WHAT SHOULD I DO NEXT?
HOW ADVANCED ENGINEERING
STUDENTS DECIDE THEIR
POST-BACCALAUREATE PLANS

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Abstract

Few previous research studies have investigated the decision processes that engineering students use when they transition from undergraduate programs to either professional practice or graduate programs. This study aims to describe how advanced engineering students decide their post-baccalaureate plans. Specifically, this study examines the factors that influence students’ choices: people, courses, projects, industrial internships, research experiences, etc.

A mixed-methods study was conducted with engineering students at a large public university in the Midwest. A survey was administered to all 2293 seniors in engineering, and a similar survey was administered to all 664 first-year graduate students in engineering. The distribution of academic programs of the 62 seniors and 43 first-year graduate students who responded to surveys was similar to that of the entire populations. In addition, four seniors and four first-year graduate students were chosen for individual one-hour interviews. The eight students included men and women, and domestic and international students, across a range of engineering fields.

According to the surveys, there were no statistically significant differences between men and women in their choices of post-baccalaureate plans. Students who had had positive undergraduate research experiences were more likely to enter graduate school immediately after graduation. Students who had had positive industrial internships were more likely to enter professional practice immediately.

According to the interviews, some students seemed to drift into graduate school without clear goals or connections with their professional identities. Some entered graduate school because they were unable to find other appropriate employment. Some students chose professional practice because they had had negative undergraduate research experiences. Although students generally reported that they had made their post-baccalaureate decisions themselves, in reality, they appeared to be strongly
influenced by people and prior experiences, particularly by the quality of any undergraduate research experiences.
Acknowledgments

I wish to thank several people for their guidance and help. This thesis would not have been possible without the help from those people. First, I would to show my greatest appreciation to Professor Michael Loui for advising my thesis with great patience and encouragement.

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Particularly, I would like to thank Carol J. Wisniewski for helping transcribe the interview data. I would also like to thank James Brooks for explaining the Social Cognitive Career Theory. Last but not least, I would like to thank the following people for helping administer the surveys: Elizabeth J. Stern, Sarah Zehr, and Susan Storm.
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1. Introduction

"Having graduated from Harvard College in 1955 with a degree in mathematics, I was confronted with a decision as to what to do next. Working for a living had little appeal, so graduate school was the obvious choice." —Richard M. Karp, 1986 [1]

When approaching the senior year, undergraduate students start to seriously consider their post-baccalaureate plans. Seniors ask themselves, “What should I do next?” Some of them may already have a specific post-baccalaureate plan, while others may just have some vague ideas about their life after undergraduate study. Should I work? Should I go to graduate school? Should I take a gap year? Should I start a company? Should I enroll in military service? Should I volunteer for some charity organizations? Picking a post-graduation plan can be difficult. The decision-making process is even harder when seniors are unsure about their strengths and weaknesses.

For engineering students, deciding on post-baccalaureate plans is particularly difficult since a bachelor’s degree in engineering enables students to develop and become professionals in many areas. Engineering students can either begin a professional career in industry or switch to business practice. Engineering students can also either enter graduate school in engineering or apply to medical school or law school. Among all those choices, the most common two are working in industry and entering graduate school in engineering. Although all engineering students must decide on post-baccalaureate plans, there is no prior research on how they make these plans.

In this thesis, we studied students’ decision-making processes when they choose between work and graduate school. Specifically, we determined what factors have influenced students’ post-baccalaureate plans through surveys and individual interviews. We particularly classified eight different decision styles. Those decision styles could help engineering students to make their post-baccalaureate
plans better. Moreover, this study may also provide some insights to engineering educators and administrators when they advise engineering student who are making post-baccalaureate plans.
2. Literature Review

2.1 Enrollment and Retention in Engineering Programs

In the United States, for the past 20 years, the enrollment of engineering students in both undergraduate and graduate programs has steadily increased, despite some minor fluctuations (as seen in Figure 2.1). More specifically, undergraduate enrollment in engineering programs has increased around 80,000 students from 1996 to 2007 (as seen in Table 2.1).

Figure 2.1 U.S. Engineering Enrollment, Undergraduate and Graduate: 1989-2009

[Diagram showing U.S. engineering enrollment by level from 1989 to 2009]
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</thead>
<tbody>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>356,177</td>
<td>365,358</td>
<td>366,991</td>
<td>361,395</td>
<td>409,557</td>
<td>421,178</td>
<td>421,791</td>
<td>411,635</td>
<td>409,326</td>
<td>405,489</td>
<td>431,910</td>
<td></td>
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<tr>
<td>Freshman</td>
<td>85,375</td>
<td>90,882</td>
<td>94,909</td>
<td>93,951</td>
<td>101,773</td>
<td>106,825</td>
<td>107,086</td>
<td>103,834</td>
<td>102,395</td>
<td>100,411</td>
<td>100,228</td>
<td>110,558</td>
</tr>
<tr>
<td>Sophomore</td>
<td>66,475</td>
<td>67,879</td>
<td>69,608</td>
<td>69,941</td>
<td>76,706</td>
<td>78,348</td>
<td>81,854</td>
<td>82,542</td>
<td>80,704</td>
<td>79,664</td>
<td>78,418</td>
<td>87,018</td>
</tr>
<tr>
<td>Junior</td>
<td>67,190</td>
<td>68,812</td>
<td>67,638</td>
<td>66,975</td>
<td>74,055</td>
<td>76,938</td>
<td>79,806</td>
<td>80,703</td>
<td>78,014</td>
<td>78,891</td>
<td>77,970</td>
<td>82,094</td>
</tr>
<tr>
<td>Senior or fifth year</td>
<td>98,732</td>
<td>98,885</td>
<td>97,502</td>
<td>92,846</td>
<td>100,584</td>
<td>105,843</td>
<td>114,363</td>
<td>117,533</td>
<td>115,927</td>
<td>116,146</td>
<td>115,104</td>
<td>119,759</td>
</tr>
<tr>
<td>Part time</td>
<td>38,405</td>
<td>38,900</td>
<td>37,334</td>
<td>37,682</td>
<td>37,685</td>
<td>41,603</td>
<td>38,069</td>
<td>37,179</td>
<td>34,595</td>
<td>34,214</td>
<td>33,769</td>
<td>32,481</td>
</tr>
</tbody>
</table>

**Source:** Engineering Workforce Commission, Engineering & Technology Enrollments, Fall 2009 American Association of Engineering Societies (2010).

*Science and Engineering Indicators 2012*
Research on enrollment in undergraduate engineering programs has generally concentrated on factors that motivate first-year students to choose engineering and factors that affect students’ persistence in engineering programs. The Academic Pathways Study (APS) [2], chapter 2 of a report from the Center for the Advancement of Engineering Education (CAEE), provides a rich description of learning experiences of engineering undergraduates. The APS conducted a cross-sectional study of over 800 students, from freshmen to seniors, as a core sample and a six-year longitudinal study of 160 undergraduates in engineering. It also covered a wide range of significant issues in undergraduate study, from motivational factors, educational experiences, confidence in engineering design to post-graduation plans and early career experiences in engineering practice. The APS classifies students’ motivational factors into four types. First, behavioral motivations come from hands-on experiences provided by engineering programs. Second, psychological motivations originate from the situations when students feel confident and enjoy learning in engineering. Third, social motivations indicate the belief that engineers improve the welfare of the society. Fourth, financial motivations are developed due to conventional expectations that engineering can guarantee a job, usually a well-paid one.

Moreover, the APS suggests that motivations also come from mentors and parents. Influences from mentors and parents are built on daily communication, and such influences can be strong and long-lasting. Herbert et al. [3] point out that the power of parental influence does not diminish over time. A daughter who is very capable in math and science can be strongly influenced by her engineer parents in her choice of majoring in engineering.

In 1995, 20.8% of the 153,600 students who had started majoring in engineering and natural sciences were no longer enrolled in the same majors (as seen in Table 2.2). As a matter of fact, abundant research has explored why undergraduates drop out of the engineering programs, and what factors contribute to their persistence in engineering. Walden and Foor [4] conclude that main causes of leaving
are students’ failure to manage technical courses, negative experiences with faculty members, and a lack of communication and contact with faculty. They also suggest that well-targeted recruiting, welcoming individuals (such as faculty members), and a caring atmosphere in a department can help students to persist in industrial engineering. While they well categorize the push (switching) and pull (persisting) factors, the research is limited because they studied only industrial engineering students in the University of Oklahoma. Research results from one single major in a university cannot be applied to all other majors in engineering and the rest of the institutions in the United States.
TABLE 2.2 PERSISTENCE AND OUTCOME OF UNDERGRADUATE STUDENTS BEGINNING 4-YEAR UNIVERSITIES IN 1995: 2001

(PERCENT)

<table>
<thead>
<tr>
<th>Major in 1995</th>
<th>Number</th>
<th>Bachelor's</th>
<th>Associate's or certificate</th>
<th>Still enrolled</th>
<th>No longer enrolled</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>All majors</td>
<td>1,369,400</td>
<td>58.0</td>
<td>6.6</td>
<td>14.4</td>
<td>20.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Agricultural/biological sciences</td>
<td>115,300</td>
<td>60.8</td>
<td>4.0</td>
<td>16.7</td>
<td>18.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Physical/math/computer sciences/engineering</td>
<td>153,600</td>
<td>59.4</td>
<td>7.3</td>
<td>14.1</td>
<td>19.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Social and behavioral sciences</td>
<td>82,600</td>
<td>62.4</td>
<td>3.4</td>
<td>14.7</td>
<td>19.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Non-S&amp;E</td>
<td>599,000</td>
<td>57.7</td>
<td>7.6</td>
<td>13.2</td>
<td>21.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Missing/undeclared</td>
<td>418,900</td>
<td>56.3</td>
<td>6.1</td>
<td>15.5</td>
<td>21.7</td>
<td>0.4</td>
</tr>
</tbody>
</table>

NOTE: Physical sciences include earth, atmospheric, and ocean sciences.


Science and Engineering Indicators 2008
Matusovich et al. [5] indicate that interest alone is not enough to support students’ persistence; instead, high utility value (perceived usefulness with an engineering degree) with moderate interest can help a student to persist. Matusovich et al. also show that when students who have mild interest in engineering and who believe that an engineering degree can at least bring them a job, more likely a well-paid one after graduation, students will continue to pursue that engineering degree. Moreover, qualitatively, Matusovich et al. find that women who persisted and gained high GPA tend to have low attainment values. Low attainment value can be defined as the individual’s reflection on the performance of certain tasks and how the reflection matches with the individual’s self-concept. They further point out that if not properly addressed, low attainment value can still pull students out of engineering programs. Similarly, the APS also agrees that students who remain in engineering programs still have doubts as late as the end of their junior year.

