AC 2010-622: PREDICTION OF SOPHOMORE RETENTION

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Predicting Sophomore Retention

Abstract

The first-year engineering program at the University of Notre Dame is a general, non-discipline-specific, two-semester course sequence intended to offer students exposure to cross-disciplinary projects that underlie the engineering approach, and to provide insight into their future study and work in the engineering profession. Course enrollments range from 300 to 400 students annually. Over seven years (Classes of 2005 through 2011, referring to the expected four-year graduation year of the entering first-year class), students have participated in in-class surveys three times during the course of the year: at the beginning and the end of the fall semester, and at the end of the spring semester. The survey questions related to, among other things, demographics, prior experiences, interests and future career goals. We analyzed the aggregate responses of these student cohorts for statistically significant differences, and evaluated the data in progressive regression models to predict student retention into the sophomore year (as determined by a student's self-selection at the end of first year to continue in an ABET-accredited engineering discipline).

The survey analysis yielded several broad conclusions. First, certain aspects of a student's pre-college experiences and preparation are statistically significant predictors of retention into the sophomore year. Second, students who enter the program with settled plans to pursue engineering-related goals after college are much more likely to be retained in the program than are students with unsettled or non-engineering-related goals.

These findings indicate the importance of prior experiences to continued engineering study, and indicate that exposure to pre-college programs that support or complement engineering, such as participation in science fairs, robotics teams or pre-engineering summer camps provides meaningful, formative experiences that lend to student exploration of and commitment to an engineering education. Additionally, those students that feel as though they have a firm plan for their future career path, even a plan not directly related to engineering such as pursuing an MBA, are more likely to continue. While not entirely surprising, these findings do reinforce the notion that students need multiple early exposures to engineering that will allow them to explore their interests and gain an understanding of their own professional identity as it relates to engineering.

Introduction

Universities in the United States are known for the flexibility they afford students in educational pathways. As noted theorist Jeffrey Arnett explains, through the American college system, "young Americans are able to keep their work options open for a long time as they try out different college majors before choosing a specific direction,"¹ and delay their transition to adulthood. A student's choice of an academic field of study relates to career goals and, in many regards, to the student's identity development as it pertains to a student's level of exploration of and commitment to a certain path.^{2,3} Some entering first-year college students have already fully explored their options and are committed to a certain career path, while others are still grappling with alternatives.

In engineering, both as a specific career path and as a discipline of study, there exists an imbalance between the need for engineers in the work force and the level of student interest in the field.⁴ This imbalance has driven educational researchers to study engineering education in terms of educational and professional persistence and the associated influencing factors. One such study reported that engineering actually has a higher rate of persistence to graduation than other fields, but nevertheless noted that the lower enrollment of women in the discipline and the limited pathways in to the discipline both contribute to lower numbers of engineering graduates nationwide.⁵ Other studies of engineering educational persistence examine factors such as grades, standardized test scores, advanced placement credit, motivation, confidence in academic performance and prior experiences, and have found high school grade-point average and quantitative SAT scores,^{6,7} as well as student motivation,⁶ to be statistically significant predictors of graduation. One study reported college grade-point average to be the most significant predictor for engineering student persistence,⁸ while other studies downplay the effect of grades, instead reporting that many non-persisters actually had earned good grades.⁹ Persistence has also been evaluated through a specific course: A longitudinal study of student performance in a chemical engineering course examined predictive factors for obtaining a C or better in the course, and found most significantly that poor performance in chemistry or physics courses predicted difficulties in that course.¹⁰ Finally, issues of self-efficacy have been linked to persistence, as “self-reported confidence in college-level math/science ability and the belief that an engineering degree enhances career security at a respectable salary were found to be significant predictors of both short and long term persistence in engineering.”¹¹

