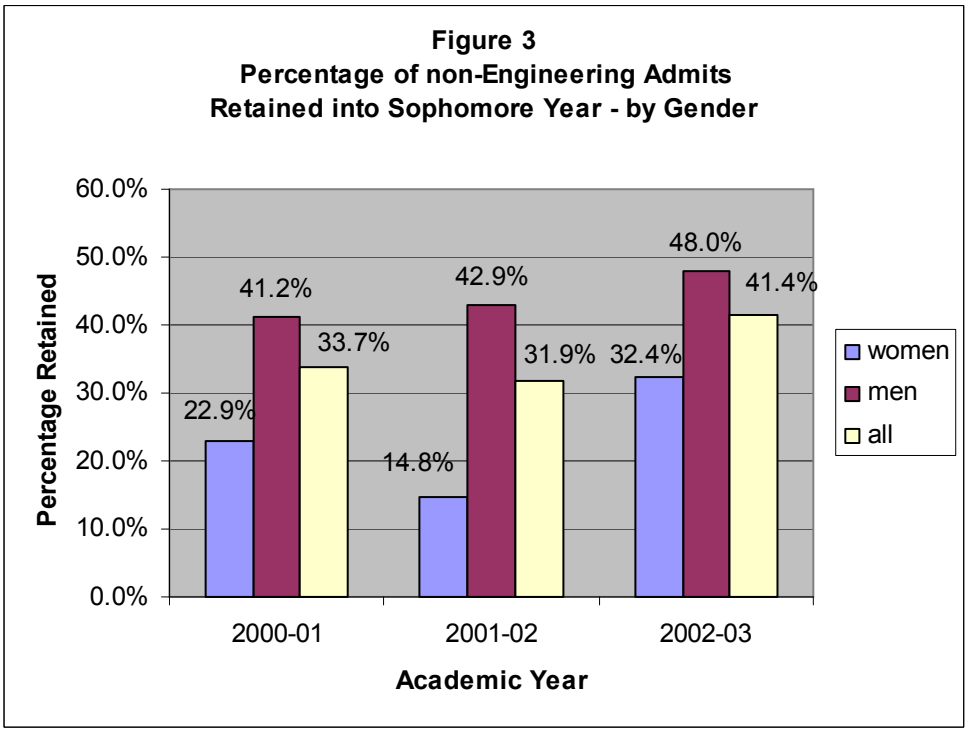
Because approximately 20 to 25 percent of the students enrolled in EG 111 regularly have indicated an intent other than engineering on their application for admission to Notre Dame (see Table 1), the College explored whether separation of the student body by gender and intent listed on the application for admission to Notre Dame could provide an indicator of the probability of retention into the sophomore year. Table 4 presents the numbers of engineering and non-engineering admits in EG 111. Interestingly, non-engineering admits have comprised a significantly larger portion of the overall population of women (26 to 40 percent) than of the overall population of men (15 to 20 percent) enrolled in the course.

Table 4
Relative Percentage of Non-Engineering Admits in EG111
Delineated by Gender

Year of Initial Enrollment		Total EG 111 Enrollment	Engineering Admits in EG 111	Non-Engineering Admits in EG 111	Percentage of Non-Engineering Admits in EG 111
2000-01	women	112	77	35	31.3%
	men	257	206	51	19.8%
2001-02	women	75	48	27	36.0%
	men	284	242	42	14.8%
2002-03	women	94	57	37	39.4%
	men	260	210	50	19.2%
2003-04	women	83	61	22	26.5%
	men	283	226	57	20.1%

Figures 2 and 3 show the percentage of students retained into the sophomore year, separated by gender and intent. From these data, the College has made four observations. First, with the exception of female non-engineering admits in 2001-02, the retention rate has remained steady or improved in nearly every demographic group. Second, extreme differences exist between the retention rate of engineering admits and the retention rate of non-engineering admits. Specifically, the retention rate for the engineering admits is nearly double that of the non-engineering admits (although slightly less than double in the most recent year). Third, the retention differential between female engineering admits and male engineering admits, while still significant, is lower than the differential observed for the class as a whole. Fourth, the retention differential between female non-engineering admits and male non-engineering admits is not only significantly large, it is greater than the retention differential observed for the class as a whole.





The results illustrated in Figures 2 and 3 demonstrate that intent as listed on the application for admission provides a strong indicator of the probability of retaining a student into the second year of the engineering curriculum. It is important to note, however, that these results do not imply that non-engineering admits possess relatively weaker academic credentials than engineering admits. In fact, as shown in Tables 5 and 6, engineering admits and non-engineering admits, as distinct demographic groups, exhibit little difference in their mean or median SAT scores and final EG 111 course grades. Instead, this result indicates a critical, and as yet undetermined, difference between engineering admits and non-engineering admits, thus identifying two groups of students (female non-engineering admits and male non-engineering admits) as those with the greatest risk of low retention into the sophomore year engineering program..

Table 5
Mean and Median SAT Scores for Engineering Admits and Non-Engineering Admits Enrolled in EG 111

Year of Initial Enrollment	Engineering Admits in EG 111 Mean / Median SAT	Non-Engineering Admits in EG 111 Mean / Median SAT
2000-01	1362 / 1380	1350 / 1360
2001-02	1378 / 1390	1376 / 1380
2002-03	1380 / 1400	1367 / 1400
2003-04	1386 / 1410	1393 / 1420

Table 6
Mean EG 111 Grades for Engineering Admits and Non-Engineering Admits

Year of Initial Enrollment	All Students Mean Grade	Engineering Admits Mean Grade	Non-Engineering Admits Mean Grade
2000-01	3.435	3.448	3.390
2001-02	3.345	3.368	3.231
2002-03	3.331	3.231	3.348
2003-04	3.212	3.240	3.110

Primary Observations and Areas for Further Study

These data have led to three primary observations, each of which warrants further study.

