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Career Plans of Undergraduate Engineering Students
Characteristics and Contexts

Shannon K. Gilmartin, anthony lising antonio, Samantha R. Brunhaver, Helen L. Chen, and Sheri D. Sheppard

Each year some 80,000 students graduate from one of over 350 universities and colleges in the United States with a bachelor of science (BS) degree in engineering (American Society for Engineering Education [ASEE] 2015; National Science Foundation [NSF] 2015). This chapter examines how many of these graduates see this degree as leading to engineering work, the types of engineering students who are more likely to go into engineering work, and the experiences that influence their entering the profession or working elsewhere. The chapter builds on findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (Sheppard et al. 2010),[1]

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1. Prior work identified positive predictors of plans to pursue engineering jobs after college, including financial motivation to study engineering (i.e., seeing engineering as a means to a job, reporting that "engineers are well paid"), psychological motivation to study engineering (i.e., being intrinsically interested in engineering, reporting that engineering is "fun"), exposure to engineering through internships, visits, and employment, and involvement in engineering

which was a part of the NSF-funded Academic Pathways Study (APS).[2] We augment the APPLES data with data from three national sources. We employ multilevel modeling techniques to consider the effects of individual-level and institution-level measures simultaneously.

Our study fits into a larger body of work on engineering career pathways, which has studied the factors influencing persistence and retention in undergraduate engineering programs[3] and the intentions of seniors to take engineering jobs upon graduation.[4] These studies point to a link between students' perceptions of educational environments in engineering and of their own engineering skills and preparedness, and their plans to continue on in an engineering career.[5]

The current work builds on this literature of how engineering students conceive of their professional futures to examine the variation of student plans with individual and environmental characteristics such as socio-economic background, major field of study, institutional selectivity, and

courses. Negative predictors included confidence in professional and interpersonal skills and extracurricular involvement in nonengineering activities. Across all of our models of postgraduation plans, confidence in professional/interpersonal skills consistently characterized students who were leaning away from engineering options and toward nonengineering options, while psychological motivation to study engineering consistently characterized students who were leaning toward engineering options and away from nonengineering options.

2. The Center for the Advancement of Engineering Education (CAEE) was established by NSF in 2003. CAEE's five partner institutions were Colorado School of Mines, Howard University, Stanford University, University of Minnesota, and University of Washington (the lead institution). CAEE consisted of three research components: Scholarship on Learning Engineering, Scholarship on Teaching Engineering, and the Institute for Scholarship on Engineering Education. The APS was a major undertaking of the Scholarship on Learning Engineering component (Clark et al. 2008).

3. Seymour and Hewitt (1997), Brainard and Carlin (1998), Eris et al. (2005, 2007, 2010), Huang, Taddese, and Walter (2000), Besterfield-Sacre, Atman, and Shuman (1997), and Besterfield-Sacre et al. (2001). Adelman (1998) used students' college transcripts in the High School and Beyond/Sophomore Cohort Longitudinal Study (1982–1993). Ohland et al. (2008, 2009, 2011) and Lord et al. (2008, 2009) analyzed the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) data set of academic records for over 75,000 first-time-in-college students matriculating in engineering from 1988 through 1998 across nine partner institutions.

4. Margolis and Kotys-Schwartz (2009) found that 65 percent of seniors at a midwestern university had some reservations about committing to an engineering career after college. In a study of 1,629 freshmen through seniors across nine institutions, Amelink and Creamer (2010) found a relationship between satisfaction with instruction and plans to work in engineering. Investigating decisions to pursue six different engineering and nonengineering career options within three years of graduation, Ro (2011) found that students who were more likely to pursue engineering work or graduate school options tended to be male, to report greater curricular emphases on core engineering thinking and professional skills in their engineering programs, to have had more active and collaborative learning experiences, and to rate their engineering and design skills highly. By contrast, students intending to work outside of engineering were more likely to report greater curricular emphasis on professional values and to have higher confidence in their understanding of the relationship between engineering and social, economic, and other contexts. Seniors compared with sophomores and students enrolled in general engineering majors compared with mechanical engineering were more likely to be considering nonengineering careers.

5. Sheppard et al. (2014) give a deeper methodological review of research on plans and pathways.

labor market conditions. It also illuminates engineering career paths beyond graduation. As Sheppard et al. (2014) note, most studies report the proportions of graduates who remain in engineering professions (e.g., Bradburn et al. 2006; Choy, Bradburn, and Carroll 2008; Forrest Cataldi et al. 2011; Regets 2006), by gender (e.g., Frehill 2007a, 2007b; Robst 2007), or within major (Reese 2003). In analyses of persistence across all science, math, technology, and engineering fields by students' achievement level measured by SAT math scores or college GPA, depending on the time point under study, Lowell et al. (2009) observed that in recent decades, the highest-performing students and graduates were leaving science and engineering pathways at a greater rate than were lower-performing students and graduates. The data for the current study highlight additional pre-labor-force factors that may be important in differentiating professional pathways.

2.1 Data

The data for this study are drawn primarily from APPLES, a fifty-item survey instrument administered to over 4,000 students across twenty-one U.S. colleges and universities in 2008 (Chen et al. 2008; Donaldson et al. 2007, 2008). Clark et al. (2008) detail the design of the larger APS and related instrumentation. Institutions were recruited to participate in the APPLES study based on a stratified sampling plan designed to capture the broad range of four-year colleges and universities in the United States (Donaldson et al. 2008). Appendix A shows the distribution of institutions by 2000 Carnegie Classification category (Carnegie Foundation for the Advancement of Teaching 2001). Institutions were geographically diverse, representing seventeen states across major U.S. regions. Sheppard et al. (2010) provide further discussion of the representativeness of these twenty-one institutions. The final Center for the Advancement of Engineering Education (CAEE) report (Atman et al. 2010) lays out major project findings.

We sample 2,143 survey respondents identifying as "juniors," "seniors," or "fifth-year seniors or more." Respondents in each academic cohort were similar on key demographic measures and measures of engineering plans following graduation, thus allowing us to aggregate cohorts and consider predictors of plans across a larger sample. Women make up 30.8 percent of the sample and thus are overrepresented compared with the U.S. population of students who earned an engineering degree in 2008. Additionally, (prospective) electrical engineering degree earners are slightly underrepresented and mechanical engineering degree earners are slightly overrepresented.[6]

We merge three additional sources of data into the APPLES survey data

6. All APPLES respondents were enrolled at their undergraduate institutions at the time of the study; thus, "degree earners" is a prospective label. See NSF (2011a) for statistics on the 2008 population of engineering degree earners by gender and major. Sheppard et al. (2010) examine the representativeness of the student respondent sample relative to the national population of engineering undergraduates.

set to analyze institutional and labor market effects: median annual wage data by engineering field and U.S. state from the Bureau of Labor Statistics' (BLS) National Cross-Industry Estimates, May 2007 (BLS 2011); and data on institutional selectivity and resources for each of the twenty-one APPLES institutions from the Integrated Postsecondary Education Data System (IPEDS), 2006 (National Center for Education Statistics [NCES] 2011), and the ASEE Engineering and Engineering Technology College Profiles, 2006 (ASEE 2011). For measures of selectivity (i.e., SAT percentile scores) at a small number of schools, 2007–2008 IPEDS data were used in the absence of such data for 2006–2007; for the student-to-faculty ratio at each institution, 2008–2009 IPEDS data were used in the absence of such data for 2006–2007.

2.1.1 Hierarchical Linear Modeling

Due to the nested students-within-institutions nature of the data set, hierarchical linear modeling (HLM) techniques were used for multivariate modeling. Ordinary least squares regression techniques may underestimate standard errors in this type of sample, given the dependence of observations within each school. Hierarchical linear modeling accounts for such clustering by partitioning between-school variance and within-school variance, thereby generating more robust standard errors and allowing us to directly estimate school-level effects on outcomes (Raudenbush and Bryk 2002). The outcome measure of interest is respondents' postgraduation plans, which we define by three mutually exclusive categories: engineering-focused plans, nonengineering-focused plans, and mixed plans. We conducted multinomial logistic regression (MLR) analyses with a multilevel specification (hierarchical generalized linear modeling) of this outcome measure.

Level 1 models focus on the relationships between students' postgraduation plans, background characteristics, educational experiences and attitudes, and education and employment contexts. The models contain eighteen independent variables.[7] Each independent variable was centered around its group mean. To facilitate interpretation and comparability of coefficients, we standardized all nondichotomous variables prior to centering. Prelimi-

7. The multinomial logistic model in a hierarchical generalized linear model is given by

$$\text{Prob}(R_{ij} = 1) = \phi_{1ij}$$
$$\text{Prob}(R_{ij} = 2) = \phi_{2ij}$$
$$\text{Prob}(R_{ij} = 3) = \phi_{3ij} = 1 - \phi_{1ij} - \phi_{2ij}$$

where each response category I is associated with a probability (ϕ). Using a multinomial logit link (logged ratio of probabilities), the Level 1 structural model is expressed as

$$\eta_{1ij} = \beta_{0j(1)} + [\text{student background characteristics (2 measures)} + \text{educational experiences/attitudes (7 measures)} + \text{major (8 measures)} + \text{expected salary (1 measure) in the form } \Sigma\beta_{qj(1)}X_{qij}]$$

$$\eta_{2ij} = \beta_{0j(2)} + [\text{student background characteristics (2 measures)} + \text{educational experiences/attitudes (7 measures)} + \text{major (8 measures)} + \text{expected salary (1 measure) in the form } \Sigma\beta_{qj(2)}X_{qij}]$$

nary Level 1 models tested the effects of "gender"[8] and "underrepresented racial/ethnic minority (URM) status" as separate, independent measures. Final models tested "URM women" versus other students based on exploratory descriptive and multivariate results that indicated this group may have unique postgraduation plans (see Sheppard et al. 2010).