According to the APS, students who express an interest in engineering sometimes report that their knowledge about engineering is limited to experiences in courses and internships. For example, in a three-month internship, the amount of guidance from the students’ mentor usually decides how much a student can learn from the internship. If the mentor provides little, the student may become discouraged about engineering. Besides, according to the APS, only 20% of the first-year undergraduates have significant prior exposure to prior engineering experiences. Potentially, when students start their engineering programs and join engineering organizations with little prior experiences, those engineering activities may not conform to their expectations. Disappointed by those engineering experiences, students are more likely to drop out of engineering programs and switch into non-engineering majors. Matusovich et al. [5] also recommend that engineering programs should continue to provide information on engineering activities and possible engineering careers to enable students to develop accurate personal views of engineering.
2.2 Professional Identity

Professional identity can also influence the level of commitment to an engineering program. According to Pierrakos et al. [6], students who demonstrate some personal identification with engineering tend to persist to complete an engineering degree. Engineering persisters tend to take initiative in engineering-related activities, such as student organizations, seminars, and undergraduate research. By contrast, students who demonstrate poor connection with engineering tend to switch to other majors [6]. Engineering switchers, who have low intrinsic motivation and identification with engineering, participate in engineering-related activities passively; they merely follow suggestions from counselors, parents, and friends.

Previous engineering experiences do not necessarily affect a student’s professional identity. Meyers et al. [7] studied whether students who gained pre-professional experiences, such as summer internship or undergraduate research, identify themselves more strongly as engineers than students who had none of those experiences. Contrary to expectations, Meyers et al. showed that pre-professional experiences do not correlate with students’ self-identification as engineers. Admittedly, both Pierrakos et al. [6] and Meyers et al. focused on limited populations, with either students from underrepresented groups [6] or students who persisted in engineering [7], respectively. Therefore, the findings from Pierrakos et al. and Meyers et al. are limited and might apply only to certain groups.

Besides the well-developed literature on freshmen experiences and on retention in undergraduate engineering programs [8], there is also abundant research on how undergraduates gradually form their personal understandings of engineering and engineers, and how students develop their professional identities when they pursue their bachelor’s degrees in engineering.

Stevens et al. [9] explored two common beliefs about engineering. One belief is engineering as a lifestyle. Specifically, engineers make good salary, have secure jobs, and expect to travel. The other
belief is called a “meritocracy of difficulty,” that engineers should be well compensated when they enter engineering practice. Because engineering curriculum consists of tough and time-consuming courses, as a reward, engineers deserve decent jobs to compensate for the hardships in school work. However, the beliefs about engineering were collected through self-reporting from students, and thus corresponding findings might not be based on knowledge about actual engineers. Stevens et al. fail to indicate whether interviewed students had gained any real-world experiences in engineering throughout their first two years of undergraduate study. Students’ concepts and expectations about engineers could be distorted by exposure to the media, such as advertisements and dramas.

To further study how students may change their understandings of engineering, Jocuns et al. [10] studied four different types of institutions, which they name Suburban Private, Technical Public, Urban Private, and Large Public. Jocuns et al. showed that the institutional culture can influence the formation of students’ professional directions. For example, Suburban Private University encourages high achievement and entrepreneurship, whereas Technical Public Institution stresses the importance of communication skills, teamwork, and ethics. Moreover, Jocuns et al. suggest that institutions can shape students’ professional identities and roles in engineering practice. Urban Private University conceives of engineering a way to pursue social good, and encourages students to actively engage in the community. In contrast, Large Public University stresses engineers’ efficiency and creativity. The culture in Large Public University leads engineering students to feel superior to students in other majors. As a result, graduates from Urban Private University are inclined to serve for community benefits, while those from Large Public University focus on personal contributions and success as engineers in society. Apparently, when students are educated in institutions with different engineering cultures, students graduate as engineers with different identities, values, and career goals. Such institutional influence, although powerful, still depends on the acceptance of individuals.
Lappenbusch and Turns [11] explored students’ preparation for engineering using portfolios. The portfolios recorded the learning experiences of engineering students. With a well-defined framework, students were encouraged to express their feelings, interpret their past industrial experiences, and build their identities as engineers [12]. By analyzing the portfolios, Lappenbusch and Turns [11] categorized students’ identities into four ways. First, affinity identity arises from a person’s participation in certain experiences in a group. Second, institutional identity arises from the values and culture of an institution. Third, discourse identity arises from conversations with other individuals, where the identity is shaped by the values if those other individuals. Fourth, natural identity refers to inborn traits. By recognizing the four categories of identity, Lappenbusch and Turns suggested that creative portfolio writing might positively impacts students’ engineering identities by consciously connecting students’ past studies to current preparation toward professional practice. As a result, students become more confident to progress and succeed in their future professional work. However, since Lappenbusch and Turns studied the effect of portfolios with only a small group of students, the impact of portfolios cannot necessarily apply to all other students with different majors, nationalities, and cultural backgrounds. Moreover, personality also influences the effect of the portfolios. For example, if a student is shy and indirect in expression, the student’s portfolio may not truly reflect that student’s preparation for engineering.

2.3 Post-baccalaureate Plans

In the literature on engineering students’ motivations, retention, and identity, most research focuses on first-year engineering students’ experiences and how they can be more successful in undergraduate engineering programs. Meanwhile, there is limited literature on seniors. In one of the few studies to include engineering seniors, Amelink and Creamer [13] point out that since peers can influence students’ career aspirations, gender biased behavior and male-dominated culture may negatively affect female students in engineering. In addition, Yurtseven [14] presents an interesting
phenomenon, which is relevant to seniors’ post-graduation plans. There are a little over 2 million engineers in the United States, but only 1.2 million of them have occupations related to engineering. Moreover, over one million engineers do not actually practice engineering, and those persons are working in fields like business and management [14]. In fact, the situation addressed by Yurtseven suggests that in order to understand why few people practice engineering, it is significant to trace back to the moment when people are about to graduate from college. Apparently, it is important to understand what factors contribute to students’ post-baccalaureate plans.

Margolis and Kotys-Schwartz [15] propose that five factors may affect students’ post-graduation plans: feeling of preparedness, internships, senior project, satisfaction with engineering program, and career values. Margolis and Kotys-Schwartz quantitatively and qualitatively analyze how influential each factor can be. However, with only two surveys over one year, Margolis and Kotys-Schwartz lack sufficient data to reach definitive conclusions or findings. Besides, the feeling of preparedness cannot be quantitatively measured. Thus, although a student may feel prepared to pursue a career in engineering, this feeling may not reflect the actual level of preparation of that student. Moreover, since most survey respondents were seniors in mechanical engineering, the corresponding survey results are restricted in one single major in engineering. Therefore, those results cannot be necessarily applied to other majors in engineering.

Basically, engineering students have two common choices for post-baccalaureate plans. The first one is to enter graduate school immediately. Most students who enroll in graduate programs in engineering intend to earn master’s degrees. In engineering, the master’s degree is a common credential as in education and business, but unlike the natural sciences, such as chemistry and physics. The APS shows that forty percent students are considering engineering graduate school, and more than sixty percent of engineering graduates have a combination of plans. Yurtseven [14] suggests that out of
2.6 million engineers, about 1.6 million do not pursue an advanced degree after receiving the bachelor’s degree in engineering. Moreover, among the 131,676 students enrolled in engineering graduate schools in 2007 (as seen in Table 2.3), few of them enter engineering graduate programs immediately. Meanwhile, international students contribute to a large percentage in engineering graduate programs in the United States. According to a survey from National Science Foundation, in 2002, around 50,000 international students, compared with 48,000 domestic students, were enrolled in engineering graduate programs in doctoral institutions in the United States (as seen in Figure 2.2). Students from foreign countries constitute almost half of the total enrollment in doctoral institutions. Similarly, foreign students dominate enrollment in engineering graduate programs in master’s institutions. Many domestic students with bachelor’s degrees prefer to work in the industry first and pursue graduate school after several years. Work experiences allow new graduates to choose their career paths and increase their competitiveness for future graduate school application.
### TABLE 2.3 GRADUATE ENROLLMENT IN ENGINEERING PROGRAMS: 1996-2008

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<tbody>
<tr>
<td>Engineering</td>
<td>103,224</td>
<td>101,148</td>
<td>100,038</td>
<td>101,691</td>
<td>104,112</td>
<td>104,493</td>
<td>119,466</td>
<td>127,377</td>
<td>123,566</td>
<td>122,565</td>
<td>123,041</td>
<td>131,676</td>
<td>137,856</td>
</tr>
<tr>
<td>Agricultural</td>
<td>1,012</td>
<td>941</td>
<td>975</td>
<td>966</td>
<td>943</td>
<td>947</td>
<td>952</td>
<td>1,058</td>
<td>1,041</td>
<td>1,059</td>
<td>1,073</td>
<td>1,126</td>
<td>1,233</td>
</tr>
<tr>
<td>Architecture\3\</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>t</td>
<td>4,601</td>
<td>5,902</td>
</tr>
<tr>
<td>Biomedical</td>
<td>2,732</td>
<td>2,847</td>
<td>2,855</td>
<td>3,069</td>
<td>3,197</td>
<td>3,599</td>
<td>4,338</td>
<td>5,301</td>
<td>5,807</td>
<td>6,067</td>
<td>6,482</td>
<td>6,904</td>
<td>7,339</td>
</tr>
<tr>
<td>Chemical</td>
<td>7,408</td>
<td>7,280</td>
<td>7,093</td>
<td>6,883</td>
<td>7,016</td>
<td>6,913</td>
<td>7,414</td>
<td>7,516</td>
<td>7,452</td>
<td>7,173</td>
<td>7,261</td>
<td>7,584</td>
<td>7,892</td>
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<td>Civil\3\</td>
<td>18,528</td>
<td>17,193</td>
<td>16,517</td>
<td>16,226</td>
<td>16,451</td>
<td>16,665</td>
<td>17,713</td>
<td>18,890</td>
<td>18,561</td>
<td>17,114</td>
<td>17,902</td>
<td>16,071</td>
<td>16,931</td>
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<tr>
<td>Electrical</td>
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<td>30,787</td>
<td>31,384</td>
<td>31,822</td>
<td>33,611</td>
<td>36,100</td>
<td>39,948</td>
<td>41,763</td>
<td>38,995</td>
<td>31,450</td>
<td>38,265</td>
<td>40,588</td>
<td>41,164</td>
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<td>Engineering science</td>
<td>1,751</td>
<td>1,647</td>
<td>1,701</td>
<td>1,627</td>
<td>1,602</td>
<td>1,798</td>
<td>2,121</td>
<td>2,240</td>
<td>2,198</td>
<td>1,951</td>
<td>2,046</td>
<td>1,806</td>
<td>2,099</td>
</tr>
<tr>
<td>Industrial/manufacturing</td>
<td>12,675</td>
<td>11,957</td>
<td>11,221</td>
<td>11,803</td>
<td>12,119</td>
<td>12,940</td>
<td>14,033</td>
<td>14,313</td>
<td>13,852</td>
<td>12,650</td>
<td>13,829</td>
<td>14,474</td>
<td>15,692</td>
</tr>
<tr>
<td>Mechanical</td>
<td>15,509</td>
<td>15,045</td>
<td>14,696</td>
<td>14,956</td>
<td>15,215</td>
<td>15,852</td>
<td>17,139</td>
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<td>17,373</td>
<td>17,919</td>
<td>18,347</td>
<td>19,585</td>
</tr>
<tr>
<td>Metallurgical/materials</td>
<td>4,747</td>
<td>4,688</td>
<td>4,680</td>
<td>4,401</td>
<td>4,377</td>
<td>4,721</td>
<td>4,992</td>
<td>5,131</td>
<td>5,059</td>
<td>5,160</td>
<td>5,268</td>
<td>5,314</td>
<td>5,539</td>
</tr>
<tr>
<td>Mining</td>
<td>371</td>
<td>348</td>
<td>304</td>
<td>328</td>
<td>327</td>
<td>240</td>
<td>267</td>
<td>278</td>
<td>308</td>
<td>279</td>
<td>244</td>
<td>222</td>
<td>290</td>
</tr>
<tr>
<td>Nuclear</td>
<td>980</td>
<td>868</td>
<td>821</td>
<td>830</td>
<td>792</td>
<td>801</td>
<td>795</td>
<td>865</td>
<td>971</td>
<td>1,013</td>
<td>1,099</td>
<td>1,201</td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td>562</td>
<td>561</td>
<td>571</td>
<td>642</td>
<td>617</td>
<td>656</td>
<td>766</td>
<td>849</td>
<td>845</td>
<td>808</td>
<td>813</td>
<td>1,014</td>
<td>1,009</td>
</tr>
<tr>
<td>Other engineering</td>
<td>3,000</td>
<td>3,085</td>
<td>4,083</td>
<td>4,689</td>
<td>4,378</td>
<td>4,910</td>
<td>5,505</td>
<td>6,712</td>
<td>6,536</td>
<td>6,298</td>
<td>6,658</td>
<td>7,029</td>
<td>7,075</td>
</tr>
</tbody>
</table>