The Center for the Advancement of Engineering conducted the Academic Pathways Study (APS), which focused on questions relating to skills identify, education and workplace.¹² A national survey that resulted from APS, the Persistence in Engineering (PIE) survey¹³ (subsequently the Academic Pathways of People Learning Engineering Survey, or APPLES),^{12,14} administered multiple times at multiples sites between 2003 and 2007, to cross-sectional populations of engineering students at all undergraduate levels, focused on questions of persistence in engineering. Quantitative findings from this survey indicated that only 42 percent of college seniors in engineering programs definitely intended to pursue a career in engineering upon graduation. Qualitative findings indicated that, “during the span of students’ tenure as undergraduates, their thoughts about career options were strongly swayed – we could even say disproportionately swayed – by a single experience, such as an internship interaction with faculty or even staff, or advice from a mentor.”¹⁵ Analyses of these studies continues, but preliminary results from PIE, in particular, show that the 24 percent of study participants who did not persist in engineering were more likely to be motivated or influenced by family to study engineering, displayed lower confidence in math and science, and indicated lower engagement in both technical and non-technical course work.^{12,16}

We have similar interests in the persistence of engineering students at the University of Notre Dame College of Engineering. As a result, we have conducted surveys that gather much of the information discussed above, and have analyzed it in parts to examine, for example, the effect of course grades on retention, the connection between SAT scores and Advanced Placement (AP) course work on retention, and the reasons why women (at one time) and minority students exhibit different retention rates. The current study, however, looked at these and other factors as

elements of a complex system of causes and effects on students' decisions to persist.

First-Year Engineering at Notre Dame

The University of Notre Dame is a medium-sized, selective, private doctoral research university that admits students on the basis of a number of factors, including standardized test scores, high school class rank/performance, extracurricular activities and demonstrated leadership potential. Students admitted to the University must demonstrate, among other things, high intellectual potential through their high school academic records. The selectivity of the admissions process yields a student body that is, in many ways, quite homogenous. At larger universities and at other, more diverse universities, some of the questions we ask might be difficult to answer due to wider differences in the level of preparation and background students bring to those institutions. At Notre Dame, however, this homogeneity makes the student body an interesting group to study, specifically for the factors relating to retention from the first year to sophomore year.

Graduation numbers reached a troubling low level in the late 1990s and, as a result, the University and the College began to scrutinize factors that affected enrollment and persistence in engineering. This longitudinal retention study thus began in the fall of 2001, with the development of a hands-on first-year engineering course sequence that continues today, although in modified form. Analyzing student demographic data, along with retention data and academic performance data, has become an important aspect of evaluating the success of that experiment on an annual basis.

Brockman *et al.*¹⁷ and others^{18,18,20} have described in detail the motivations for and structure of the Introduction to Engineering Systems I and II (EG 10111 and EG 10112) courses. The course sequence comprises a series of team-oriented projects conducted over two semesters, and emphasizes a student-centered learning paradigm. The course radically changed the way that the College of Engineering at the University of Notre Dame prepared first-year students to begin discipline-specific engineering studies in the sophomore year. Also, because the course content has evolved each year, as a result of student feedback as described in Pieronek *et al.*¹⁸ and McWilliams *et al.*,^{20,21} survey data as well as retention data have helped to assess the effects and effectiveness of those changes.

Students participate in surveys administered three times over the course of the year. The first survey, conducted within the first week of the fall semester, provides baseline data for the students, which give us an understanding of what they are like when they enter the university (demographic characteristics, college preparation, post-college aspirations) and allows us to examine trends across incoming cohorts. The second survey, conducted immediately prior to the end of the fall semester and before fall grades are determined, assesses student satisfaction with the first of the two courses and gathers some data on the likelihood that students will continue in engineering. This survey was first administered to the Class of 2007 after identifying the need to capture information from those who chose to leave the course after the fall semester. The third survey, conducted immediately prior to the end of the spring semester and before spring grades are determined, provides feedback similar to that of the second fall survey. Students complete the surveys during class time, so response rates are high – typically over 65 percent – and we see no participation differences across demographic groups (gender or race/ethnicity).

Overall, these surveys provide data on nearly 2,300 first-year engineering students, with complete data sets available for over 1,700 students.