Level 2 models, which focus on the effect of differences in institutional selectivity and resources on postgraduation plans, are more difficult to estimate given that there are only twenty-one institutions in the APPLES data set. Preliminary analyses of simple correlations showed how these institutional characteristics clustered into thematic groups and were related to postgraduation plans. These groups formed the basis of the subsequent testing sequence designed to account for limited variation in institutions. Some thematic groups included only one variable, for example, percentage of undergraduates enrolled as part-time students. Other groups comprised two variables (representing academic selectivity, financial aid receipt, enrollment characteristics, and student-faculty ratio), which we first modeled as the relationship between a variable and the outcome alone and then in conjunction with its companion measure (this allowed us to assess if a variable's predictive power was independent of a related measure—and which of the two was the stronger predictor). Ten sets of Level 2 models were constructed according to this heuristic. Each Level 2 variable was centered around the grand mean. As with the Level 1 models, nondichotomous variables were standardized prior to centering.

Finally, post hoc univariate analyses were conducted to elaborate on findings from multivariate models. These included one-way ANOVAs with post hoc multiple comparisons, and Welch robust tests of equality of means where variance was heterogeneous. For pairwise comparisons, we used Bonferroni tests in the case of homogeneous variance, and Games-Howell tests in the case of heterogeneous variance.

2.1.2 Outcome Measures

To measure students' postgraduation plans, the APPLES survey asked students "How likely is it that you would do each of the following after

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where η is the log-odds of being in category (1) or (2) relative to category (3) as a function of the group mean (β_0) and covariates (X).

At Level 2, the model is given by

$$\beta_{0j(1)} = \gamma_{0(1)} + \Sigma\gamma_{0s(1)}W_{sj} + \mu_{0j(1)}$$
$$\beta_{0j(2)} = \gamma_{0(2)} + \Sigma\gamma_{0s(2)}W_{sj} + \mu_{0j(2)}$$
$$\beta_{qj(m)} = \gamma_{q0(m)},\ q = 1, \ldots, 17$$

where the group mean is a function of the grand mean (γ_0) and covariates (W).

8. To retain the maximum number of cases for our multivariate models, gender was imputed for twenty missing values using logistic regression techniques, and mean-replacement was used for missing values on other independent variables, including four composite measures (the proportion of missing values on any given variable was low, ranging from < .5 percent to 2.5 percent).

graduation?" and listed four possible options: "work in an engineering job," "work in a nonengineering job," "go to graduate school in an engineering discipline," and "go to graduate school outside of engineering."[9] Each item was measured on a five-point scale, from 0 = "definitely not" to 4 = "definitely yes." Respondents were then placed into one of three analytic groups based on combinations of responses across all four postgraduation categories:

"engineering-focused students" are those who marked probably/definitely yes to one or both engineering options (job, graduate school) and probably/definitely no to both nonengineering options (job, graduate school);
"nonengineering-focused students" are those who marked probably/definitely yes to one or both nonengineering options and probably/definitely no to both engineering options; and
"all other plans" include all other possible response combinations to the four postgraduation survey items.

We developed a second classification to analyze a narrower subset of students falling into the "all other plans" group. In this classification, we replaced "all other plans" by "cross-field plans," which includes only those response combinations where students marked probably/definitely yes to at least one engineering option and one nonengineering option. This "refined sample" reduced the observations for analysis from 2,143 students to 1,318 students.

Level 1 and Level 2 MLR analyses were conducted on the groups defined by each classification scheme. To support interpretation of the multinomial results, each of the four constituent pathways questions (likelihood to "work in an engineering job," "work in a nonengineering job," "go to graduate school in an engineering discipline," "go to graduate school outside of engineering") also was modeled separately with the same Level 1 specification using HLM. We do not present the results of these supplementary analyses in this chapter, but reference them when necessary to clarify discussion of the MLR results. Detailed results of these analyses are available from the authors upon request.

Taking Level 1 measures first, we measured students' self-reported socioeconomic background (SES) by a question: "Would you describe your family as: . . . ?" This item was measured on a five-point scale, from 0 = "low income" to 4 = "high income." We identified nine major fields of study: aerospace engineering, chemical engineering, civil and environmental engineering, computer science/engineering, electrical engineering, industrial engineering, mechanical engineering, "bio-x" engineering, and "other engineering." The majority of institutions in the sample include

9. Students were not presented with a list of specific engineering jobs on the APPLES instrument. Rather, they were asked about "engineering jobs" in the aggregate; the intention was to elicit students' interest in these jobs as they conceived them to be. Interpretive limitations to these measures are discussed in Sheppard et al. (2014).

civil and environmental engineering in one department, so these majors were aggregated into a single major with 280 respondents marking "civil" and twenty-two respondents marking "environmental." Computer science/engineering includes only students reporting "computer science/engineering (in engineering)" as distinct from a computer science program outside of engineering. In addition to the majors listed on the survey, we developed two categories from students' write-in responses to an "other engineering major" open-ended field: "bio-x," which covers bioengineering programs such as bioengineering, biomedical engineering, and so forth; and "other engineering," which includes agricultural engineering, construction engineering, engineering math and physics, engineering operations research and business, general engineering, materials and metallurgical engineering, nuclear engineering, ocean engineering, and other engineering. Two APPLES institutions offer a "general engineering" degree only; all respondents at these two schools are classified as "other engineering" majors. Mechanical engineering is the reference group for all regression models.

Drawing from BLS 2007 median annual earnings data by state, students were assigned an expected earnings based on their engineering major and the state in which their college was located. The BLS engineering fields generally correspond with APPLES major groups, but where possible we assigned students in more detailed majors earnings from more detailed BLS occupations as described in the footnote.[10] We also used several variables that earlier work on the APPLES data set found to be strong predictors of students' postgraduation plans as covariate controls for the models:

Financial motivation. A three-item composite measure of students' financially motivated reasons to pursue engineering study.
Intrinsic psychological motivation. A three-item composite measure of students' "intrinsic" reasons to pursue engineering study.
Exposure to engineering work. Obtained from the survey question "How much exposure have you had to a professional engineering environment as a visitor, intern, or employee?" based on a four-point scale from 0 = "no exposure" to 3 = "extensive exposure."
Involvement in engineering classes.
Participation in nonengineering activities. Obtained from the survey question "How often are you involved in the kinds of nonengineering activities

10. Civil engineering majors were assigned median earnings for civil engineers. Environmental engineering majors were assigned earnings for environmental engineers. Students in computer science/engineering majors were assigned an average median earnings across three BLS fields: computer hardware engineers, computer software engineers: applications, and computer software engineers: systems software. Students in bio-x engineering majors were assigned a median earnings for biomedical engineers. For students in the "other engineering" major group, a "match" to BLS data was made wherever possible, for example, materials engineers in our "other engineering" major group were assigned median earnings for materials engineers in the BLS data. However, median earnings for these "other" fields were not available for every field in every state; in the case of a nonmatch, these students were assigned a median for the BLS "other engineering" category.

described above (hobbies, civic or church organizations, campus publications, student government, social fraternity or sorority, sports, etc.)?" and measured on a four-point scale from 0 = "never" to 3 = "frequently."

GPA index. A single-item variable reflecting self-reported cumulative grade point average measured on an eight-point scale from 0 = "C− or lower" to 7 = "A or A+," which we converted to a 100-point scale.

Professional/interpersonal confidence. A six-item composite measure of students' self-concept in professional and interpersonal domains.

Responses to survey items comprising each composite measure were summed, normalized, and multiplied by 100 for reporting purposes prior to standardizing. See appendix B for a list of constituent items in each composite measure and corresponding Cronbach's alpha values.

As noted earlier, gender and URM status were tested as separate measures in a preliminary series of models; given results from this analysis, we included a measure for "URM women" in the final analysis as the group of students whose postgraduation plans diverged most from others. Students classified as URM are those marking American Indian/Alaska Native, Black/African American, Hispanic/Latino(a), and/or Native Hawaiian/Pacific Islander racial/ethnic backgrounds.

Level 2 measures that reflected institutional resources and selectivity were selected from IPEDS and ASEE data sets. These included SAT composite scores among incoming enrollees, percentage of part-time undergraduates, student-to-faculty ratios in engineering schools and institution-wide, and institutional control (public vs. private). Since engineering resources may be related to institutional size, we also included IPEDS figures for undergraduate, graduate, and total enrollment. Among the possible undergraduate financial aid measures in IPEDS (e.g., percentage of students receiving aid from institutions, aid from state-based sources, etc.), we included federal aid and student loan aid to capture the relationship between students' socioeconomic characteristics and institutional selectivity, revenue, and expenditures found in the literature (Astin 1993; Astin and Oseguera 2004; Reardon, Baker, and Klasik 2012; Titus 2006).

Two additional sets of variables measure the proportional size of undergraduate and graduate engineering programs of the APPLES institutions (tested as exploratory measures of resources), and the process by which undergraduates declare an engineering major at each school. The "major declaration process" has been noted as a possible influence on students' perceptions of and movement into/out of engineering (Garrison et al. 2007; Lichtenstein et al. 2009).

We obtained the institutional characteristics in the Level 2 model sequence as aggregates from student reports to the level of the institution and/or as institution averages as follows (with the source of each measure in parentheses):

SET 1: Academic selectivity (IPEDS). SAT composite, calculated as the sum of SAT-Math 75th percentile score and SAT-Critical Reading 75th percentile score; SAT ratio, calculated as a ratio of SAT-Math 75th percentile score to SAT-Critical Reading 75th percentile score.