\*Not applicable.  
\1\Data for 2007 and 2008 may not be comparable to previous years' data because some surveyed fields were reclassified, new fields were added, and the survey was redesigned to improve coverage and coding.  
\2\Because three fields were added to the survey in 2007, previous years' totals for all fields are not comparable to the 2007 and 2008 totals.  
\3\Before 2007, architecture was included under civil engineering instead of being reported as a separate field of engineering.  
\4\Three science fields--family and consumer science/human science, multidisciplinary/interdisciplinary studies, and communication—were added to the survey in 2007; some of the data may have been reported under other fields prior to 2007.  
\5\Before 2007, neuroscience was included under the health/medical field of neurology instead of being reported as a separate field of science.  

NOTE: The survey on which this table is based includes institutions in other jurisdictions, including Guam, Puerto Rico, and the U.S. Virgin Islands. Some data have been revised from previously published figures. Detail may not sum to totals because of rounding.  

(This table was prepared September 2010.)
Besides graduate school, the other common post-baccalaureate choice for engineering students is to enter the workplace to begin their careers. Students' choices of careers are influenced by many factors. There is literature on the factors that influence how students choose their career paths and why students choose certain careers instead of others. Lent et al. [16] derived the Social Cognitive Career Theory (SCCT) primarily from Bandura's social cognitive theory [17]. Bandura believes that people can learn through observation. For example, children learn through models such as their parents. Moreover, Bandura also concludes that a person's behavior both influences and is influenced by personal factors and the social environment. Based on Bandura's theory, Lent et al. [16] developed a framework on career development. Several building blocks of that framework are most important and are highlighted in Figure 2.3. The first one is self-efficacy. Self-efficacy is defined as beliefs that the individual has the
abilities to succeed. According to Lent et al. [16], the primary sources of self-efficacy come from personal performance and accomplishments, vicarious learning (learning through observation), social persuasion, and physiological and affective states. For instance, if a student takes mathematical courses and manages to learn them well, that student will build up confidence to take tougher math courses. Such confidence indicates that successful past learning experiences are the source of self-efficacy (as seen in Figure 2.3). Self-efficacy could explain students' motivations in initiating certain actions. In particular, self-efficacy suggests that students choose a major in engineering because of their confidence in math and science courses. Such confidence can be developed from learning experiences in childhood and influences from parents who are engineers.
Figure 2.3 The Social Cognitive Theory of Career Development [16]
In Figure 2.3, under the block of “Self-efficacy,” there is a block called “Outcome Expectations.” In SCCT, outcome expectations refer to the individual’s beliefs about the outcomes of particular behaviors [16]. With confidence from prior successful experiences, such as proficiency at playing basketball in the childhood, a person expects success in the future, such as expecting to be the star of a college basketball team. According to SCCT, with a combined influence from self-efficacy and outcome expectations, a person forms an interest and establishes certain goals. In Figure 2.3, the blocks of “Interest” and “Choice Goals” are in series, adjacent to “Self-efficacy” and “Outcome Expectations.” The block of “Choice Goals” indicates the determination to engage in a particular activity or to produce a particular outcome. Such determination can be affected not only by a personal interest, but also by contextual influences, which are tied to inputs such as gender and race/ethnicity (as seen in Figure 2.3). For instance, suppose a domestic engineering student and an international engineering student have equivalent qualifications and levels of interest in working as engineers after graduation. When they look for same entry-level engineering positions, compared with the domestic student, the international student has a smaller chance to acquire an interview due to a lack of citizenship or permanent residency. As a result, the international student would be inclined to postpone entering engineering workplace immediately after graduation, although the international student may be as interested in an industrial job as the domestic student.

Meanwhile, although SCCT illustrates several predominant causal pathways from past experiences, and self-efficacy, outcome expectations to interest, career goals, and choice actions, it fails to indicate the strength of those causal effects between blocks. Therefore, in my research, I will explore the dominant factors that influence engineering students’ post-baccalaureate plans and the extent to which those factors affect students’ post-graduation decisions. Moreover, my research on students’ post-baccalaureate plans could not only explain what factors affect undergraduates’ decisions about
their post-graduation plans, but also provide effective guidance for seniors or juniors who are still struggling with what post-graduation paths to follow.
3. Research Method

In this project, we employed both quantitative and qualitative methods to gather data. Specifically, we conducted surveys and individual interviews among seniors and first-year graduate students within the College of Engineering at the University of Illinois at Urbana-Champaign in the fall of 2011. To administer the survey and conduct individual interviews, we completed the following online training modules:

1. UIUC Human Subjects Training Module

2. CITI Training Module at the Collaborative Institutional Training Initiative (CITI)
   - Internet Research - SBR, Basic Course
   - International Research - SBR, Basic Course
   - Required UIUC Training Modules, Basic Course

This project received approval from the UIUC Institutional Review Board as IRB#12244.

All 2293 seniors and all 664 first-year graduate students in the College of Engineering were invited by e-mail to participate in an online survey and an optional follow-up interview (as seen in Table 3.1). Only students 18 years or older were eligible to participate. The recruitment e-mail messages explained that the purpose of the research is to identify the factors that contribute to the post-graduation plans of advanced engineering students and what helps to form their identities as engineers. The recruitment messages are included in Appendix A.
TABLE 3.1 FIRST-YEAR GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Major</th>
<th>Degree</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>MS/PhD</td>
<td>26</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Agricultural &amp; Biological Engineering</td>
<td>MS</td>
<td>16</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Bioengineering</td>
<td>MS</td>
<td>21</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Bioinformatics</td>
<td>MS</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>MS/PhD</td>
<td>141</td>
<td>34</td>
<td>107</td>
</tr>
<tr>
<td>Computer Science</td>
<td>MCS/MS/PhD</td>
<td>103</td>
<td>19</td>
<td>84</td>
</tr>
<tr>
<td>Electrical &amp; Computer Engineering</td>
<td>MS/PhD</td>
<td>78</td>
<td>7</td>
<td>71</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>MS</td>
<td>24</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Environmental Science in Civil Engineering</td>
<td>MS</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Financial Engineering</td>
<td>MS</td>
<td>43</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>MS</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Materials Science &amp; Engineering</td>
<td>MS/PhD</td>
<td>47</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>MS/PhD</td>
<td>71</td>
<td>13</td>
<td>58</td>
</tr>
<tr>
<td>Nuclear, Plasma, Radiology Engineering</td>
<td>MS/PhD</td>
<td>18</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Physics</td>
<td>PhD</td>
<td>51</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>Systems &amp; Entrepreneurial Engineering</td>
<td>MS/PhD</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Teaching of Physics</td>
<td>MS</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Theoretical &amp; Applied Mechanics</td>
<td>MS</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>664</td>
<td>150</td>
<td>514</td>
</tr>
</tbody>
</table>
3.1 Surveys

We prepared separate but similar online surveys for seniors and for first-year graduate students. In the consent screen, students were allowed to choose whether their responses could be used for research purposes. If a student decided to quit in the middle of the survey, he or she could stop the survey without having his or her data saved. The survey requested no personally identifying information, such as name, student ID, or e-mail address, to guarantee that students’ responses would keep confidential and anonymous. The survey for seniors had 25 questions, including 9 open-ended questions. The survey for first-year graduate students had 27 questions, including 10 open-ended questions. Detailed information on survey questions are in Appendix B.

The estimated survey completion time was around 15 to 20 minutes. For seniors, they were given 5 days to complete their survey. For first-year graduate students, they were given 10 days to complete their survey due to the final exam week, and an additional reminder e-mail was sent 3 days before the survey ended.

Sixty-two seniors and 43 first-year graduate students responded. All 105 respondents consented for their responses to be used. The distribution of 105 survey respondents is shown in Table 3.2 and Table 3.3.

<table>
<thead>
<tr>
<th>Major</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Agricultural &amp; Biological</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bioengineering</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Civil &amp; Environment Engineering</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Computer Science</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Major</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Aerospace Engineering</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Agricultural &amp; Biological Engineering</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bioengineering</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Civil &amp; Environment Engineering</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Computer Science</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Electrical &amp; Computer Engineering</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Materials Science &amp; Engineering</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical Engineering &amp; Engineering Mechanics</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Nuclear, Plasma, Radiology Engineering</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Physics</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Transportation Engineering</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>
3.2 Individual Interviews

In the survey recruitment e-mail messages, both seniors and first-year graduate students were invited to participate in an optional follow-up interview. The messages stated that it was an individual interview and the messages provided the contact information on how to participate in an interview. Each interview would last up to 60 minutes. The recruitment message also included the compensation and assured the confidentiality of participation in an interview.