The results of the first survey, in particular, provide important information about the types of students enrolled in the EG 10111 course and, when combined with other data such as SAT scores and ultimate sophomore-year major, helps us to understand the types of students who persist in engineering. Pieronek *et al.*¹⁸ discusses the fact that students with certain characteristics are retained into sophomore year at a higher rate than students who do not possess those characteristics. For example, we know that students who select an engineering major on their application for admission and then enroll in the EG 10111 course are retained into sophomore year at a much higher rate than students who selected a non-engineering major but enrolled in the course anyway. We know that white students are retained at a higher rate than non-white students. And we know from other studies as described in Pieronek *et al.*¹⁸ that the course content can differentially affect retention of various groups, especially on the basis of gender. The analysis presented in this paper, however, is our first attempt to comprehensively examine all of the student characteristics captured on the surveys – and primarily on the first survey – and from other data we have, to understand which characteristics have the most significant relationship to retention.

Incoming Student Characteristics

The first survey in the fall presents the entry characteristics of the students. Over the seven years of the survey, the demographic characteristics of the students enrolled in the fall course, EG 10111, have changed somewhat. Female enrollment has risen from 20 to 30 percent of the class. Non-white (minority) enrollment varied with University enrollment of non-white students and did not exhibit any consistent trends over the years of the survey. (Note that this analysis includes Asian/Pacific Islander students in with the traditional under-represented minority ethnic groups of African-American, Hispanic/Latino and Native American. The data were run both ways, including Asian/Pacific Islander students with white students and with under-represented minority students, with no difference in results, probably due to the fact that the Asian/Pacific Islander population at Notre Dame is small, at 3 to 5 percent of each class.)

Students presented median SAT quantitative scores at or above 710, and median SAT verbal scores around 680. The median number of college credit hours resulting from Advanced Placement test scores is 10 credit hours most years, although the more recent classes have shown some upward trends in this area. For most students, these credits represent credit for the first calculus class, first-year composition and one additional liberal arts course in history or social science. Taken together, these trends indicate that a majority of students come to the program well prepared for college course work.

The surveys also ask students about their participation in applied and pre-college math, science and engineering programs. Applied activities include working on a car engine, building an electric circuit, repairing a small appliance, installing hardware or software on a computer and experience with various software programs, and the participation of those students in each cohort year ranged from 62 to 78 percent, with most years close to 70 percent. Pre-college activities include

participation in school science fairs, robotics teams, pre-engineering summer programs, space camp and the like. Approximately 70 percent of the Classes of 2005 through 2008 reported participation in such activities, but that number jumped to nearly 90 percent for subsequent classes when additional activities were added to the list of options. Participation in both types of activities has been increasingly strong and has shown a slight increase over time, indicating that incoming students, in addition to being academically prepared for challenging course work, have shown early interest in the substantive content of the engineering curriculum.

Notre Dame students do not make their decisions about college majors and career paths in isolation, and are very possibly strongly influenced by family members. Approximately sixty percent of the students enrolled in EG 10111 come from families with at least one engineer in the immediate family. Having such direct access to engineers suggests that many of these students should have realistic expectations about the requirements of both the degree and the career, as well as support at home to help them meet these requirements.

Around 70 percent of all students report that they expect to complete their engineering bachelor's degree, indicating, then, that 30 percent of the students who start EG 10111 are unsure of their plans. We see steady percentages of students intending to major in aerospace engineering (15 percent), mechanical engineering (20 percent) and civil engineering (10 percent), but decreases over time in computer science and engineering (15 to 5 percent) and electrical engineering (8 to 5 percent), while the percentage interested in chemical engineering has increased (from 10 to 25 percent over the years of the survey).

Students also report their career aspirations immediately following graduation and 20 years later. Approximately half of all students surveyed indicated post-graduation plans to attend engineering graduate school or to take a job in an engineering industry, and about one-sixth of the group indicated post-graduation plans to pursue an MBA degree. On the longer, 20-year horizon, one-third of the group expected to be employed as a manager, either on the business or engineering side of a firm, and another third expected to be employed either in research and development or product/process design. Very few students (around 5 percent of each cohort) indicated plans to pursue a career in academia.