SET 2: Percentage of undergraduates receiving financial aid (IPEDS). Percentage of undergraduates receiving federal grant aid; percentage of undergraduates receiving student loan aid.

SET 3: Percentage of part-time undergraduates (IPEDS).

SET 4: Institutional type: Undergraduate/graduate (IPEDS). Percentage of total students who are graduate students; nearly exclusive undergraduate institution versus institution with graduate students, based on percentage of total students who are graduate students and triangulated with Carnegie Classification: Enrollment Profile and Size and Setting (we classified institutions with less than 10 percent of graduate students among total enrollment as a "nearly exclusive undergraduate institution").

SET 5: Size of institution and engineering programs: ***Total*** *enrollments (IPEDS)*. Estimated enrollment total; percentage of total students enrolled who are in engineering.

SET 6: Size of institution and engineering programs: ***Undergraduate*** *enrollments (IPEDS)*. Estimated undergraduate enrollment total; percentage of undergraduate students enrolled who are in engineering.

SET 7: Size of institution and engineering programs: ***Graduate*** *enrollments (IPEDS)*. Estimated graduate enrollment total; graduate engineering students as a proportion of all engineering students.[11]

SET 8: Student-to-faculty ratio. Student-to-faculty ratio (IPEDS); engineering student-to-faculty ratio, calculated as a ratio of total engineering undergraduates (full time plus part time) to engineering teaching faculty (tenure/tenure track plus nontenure track) (ASEE).

SET 9: Major declaration process (APPLES institutional profiles). Student enters institution in engineering program versus student declares engineering major later, after matriculation.

SET 10: Institutional control (APPLES institutional profiles). Public institution versus private institution.

2.2 Findings on Postgraduation Plans of Engineering Students

The APPLES instrument allowed us to examine postgraduation plans relative to pursuing a job in the labor market and/or attending graduate school in engineering or outside of engineering. Survey respondents indicated their postgraduation plans for work or graduate school in four questions, as illustrated in the top panel of table 2.1. Plans for working as a

11. "Percentage of graduate students enrolled who are in engineering" cannot be calculated because two institutions in the sample do not have graduate student enrollments.

practicing engineer are most common (~81 percent) as opposed to plans for obtaining a nonengineering job. Graduate school plans, however, are mixed. Forty-three percent of students indicated plans for attending a graduate program in engineering, and nearly one-third indicated graduate plans in other fields. Clearly, many students indicated some degree of interest in both engineering and nonengineering options.

As described earlier, we created two sets of mutually exclusive categories of students from those four separate questions in order to understand student retention in engineering careers more fully. Examining these exclusive categories in the bottom panel of the table, we see that most junior and senior engineering students have not ruled out future employment or education in both engineering and nonengineering fields. In fact, *less than 30 percent of students are strictly engineering focused in their plans*. Among respondents in the narrower sample, the proportions of students who are engineering focused and have cross-field plans are nearly equal.

Table 2.2 shows that the distributions of men and women across

Table 2.1 **Postgraduation plans among junior and senior engineering majors (N = 2,143)**

	Percent marking:				
	Definitely not	Probably not	Maybe	Probably yes	Definitely yes
Engineering job	3.2	6.3	9.5	32.9	48.2
Nonengineering job	11.4	33.1	30.0	19.3	6.2
Engineering graduate school	9.9	18.3	28.9	27.1	15.7
Nonengineering graduate school	18.5	27.2	26.0	19.9	8.4
Combinations of postgraduation plans: Percent who are classified as:					
Engineering focused	28.1				
Nonengineering focused	6.5				
Having "all other plans"	65.4				
Combinations of postgraduation plans, refined sample analyses (n = 1,318): Percent who are classified as:					
Engineering focused	45.7				
Nonengineering focused	10.5				
Having cross-field plans	43.8				

Notes: In "combinations of plans," "engineering-focused students" are those who marked probably/definitely yes to one or both engineering options (job, graduate school), and probably/definitely no to both nonengineering options (job, graduate school). "Nonengineering-focused students" are those who marked probably/definitely yes to one or both nonengineering options, and probably/definitely no to both engineering options. "All other plans" include all other possible response combinations to the four postgraduation survey items. "Cross-field plans" include only those response combinations where students marked probably/definitely yes to at least one engineering option and one nonengineering option.

Table 2.2 **Postgraduation plans among junior and senior engineering majors by gender, SES, and major[a]**

		Percentage among													
		Gender		Perceived family income[b]			Major								
	All students	Women	Men	Low income	Middle income	High income	Aero	Bio-x	Chem.	Civil/ Env.	Comp. sci/E.	Elec.	Indus.	Mech.	Other
						Full sample									
N	*2,143*	*658*	*1,465*	*516*	*830*	*756*	*98*	*119*	*125*	*302*	*229*	*295*	*167*	*584*	*224*
Engineering focused	28.1	24.6	29.9[c]	27.7	32.0	24.7[d]	26.5	21.0	20.0	41.7	30.1	31.2	9.0	27.1	29.5[e]
Nonengineering focused	6.5	7.9	5.9	3.9	5.2	9.5	3.1	24.4	12.0	2.6	6.1	3.1	11.4	4.5	7.1
All other plans	65.4	67.5	64.2	68.4	62.8	65.7	70.4	54.6	68.0	55.6	63.8	65.8	79.6	68.5	63.4
						Refined sample									
N	*1,318*	*406*	*903*	*306*	*522*	*472*	*56*	*82*	*69*	*194*	*144*	*193*	*86*	*354*	*140*
Engineering focused	45.7	39.9	48.5[c]	46.7	51.0	39.6[d]	46.4	30.5	36.2	64.9	47.9	47.7	17.4	44.6	47.1[e]
Nonengineering focused	10.5	12.8	9.5	6.5	8.2	15.3	5.4	35.4	21.7	4.1	9.7	4.7	22.1	7.3	11.4
Cross-field plans	43.8	47.3	42.0	46.7	40.8	45.1	48.2	34.1	42.0	30.9	42.4	47.7	60.5	48.0	41.4

Note: Aero = aerospace engineering, Bio-x = bio-x engineering, Chem. = chemical engineering, Civil/Env. = civil/environmental engineering, Comp. sci./E. = computer science/engineering, Elec. = electrical engineering, Indus. = industrial engineering, Mech. = mechanical engineering, Other = other engineering.

[a]In "postgraduation plans," "engineering-focused students" are those who marked probably/definitely yes to one or both engineering options (job, graduate school), and probably/definitely no to both nonengineering options (job, graduate school). "Nonengineering-focused students" are those who marked probably/definitely yes to one or both nonengineering options, and probably/definitely no to both engineering options. "All other plans" include all other possible response combinations to the four postgraduation survey items. "Cross-field plans" include only those response combinations where students marked probably/definitely yes to at least one engineering option and one nonengineering option.

[b]The five categories in this response scale are collapsed to three for these analyses: Low income = "low income" and "lower-middle income"; middle income = "middle income"; high income = "upper-middle income" and "high income."

[c]Women mean engineering focused < men mean engineering focused in full sample at $p < .05$, in refined sample at $p < .01$ (independent sample t-test).

[d]Middle income mean engineering focused > high income mean engineering focused in full sample at $p < .01$, in refined sample at $p < .01$ (one-way ANOVA with post hoc pairwise comparisons).

[e]Mean engineering focused varies significantly between majors (overall ANOVA for full sample, $p < .001$; overall ANOVA for refined sample, $p < .001$). See text for additional details.

postgraduation plan categories differ from the overall sample. Women are about 34 percent more likely than men to indicate nonengineering-focused postgraduation plans and 13 percent more likely to indicate cross-field plans.

Table 2.2 also reports the distribution of postgraduation plans by students' perceived family income and undergraduate major. Although the trends are not linear, high-income students tend to have the lowest rates of engineering-focused plans and the highest rates of nonengineering-focused plans, with more than double the rate of nonengineering-focused plans than their low-income peers. With regard to major, civil and environmental engineers are the most focused on engineering jobs and/or graduate study, and the least focused on nonengineering jobs and/or graduate study. At over one-third in the refined sample, bio-x majors are the most focused on nonengineering pathways. Industrial engineers have the largest proportion of students interested in both engineering and nonengineering options and the lowest rates of engineering-focused plans across all major groups.

2.2.1 Level 1 MLR Results—Student Factors

Multinomial logistic regression allows us to examine the characteristics in tables 2.1 and 2.2 and additional factors simultaneously in distinguishing students among categories of postgraduation plans. Table 2.3 shows the results of Level 1 MLR models for the full sample and the narrower sample, with engineering-focused students as the reference group.

The patterns for control variables in both full and refined sample multinomial models are consistent with those in earlier work: intrinsic psychological motivation to study engineering, financial motivation to study engineering, exposure to the engineering profession, and academic involvement in engineering are associated with plans oriented exclusively to engineering. For instance, students scoring one standard deviation higher on intrinsic psychological motivation toward engineering have just .38 times (exp(−.98)) the odds of being nonengineering focused relative to their lower-scoring peers (panel A). In contrast, students scoring one standard deviation higher on participation in nonengineering extracurricular activities and confidence in professional/interpersonal skills have 1.6 and 2.0 times the odds, respectively, of being nonengineering focused.