Among students who responded according to the contact information, we selected eight students to participate in the interview. We chose the participants based on their genders, majors, domestic/international status, and academic standing (as seen in Table 3.4). For instance, we selected Jason, who was a male and majored in engineering physics, to balance international and domestic students among the undergraduate interviewees. We selected Jennifer who was more inclined to science instead of engineering, to ensure a diversity of nationalities, majors and genders. We also selected only graduate student interviewees who directly entered graduate study after they received their bachelor’s degrees. Consequently, interview volunteers who had either taken a gap year or worked after undergraduate study were eliminated from the candidate list. This selection criterion served to control the factors that may influence a student to choose graduate study.
### TABLE 3.4 INDIVIDUAL INTERVIEWS PARTICIPANTS

<table>
<thead>
<tr>
<th>Pseudonyms</th>
<th>Gender</th>
<th>Major</th>
<th>Academic Standing</th>
<th>Domestic/International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patricia</td>
<td>Female</td>
<td>Bioengineering</td>
<td>5th year</td>
<td>Domestic</td>
</tr>
<tr>
<td>Jason</td>
<td>Male</td>
<td>Engineering Physics</td>
<td>Senior</td>
<td>International</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>Female</td>
<td>Civil &amp; Environmental Engineering</td>
<td>Senior</td>
<td>Domestic</td>
</tr>
<tr>
<td>Brian</td>
<td>Male</td>
<td>Industrial Engineering</td>
<td>Senior</td>
<td>Domestic</td>
</tr>
<tr>
<td>Richard</td>
<td>Male</td>
<td>Computer Science</td>
<td>First-year Graduate Student</td>
<td>Domestic</td>
</tr>
<tr>
<td>Lisa</td>
<td>Female</td>
<td>Computer Engineering</td>
<td>First-year Graduate Student</td>
<td>International</td>
</tr>
<tr>
<td>Jennifer</td>
<td>Female</td>
<td>Physics</td>
<td>First-year Graduate Student</td>
<td>Domestic</td>
</tr>
<tr>
<td>Daniel</td>
<td>Male</td>
<td>Mechanical Engineering</td>
<td>First-year Graduate Student</td>
<td>International</td>
</tr>
</tbody>
</table>

Each of the eight interviewees provided their available dates and times by e-mailing me through the contact information in the recruitment e-mail message. After each interviewee’s meeting was scheduled, a conference room on campus was reserved to hold the interview. Before each interview, each interviewee signed a consent form that stated the interview procedure, voluntariness, compensation, benefits and risks, and confidentiality. All signed consent forms interviews have been privately stored. A copy of the consent form is included in Appendix C. As compensation for their participation, interviewees received a $10 gift card.

During the interview session, each interviewee was asked several questions in a semi-structured form. Questions varied depending on the experiences of different interviewees. Interview questions also varied according to the academic standing of each interviewee, i.e., seniors or graduate students. If the
interviewee intended to stop the interview, he or she was able to leave at any time. An interviewee was also able to skip any questions that he or she preferred not to answer. All eight interviewees remained for the entire interview session. All interview sessions were recorded with a digital voice recorder and were later transcribed verbatim. The interview questions are in Appendix D.
4. Survey Results

4.1 Respondents

Table 4.1 presents the total number of survey respondents and their genders and academic standings.

TABLE 4.1 SUMMARY ON SURVEY RESPONDENTS

<table>
<thead>
<tr>
<th>Total Respondents</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>38</td>
<td>67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Undergraduates</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>23</td>
<td>39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First-year Graduate Students</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>15</td>
<td>28</td>
</tr>
</tbody>
</table>

Out of the 105 respondents, 4 students felt unsure about their post-graduation plans and one student planned to enroll in military service after undergraduate study. As a result, those five students were removed from the data. In total, 100 responses were analyzed.

Moreover, in Table 4.2 and subsequent tables, “Work” counts the number of advanced undergraduate engineering students who plan to work in the industry after graduation. The “Graduate School” category combines all first-year graduate students with those advanced undergraduate engineering students who plan to enter graduate school after graduation.

TABLE 4.2 DISTRIBUTION ON POST-BACCALAUREATE PLANS

<table>
<thead>
<tr>
<th>Work</th>
<th>Graduate School</th>
<th>Not decided</th>
<th>Military Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>61</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Some students did not answer some survey questions; at the very minimum, for each question, 77 responses were used, but mostly 95 - 100 responses were used for the statistical analysis. We use Fisher’s Exact Test [18] for 2x2 contingency tables to check whether different factors, such as research experiences and industrial internships, were significantly different in students’ choices between industrial jobs and graduate schools. In section 4.7, the Mann Whitney-U test [18] was used to check whether there is significant difference between students who participated in student organizations and those who did not in their decisions between industrial jobs and graduate schools. In section 4.8, the Chi-square test was used to check whether there is significant difference between two categories, either Male vs. Female or Work vs. Graduate School. A difference is considered significant if the statistical test produced a $p$ value of 0.05 or less and such $p$ value is marked with an asterisk (*).

### 4.2 Genders

In Table 4.3, Fisher’s Exact Test shows that there is no statistically significant difference between men and women in their decisions between industrial jobs and graduate schools.

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Graduate School</td>
<td>23</td>
<td>38</td>
</tr>
<tr>
<td>$p$ value</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 4.3 GENDERS
4.3 Research Experiences

In Table 4.4, “Have Research Experiences” counts the number of engineering students who have done research when they were undergraduates, either in a lab or in a form of senior project or senior thesis. Research-based internships are also included.

<table>
<thead>
<tr>
<th></th>
<th>Have Research Experiences</th>
<th>No Research Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Graduate School</td>
<td>43</td>
<td>18</td>
</tr>
<tr>
<td>p value</td>
<td>0.0019*</td>
<td></td>
</tr>
</tbody>
</table>

According to Table 4.4, there is statistically significant difference between students who had research experiences and those who had none in their choices between industrial jobs and graduate schools. Meanwhile, we should not conclude that an undergraduate research experience predisposes the students to choose graduate school: the quality of that research experience matters. Based on responses from open-ended survey questions, research experiences, including research-based internships, have both strong positive and negative influences on students’ decisions to enter graduate school. Students who had negative research experiences, even a single one, tend to look for a job after graduation rather than continue to graduate school.

**Original open-ended survey questions**

**For undergraduate students:** Have you had any research experiences? How do those experiences contribute to your post-graduation plans?


For first-year graduate students: Did you conduct any independent research during your undergraduate study? How did undergraduate research experiences contribute to your decision to pursue graduate school?

Positive influences

I did past research in the ABE department and I currently work in the MechSE department. These research experiences have supported my decision to further my studies in graduate school. I am excited about my current research, and I hope to continue it in graduate school. —Agricultural & Biological Engineering; Senior

They showed me that I excelled in and understood the laboratory research process. Since this is what a large part of grad school looks like, I thought I would extend and improve those skills by pursuing a PhD. —Mechanical Science & Engineering; First-year Graduate Student

My [research] internships showed me that I wanted to do higher level engineering so I needed more schooling. —Transportation Engineering; First-year Graduate Student

One in Germany and two research summer positions. The research positions gave me perspective into the latest advances in the field and piqued my interest in further research. —Civil Engineering; First-year Graduate Student

Negative influences

I’ve researched for a group on campus for one summer as well. It made me realize I did not want to do intensive research and made me realize I do not want to do graduate school in engineering. If I do graduate school later on, it will most likely be in a different discipline, such as business or administration. —Bioengineering; Senior
Undergraduate Research Lab. [I] worked with a grad student, topic ended up being boring, which caused me to be less interested in research. —Computer Engineering; Senior

It has actually lowered my interest in graduate school. I think that as an engineer, having an advanced degree can make you too specialized and limit job options. —Chemical Engineering; Senior

4.4 Internships

In Table 4.5, “Have Internships” counts the number of advanced engineering students who worked in industrial positions, in a form of summer internship or co-op. Very few survey respondents had previously worked full time. Research-based internships are excluded from this count.

<table>
<thead>
<tr>
<th></th>
<th>Have Internships</th>
<th>No Internship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>32</td>
<td>7</td>
</tr>
<tr>
<td>Graduate School</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td><em>p value</em></td>
<td>0.014*</td>
<td></td>
</tr>
</tbody>
</table>

According to Table 4.5, there is statistically significant difference between students who had industrial internship experiences and those who had none in their decisions between industrial jobs and graduate schools. Based on responses from open-ended survey questions, industrial experiences have mainly positive influences on students’ post-graduation plans. Particularly, students who are positively influenced by their internships tend to work in the industry after graduation. Very few students report negative industrial experiences.
Original open-ended survey questions

**For undergraduate students:** Have you had any internship or co-op experiences? How do those influence your post-graduation plans?

**For first-year graduate students:** Have you had any internship or co-op experiences? How did those influence your decision to pursue graduate study?

Positive responses

[I had] multiple internships and co-ops. They have exposed me to the working industry and have likely influenced me to search for a job as opposed to continue my education. —Mechanical Engineering; Senior

One was at a bank and the other a small consulting firm in the UK. I knew … I really enjoyed these internships which reinforced my want to go into the business field. —General Engineering; Senior

I had an internship with a company and it solidified my decision to go into that particular field and with that company. —Civil Engineering; Senior

Have had three internships, all of which have helped me immensely decide what I want to do and where. They have convinced me not to attend Grad School, and I will enter employment directly in industry at my point of graduation. —Materials Science & Engineering; Senior

I worked for Motorola Mobility Inc. It gave me a good picture of how engineering worked in the professional world, and increased my confidence that I could make it as an engineer. —Computer Science; Senior
Negative responses

I realized that maybe I don’t have it in me to go to work every day and do the same thing over and over for 50 years, and think about my retirement plan. I want to be a researcher and a faculty member, and pursue new knowledge and help to improve processes and products through research.
—Civil Engineering; First-year Graduate Student

Many [internships] and [those internships are] full-time employment. I've worked full-time for nearly 25 years. Most industry jobs are boring. Or they have you working 70 hours for the benefit of someone else, not you. I got sick and tired of being treated like someone's tool instead of someone's partner and decided not to put up with it anymore. [I] also got sick of having to work for unethical people. Not putting up with that anymore either. —Computer Science; First-year Graduate Student

[I had] one [internship]. [It is] an internship with IDOT. I would say it influenced my path in undergrad more, in that I was able to rule out any interest in construction management after that job—it seemed too fluffy and too much about interpersonal skills, which I don’t feel strong enough in to base my career off of. —Civil & Environmental Engineering; Senior

4.5 People

In Table 4.6, “Large Influence from People” counts the number of advanced engineering students reported that their post-graduation plans were influenced by people whom they consulted. Those people include but are not limited to family members, advisors, mentors, faculty members, coworkers, and friends.