When asked about the most important factors that motivated students to choose engineering, students were most likely to cite as very important, positive factors their own interest in the subject matter (70 percent), their own interest in science and math (65 percent), and engineering career opportunities (55 percent). Advice from others, including parents, friends and counselors or advisors had very little impact (10 percent cited advice from parents, while almost no students cited advice from other sources). In terms of their strongest motivator for studying engineering, approximately 60 percent of students indicated that they felt that engineering would make the best use of their skills, interests and abilities.

The demographic data described above suggest that Notre Dame recruits talented cohorts of first-year students who come to the University with high expectations, ambitious goals and strong self-confidence. Yet all of these positives can lead to some negatives for the program. Students who experience great academic success in high school are likely to expect that success to continue in

college, and therefore might struggle emotionally or motivationally when they are unable to achieve superior status among their classmates. Marsh *et al.*²² suggest that negative effects of this transition from big fish in a small pond to small fish in a big pond are pervasive among high-achieving students from strong high schools, and indicate a need to make sure that first-year students set realistic goals for academic achievement and maintain perspective about their academic struggles. In addition to suggesting that the surveyed students are well prepared for the engineering curriculum, these data also indicate that many first-year students have shown an early interest in engineering, science and math. Not all of these students have expressed certainty that engineering presents the best academic or career choice for them, however.

Predicting Retention: Bivariate Analysis

This section presents a set of bivariate analyses that examine statistical differences in retention rates between the demographic groups discussed above, based on incoming student characteristics as well as the result of the fall survey given at the beginning of EG 10111.

Collectively, through the Class of 2011, we retained 65 percent of women and 69 percent of men to sophomore year. Table 1 shows the improvement in retention over the seven-year span of the survey, including the marked improvement in the retention of women.

Table 1
Retention to Sophomore Year, by Gender

	2005	2006	2007	2008	2009	2010	2011
Overall	58%	61%	66%	71%	73%	68%	71%
Men	62%	65%	65%	71%	74%	68%	71%
Women	42%	49%	69%	69%	72%	66%	69%

Although chi-square results just miss the statistically significant level (chi-square = 4.565, $p = 0.102$), it is interesting to note the slight difference between genders on fall and spring retention. Women are more likely than men to leave the engineering program after the fall semester, but are equally likely as men to leave after the spring semester. Therefore, if a female student remains in the program to the beginning of the second semester, she is just as likely as a male student to be retained into the sophomore year engineering program.

Collectively, through the Class of 2011, we retained 72 percent of white and 64 percent of nonwhite students, a statistically significant difference (chi-square = 10.781, $p = 0.005$). Non-white students are more likely than white students to leave after both fall and spring semesters, but non-whites leave at higher rates at the end of the fall semester. Retention rates of non-white students varied widely during the years of the survey.

We have also seen statistically significant differences in retention on the basis of SAT quantitative and verbal scores and the number of credits earned through Advanced Placement (AP) work.

Persisters have a mean SAT quantitative score of 720, while those who left after either the fall or the spring semester have a mean SAT quantitative score of 698 ($F = 29.503$, $p = 0.000$).

Persisters have a mean SAT verbal score of 683, while those who left after the fall semester have a mean SAT verbal score of 673 and those who left after the spring semester have a mean SAT verbal score of 670 ($F = 6.361$, $p = 0.002$). And stayers have an average of 14.1 hours of college credit due to AP, while fall leavers have 10.8 and spring leavers have 10.5 hours ($F = 25.845$, $p = 0.000$). Not surprisingly, then, those students who come to Notre Dame most prepared for the academic rigors of college work, as measured by SAT scores and AP credits, are those most likely to be retained in the engineering program. (Note that we use SAT scores and AP credits here not as indicators of academic performance, but rather, as indicators of a student's pre-college educational experience, assuming that stronger schools offer more advanced coursework than weaker schools, and knowing that the University's Office of Admissions expects students to take the most challenging curriculum their high schools offer.)