Note also that for most of the variables in the models, statistically significant coefficients for the full and refined samples are similar in magnitude, as are the standard errors. In a few cases, coefficients for the same variable differ considerably across the two models, which may indicate sensitivity to either sample size or the different compositions of the "all other plans" and "cross-field plans" categories; those results should be interpreted with caution. For example, grade point average (GPA) self-reported by students on the APPLES instrument differentiates students with engineering-focused plans from those with "all other plans," but not from those with specific cross-field plans nor students with nonengineering-focused plans. Supplementary HLM models of each constituent pathway find that GPA

Table 2.3 **Results of multinomial logit models of students' postgraduation plans**

A. Postgraduation plans: Full sample (N = 2,143)	Level-1 conditional model			B. Postgraduation plans: Refined sample (N = 1,318)	Level-1 conditional model		
	Coefficient	SE	*P*-value		Coefficient	SE	*P*-value
For category 0: Nonengineering focused (reference group: engineering focused)				For category 0: Nonengineering focused (reference group: engineering focused)			
Intercept	−2.50	0.42	0.000	Intercept	−2.58	0.46	0.000
URM women[a]	−0.95	0.65	0.143	URM women[a]	−0.97	0.71	0.173
Perceived family income (standardized)	0.07	0.12	0.561	Perceived family income (standardized)	0.03	0.13	0.826
Financial motivation (standardized)	−0.49	0.11	0.000	Financial motivation (standardized)	−0.57	0.12	0.000
Intrinsic psychological motivation (standardized)	−0.98	0.10	0.000	Intrinsic psychological motivation (standardized)	−1.11	0.12	0.000
Exposure to engineering work (standardized)	−0.38	0.12	0.002	Exposure to engineering work (standardized)	−0.49	0.13	0.000
Involvement in engineering classes (standardized)	−0.39	0.11	0.001	Involvement in engineering classes (standardized)	−0.40	0.13	0.002
Participation in nonengineering activities (standardized)	0.46	0.14	0.002	Participation in nonengineering activities (standardized)	0.52	0.15	0.001
GPA index (standardized)	0.08	0.12	0.512	GPA index (standardized)	0.10	0.14	0.485
Professional/interpersonal confidence (standardized)	0.68	0.12	0.000	Professional/interpersonal confidence (standardized)	0.73	0.13	0.000
Aerospace engineering[b]	−0.43	0.77	0.577	Aerospace engineering[b]	−0.47	0.83	0.573
Bio-x engineering[b]	1.44	0.42	0.001	Bio-x engineering[b]	1.62	0.46	0.001
Chemical engineering[b]	1.19	0.47	0.012	Chemical engineering[b]	1.58	0.52	0.003
Civil/environmental engineering[b]	−1.31	0.48	0.006	Civil/environmental engineering[b]	−1.15	0.52	0.026
Computer science/engineering[b]	0.67	0.47	0.154	Computer science/engineering[b]	0.92	0.50	0.067
Electrical engineering[b]	0.17	0.45	0.701	Electrical engineering[b]	0.16	0.47	0.734
Industrial engineering[b]	0.78	0.49	0.108	Industrial engineering[b]	0.53	0.53	0.323
Other engineering[b]	0.32	0.48	0.503	Other engineering[b]	0.34	0.53	0.514
Expected salary given major field and state (using median salaries from BLS occupation data, 2007) (standardized)	−0.34	0.17	0.044	Expected salary given major field and state (using median salaries from BLS occupation data, 2007) (standardized)	−0.35	0.18	0.057

(*continued*)

Table 2.3 (continued)

A. Postgraduation plans: Full sample ($N = 2,143$)	Level-1 conditional model			B. Postgraduation plans: Refined sample ($N = 1,318$)	Level-1 conditional model		
	Coefficient	SE	*P*-value		Coefficient	SE	*P*-value
For category 1: All other plans (reference group: engineering focused)				For category 1: Cross-field plans (reference group: engineering focused)			
Intercept	0.97	0.15	0.000	Intercept	0.03	0.18	0.870
URM women[a]	0.28	0.22	0.205	URM women[a]	0.66	0.26	0.011
Perceived family income (standardized)	−0.02	0.06	0.692	Perceived family income (standardized)	0.00	0.07	0.957
Financial motivation (standardized)	−0.03	0.05	0.596	Financial motivation (standardized)	0.02	0.07	0.762
Intrinsic psychological motivation (standardized)	−0.30	0.06	0.000	Intrinsic psychological motivation (standardized)	−0.29	0.08	0.000
Exposure to engineering work (standardized)	−0.06	0.06	0.302	Exposure to engineering work (standardized)	−0.07	0.07	0.337
Involvement in engineering classes (standardized)	−0.27	0.06	0.000	Involvement in engineering classes (standardized)	−0.35	0.07	0.000
Participation in nonengineering activities (standardized)	0.05	0.06	0.369	Participation in nonengineering activities (standardized)	0.08	0.07	0.252
GPA index (standardized)	−0.18	0.06	0.002	GPA index (standardized)	−0.11	0.07	0.124
Professional/interpersonal confidence (standardized)	0.26	0.06	0.000	Professional/interpersonal confidence (standardized)	0.46	0.07	0.000
Aerospace engineering[b]	0.05	0.29	0.859	Aerospace engineering[b]	−0.01	0.36	0.982
Bio-x engineering[b]	−0.05	0.28	0.864	Bio-x engineering[b]	0.16	0.33	0.636
Chemical engineering[b]	0.27	0.27	0.327	Chemical engineering[b]	0.31	0.34	0.365
Civil/environmental engineering[b]	−0.73	0.18	0.000	Civil/environmental engineering[b]	−0.71	0.23	0.002
Computer science/engineering[b]	−0.06	0.23	0.801	Computer science/engineering[b]	0.01	0.28	0.968
Electrical engineering[b]	−0.07	0.19	0.701	Electrical engineering[b]	−0.01	0.23	0.969
Industrial engineering[b]	0.67	0.30	0.027	Industrial engineering[b]	0.54	0.34	0.119
Other engineering[b]	−0.20	0.24	0.403	Other engineering[b]	−0.11	0.30	0.720
Expected salary given major field and state (using median salaries from BLS occupation data, 2007) (standardized)	−0.09	0.10	0.374	Expected salary given major field and state (using median salaries from BLS occupation data, 2007) (standardized)	−0.07	0.12	0.534
Variance components				Variance components			
Tau category 0	2.84			Tau category 0	3.40		
Tau category 1	0.40			Tau category 1	0.52		
Sigma squared[c]	3.29			Sigma squared[c]	3.29		

Note: Robust standard errors could not be computed for the level-1 conditional models. Preliminary analyses were conducted testing URM status and gender as separate measures. Coefficients for both were nonsignificant in the full sample model. In the refined sample model, URM status was a positive predictor of category 1 ("cross-field plans") ($b = .42$, $se = .19$, $p = .028$), and gender (0 = female, 1 = male) was borderline significant and negative ($b = -.30$, $se = .15$, $p = .051$).

[a]Reference group: All other students.

[b]Reference group: Mechanical engineering.

[c]Approximation based on the standard logistic distribution where variance equals pi squared/3.

is a negative predictor of plans to pursue an engineering job ($b = -.59$, $p < .001$) and a positive predictor of plans to pursue engineering graduate school ($b = .20$, $p < .001$) with no significant relationship between GPA and plans for nonengineering jobs or graduate study. At a minimum, these results suggest that students with higher grades have a comparable likelihood of being nonengineering and engineering focused at this stage, although engineering focus may entail an engineering graduate degree rather than engineering employment.

With these factors statistically controlled, we focus on relationships between postgraduation plans and SES, major, and salary by field and state where the student was educated.[12] We give particular attention to URM women in engineering on the basis of earlier analyses. The second panel of table 2.3 shows that being a URM woman increases the odds of having cross-field plans versus engineering-focused plans in the refined sample. Supplementary HLM analyses indicate that URM women are more likely than their peers to be considering nonengineering jobs ($b = .22$, $p < .05$) and engineering graduate school ($b = .22$, $p < .05$). Although our perceived family income SES measure is negatively correlated with plans for pursuing an engineering job and an engineering graduate degree ($r = -.13$ and $r = -.14$, respectively, $p < .001$), a finding that holds in the supplementary models ($b = -.56$ and $b = -.10$, respectively, $p < .001$), it does not distinguish engineering-focused students from others in the MLR analysis, indicating that it works through other variables in the MLR model.

Relative to students in mechanical engineering, civil/environmental engineering majors are more likely to report strictly engineering-focused career plans. Students who are bio-x and chemical engineering majors, on the other hand, have three to five times the odds of having nonengineering plans as do mechanical engineering majors. Industrial engineers (full sample only) tend to report mixed plans. Students' plans in other majors are statistically similar to those among mechanical engineering majors.

Labor market influences were measured by field-specific median earnings in the state where a respondent's university is located. Table 2.4 shows that across all states in our sample, earnings vary considerably with major, being highest for aerospace and computer engineers and lowest for biomedical and civil engineers.[13] In our full-sample MLR model, higher salaries differentiated engineering-focused students from nonengineering-focused ones.

2.2.2 Level 2 MLR Results—Institutional Factors

At Level 2, we tested for institutional factors related to students' pathways in or outside of engineering. Because of the limited number of institutions in our sample, we examined seventeen institutional characteristics in ten

12. Consideration of labor market earnings and majors distinguishes our Level 1 analysis from the earlier APPLES project (Sheppard et al. 2010).

13. Table 2.4 and national estimates differ due to state-by-state variation in field specific labor markets (see BLS 2011).

Table 2.4 **May 2007 average median salary among states in the APPLES institutional sample by occupational category**

Occupational category	Average median salary
Aerospace engineers	82,847
Computer hardware/software engineers[a]	82,316
Chemical engineers	77,842
Electrical engineers	77,455
Industrial engineers	70,630
Mechanical engineers	70,219
Environmental engineers	69,637
Civil engineers	68,598
Biomedical engineers	67,299

Source: Bureau of Labor Statistics (2011).