Moreover, in Table 4.6, “Little Influence from People” counts the number of advanced engineering students who reported that they decided on their own regarding post-graduation plans.
 According to Table 4.6, there is no statistically significant difference between students who are influenced by people, such as mentors and friends, and those who are not in their choices between industrial jobs and graduate schools.

However, based on responses from open-ended survey questions, people like as family members and advisors are indispensable in students’ decisions on their post-graduation plans.

Original open-ended survey questions

For undergraduate students: Who (individuals can be parents, mentors, faculty, friends, etc.) have influenced your post-graduation plans? In what ways?

For first-year graduate students: Who (individuals can be parents, mentors, faculty, friends, etc.) have influenced your decision to pursue graduate school instead of working in the industry? In what ways?

Responses

I suppose my master’s thesis advisor was a supportive influence in my decision for pursuing a PhD. He would answer any questions I had on the subject and generally recommended that I pursue it.

—Civil & Environmental Engineering; First-year Graduate Student
Faculty and family have really influenced my decision because I found something I really like and they were supportive of my choice. —Civil Engineering; Senior

Mom and grandparents convinced me that learning more was essential. [Name of professor] has been so nice to me and convinced me that I need more experience in research. —Agricultural & Biological Engineering; First-year Graduate Student

Parents, faculty, and friends have been equally important on listening to my aspirations and providing me insight to what they think of my opinions. This has been very important in my decisions. —Nuclear Engineering; Senior

4.6 Attachment

In Table 4.7, “Attachment to My Department” counts the number of advanced engineering students who felt connected to their departments when they were undergraduates. Students who reported such attachment as somewhat connected to very closely connected are included.

In addition, in Table 4.7, “No Attachment to My Department” counts the number of advanced engineering students who reported little connection to their departments when they were undergraduate students.

<table>
<thead>
<tr>
<th></th>
<th>Attachment to My Department</th>
<th>No Attachment to My Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Graduate School</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>( p ) value</td>
<td>0.026*</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 4.7 ATTACHMENT
According to Table 4.7, there is a significant difference between students who felt connected with their engineering departments and those who have little in their decisions between industrial jobs and graduate schools. Specifically, more students choose graduate schools because of such attachment to their engineering departments and faculty members. A good connection to the department also attracts undergraduate students to stay in the same program.

**Original open-ended survey questions**

**For undergraduate students:** How closely do you feel you are connected to your engineering department? How does that affect your post-graduation plans?

**For first-year graduate students:** How closely did you feel you connected to your engineering department, during your undergraduate study? How did that affect your decision to pursue graduate study?

**Responses**

*I feel really close to the MatSE department and am applying there for grad school because of it.*

—Materials Science & Engineering; Senior

*I am very close to the ABE department, and many faculties recognize me within the department. I am currently considering mechanical engineering for my Master’s degree.* —Agricultural & Biological Engineering; Senior

*I had a good relationship with all faculty and staff, and also with graduate students. Faculty encouraged me to pursue research studies and I saw how grad students worked and I thought I would fit in their shoes.* —Bioengineering; First-year Graduate Student
I really connected with my professors...Because I had such a good report with my professors, I really heeded their advice to go to graduate school. —Computer Science; First-year Graduate Student

[I felt] so connected that I actually applied to the same department. —Bioengineering; First-year Graduate Student

4.7 Student Organizations

In Table 4.8, “Participation in Student Organizations” counts the number of advanced engineering students who participated in student organizations during their undergraduate study. We use a Very active to Not active at all scale to describe how active students participated in the student organizations when they were undergraduates.

TABLE 4.8 STUDENT ORGANIZATIONS

<table>
<thead>
<tr>
<th></th>
<th>1-Very active</th>
<th>2-Active</th>
<th>3-Neutral</th>
<th>4-Not that active</th>
<th>5-Not active at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>23</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Graduate School</td>
<td>27</td>
<td>16</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>p value</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Table 4.8, the Mann Whitney-U test [18] shows that there is no significant difference between students who participated in student organizations and those who did not in their choices between industrial jobs and graduate schools.

However, based on responses from open-ended survey questions, participation in student organizations can help students develop professional skills.
Original open-ended survey questions

For undergraduate students: How do these experiences, in student or community organizations, affect your post-graduation plans?

For first-year graduate students: How did these experiences, in student or community organizations, affect your decision to pursue graduate school?

Responses

[Participation in student organizations] helped me acquire soft skills which helped me a lot in the workplace and I got to create a network. —Civil Engineering; Senior

These experiences helped develop my interpersonal communication skills to make me a better engineer. —Agricultural & Biological Engineering; Senior

They have significantly improved my network of professionals in engineering, allowing me further insight into the field. They have also given me great amounts of interpersonal experience, a necessity for any engineer. —Materials Science & Engineering; Senior

4.8 Other Results

Besides significant factors on students’ post-baccalaureate plans, there are several interesting results regarding the images of engineers.

Survey question 1: What were the three most important reasons for choosing a major in engineering when you were first admitted to an engineering program?

a. Financial support for studying in engineering

b. Curiosity about gadgets (such as electronic devices, robots)
c. Salary as an engineer

d. High school counselors’ advice

e. Ability in mathematics and science

f. Suggestions from family members

g. Foundation for careers in other professions (e.g. law, medicine)

h. Other

Results

Table 4.10 and Table 4.11 collect the number of students, male versus female, based on each of the reasons why students choose an undergraduate major in engineering. Moreover, Figure 4.1 and Figure 4.2 present the percentage of each reason in a form of bar graphs. Based on the bar graphs, Table 4.9 summarizes the top three reasons based on genders and academic standings.

<table>
<thead>
<tr>
<th>Top Three Reasons</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Undergraduate Students</strong></td>
<td>• Ability in mathematics and science</td>
<td>• Ability in mathematics and science</td>
</tr>
<tr>
<td></td>
<td>• Curiosity about gadgets</td>
<td>• Suggestions from family members</td>
</tr>
<tr>
<td></td>
<td>• Salary as an engineer</td>
<td>• Salary as an engineer</td>
</tr>
<tr>
<td><strong>First-year Graduate Students</strong></td>
<td>• Ability in mathematics and science</td>
<td>• Ability in mathematics and science</td>
</tr>
<tr>
<td></td>
<td>• Curiosity about gadgets</td>
<td>• Salary as an engineer</td>
</tr>
<tr>
<td></td>
<td>• Salary as an engineer</td>
<td>• Curiosity about gadgets &amp; financial support for studying in engineering</td>
</tr>
</tbody>
</table>
Table 4.9 shows that the top reason to choose an undergraduate major in engineering is “Ability in mathematics and science”. Another reason that all students picked is “Salary as an engineer”, which confirms the beliefs about engineers have secure jobs and are well-paid [25].

Table 4.10 and Table 4.11 present the data from survey question 1. Results from the Chi-square test are also included.

### TABLE 4.10 SURVEY QUESTION 1 RESPONSES—UNDERGRADUATE STUDENTS

<table>
<thead>
<tr>
<th>“WHY” choose an undergraduate major in engineering</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial support for studying in engineering</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Curiosity about gadgets</td>
<td>27</td>
<td>8</td>
<td>35</td>
<td>21.9</td>
<td>13.1</td>
</tr>
<tr>
<td>Salary as an engineer</td>
<td>25</td>
<td>13</td>
<td>38</td>
<td>23.8</td>
<td>14.3</td>
</tr>
<tr>
<td>High school counselors’ advice</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Ability in mathematics and science</td>
<td>34</td>
<td>20</td>
<td>54</td>
<td>33.8</td>
<td>20.3</td>
</tr>
<tr>
<td>Suggestions from family members</td>
<td>12</td>
<td>17</td>
<td>29</td>
<td>18.1</td>
<td>10.9</td>
</tr>
<tr>
<td>Foundation for careers in other professions</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>3.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td>9.4</td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>115</strong></td>
<td><strong>69</strong></td>
<td><strong>184</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chi-square Test Result</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.20</strong></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 4.11 SURVEY QUESTION 1 RESPONSES—FIRST-YEAR GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>“WHY” choose an undergraduate major in engineering</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial support for studying in engineering</td>
<td>8</td>
<td>5</td>
<td>13</td>
<td>8.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Curiosity about gadgets</td>
<td>17</td>
<td>5</td>
<td>22</td>
<td>14.2</td>
<td>7.8</td>
</tr>
<tr>
<td>Salary as an engineer</td>
<td>10</td>
<td>6</td>
<td>16</td>
<td>10.3</td>
<td>5.7</td>
</tr>
<tr>
<td>High school counselors’ advice</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Ability in mathematics and science</td>
<td>21</td>
<td>14</td>
<td>35</td>
<td>22.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Suggestions from family members</td>
<td>8</td>
<td>4</td>
<td>12</td>
<td>7.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Foundation for careers in other professions</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>6.4</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74</strong></td>
<td><strong>41</strong></td>
<td><strong>115</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chi-square Test Result: 0.87

---

**Figure 4.1 “WHY” choosing a major in engineering—Undergraduate students**
Survey question 7: How do you define "engineer" now? Rank the following answers. (6-most important identity, 1-least important identity)

The engineer...

a. Brings social benefits to the community

b. Develops new products and processes

c. Improves processes or products

d. Makes or saves money for employers

e. Solves problems

f. Works within constraints
Results

Table 4.12, Table 4.13, and Table 4.14 present an average rating of each responsibility of engineers based on a ranking scale of 1 (least important identity) to 6 (most important identity). Results from the Chi-square test are also included. Table 4.15, Table 4.16, and Table 4.17 summarize how students rank engineers’ identities. All data are arranged into different categories, Work vs. Graduate School and Male vs. Female (both undergraduates and first-year graduate students).