The surveys asked students about the frequency with which they participated in applied activities that would indicate a natural curiosity about or propensity toward the field of engineering. This characteristic, too, produced statically significant retention differences (all chi-square results, for each of the activities, significant at $p < 0.100$). Overall, 70 to 75 percent of students who participated occasionally or frequently in these activities remained in engineering as sophomores, compared with a 55 to 65 percent retention of those who participated only once or never. In general, this seems to indicate that taking an early interest in engineering-related projects and seeking out opportunities to pursue those interests seems to predict retention.

Students with at least one relative in engineering are statistically significantly more likely to remain in engineering (73 percent retained to sophomore year) than students with no relatives in engineering (66 percent retained), regardless of whether the family member is a parent, sibling or more extended family member such as a grandparent, aunt or uncle (all chi-square results significant at $p < 0.100$). This suggests that either knowledge of the field of engineering or family pressures and expectations, or both, play a positive role in retaining students in engineering into the sophomore year.

Students who indicated a post-graduation goal of attending engineering graduate school or getting a job in an engineering industry are statistically significantly more likely to remain in engineering as sophomores (75 percent) than those who do not have those plans (66 percent) (both chi-square results significant at $p = 0.000$). Students interested in pursuing an MBA are no more likely to be retained than those not interested in an MBA (chi square = 0.649, $p = 0.723$), but students who show interest in other types of post-baccalaureate work such as law school, medical school or non-engineering graduate programs are far more likely to leave the program (only 53 percent retained) than those without such interests (70 percent retained) (chi-square = 42.859, $p = 0.000$).

Similarly, their goals for 20 years after graduation help to form a picture about the types of students retained in the program. Students with a long-term goal of working in research and development, product or process design and engineering management are retained at a higher rate (75 percent) than those without those goals (66 percent) (all chi-square results significant at $p <$

0.100). But students with a goal of either teaching or teaching and researching in an academic setting are more likely to leave the program than those with other plans (chi-square = 7.403, $p = 0.025$). This finding is particularly interesting given that students with an interest in engineering graduate school are more likely to be retained than students without such plans. This perhaps indicates that interest in pursuing a master's degree in engineering might be predictive of retention in the program, but that interest in pursuing a doctoral degree is not. This is certainly an area for further study. And, although students who plan to pursue an MBA are no more likely to be retained in the program than students without such plans, students with interests in self-employment or holding a business manager position are less likely to be retained (56 percent) than those without such plans (69 percent) (all chi-square results significant at $p < 0.000$).

In addition, students who, within the first few weeks of college life, expect to complete their engineering degree are retained at a much higher rate (78 percent) than students who do not expect to complete that degree (46 percent) (chi-square = 207.802, $p = 0.000$). Taken together with the post-graduation and 20-year career plan results, we see that students who enter the program with specific plan for a career in engineering have a much higher probability of retention than those with other plans.

In terms of academic achievement, not surprisingly, students who remain in the program in sophomore year have higher grades in the EG 10111/2 courses, and higher overall semester grade-point averages, than students who leave in the fall or the spring. Retained students generally performed at the B+ level, while students who left generally performed at the B to B-level (all differences statistically significant at the 0.000 level) and yet were also in good academic standing. But, it is important to note that, at least for the fall survey data, students do not know with certainty their grades at the time they complete the survey. Thus, it becomes a chicken-and-egg question of whether students who suspect low grades decide to leave, or whether students decide to leave for other reasons, turn their attention to other courses or activities and, as a result, earn lower grades in the engineering course.

Examining students by the major they identify on the surveys at the start of the fall semester shows that students who are undecided or have identified a non-engineering major are much more likely to leave engineering than students who identify a specific field of engineering. Overall, only about one-third of those who identify a specific field of engineering as a major leave engineering prior to sophomore year, but 50 percent of students undecided about their engineering major, and 80 percent of students who had intentions to pursue some other, non-engineering major leave prior to sophomore year.