Notes: These occupational categories map to the "core" APPLES majors in the present study. Average median salaries for other occupational categories that map to smaller APPLES majors (e.g., "marine engineers") are available on request.

[a]This category represents the aggregate of three BLS categories: computer hardware engineers; computer software engineers, applications; and computer software engineers, systems software.

separate models. Figure 2.1 captures statistically significant ($p < .05$) results and includes estimated coefficients for the full sample only. Because of the small number of institutions in the APPLES sample, results should be interpreted with caution.

Relative to engineering-focused students, nonengineering-focused students are more likely to attend institutions that enroll undergraduate populations with higher SAT scores, lower rates of federal financial aid receipt, and lower rates of part-time attendance. Students attending private institutions also are more likely to be nonengineering focused (> ten times the odds) than their counterparts at public institutions. The magnitudes of the coefficients for the standardized variables suggest that institution-level SES (as reflected by the receipt of aid) is the strongest differentiator of postgraduation plans. We note that several of these institutional characteristics are intercorrelated, with the strongest correlation observed between SAT composite score and private institutions ($r = .81, p < .001$) and SAT composite score and percentage of students receiving federal aid ($r = -.78, p < .001$).

The size and type of programs did not differentiate postgraduation plans, with sole exception of graduate student enrollment: undergraduate engineering majors attending institutions with higher proportions of graduate students tend to have higher rates of nonengineering postgraduation plans (in the APPLES sample of schools, the proportion of graduate students is not correlated with other significant institution-level predictors). Institutional characteristics did not differentiate students with engineering-focused plans from those with "all other plans" or more specific "cross-field plans"; and whether an engineering major is declared upon admission or

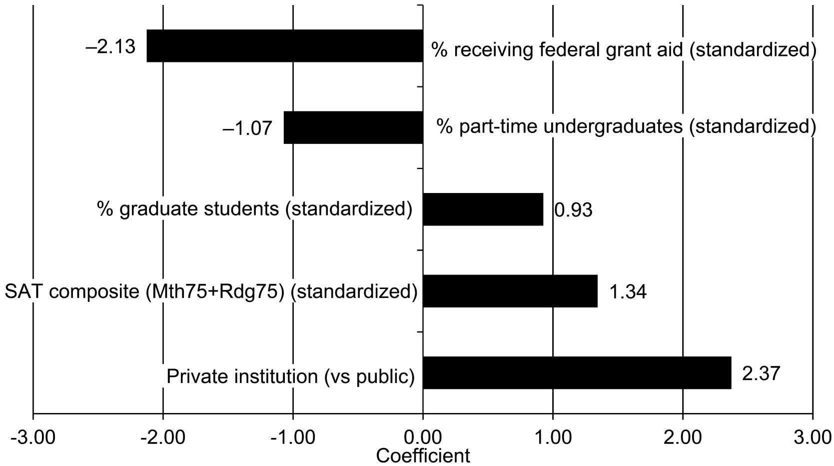

Fig. 2.1 Level 2 predictors of nonengineering-focused plans (vs. engineering-focused plans), full sample analysis (*N* = 2,143)

Note: Predictors are significant at $p < .05$ holding all Level 1 variables constant. Due to limitations of institutional sample size ($N = 21$), each variable was tested in a separate model. Standard errors are available on request. Methodology reports additional details.

during matriculation is not related to plans to persist in engineering postbaccalaureate.

2.2.3 Exploring the Role of SES

Supplementary HLM analyses of postgraduation plans indicate a negative relationship between perceived family income and plans to work or to study in an engineering field, holding all other variables in the model constant. Since SES does not emerge as significant in the MLR analyses (table 2.3), we conducted additional analyses to better understand its role in the postgraduation plans of engineering students. Table 2.5 shows how low-, middle-, and high-income students differ by major and by institutional characteristics related to plans in the MLR analyses. Patterns by major fit with the results in tables 2.2 and 2.3. Modestly greater proportions of high-income students than low-income students major in fields associated with nonengineering postgraduation plans (bio-x, chemical, and industrial) and a somewhat smaller proportion major in civil/environmental engineering, which is associated with engineering-focused plans. These differences are not significantly different from zero, however.

With respect to institutional factors that might be related to SES, we earlier found that more selective and private institutions were associated with nonengineering-focused plans. Table 2.5 shows the expected trend between SES and institutional selectivity and SES and institutional control, with low-income students 56 percent less likely than high-income students to

Table 2.5 **Student SES by major and by select institutional characteristics[a]**

	Percentage among			Significance tests (one-way ANOVA post hoc pairwise comparisons)[b]		
	Low income	Middle income	High income	Mean low inc. vs. mean mid. inc.	Mean mid. inc. vs. mean high inc.	Mean low inc. vs. mean high inc.
N	*516*	*830*	*756*			
		Major				
Aerospace engineering	3.9	5.1	4.4	n/s	n/s	n/s
Bio-x engineering	4.1	4.9	6.9	n/s	n/s	n/s
Chemical engineering	5.6	5.4	6.3	n/s	n/s	n/s
Civil/environmental engineering	15.3	15.3	12.0	n/s	n/s	n/s
Computer science/engineering	13.4	10.4	9.7	n/s	n/s	n/s
Electrical engineering	14.9	13.1	13.5	n/s	n/s	n/s
Industrial engineering	6.4	6.7	9.7	n/s	n/s	n/s
Mechanical engineering	27.3	29.2	25.5	n/s	n/s	n/s
Other engineering	9.1	9.9	12.0	n/s	n/s	n/s
		Institutional characteristics				
SAT composite (math 75th + reading 75th): Quartiles						
Highest quartile (1,500–1,580)	12.4	13.9	28.0	n/s	***	***
Second-highest quartile (1,290–1,460)	36.6	39.3	40.5	—	—	—
Third-highest quartile (1,130–1,250)	32.8	32.2	24.5	—	—	—
Lowest quartile (960–1,100)	18.2	14.7	7.0	n/s	***	***
Institutional control[c]						
Public institution	70.7	71.1	58.3	—	—	—
Private institution	29.3	28.9	41.7	n/s	***	***
Percent undergraduates receiving federal financial aid: Quartiles						
Highest quartile (37–69%)	21.7	12.2	6.2	***	***	***
Second-highest quartile (22–28%)	20.2	20.0	14.6	—	—	—
Third-highest quartile (17–21%)	47.7	54.7	54.8	—	—	—
Lowest quartile (6–13%)	10.5	13.1	24.5	n/s	***	***
Percent part-time undergraduates: Quartiles						
Highest quartile (28–44%)	26.7	18.8	8.5	**	***	***
Second-highest quartile (16–26%)	32.6	35.9	31.5	—	—	—
Third-highest quartile (7–12%)	17.4	23.4	30.8	—	—	—
Lowest quartile (0–3%)	23.3	21.9	29.2	n/s	**	*
Percent graduate students: Quartiles						
Highest quartile (29–60%)	33.1	39.8	48.3	*	**	***
Second-highest quartile (18–26%)	41.9	39.3	31.9	—	—	—
Third-highest quartile (15–17%)	16.7	13.7	8.2	—	—	—
Lowest quartile (0–12%)	8.3	7.2	11.6	n/s	**	n/s

[a]The five categories in the SES response scale are collapsed to three for these analyses: Low income = "low income" and "lower-middle income"; middle income = "middle income"; high income = "upper-middle income" and "high income."

[b]For institutional characteristics cut into quartiles, ANOVAs were conducted among the highest quartile and lowest quartile only.

[c]Of the twenty-one institutions in the APPLES institutional sample, thirteen are public and eight are private.

***$p < .001$

**$p < .01$

*$p < .05$

n/s = not significant

attend the most selective schools, and over two times more likely to attend the least selective institutions. High-income students are 42 percent more likely to attend a private institution. Qualities of the student body that predict engineering-focused plans are also associated with SES. Low-income students are more likely than high-income students to attend high financial aid institutions and schools with greater part-time attendance and less likely to attend schools with high percentages of graduate student enrollments. These patterns suggest that institutions play a role in the differing postgraduation destinations of low- and high-SES engineers.

2.2.4 Exploring the Role of the Labor Market

Table 2.3 showed that the median salary of professionals in the same field and in the same state in which students' college or university is located modestly differentiates students with engineering-focused postgraduation plans from students with nonengineering-focused plans. In supplementary HLM analyses, the earnings variable does not emerge as a significant predictor of constituent pathways, although it is weakly correlated with plans to pursue engineering graduate study ($r = .13$, $p < .001$) and to obtain an engineering job ($r = -.05$, $p < .05$). A closer look at findings by major sheds light on this pattern. Relative to other majors, computer science/engineering majors have the highest rate of intention to pursue engineering graduate school (51 percent reporting "probably" or "definitely" yes; data available by request), and computer hardware/software engineers are among those with the highest earnings (table 2.4). This helps explain the disappearance of the positive simple correlation between earnings and engineering graduate school when major is controlled in the supplementary model. Moreover, in the companion model of plans to pursue an engineering job, computer science/engineering majors are significantly less likely to consider engineering jobs than mechanical engineering majors (the reference group). The negative simple correlation between salary and engineering job plans could thus be an artifact of this computer science/engineering trend.

The modest role of the salary measure in these models does not mean that financial motivation is irrelevant to students. Financial motivation to pursue engineering studies differentiates students with engineering-focused plans from those focused on nonengineering options (table 2.3); in the HLM models of constituent pathways, it is a positive predictor of plans to work in an engineering job after graduation ($b = .93$, $p < .001$). Interestingly, there is no difference in mean financial motivation by students' perceived family income.