<table>
<thead>
<tr>
<th>Engineers’ responsibilities</th>
<th>Work (observed)</th>
<th>Graduate School (observed)</th>
<th>Total</th>
<th>Work (expected)</th>
<th>Graduate School (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brings social benefits to the community</td>
<td>2.87</td>
<td>3.31</td>
<td>6.18</td>
<td>3.09</td>
<td>3.09</td>
</tr>
<tr>
<td>Develops new products and processes</td>
<td>3.54</td>
<td>3.79</td>
<td>7.33</td>
<td>3.67</td>
<td>3.67</td>
</tr>
<tr>
<td>Improves processes or products</td>
<td>4.10</td>
<td>3.89</td>
<td>7.99</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Makes or saves money for employers</td>
<td>2.95</td>
<td>2.70</td>
<td>5.65</td>
<td>2.83</td>
<td>2.83</td>
</tr>
<tr>
<td>Solves problems</td>
<td>4.49</td>
<td>4.33</td>
<td>8.82</td>
<td>4.41</td>
<td>4.41</td>
</tr>
<tr>
<td>Works within constraints</td>
<td>3.05</td>
<td>2.98</td>
<td>6.03</td>
<td>3.02</td>
<td>3.02</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>21</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi-square Test Result</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 4.13 MALE VERSUS FEMALE—UNDERGRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Engineers' responsibilities</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brings social benefits to the community</td>
<td>3.10</td>
<td>3.43</td>
<td>6.53</td>
<td>3.27</td>
<td>3.26</td>
</tr>
<tr>
<td>Develops new products and processes</td>
<td>3.21</td>
<td>3.61</td>
<td>6.82</td>
<td>3.41</td>
<td>3.41</td>
</tr>
<tr>
<td>Improves processes or products</td>
<td>4.13</td>
<td>3.83</td>
<td>7.96</td>
<td>3.98</td>
<td>3.98</td>
</tr>
<tr>
<td>Makes or saves money for employers</td>
<td>2.82</td>
<td>2.91</td>
<td>5.73</td>
<td>2.87</td>
<td>2.86</td>
</tr>
<tr>
<td>Solves problems</td>
<td>4.44</td>
<td>4.39</td>
<td>8.83</td>
<td>4.42</td>
<td>4.41</td>
</tr>
<tr>
<td>Works within constraints</td>
<td>3.31</td>
<td>2.83</td>
<td>6.14</td>
<td>3.07</td>
<td>3.07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21.01</strong></td>
<td><strong>21</strong></td>
<td><strong>42.01</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chi-square Test Result** 1.00

### TABLE 4.14 MALE VERSUS FEMALE—FIRST-YEAR GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Engineers' responsibilities</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brings social benefits to the community</td>
<td>3.43</td>
<td>2.73</td>
<td>6.16</td>
<td>3.08</td>
<td>3.08</td>
</tr>
<tr>
<td>Develops new products and processes</td>
<td>3.82</td>
<td>4.60</td>
<td>8.42</td>
<td>4.21</td>
<td>4.21</td>
</tr>
<tr>
<td>Improves processes or products</td>
<td>3.82</td>
<td>4.00</td>
<td>7.82</td>
<td>3.91</td>
<td>3.91</td>
</tr>
<tr>
<td>Makes or saves money for employers</td>
<td>2.61</td>
<td>2.87</td>
<td>5.48</td>
<td>2.74</td>
<td>2.74</td>
</tr>
<tr>
<td>Solves problems</td>
<td>4.57</td>
<td>3.87</td>
<td>8.44</td>
<td>4.22</td>
<td>4.22</td>
</tr>
<tr>
<td>Works within constraints</td>
<td>2.75</td>
<td>2.93</td>
<td>5.68</td>
<td>2.84</td>
<td>2.84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
<td><strong>21</strong></td>
<td><strong>42</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chi-square Test Result** 1.00
### TABLE 4.15 ENGINEERS’ RESPONSIBILITIES RANKING RESULTS—WORK VERSUS GRADUATE SCHOOL

<table>
<thead>
<tr>
<th>Most Important Responsibility</th>
<th>Work</th>
<th>Graduate School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Solves Problems</td>
<td>• Solves Problems</td>
</tr>
<tr>
<td></td>
<td>• Improves processes or products</td>
<td>• Improves processes or products</td>
</tr>
<tr>
<td></td>
<td>• Develops new products and processes</td>
<td>• Develops new products and processes</td>
</tr>
<tr>
<td></td>
<td>• Works within constraints</td>
<td>• Brings social benefits to the community</td>
</tr>
<tr>
<td></td>
<td>• Makes or saves money for employers</td>
<td>• Works within constraints</td>
</tr>
<tr>
<td></td>
<td>• Brings social benefits to the community</td>
<td>• Makes or saves money for employers</td>
</tr>
</tbody>
</table>

### TABLE 4.16 ENGINEERS’ RESPONSIBILITIES RANKING RESULTS—UNDERGRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Most Important Responsibility</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Solves Problems</td>
<td>• Solves Problems</td>
</tr>
<tr>
<td></td>
<td>• Improves processes or products</td>
<td>• Improves processes or products</td>
</tr>
<tr>
<td></td>
<td>• Works within constraints</td>
<td>• Develops new products and processes</td>
</tr>
<tr>
<td></td>
<td>• Develops new products and processes</td>
<td>• Brings social benefits to the community</td>
</tr>
<tr>
<td></td>
<td>• Brings social benefits to the community</td>
<td>• Makes or saves money for employers</td>
</tr>
<tr>
<td></td>
<td>• Makes or saves money for employers</td>
<td>• Works within constraints</td>
</tr>
</tbody>
</table>
TABLE 4.17 ENGINEERS’ RESPONSIBILITIES RANKING RESULTS—FIRST-YEAR GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Most Important Responsibility</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Solves Problems</td>
<td>• Develops new products and processes</td>
</tr>
<tr>
<td></td>
<td>• Improves processes or products &amp; Develops new products and processes</td>
<td>• Improves processes or products</td>
</tr>
<tr>
<td></td>
<td>• Brings social benefits to the community</td>
<td>• Solves Problems</td>
</tr>
<tr>
<td></td>
<td>• Works within constraints</td>
<td>• Works within constraints</td>
</tr>
<tr>
<td></td>
<td>• Makes or saves money for employers</td>
<td>• Makes or saves money for employers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Brings social benefits to the community</td>
</tr>
<tr>
<td>Least Important Responsibility</td>
<td>• Develops new products and processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improves processes or products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Solves Problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Works within constraints</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Makes or saves money for employers</td>
<td></td>
</tr>
</tbody>
</table>

Survey question 8: What kinds of skills are essential to engineers? Choose the 3 most important ones.

a. Good communication skills

b. Ability to use resources to solve problems

c. Teamwork

d. Ethical standards

e. Life-long learning

f. Business perspectives

Results

Table 4.19 and Table 4.20 collect the number of students, male versus female, according to each of the essential skills to engineers. Results from the Chi-square test are also included. Moreover, Figure
4.3 and Figure 4.4 present the percentage of essential skills in a form of bar graphs. Based on the bar graphs, Table 4.18 summarizes the three most important skills to engineers categorized into Male vs. Female (both undergraduate students and first-year graduate students).

<table>
<thead>
<tr>
<th>Three Essential Skills</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
</table>
| **Undergraduate Students** | • Ability to use resources to solve problems  
• Good communication skills  
• Teamwork & Life-long learning | • Ability to use resources to solve problems  
• Teamwork  
• Life-long learning |
| **First-year Graduate Students** | • Ability to use resources to solve problems  
• Good communication skills & Teamwork & Life-long learning | • Ability to use resources to solve problems  
• Ethical standards  
• Life-long learning |

Table 4.18 shows that the most important skill to engineers is “Ability to use resources to solve problems”. Another skill that all students picked is “Life-long learning”. These two skills show that students believe engineers should not only preserve in solving hard problems, but also have wisdom to find smart ways to solve those problems. Thus, engineers should always absorb new knowledge.
### TABLE 4.19 SURVEY QUESTION 8 RESPONSES—UNDERGRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Three Essential Skills to Engineers</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good communication skills</td>
<td>27</td>
<td>11</td>
<td>38</td>
<td>23.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Ability to use resources to solve problems</td>
<td>33</td>
<td>19</td>
<td>52</td>
<td>32.7</td>
<td>19.3</td>
</tr>
<tr>
<td>Teamwork</td>
<td>18</td>
<td>16</td>
<td>34</td>
<td>21.4</td>
<td>12.6</td>
</tr>
<tr>
<td>Ethical standards</td>
<td>17</td>
<td>9</td>
<td>26</td>
<td>16.4</td>
<td>9.6</td>
</tr>
<tr>
<td>Life-long learning</td>
<td>18</td>
<td>12</td>
<td>30</td>
<td>18.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Business perspectives</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>3.8</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>117</strong></td>
<td><strong>69</strong></td>
<td><strong>186</strong></td>
<td><strong>Chi-square Test Result</strong></td>
<td>0.74</td>
</tr>
</tbody>
</table>

### TABLE 4.20 SURVEY QUESTION 8 RESPONSES—FIRST-YEAR GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Three Essential Skills to Engineers</th>
<th>Male (observed)</th>
<th>Female (observed)</th>
<th>Total</th>
<th>Male (expected)</th>
<th>Female (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good communication skills</td>
<td>18</td>
<td>6</td>
<td>24</td>
<td>15.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Ability to use resources to solve problems</td>
<td>24</td>
<td>13</td>
<td>37</td>
<td>24.3</td>
<td>12.7</td>
</tr>
<tr>
<td>Teamwork</td>
<td>18</td>
<td>6</td>
<td>24</td>
<td>15.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Ethical standards</td>
<td>8</td>
<td>11</td>
<td>19</td>
<td>12.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Life-long learning</td>
<td>18</td>
<td>9</td>
<td>27</td>
<td>17.7</td>
<td>9.3</td>
</tr>
<tr>
<td>Business perspectives</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>46</strong></td>
<td><strong>134</strong></td>
<td><strong>Chi-square Test Result</strong></td>
<td>0.26</td>
</tr>
</tbody>
</table>
Figure 4.3 “Essential skills” to engineers—Undergraduate students

Figure 4.4 “Essential skills” to engineers—First-year Graduate Students
5. Interview Results

5.1 Backgrounds

We assigned pseudonyms to the eight interview participants. Table 5.1 presents their assigned names, majors, academic standing, and status (domestic/international).

<table>
<thead>
<tr>
<th>Name</th>
<th>Major</th>
<th>Academic Standing</th>
<th>Domestic/International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daniel</td>
<td>Mechanical Engineering</td>
<td>First-year Graduate Student</td>
<td>International</td>
</tr>
<tr>
<td>Jason</td>
<td>Engineering Physics</td>
<td>Senior</td>
<td>International</td>
</tr>
<tr>
<td>Richard</td>
<td>Computer Science</td>
<td>First-year Graduate Student</td>
<td>Domestic</td>
</tr>
<tr>
<td>Brian</td>
<td>Industrial Engineering</td>
<td>Senior</td>
<td>Domestic</td>
</tr>
<tr>
<td>Patricia</td>
<td>Bioengineering</td>
<td>Senior</td>
<td>Domestic</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>Civil &amp; Environmental</td>
<td>Senior</td>
<td>Domestic</td>
</tr>
<tr>
<td>Jennifer</td>
<td>Physics</td>
<td>First-year Graduate Student</td>
<td>Domestic</td>
</tr>
<tr>
<td>Lisa</td>
<td>Computer Engineering</td>
<td>First-year Graduate Student</td>
<td>International</td>
</tr>
</tbody>
</table>

5.2 Biographies

With different majors and cultural backgrounds, the interviewees contributed diverse perspectives on how students decide their post-graduation plans. We present a biographical sketch of each interviewee.
Daniel (Mechanical Engineering; First-year Graduate Student; International)

After he earned a bachelor’s degree in his home country, Daniel began graduate study in mechanical engineering in the United States. Originally, he had thought that engineering was "really cool," but after he took some undergraduate engineering courses, he realized that engineering was more complicated and practical than he had imagined. As an undergraduate, Daniel had planned to pursue a career in industry, but he felt unprepared to enter the engineering workplace directly after graduation. Moreover, strongly influenced by peers who chose graduate school, Daniel followed the same path. Although he lacked an interest in research, he felt more comfortable and confident as a graduate student than he expected he would have felt as an employed engineer.