These bivariate analyses, taken together, indicate that some natural attrition occurs after the first semester as students whose interests are not quite in line with the opportunities offered by an engineering degree change majors. Those likely to leave before sophomore year either do not expect to complete an engineering bachelor's degree, are undecided about their major in general, have interests in advanced degrees in law or medicine, see themselves as business managers or business owners 20 years after graduation, or -- perhaps most interestingly -- intended to pursue an academic career in engineering. This last area is ripe for further study.

Predicting Retention: Multivariate Analysis

Most of the results of the bivariate analysis are not terribly surprising. However, performing a multivariable regression analysis using these same parameters gives an indication of the relative effects on retention of these various demographic and personal characteristics. This section presents the results of a logistic regression analysis examining the effects of multiple independent variables on retention in the program.

Table 2 presents five different models that examine the effects of demographic characteristics, college preparation, applied activities, aspirations immediately after and 20 years after graduation, and motivations for majoring in engineering.

Table 2
Logistic Regression Predicting Sophomore Retention

Model Number:	1	2	3	4	5
<i>Demographic Characteristics</i>					
white	0.374***	0.207	0.251	0.304	-0.084
male	0.060	-0.052	-0.080	-0.045	-0.206
engineer in family	0.249***	0.140*	0.206***	0.193**	0.137*
<i>College Preparation</i>					
SAT Q		0.001	0.001	0.001	-0.002
SAT V		0.000	0.001	0.001	0.000
AP credits		0.019***	0.022***	0.024***	0.005
<i>Applied activities</i>					
worked on a car engine		-0.314*	-0.400*	-0.425*	-0.347
built circuit		0.380*	0.331*	0.287	0.266
installed software		0.325*	0.371*	0.396*	0.377*
installed hardware		0.324**	0.286*	0.233	0.317*
repaired small appliance		0.217	0.215	0.149	0.164
<i>Aspirations: year after graduation</i>					
engineering grad school			0.799***	0.724***	0.687***
MBA			0.737***	0.721***	0.750***
other post grad school			-0.152	-0.033	-0.020
engineering job			0.894***	0.786***	0.709***
<i>Aspirations: 20 years after graduation</i>					
academia			-0.112	-0.047	0.056
research & development			0.663***	0.573**	0.587**
design			0.717***	0.559*	0.481*
self-employed			-0.262	-0.287	-0.418
business manager			-0.006	0.065	0.054
engineering manager			0.619***	0.542**	0.694**
<i>Motivations for Engineering major</i>					
people expect it				-0.163	-0.766
makes use of my skills				1.410***	0.852**
desire for high-status job				0.722*	0.437
serve comm./help others				1.288***	0.773*
<i>Academic Achievement</i>					
First semester GPA					0.665***
EG111 grade					0.840***
N	2280	1773	1773	1773	1733

* p<.05, **p<.01, ***p<.001

Model 1 tests which student characteristics are most predictive of retention to sophomore year. The variable "engineer in family" indicates whether or not a student reports that any immediate family member is an engineer. The positive and significant coefficient reveals that those students who have an engineer in the family are more likely to be retained in the program than students without an engineer in the family, holding all other variables constant. This model also indicates that white students are more likely than non-whites to be retained as also shown in the bivariate analysis, but this effect is not seen in subsequent models that address other aspects of a student's background and, in fact, disappears when controlling for SAT scores, AP credits and involvement in applied engineering activities as shown in Model 2.

Model 2 adds the three variables intended to measure academic preparation for college: SAT quantitative score, SAT verbal score, and number of credits earned due to AP. Although SAT scores do not reliably predict retention, the number of credits earned due to AP does. The significant, positive coefficient for this variable suggests that the likelihood of sophomore retention increases as the number of AP credits increases. The most likely interpretation of this finding is that the number of college credits earned through AP reflects academic preparation for college, and the more prepared a student is for the rigors of an engineering program, the more likely the student will remain in the program through the sophomore year. This interpretation is strengthened by the fact that this effect remains significant in subsequent models until Model 5, when first-semester academic achievement measures are added, indicating that the stronger a students' academic work in college, the more likely the student will remain in engineering. As noted above, however, this simply begs some chicken-and-egg questions. Does the student remain in engineering because of good grades, or does a student who is committed to engineering earn good grades? Conversely, does a student leave engineering because of not-so-good grades, or does a student who is not committed to engineering turn attention elsewhere before the end of the semester and fail to put in the effort required to earn better grades?