2.2.5 Exploring the Role of Major Field of Study

Delving deeper into the "cross-field plans" category in table 2.2 allows us to analyze further the career plans among students who are neither engineering nor nonengineering focused—students who indicate strong interest in pursuing at least one of two engineering pathways (job or graduate school) and at least one of two nonengineering pathways (job or graduate school). The proportion of students with an engineering focus varies from 17 percent (industrial engineering majors) to 65 percent (civil and environmental majors), whereas students with a nonengineering focus varies from 4 percent (civil and environmental majors) to 35 percent (bio-x majors). Civil and environmental engineering majors are least likely to have cross-field plans (30.9 percent), and industrial engineering majors are most likely (60.5 percent).

The analysis in table 2.6 is framed around two clusters of majors: those with 40 percent or more who are engineering focused (aerospace, civil/environmental, computer science/engineering, mechanical, electrical, and other engineering) and those with less than 40 percent who are engineering focused (bio-x, chemical, industrial). Note that the motivation and confidence means are calculated among the full sample of respondents even as the clusters are demarcated by refined sample proportions. We highlight patterns in civil/environmental, bio-x, and industrial engineering to exemplify interrelationships.

The cluster of majors with 40 percent or more of engineering-focused students includes some of the oldest fields in engineering, as indicated by the year the fields' professional societies were established: the American Society of Civil Engineering (1852), the American Society of Mechanical Engineers (1880), and the Institute of Electrical and Electronic Engineers (1884). Civil engineering majors are the most focused in their engineering plans. They also have higher mean scores on intrinsic psychological motivation and lower mean scores on financial motivation (which fits with their relatively lower earnings in table 2.4), and among the lowest mean scores for professional/interpersonal confidence "as compared with [their] classmates." This may reflect selection effects. The MLR model coefficients also indicate that even with these motivation and confidence measures controlled, civil/environmental majors have significantly higher odds of engineering-focused plans than students in the reference group, mechanical engineering (table 2.3).

In the second cluster, less than 40 percent of students have engineering-focused plans. This cluster contains two of the more recently created fields, industrial engineering and bioengineering (the Institute of Industrial Engineers was established in 1948, and the American Institute for Medical and Biological Engineering was established in 1991). Bio-x majors, in fact, have the highest proportion of students focused on nonengineering graduate school and/or job options after college. Simultaneously, they report significantly lower financial motivation to study engineering than students in any other major group except for aerospace, civil/environmental, and other engineering, lower intrinsic psychological motivation, and average levels of professional/interpersonal confidence. Perhaps many bio-x students select

Table 2.6 **Mean construct scores by major and gender: Intrinsic psychological motivation, financial motivation, and professional/interpersonal confidence**

	Intrinsic psychological motivation			Significance test for gender difference	Financial motivation			Significance test for gender difference	Professional/interpersonal confidence			Significance test for gender difference
	All students	Women	Men	(*t*-test)	All students	Women	Men	(*t*-test)	All students	Women	Men	(*t*-test)
Higher rates of engineering-focused plans[a]												
Aerospace engineering	82.5	87.2	81.8	n/s	58.9	45.3	61.0	n/s	68.5	64.1	69.1	n/s
Civil/environmental engineering	80.8	82.9	79.7	n/s	64.4	62.8	65.4	n/s	67.0	67.7	66.7	n/s
Computer science/engineering	80.5	75.0	81.9	n/s	66.0	65.2	65.9	n/s	66.7	66.8	66.6	n/s
Electrical engineering	82.8	87.7	81.5	*	67.5	72.3	66.2	n/s	69.3	72.1	68.7	n/s
Mechanical engineering	81.4	78.9	82.1	n/s	64.6	65.1	64.8	n/s	68.1	68.9	67.9	n/s
Other engineering	81.5	83.4	79.6	n/s	63.8	61.9	65.5	n/s	68.9	66.6	70.9	n/s
Lower rates of engineering-focused plans[a]												
Bio-x engineering	78.2	77.4	78.7	n/s	55.8	52.6	58.8	n/s	69.4	66.4	72.2	*
Chemical engineering	77.3	75.6	79.0	n/s	66.3	68.5	64.5	n/s	68.9	67.5	70.8	n/s
Industrial engineering	69.7	66.1	73.2	n/s	71.5	73.8	68.6	n/s	73.3	70.5	76.1	*

Notes: Among all students, ANOVA for intrinsic psychological motivation is significant at $p < .001$. Looking at pairwise comparisons, all means are significantly different from industrial engineering except for chemical engineering. Among all students, ANOVA for financial motivation is significant at $p < .001$. Looking at pairwise comparisons, all means are significantly different from bio-x engineering except for aerospace engineering, civil/environmental engineering, and other engineering. In addition, aerospace engineering is significantly different from industrial engineering. Among all students, ANOVA for professional/interpersonal confidence is significant at $p < .01$. Looking at pairwise comparisons, industrial engineering is significantly different from civil/environmental engineering, computer science/engineering, and mechanical engineering.

[a] "Higher rates of engineering-focused plans" include those majors with 40 percent or more of students who report engineering focus, based on the refined sample proportions (see table 2.2). "Lower rates" include those majors with less than 40 percent. Means are reported among students in the full sample.

***$p < .001$

**$p < .01$

*$p < .05$

n/s = not significant

their majors as a bridge to other industries and occupations, not for the affective and financial returns to engineering studies per se.

Despite the comparable (and recent) histories of the respective fields, bio-x majors contrast with industrial engineering majors, who have lower rates of engineering and nonengineering-focused plans, and higher rates of cross-field plans. Table 2.6 shows that industrial engineering majors: (a) are significantly less psychologically motivated to study engineering than students in every other major group except chemical engineering; (b) have the highest rates of financial motivation to study engineering; and (c) have the highest professional/interpersonal confidence, significantly higher than students in some of the largest (and oldest) degree programs in engineering (mechanical engineering and civil engineering). These data suggest that students who pursue industrial engineering degrees may have a distinctive set of interests and self-concepts, and that industrial engineering academic environments may have unique emphases relative to other engineering fields, which we explore in the next section.

Motivation and confidence does not differ much between women and men within major in the APPLES sample, with some variation on some dimensions (e.g., in industrial engineering men are neither more nor less financially motivated to study engineering than are women, but are more confident in their professional/interpersonal skills). Motivational differences between majors are more pronounced among women than among men, while confidence differences between majors are more pronounced among men than among women.[14] Recent work suggests that women may pursue engineering degrees for different reasons than men (Orr et al. 2009), which might help explain the different proportions of women and men in engineering subfields to begin with (NSF 2011a).

2.2.6 The Dynamic Early Career Path of Engineers

The data on late-stage engineering majors (juniors and seniors) opens a window into how today's engineering students conceive their professional futures, and how educational and employment contexts may affect their plans. *The most striking finding in our analysis in this regard is that a substantial majority of engineering students are not committed to a purely engineering future*. That over two-thirds of students in the APPLES sample have nonengineering, mixed, or uncertain plans raises questions about what drives students to pursue pathways outside of engineering. One conjecture is that the engineering major and field communicate a flexible career pathway to students, particularly in certain subfields. Perhaps the training students receive in engineering programs illuminates options through and outside of

14. When data are disaggregated by gender, industrial engineering majors have the highest mean professional/interpersonal confidence among men only, suggesting stronger self-selection based on confidence for men, conditional effects of the industrial engineering academic environment, or both.

traditional engineering. A more negative interpretation is that experience in the major leads many students to reconsider their engineering career plans. While we cannot differentiate precisely between these interpretations, additional findings are suggestive of the former.

First, nonengineering-focused students tend to be lower in intrinsic motivation for engineering work and its financial rewards—an indication that the field itself is not a strong draw for a subset of students who nonetheless persist in the major to their third and fourth year of college. Further, these students have relatively high professional/interpersonal self-confidence and tend to attend private, selective, and well-funded institutions. They thus appear to be among the better-prepared and competitive undergraduate engineers whose college experiences arguably give them a broader view of viable career options for someone with their training and skill set. This interpretation is supported by Lowell et al. (2009), who document a significant decline in the retention of top academic performers in science, technology, engineering, and mathematics (STEM) related jobs after college, and by Herrera and Hurtado (2011), who show that college students at more selective institutions have a lower probability of sustained STEM career interests than students at less selective institutions.

The APPLES data measure the point at which students are starting to think tangibly about their professional futures along engineering career pathways. To add further perspective to the findings above, we turn to data from the 2006 National Survey of Recent College Graduates (NSRCG) (NSF 2011b), as analyzed and reported in Sheppard et al. (2014). These data, collected from graduates of 2003, 2004, and 2005, show that some two years after graduation, 60 percent of engineering graduates were working in an engineering job, 18 percent were working in other science and engineering-related fields,[15] and 14 percent were working in nonengineering-related fields (the balance were in school or not employed). Compared with the approximately one-third of APPLES junior and senior engineering majors reporting engineering-focused postgraduation plans, the NSRCG data raise the possibility that the early career pathway of engineers may still be in a highly dynamic stage. Indeed, the 32 percent of recent graduates working outside of engineering[16] exceeds the 26 percent of students in the APPLES sample who planned to pursue nonengineering jobs after graduation, and is considerably higher than the 7 percent who were exclusively focused on a nonengineering pathway. The primary reasons that engineering graduates gave for pursuing jobs "unrelated to their highest degree" provide insight into why a majority of engineering students are not planning for engineering options only following graduation. These include "pay and

15. Computer and mathematical sciences, life sciences, physical sciences, social sciences, and "other" related fields.

16. Of whom 44 percent (= 14/32) were in fields not related to engineering and science.

promotion opportunities," "working conditions," "job location," "change in professional/career interests," "family," and "job in highest degree field not available" (Sheppard et al. 2014).