Jason (Engineering Physics; Senior; International)

Unlike most first-year undergraduate students, when Jason entered college, he already had a post-baccalaureate plan: he would return to his home country and work as a research assistant for the company that sponsored his undergraduate studies. Inspired by fundamental concepts in physics, Jason chose to major in engineering physics. He enjoyed learning about physical laws and concepts in the natural sciences. He also dreamed that he would make scientific discoveries. With a passion for research, he became actively involved in undergraduate research. While still an undergraduate, Jason was already planning not only his graduate studies, but also his postdoctoral fellowship and scientific career. In addition, he planned to invest in the stock market.

Richard (Computer Science; First-year Graduate Student; Domestic)

Since the 9th grade, Richard has worked intensively with computers. As an undergraduate, Richard majored in computer science, and he continued toward a PhD degree in the same subject. Richard believed that a PhD degree would bring him more career opportunities than a bachelor’s degree.
alone. Besides, Richard said he had a high tolerance for failures. He did not feel stressed when his advisor pushed him to work harder. If graduate school turned out to be boring or different from what Richard had expected, he would take the risk of leaving graduate study without a PhD, find a job, and be satisfied about it.

**Brian** (Industrial Engineering; Senior; Domestic)

Being passionate, confident, and independent, Brian looked forward to entering engineering workplace after graduation from undergraduate study. According to Brian, engineers should think creatively, and they should accept a challenging problem even if they do not know exactly how to approach that problem. Brian dreamed that he would become such a creative engineer in the industry.

To accomplish his goal, Brian took leadership roles in different student organizations. These experiences further sharpened his communication skills and time management skills, which could help him succeed in an industry job. Through several internship experiences, Brian learned what to expect in the workplace. Meanwhile, Brian felt proud that he would have a job that would allow him to pay off his debts and to live on his own without any financial support from his family.

**Patricia** (Bioengineering; Senior; Domestic)

Because Patricia hoped to enter an MD-PhD program, she spent considerable time and effort on preparing for the MCAT (Medical College Admissions Test). However, after she received a low score on the MCAT, she reconsidered whether a MD-PhD program was the right fit for her. As Patricia interacted with lab coworkers in a research lab and peers inside student organizations, she learned that MD-PhD students usually struggled with an extraordinary intense curriculum and a high stress level. Although Patricia enjoyed doing medical research, she doubted that she would be pleased with a life dominated by graduate work and medical school only. After careful consideration, Patricia stopped preparing for MCAT and extended undergraduate studies by one more year, preparing for a master’s degree application.
Through this process, Patricia realized that she understood her strengths and weaknesses better. She believed that her decision to pursue a master’s degree would be rewarding in the long term.

Elizabeth (Civil & Environmental Engineering; Senior; Domestic)

Since Elizabeth enjoyed her undergraduate studies, she continued studying in graduate school instead of entering the professional practice immediately. Meanwhile, a master’s program offered Elizabeth more time to prepare the professional licensing exam. Elizabeth was excited about projects and teamwork. Among her experiences, Elizabeth felt that her internships most helped her decide her post-graduation plans. Those internships not only helped her choose a career plan, but also let her recognize that what she really felt satisfied about. Besides, when Elizabeth considered graduate school, she also sought suggestions from her parents and friends, who supported her during the decision making process. Conversations with parents and friends helped Elizabeth understand the specific trade-offs among different post-graduation choices.

Jennifer (Physics; First-year Graduate Student; Domestic)

Starting from freshmen year, Jennifer majored in chemical engineering simply because she liked and was good at math and chemistry. Meanwhile, she pondered over what she could do after undergraduate study. When Jennifer struggled with her post-baccalaureate plans, she initiated a long talk with a professor for a physics course which she had truly enjoyed in every aspect. Inspired by the conversation, she joined in a student organization especially for physics students. By sophomore year, Jennifer switched her major into physics and set her goal to earn a graduate degree in physics. She regarded going to graduate school a natural progression from her undergraduate study based on all her undergraduate experiences, including an internship, a research assistantship and a teaching assistantship. Those experiences confirmed her decision to study physics in graduate school. As a result of her prior experiences, Jennifer continued to be passionate about her life in the graduate school.
Lisa (Computer Engineering; First-year Graduate Student; International)

As an undergraduate student, Lisa was excited about technology and solving challenging problems. She also believed that engineers should always learn about new trends in technology. Meanwhile, Lisa set her goal to stay in the United States instead of going back to her home country. She knew that two possible ways to accomplish her goal were either finding a job or entering graduate school. Failing to land a job in the United States, Lisa instead chose to enroll in a PhD program after her undergraduate study. Lisa believed that a PhD could not only help her stay in the United States, but also opened more career choices. She was also persuaded by her friends and company representatives that a PhD degree would bring a higher starting salary and more promotion opportunities.

5.3 Archetypes

The eight interviewed participants described similar factors that influenced their post-graduation plans, such as internship and research experiences. Although they shared some similarities, the eight interviewees expressed different personalities and decision styles. Obviously, various styles and attitudes played important roles in interviewees’ decision-making process. To fully represent different styles, we define eight archetypes. Each student might fit several archetypes (Table 5.2).
### Table 5.2 Eight Archetypes

<table>
<thead>
<tr>
<th>Avoider</th>
<th>Opportunist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attributes:</strong> Eschews intimidating situations that cause insecurity and reduce confidence</td>
<td><strong>Attributes:</strong> Seizes opportunities when they arise; seeks personal benefits</td>
</tr>
<tr>
<td>Drifter</td>
<td>Planner</td>
</tr>
<tr>
<td><strong>Attributes:</strong> Follows trends; easily influenced by other people</td>
<td><strong>Attributes:</strong> Organized; systematic; following goals step by step</td>
</tr>
<tr>
<td>Pragmatist</td>
<td>Idealist</td>
</tr>
<tr>
<td><strong>Attributes:</strong> Practical in actions and decisions</td>
<td><strong>Attributes:</strong> Enthusiastic; passionate; optimistic</td>
</tr>
<tr>
<td>Tort</td>
<td>Adventurer</td>
</tr>
<tr>
<td><strong>Attributes:</strong> Content with current conditions; resists change; avoids potential risks</td>
<td><strong>Attributes:</strong> Takes risks; embraces change; loves challenges</td>
</tr>
</tbody>
</table>

**Avoider**

The Avoider feels anxious and fearful in risky situations. Usually, the Avoider identifies these situations and understands their potential risks. Lacking confidence and courage, the Avoider intentionally avoids encountering these risky situations. As a consequence, when confronted with an uncomfortable situation, the Avoider often hesitates, and then chooses to escape that situation with rationalizations.

_I don't feel prepared for a real job yet ... I haven't had any winter driving experience at all .... being that far from parents (like Chicago) and being that far from everyone I know and having to drive myself all over the place to work, to the store, to the gym, everywhere all the time is really intimidating for me._ —Elizabeth
Sometimes, the Avoider does not have good reasons for avoiding certain situations.

*I don’t have particular reason for doing it, because maybe I don’t really feel like going directly going into industry just after my undergraduate year.* —Daniel

**Opportunist**

The Opportunist takes advantage of upcoming opportunities and chooses the one that can maximizes personal benefits. The Opportunist also analyzes the current situation and actively looks for opportunities that can improve the situation. Usually, the Opportunist sets an explicit goal to achieve. When opportunities occurring, the Opportunist will prudently evaluate them and select the one that can best fulfill the goal.

*Any company will sort of taking international students I have applied for, those include like trading, consulting, programming, so I definitely consider just getting jobs. That’s actually one thing I think I could have gone to work in the industry and come to grad school afterwards, but I didn’t get any jobs.* —Lisa

Sometimes, the Opportunist will seize an opportunity because of its long term benefits, even when the opportunity itself does not interest the Opportunist personally. Similarly, if an opportunity could guarantee better income or instant career promotion, the Opportunist would grasp that opportunity immediately. The Opportunist prioritizes income and career promotion over personal interests.

*To become, say a professor is a little stressful and maybe not completely something I should do but I might as well try in a sense. To get to that level where people would trust you with that kind of thing, especially at the undergraduate university level, you need to have a PhD ... What do I hope to gain*
from this and that is what I hope to gain ... if I manage to complete a PhD that opens an extra door of saying maybe I can be a professor, maybe I can be trusted to be a mentor for other students. —Richard

The biggest difference between the Avoider and the Opportunist is their motivation. The Avoider tries to avoid uncomfortable situations, whereas the Opportunist seeks opportunities that are most rewarding. For example, when the Avoider decides on post-baccalaureate plans, the Avoider might wish to avoid social interactions required in an industrial position. The Avoider would choose graduate school because it would require fewer social interactions, rather than because of an interest in research. By contrast, the Opportunist might apply for job openings and to graduate programs simultaneously. When offered admission to a graduate program but no suitable industrial job, the Opportunist would choose to enter graduate school.

Drifter

The Drifter is greatly influenced by the environment and adopts the values and goals of others. The Drifter also observes the surroundings and knows what most people are pursuing. Thus, other people strongly influence the Drifter’s decisions. Because the Drifter listens to different opinions, the Drifter tends to be indecisive. Rather than think independently, the Drifter imitates and follows the actions of most others. The Drifter enters professional practice or graduate school without clear reasons or goals.

Back in my undergraduate, most of the people go to grad school. It’s like the trend. In that time, I don’t have very distinct, clear plan for my future life. I just follow the trend. —Daniel

They all very strongly stressed that if you really want to pursue a PhD, you really have to have interests in that. I am not sure whether I have and thus I choose master. —Daniel
Just because people say it's harder to go back to school after you've been working. So that's why I wanted to go straight from undergrad to master. —Brian

Planner

The Planner is highly organized and composes explicit plans for achieving goals. The Planner loves to schedule and prepare everything ahead in order to meet deadlines. Besides, the Planner considers not only the overall goal, but also the details of each step. Compared with others, the Planner takes a long-term perspective on life, and invests time and effort planning for lifelong benefits.