A secondary, and perhaps not incompatible, interpretation of the positive significant effect of AP credits on retention is that this variable may serve as a proxy for quality of the high school from which students graduate, and higher quality schools (because of the opportunities they can provide to students) produce students well prepared for the challenges of the first year of study in engineering. Either way, and not surprisingly, students academically well-prepared for college tend to remain in the program in the sophomore year.

Model 2 also includes variables indicating whether or not students engaged in any engineering-related applied activities before starting college. These activities include installing software or hardware, building a circuit, and repairing a car engine or small appliance. Students with computer-related experience are more likely to be retained in the program than students without such experience. Interestingly, students with experience working on car engines are less likely than those without these skills to be retained. One possible interpretation of this result is that students who like to tinker with mechanical systems such as automobiles have a different impression of what engineering might be, and could be turned off by a curriculum that is more theoretical than hands-on.

Model 3 adds variables concerning students' post-college aspirations. Not surprisingly, students

who, in their first few weeks at ND, indicate that they expect to be employed in an engineering industry job or enrolled in an engineering graduate program the year after graduation from college are more likely to be retained in the program than students without these goals. Results are similar for students interested in pursuing an MBA immediately after college. A related finding holds for students who express interest in employment in specific types of engineering jobs (research and development or design) or as a manager in an engineering firm twenty years after graduation. Taken together, these results suggest that students who enter the program with specific goals to pursue Engineering-related or management positions within the Engineering field are more likely to be retained than are students without such firm plans. Note, too, the negative coefficient on the variable representing student interest in other post-graduate education, meaning primarily law or medical school. Although this variable did not produce a statistically significant coefficient, it is interesting to note that the variable has a negative effect on retention in engineering.

Model 4 adds variables related to students' motivations for choosing engineering as a major. Sophomore retention is more likely for students who report that engineering will allow them to use their skills than for students who respond to the contrary, and is also more likely for students who view the field of engineering as an opportunity to serve the community and help others than for students for whom this is not true. However, there is no significant effect on retention because of any quest for status or because important people in students' lives expect them to major in engineering.

Model 5 expands on Model 4 by adding the academic achievement variables. It is interesting to note that, once these variables are added to the regression, the effects on retention of having an engineer in the family drop noticeably, and the effects of AP course work approach zero.

Models 3, 4 and 5 provide perhaps the most interesting information, in that they show that student plans for the year immediately following graduation are the most significant predictors of student retention to the sophomore year. These variables remain significant even after controlling for student motivations for studying engineering and student success in the first semester of the program.

Conclusion

The bivariate and multivariate analyses of a comprehensive set of data related to student preparation, experiences and motivation yields a picture of the sort of student for whom our first-year engineering program is successful. Certain students are more likely to be retained to sophomore year: those with strong college preparation backgrounds from high school, those with reasonably good academic performance in the first year, those who come to college from families with at least one engineer, and students who have experience with applied engineering activities.

Overall, we see no significant effects related to gender, and the effects related to race/ethnicity disappear when controlling for pre-college preparation -- a finding also reported in other studies of factors influencing engineering graduation rates.^{5,7} And, consistent with other studies of persistence,⁵ we confirm that student engagement is the underlying issue. Students who begin their studies in engineering and who are well prepared for academic success in college, with prior

knowledge and/or experience with engineering concepts, or with specific plans directing them toward an engineering career are likely to be retained in the program to sophomore year. Again, this is perhaps no surprise, but does confirm that the engineering program functions as intended: students who want to be engineers, by and large, become engineers. And because other studies¹⁵ report that students make long-term career decisions based on limited experiences, these data point to an opportunity to directly address, through the first-year course but in a different way, those students with less certain plans.

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