First, students who indicate engineering as their intended major on their original application for admission to the Notre Dame appear to have a substantially higher probability than non-engineering admits of being retained into the sophomore engineering curriculum. The College has noted that this differential is not related to standard measures of academic potential (e.g., SAT scores or class performance as measured by final grades). Thus, the College believes that further exploration is warranted to better understand such issues as: (i) the factors that lead non-engineering admits to enroll in EG 111; (ii) the factors that cause non-engineering admits to leave the engineering curriculum at a higher rate than engineering admits; and (iii) the academic majors ultimately selected by the non-engineering admits who leave engineering.

In part, as an effort to address questions such as these, the College has administered an entrance survey to all EG 111 students within the first two weeks of class. Described in Pieronek *et al.*,[3] this survey may provide valuable insights into individual students' reasons for considering engineering, and may aid in understanding how these students view their own skills in areas such as mathematics, science, problem-solving and communication. Depending on whether these surveys indicate other significant, subjective differences between engineering admits and non-engineering admits, the College will consider tailoring a subsection of the EG 111 course to non-engineering admits and/or offering other activities to these students in an effort to target their interests more directly, with the goal of improving retention of this group of students.

Second, the differential in retention rate for female engineering admits versus male engineering admits is lower than the differential in retention rate between men and women in the course as a whole. Although the presence of any retention differential remains a concern for the College, the data provide some reassurances, insofar as they do not describe any dramatic retention differential based on gender for those students expressing, in advance, an active interest in engineering. Consequently, efforts to improve the EG 111/112 course and increase the retention rate of all engineers may have similar effects on both the male and female populations of engineering admits. Further, this observation provides an incentive to reassess early data sets divided purely by gender, but not further segmented to consider intended major (e.g., Pieronek *et al.*[3]). This observation also provides motivation to work with Notre Dame's Office of Admissions to increase the pool of women engineers for the College's programs by seeking additional applications from women who would legitimately identify engineering as their intended major.

Third, the retention rate for female engineering admits is significantly higher than the retention rate for female non-engineering admits, while the retention rate for male engineering admits is only somewhat higher than the retention rate for male non-engineering admits. This finding has helped to identify female non-engineering admits as the most at-risk population, with male non-engineering admits as the next most at-risk population. Once again, data from the first-year survey may provide additional insights into other differences between engineering admits and

non-engineering admits, and may help to determine whether any additional efforts might improve the EG 111/112 experience for all students.

Follow Through

The discovery of the link between intended major as indicated on the application for admission and the retention of both male and female engineering students provides an interesting path for further exploration. To date, women have been considered to be at higher risk for leaving the engineering curriculum as compared to men. This has resulted in targeting of retention efforts toward all women, without considering the distinct needs of different subgroups of women. Further, the College has not yet initiated any retention efforts targeted toward any group of men, as no specific group of men had been considered to be at higher risk for dropping the course. The results of this study have demonstrated that that male non-engineering admits are retained at a substantially lower rate than female engineering admits, thus providing incentive to restructure some of the College's retention efforts.

Objective academic performance data, as captured by relative SAT scores and course grades, provide no consistent clues regarding which students are more at risk for leaving engineering. Consequently, other indicators are being sought that provide deeper insight into the types of students who are retained in the engineering curriculum and those who leave the engineering curriculum. Given the strong demographic separation noted in this study, substantial opportunity exists for reevaluating other information, such as that provided on the first-year survey, to aid in discerning groups of students with higher or lower affinity for engineering.

References

1. Brockman, J.B., Fuja, T.E, Batill, S.M., "A Multidisciplinary Course Sequence for First-Year Engineering Students," 2002 ASEE Annual Conference and Exposition, Montreal, Quebec, Canada, June 2002.
2. The College Board, "Guidelines on the Uses of College Board Test Scores and Related Data," College Entrance Examination Board, 2002.
3. Pieronek, C., McWilliams, L.H, Silliman, S.E., "Initial Observations on Student Retention and Course Satisfaction Based on First-Year Engineering Student Surveys and Interviews," 2003 ASEE Annual Conference and Exposition, Nashville, Tennessee, June 2003.

CATHERINE PIERONEK
Catherine Pieronek, J.D., has served as director the Women's Engineering Program at the University of Notre Dame since 2002. She has worked as a senior systems engineer on NASA spacecraft projects at TRW Space & Defense Sector, and as director of external relations for the Notre Dame Law School. She earned her B.S.A.E. from the University of Notre Dame, her M.S.A.E. from UCLA, and her J.D. from the Notre Dame Law School.

JOHN J. UHRAN
Dr. John J. Uhran is the senior associate dean for academic affairs, professor of computer science and engineering and professor of electrical engineering in the College of Engineering at the University of Notre Dame, where he has been a member of the faculty since 1966.

LEO H. McWILLIAMS

Dr. Leo H. McWilliams has served as course coordinator for the First-Year Engineering Program at the University of Notre Dame since 2001. Prior to joining the Notre Dame faculty, he worked as a principal engineer at Honeywell International. Dr. McWilliams received his B.A. in economics, B.S.E.E., M.S.E.E. and Ph.D. from the University of Notre Dame.

STEPHEN E. SILLIMAN
Dr. Stephen E. Silliman is a professor of civil engineering and geological sciences and an associate dean for undergraduate programs in the College of Engineering at the University of Notre Dame. He joined the faculty in 1986, and his primary area of research is in groundwater hydrology with recent focus on water resources in developing countries.