If the career pathways of today's young engineers are marked by flexibility and flux, how does this compare with engineering pathways in the past? Earlier NSRCG data indicate that trends are not substantially different. Findings from the 1993 NSRCG, which surveyed graduates of 1991 and 1992, show that 61 percent of engineering graduates were employed in an engineering occupation (NSF 2012). This suggests that engineering graduates are neither more nor less likely to pursue engineering work now than they were in the 1990s. Slightly larger shifts are seen in other occupations. Recent engineering graduates are more likely than 1990s graduates to pursue science occupations and computer- and math-related occupations, and less likely to pursue occupations unrelated to science and engineering. Thus, while engineering graduates have long applied their degrees to nonengineering work, the destination occupations are variable.

To put these student and practitioner findings on engineering pathways in a larger context, consider professional persistence in other fields. Other professions vary in rates of persistence to practice upon degree completion (where "degree" refers to the minimum credential to practice—a bachelor's degree in engineering compared with an MD for medicine and a JD for law). The pattern of persistence into the profession among engineering graduates with a BS is closer to that in law, where about two-thirds of U.S. law graduates from 2011 obtained a job requiring passage of the bar (National Association for Law Placement 2012a, 2012b), than with patterns in medicine, where the vast majority of graduates pursue additional medical-related education after obtaining their MD (National Resident Matching Program and the Association of American Medical Colleges 2011).[17] Although the dynamics of self-selection into or out of a profession may differ depending on the profession and its licensure processes, these statistics are notable in contextualizing engineering's migratory pathways after investing in the "gateway" degree.

17. Among the 41,623 U.S. law graduates from the class of 2011 for whom employment status was known (94 percent of the entire class), 65.4 percent obtained a job requiring passage of the bar. An additional 12.5 percent reported having jobs for which a law degree is beneficial, but passage of the bar is not required. About 7 percent were employed in a nonprofessional or a professional position other than law, and less than 1 percent was employed in an unknown position. The remaining 15 percent were not employed or full-time students (National Association for Law Placement 2012a, 2012b). In contrast, the total number of medical school graduates in 2011 was 17,364 (Association of American Medical Colleges 2011). Fully 16,599 of the active applicants in the 2011 Main Residency Match were seniors from U.S. Allopathic Medical Schools (National Resident Matching Program and the Association of American Medical Colleges 2011). This suggests that the overwhelming majority (over 95 percent) of MDs go on to seek additional training to practice medicine.

2.2.7 The Role of Engineering Subfields

Postgraduation plans, as well as individual characteristics such as motivation for pursuing engineering studies and professional/interpersonal self-confidence, vary by engineering major. Early career occupational outcomes vary similarly. For example, consistent with our results on plans, civil engineering majors in the NSRCG 2006 data set reported the highest rates of working in the same field as their major two years after college (Sheppard et al. 2014). It appears that some majors are more tightly coupled with engineering career pathways than are others. Individual characteristics of students in the major may explain at least part of this coupling.

Individual characteristics may have both a direct relationship with postgraduation plans and an indirect relationship, operating through self-selection into certain fields. For instance, students choosing civil engineering may perceive technical career pathways that appeal to their enjoyment of engineering work. Bio-x students, with lower levels of financial and psychological motivation to study engineering, may select their programs as a route to medical school pathways. Students with high levels of financial motivation may be drawn to industrial engineering programs because they perceive hybrid (engineering and management) pathways through them that yield higher financial returns. This interpretation assumes that the effects of major are incidental to the institution in that students take cues from the field and translate them into decisions of major choice. However, Brawner et al. (2009, 2012) found that the mode by which students enter an engineering major may have some association with the major they choose. For example, students declaring industrial engineering were more likely to have come to this major from an "undecided" status within schools of engineering as compared with "direct admits" and students enrolled in schools with mandatory first-year engineering programs. Moreover, industrial engineering was among the few engineering programs that gained student majors after the third semester of college and through graduation. Recall that the major declaration process did not show a statistically significant relationship with students' postgraduation plans in the present study; Brawner et al.'s findings hint that the effect of matriculation channels may act indirectly through major choice.

A different interpretation assumes that student experiences in the major influence postgraduation choices. Cultural distinctions between engineering fields can be present among various departments of engineering in a college, thereby exposing students to distinctive values, norms, and expectations pertaining to their major. In her study of five engineering departments, Petrides (1996) found departmental cultural characteristics (e.g., prestige of the field, what motivated people to be in the field, percentage of women in the field) to be related to graduate students' postgraduation plans. This suggests that different branches of engineering attract and socialize individuals in different ways and provide distinct and varied models of the school-to-career connection. We might further expect that specific engineering departments vary in important ways in their pedagogy, curriculum, and other educational experiences that give rise to variation in postgraduation plans and expectations across the subfields. Given how career plans vary with the age of subfields, broad cultural differences in the expectations for career outcomes would not be surprising.

Other drivers include field- and region-specific labor markets—the data in this study indicate some sensitivity to the salaries in each engineering-occupational category. However, it may be that the stronger driver is the alternative salaries available in nonengineering positions and industries connected to students' majors (transmitted through socialization, job fairs, internship opportunities, alumni contacts, and so on). These alternative salary data for students in each major are not collected in a systematic, cross-institutional way, although records at individual institutions' career development offices might offer preliminary insight.

2.2.8 Additional Student-Level Factors in Engineering and Nonengineering Pathways

Findings from the multinomial models show that URM women are more likely to have cross-field postgraduation plans than their peers, while supplementary models find that URM women are more likely to be looking toward engineering graduate school and nonengineering jobs.[18] Sheppard et al.'s (2010) analyses of senior respondents in the APPLES data indicated that URM and non-URM women and men have comparable rates of exposure to the engineering profession, interaction with instructors, and involvement in engineering courses. At the same time, URM women and men ascribed more importance to professional/interpersonal skills in engineering practice, and were more psychologically motivated to study engineering than their non-URM peers. Senior URM women also reported significantly lower grade averages than did senior non-URM women (the same was not true among senior men and among first-year URM and non-URM women in the APPLES sample). Thus, different groups of students may have similar rates of participation in various aspects of their engineering programs, but different kinds of motivation for pursuing engineering work. Other researchers have noted that academic and background characteristics operate differently for URM and non-URM students in terms of career pathways. For example, in longitudinal models of sustained STEM-career interests, Herrera and Hurtado (2011) found that positive predictors for URM students included

18. URM women are 6.8 percent of the sample. Nationally, they represent only 3.7 percent of all enrolled engineering students, 3.1 percent of all engineering bachelor's degree earners, and 1.8 percent of all employed engineers (NSF 2011a). Their experiences in engineering education merit particular attention in terms of the supply and diversity of engineering professionals in the coming decades.

high school GPA and working with a faculty member on research, while positive predictors for non-URM students included SAT score (and negative predictors included SES). Of course, which specific experiences encourage URM women to consider cross-field career pathways more so than other students are not identified in our study.

Exposure to Professional Engineering Work

Building on work that identifies career-planning correlates of internships (Margolis and Kotys-Schwartz 2009), the findings from these models suggest that exposure to a professional engineering environment through internships, visits, and employment increases the odds of having engineering-focused plans versus nonengineering-focused plans. The causal order of this relationship is unclear, but the link is important to conversations about school-to-work opportunities in the undergraduate engineering curriculum. In a study of 484 alumni from four U.S. engineering schools, Brunhaver et al. (2012) found that alumni employed in engineering fields four years after graduating were more likely to have participated in an internship or co-op as an undergraduate than were alumni who were employed in nonengineering fields. They also were more likely to report that they had been hired to an employed position through an undergraduate internship or co-op. This suggests that undergraduate internship and co-op opportunities may help to build a bridge for college students to engineering career pathways, although it is not evident which parts of these experiences reinforce retention in the field besides the possibility of a firm job offer.

Professional/Interpersonal Confidence

The multivariate models show that engineering students with higher professional/interpersonal confidence are less focused on engineering pathways, and more focused on nonengineering or cross-field pathways, after graduation. This finding relates to Salzman and Lynn's (2010) research on industry perceptions of new engineering hires that suggests that companies see new hires as not lacking for technical skill, but as having lower than desired levels of communication and business skills. Managers stressed that engineers must have not only technical competence, but the ability to articulate ideas and collaborate across business functions in order to be successful. Our models hint that engineers with these abilities may be eyeing nonengineering opportunities from the get-go; it is possible that students' participation in professional engineering environments as undergraduates fails to expose them to the full range of skills and talents needed among engineers, and/or to show them how these skills are applied in these settings. It also is possible that students with nonengineering plans and higher levels of professional/interpersonal confidence opt out of those undergraduate experiences altogether, thus limiting their view on the relevance of diverse skills in engineering practice.

However, Brunhaver et al. (2013) found that engineering majors employed in engineering four years after graduating have levels of professional/interpersonal self-efficacy comparable to engineering majors in nonengineering employment. This suggests that time in postgraduation employment may compensate for initial differences in confidence. It should be noted that APPLES confidence measures asked students to rate themselves relative to classmates, while the professional self-efficacy measures referred to task-specific confidence in, for example, "communicating my ideas effectively to people in different positions or fields."

Other data highlight the role of factors outside the college environment that influence professional/interpersonal confidence. Sheppard et al. (2010) observed that both first-year and senior engineering students who reported higher family income levels had higher professional/interpersonal confidence than peers from lower family income backgrounds. Additionally, Colbeck, Campbell, and Bjorklund's (2000) qualitative evaluation of group work among undergraduate engineers reported that while students gained appreciation for communication and conflict resolution in project design teams—skills they perceived as important to professional practice—they did not see faculty providing much guidance in how to work effectively in these teams. Students drew from other experiences (inclusive of internships) to develop understanding of what group work meant and looked like. This raises questions of which curricular components link professional/interpersonal skills to engineering work in a systematic, developmental, and structured way.

Socioeconomic Background

We also note that socioeconomic status appears to be playing a role in the pathways to engineering-focused careers. Undoubtedly, one of the pull factors into the engineering profession is the promise of one of the better immediate returns on education in the form of salaried compensation (Carnevale, Rose, and Cheah 2011; Carnevale, Strohl, and Melton 2011). It is not clear if lower SES students see a career in engineering as a means to realize greater returns on their education more so than do higher SES students.[19] We do find that lower SES students tend to matriculate at less selective, public institutions and institutions that enroll greater proportions of part-time students and students receiving financial aid (a finding supported by Astin [1993], Astin and Oseguera [2004], Reardon, Baker, and Klasik [2012], and Titus [2006]). The results linking these institutional characteristics to engineering-focused students imply a peer effect at such institutions that favors engineering-focused pathways. While public and less selective insti-

19. Previous research suggests that lower SES students have similar perceptions of college returns as do their higher SES peers (Rouse 2004) and have similar returns to a bachelor's degree versus a high school diploma (Perna 2003), but this research has not been conducted specifically on engineering students.

tutions may not be intentionally creating norms around engineering career pathways, such norms may be developed by the students (who are more often lower income) they tend to attract and enroll. More focused study of the normative expectations for postgraduation pathways at more/less selective colleges, public/private institutions, and more generally those that enroll primarily lower/higher SES students is needed to better understand these relationships.

2.3 Implications

The findings that most engineering majors see engineering jobs in their futures, but not to the exclusion of nonengineering plans, and that students with engineering-focused plans have distinctive profiles connected with individual factors and their major and institutional characteristics have implications for educational practice.

First, it suggests that engineering education needs to build more awareness of the dynamic pathways of current and future students through informal and formal programs that allow students to see different applications of engineering work.[20] However, for these programs to be particularly effective, students need the opportunity to reflect on how different applications of engineering fit for who they are and what they want to achieve. Helping students address this "fit" question is crucial in supporting student development and cannot be done by the engineering faculty alone; it calls for partnerships across the university, with professional societies, and with industry (Sheppard et al. 2009).

Second, it suggests that it is important to increase public understanding that engineering is not a monolithic enterprise in the academy or in the workforce. Engineering work generally involves solving technical-based problems, often on distributed and/or multidisciplinary teams, but the particulars can greatly affect what the "lived" engineering experience is. While this makes it more complicated to explain what engineering is to a young person considering which academic and professional pathway might be right for them, it also provides the opportunity to illustrate how an engineering pathway can be customized for an individual's particular interests, strengths, and goals, and to change perceptions of engineering as "one-size-fits-all," to engineering as a professional pathway that opens up many options.[21]

20. The expansion of hands-on design courses, starting in the first year of college, is one step in this direction (Sheppard et al. 2009), as are a greater variety of extracurricular experiences (e.g., Engineers without Borders, Solar Car projects, Design for America, etc.) and mentoring programs (e.g., MentorNet).

21. This perception work needs to start in middle and high school, where academic choices are being made that affect later options, and builds on calls to "change the conversation" about what engineering encompasses (Committee on Public Understanding of Engineering Messages, National Academy of Engineering 2008). In presenting engineering as an expansive realm of options rather than a narrow realm of technical problem solving, this also may help to recon-

Third, our findings indicate that it may be appropriate for engineering programs to frame their thinking around "our program graduates individuals capable of engineering thinking," rather than "our program graduates engineers." This might liberate programs from needing to cover a long list of "essential knowledge domains," and help them to focus more on the ways of approaching and identifying problems that are unique to the practices of engineering and applicable in a variety of fields.

Fourth, our analysis directs attention at the need for more detailed investigation of linkages between "persistence in the major" and "persistence in the profession," including longitudinal studies of engineering graduates' pathways into nonengineering as well as engineering fields (e.g., via master's- or PhD-level training in business, biological sciences, and information sciences). In terms of attracting a wider group of students into engineering, examining how lower SES students conceive of engineering in the environments in which they tend to matriculate seems critical to understanding the role of socioeconomic characteristics in the development of the engineering workforce. Further research also needs to tease out the interaction between students' financial motivations and perceptions of the labor market, and more disaggregated labor market characteristics than our state-level BLS data.

Finally, we need to know more about what happens in the actual span of time between engineering majors' final years in their programs and their entry into the workforce, which can help schools of engineering better prepare their graduates for what is ahead. Our examination of outcomes in a multilevel framework opens the door for further work on the impact and interactions of personal and institutional factors on engineering career pathways.

Appendix A

Participating APPLES Institutions by Carnegie Classification

The 2000 Carnegie Classification (Carnegie Foundation for the Advancement of Teaching 2001) was used as the basis for the APPLES stratified institutional sampling plan (see Donaldson et al. 2008). The updated 2010 Carnegie Classification categories are presented for comparison.

ceptualize engineering as a field with multiple points of entry, rather than one lockstep path that begins at a very young age. Institutions with different resource supports and constraints presumably have much to learn from one another about supporting dynamic pathways and diverse students. Cross-institution conversation can reduce the start-up costs of new initiatives and contribute to more equitable opportunity structures for aspiring engineers.

Table 2A.1 Updated 2010 Carnegie Classification categories

Institution	2000 Carnegie Classification	Basic Carnegie Classification (2010)
Alabama A&M University	Doctoral/research intensive	Master's L: Master's colleges and universities (larger programs)
Arizona State University	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
CUNY New York City College of Technology	Master's colleges and universities I	Bac./assoc: Baccalaureate/associate colleges
Columbia University	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
Florida Atlantic University	Doctoral/research intensive	RU/H: Research universities (high research activity)
Georgia Institute of Technology	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
Harvey Mudd College	Baccalaureate colleges—Liberal arts	Bac./A&S: Baccalaureate colleges—Arts & sciences
Kettering University	Specialized institutions—Schools of engineering and technology	Master's M: Master's colleges and universities (medium programs)
Massachusetts Institute of Technology	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
Montana Tech of the University of Montana	Specialized institutions—Schools of engineering and technology	Bac./diverse: Baccalaureate colleges—Diverse fields
North Carolina A&T State University	Master's colleges and universities I	DRU: Doctoral/research universities
Northwestern University	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
Oklahoma Christian University	Baccalaureate colleges—General	Master's M: Master's colleges and universities (medium programs)
Franklin W. Olin College of Engineering	Not classified	Spec./Eng.: Special focus institutions—Schools of engineering
Portland State University	Doctoral/research intensive	RU/H: Research universities (high research activity)
Purdue University	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
San Jose State University	Master's colleges and universities I	Master's L: Master's colleges and universities (larger programs)
Smith College	Baccalaureate colleges—Liberal arts	Bac./A&S: Baccalaureate colleges—Arts & sciences
University of Minnesota–Twin Cities	Doctoral/research extensive	RU/VH: Research universities (very high research activity)
University of Texas at El Paso	Doctoral/research intensive	RU/H: Research universities (high research activity)
West Virginia University Institute of Technology	Baccalaureate colleges—General	Bac./diverse: Baccalaureate colleges—Diverse fields

Appendix B

Composite Measures Used in Multivariate Models

(Question numbers refer to those on the APPLES instrument)

Motivation: Financial (α = .81)

Q9b. Reason for pursuing engineering studies: Engineers make more money than most other professionals[a]
Q9e. Reason for pursuing engineering studies: Engineers are well paid[a]
Q9g. Reason for pursuing engineering studies: An engineering degree will guarantee me a job when I graduate[a]

Motivation: Intrinsic Psychological (α = .75)

Q9k. Reason for pursuing engineering studies: I feel good when I am doing engineering[a]
Q9m. Reason for pursuing engineering studies: I think engineering is fun[a]
Q9o. Reason for pursuing engineering studies: I think engineering is interesting[a]

Confidence in Professional and Interpersonal Skills (α = .82)

Q11a. Self-rating compared to your classmates: Self-confidence (social)[b]
Q11b. Self-rating compared to your classmates: Leadership ability[b]
Q11c. Self-rating compared to your classmates: Public-speaking ability[b]
Q11f. Self-rating compared to your classmates: Communication skills[b]
Q11h. Self-rating compared to your classmates: Business ability[b]
Q11i. Self-rating compared to your classmates: Ability to perform in teams[b]

Academic Involvement—Engineering-Related Courses (α = .71)

Q16a. Frequency during current school year: Came late to engineering class (reverse-coded)[c]
Q16b. Frequency during current school year: Skipped engineering class (reverse-coded)[c]
Q16c. Frequency during current school year: Turned in engineering assignments that did not reflect your best work (reverse-coded)[c]
Q16d. Frequency during current school year: Turned in engineering assignments late (reverse-coded)[c]

[a]Four-item scale: 0 = not a reason, 1 = minimal reason, 2 = moderate reason, and 3 = major reason.

[b]Five-point scale: 0 = lowest 10 percent, 1 = below average, 2 = average, 3 = above average, and 4 = highest 10 percent.

[c]Four-point scale: 0 = never, 1 = rarely, 2 = occasionally, and 3 = frequently. Reverse-coded for computation.

Computing the Multi-item Variable Scores

To compute each score, item scores were summed; the scale was then normalized and multiplied by 100 for reporting.

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