I like to plan for long terms. I planned my post-graduation plan long time ago. Now I am planning for my post post-graduation's plan, what I am going to do after my post-doc. Do I want to start a family? What kind of house do I want to buy? What should I start investing now? I am turning 21 right now and I can start investing in commodities, stocks, shares and all these very adult-like stuffs. I start planning and thinking about it, start taking actions. —Jason

When the Planner sets a goal, the Planner understands that goal can solve certain problems and brings a more financially stable life. Usually, each action from the Planner has a purpose.

I felt like the real-world experience would be helpful in going back to school just to kinda get that different vibe. I think taking a little break from class and academics would be good for me personally ... get a job and pay those all of so I have a clean slate in terms of debt. Then once I have some experience, seek a master's degree in engineering or an MBA. —Brian

The Drifter and the Planner have different sources of influences. The Drifter is dominated by the trends and others’ opinions, whereas the Planner follows specific plans. The Planner takes others’ suggestions only for reference, whereas the Drifter blindly accepts those suggestions. For example, although the Planner consults people such as advisors and friends, the Planner will not change the
original plan due to what most people has chosen. However, unlike the Planner, the Drifter hesitates among different post-graduation plans. If most of the Drifter’s acquaintances choose industrial jobs over graduate school, the Drifter will do the same.

Pragmatist

The Pragmatist is unemotional and prioritizes the practical aspects and consequences of decisions. The Pragmatist chooses a career goal that is logically related to his or her academic program. Then the Pragmatist chooses an industry job or graduate school that is an essential step toward that goal. When making short-term career plans, the Pragmatist emphasizes financial compensation. The Pragmatist strives to achieve a goal while minimizing time and effort.

It would be relatively easy for me to get a job in Korea ... but I want to stay in the states. So one way I can do that is to get a job in the United States or go to grad school, don’t want to go back to Korea, so I go to grad school. —Lisa

Starting salary for a PhD will be around 7,000 or 8,000 per month that give you 80,000 to 90,000 a year. That’s why I do a PhD and it gives you a good income. If you lose a job, with a PhD, you can go anywhere that is willing to accept you. —Jason

Besides financial concerns like income, the Pragmatist also values career development in the long term. The Pragmatist understands that some jobs have the potential for regular career promotion and advancement into managerial positions. Targeting at a better career path, the Pragmatist actively pursues higher education, such as a PhD degree, even with little interest in and passion for the degree itself.

If you have a Master or doctor degree, when you applied for jobs, you can get a very different proposals, salary will be very different, the promotion, the job expectation will be very different, so I
think having a higher degree may help me that going into industry after my undergraduate year.

—Daniel

Idealist

The Idealist is driven by emotions and feelings, and pursues the ideal over the practical. The Idealist naturally follows feelings and ignores many practical concerns. Instead of evaluating both advantages and drawbacks, the Idealist concentrates only on the advantages.

Well, I always wanted to go [to graduate school]. I feel like the reason I really wanted to go was that graduate school really makes you an independent scientist. —Jennifer

I mean if there is no physics major in the world, I will be fine doing mechanical or electrical. Just I prefer doing physics. —Jason

When the Idealist becomes immersed in one activity with great interest, the Idealist tends to accentuate the positive and ignore the negative.

But then what you can do in computer science is you make up the rules. You have your own universe and you make your own creation. —Richard

The Pragmatist and the Idealist hold opposite attitudes. The Pragmatist makes decisions logically and practically, while the Idealist measures different situations depending only on feelings. When the Pragmatist plans to enter the industry after graduation, the Pragmatist first considers the job expectations, such as income and promotion opportunities. When the Pragmatist plans to enter graduate school, the Pragmatist concentrates on the affordability of graduate school, such as scholarships and assistantships. In contrast, when deciding between an industrial job and graduate school, the Idealist puts personal interests on the highest priority. If a job could bring feelings of
happiness and accomplishment, the Idealist would take that job even if the income is lower. Similarly, to Idealist, research areas are more important than whether a graduate degree could bring better career advancement. As a result, the Idealist’s decisions can be impetuous and lack practical consideration.

**Tortoise**

The Tortoise is content with the current situation and feels secure with low risk choices. The Tortoise is usually afraid of changing. For instance, the Tortoise feels uncomfortable adapting to a new environment or trying a new flavor of food. Since changes can bring unnecessary troubles and uncertainties, the Tortoise avoids the potential risks.

*I’m not really a big fan of change so I don’t really feel like embracing the giant change from being a student to being an adult yet so I’m totally cool with sticking around and being a student some more.* — Elizabeth

When the Tortoise decides between two options, the Tortoise picks the one with lower risk.

*But I did the grad school applications way more seriously because I did believe that trying to do this first would be worthwhile even if it was finished versus getting a job and saying I should have done a PhD. So in a sense this is just a safe choice.* — Richard

When the Tortoise has to adapt to a new environment and change the current lifestyle, the Tortoise always feels unprepared. The Tortoise is inclined to postpone fitting into the new environment until the Tortoise feels prepared both physically and mentally.

*For undergraduate year, what I learned is more basics, basic knowledge and not very common in everyday life. So I think what I learned in undergraduate year is not enough for me to enter the industry.* — Daniel
Adventurer

The Adventurer approaches difficulties with a positive attitude and is not afraid of failure. The Adventurer is always ready for challenges in the life and is passionate about difficult tasks. Besides, the Adventurer actively explores, analyzes, and solves challenges.

_I wanted something that I found more challenging or that would engage my brain a little bit more than just interacting with people all of the time._ —Elizabeth

With strong desire to change, the Adventurer pursues a life that can make positive impacts. Meanwhile, the Adventurer is confident in personal strengths and believes that hard work will eventually make dreams happen.

_Yeah, I’m still young so I’ve also thought about pursuing other hobbies and careers. I really wanted to be a talent agent at one point - like a manager … So if I was going to do it, it would be now while I’m young._ —Brian

_Part of [the reasons to involve in student organizations] is just being part of something bigger than myself and trying to give back and make an impact on other people and on situations that I want to change. Really just making change - not being here for just no reason but actually doing things and making differences._ —Brian

Most important, the Adventurer is not afraid to fail because the Adventurer believes that persistence and perseverance will eventually bring success. Even if the initial try fails, the Adventurer is still optimistic about other possible solutions.

_I’m not seriously minded nor say afraid to fail than some of the other students I see. So this is why I’m like - it’s okay to fail grad school - just go to it._ —Richard
The Tortoise and the Adventurer hold opposite attitudes toward risk. The Tortoise hates risking in things, while the Adventurer prepares for encountering challenges. When the Tortoise makes post-baccalaureate plans, the Tortoise evaluates different choices, such as graduate school and industrial jobs. The Tortoise finally chooses the one that requires fewest changes and involves least risk. Moreover, considering job offers, the Tortoise picks the one with a stable position and salary, like in a big company. On the contrary, the Adventurer strives to accomplish daring goals. As a result, the Adventurer might choose a position at a start-up company that involves interesting people and projects. Meanwhile, the Adventurer is willing to risk losing that job or receiving lower income. The Tortoise and the Adventurer take the different approaches to graduate school. The Tortoise would be inclined to a program with high ranking and sufficient resources for financial aid. However, the Adventurer would value a program with exciting research projects and faculty members, instead of ranking and financial strength of that program.
6. Discussion

6.1 Important Findings

6.1.1 Research Experiences

We usually assume research experiences allow students to figure out their future concentration areas and prepare them for doing more research in the future. Meyers et al. [7] also point out that research experiences can help students identify and confirm their interests. Our study indicates that research experiences are correlated with interest in graduate school, but the direction of influence is unclear. A research experience could motivate an undergraduate to consider graduate study, or conversely, an undergraduate interested in graduate study might choose to obtain a research experience.

Moreover, according to the survey and interview results, 7 out of 15 undergraduate students who had prior research experiences and planned to work after graduation suffered negative research experiences. Such negative research experiences directly cause students to stop considering graduate school. Specifically, a single negative research experience can lower undergraduate students’ passion for research. When research experiences disappoint students, they may lose their interest in research and graduate school.

In the surveys, some undergraduate students reported that their negative research experiences were due to different reasons. Those reasons include intensive work load, slow research progress, and boring research topics. Students seemed to expect research to be relaxed, productive, and interesting, but their real experiences contradicted their expectations.

To help undergraduate students have better research experiences, the roles of professors and students themselves are mutually important. When introducing research topics, professors should not
present only the most interesting part of those research topics to attract students to undergraduate research opportunities. Instead, it is important for professors to share some setbacks and obstacles in their research and how they overcame those difficulties. Understanding both exciting and difficult parts of doing research, students can develop accurate expectations. Once students join a research group, they should communicate regularly with graduate students and advisors. Effective communication with graduate students and advisors could encourage students who become discouraged when obstacles occur in their research. Thus, connecting with graduate students and advisors will help undergraduate students overcome those obstacles and regain their passion about research.

6.1.2 Industrial Internships

In the surveys, when undergraduate students recalled their industrial internships, 43 out of 44 undergraduate students who had prior industrial experiences described their experiences as positive. Specifically, 32 out of those 44 undergraduate students chose to directly enter engineering workplace due to their internship experiences. During those internships, some undergraduate students hesitated between work and graduate school. However, after communicating with colleagues and supervisors inside their companies, most undergraduate students were persuaded and decided to work instead of entering graduate school after graduation. Moreover, in the surveys, industrial internships helped students to figure out their career interests and further reinforced students’ thoughts about entering the engineering workplace. 1 out of 44 undergraduate students reported their internships as negative. Those students chose graduate school over industrial jobs.

6.1.3 Attachment

In the survey, around sixty percent of the first-year graduate respondents reported close attachment to their engineering departments when they were undergraduates. Most important, because of close attachment to the department, through interaction with faculty members, those first-
year graduate students chose to enter graduate school. Some of them even stayed in the same
department because they had bonded with faculty and staff in their department. For many first-year
graduate students, when they were undergraduate students, faculty and staff not only provided them
abundant resources and suggestions for graduate school but also encouraged them throughout the
decision processes on post-graduation plans.

On the other hand, 34 out of 62 undergraduate students survey respondents reported that they
felt attached to the department, but such attachment did not influence them to choose graduate school
rather than industrial jobs, or vice versa. Moreover, quite a few undergraduate students have little
connection to their departments and most of their post-graduation plans are barely influenced by the
disconnection.

6.1.4 Decision Styles

By studying the interview participants, we developed eight archetypes of decision styles:
Avoider, Opportunist, Drifter, Planner, Pragmatist, Idealist, Tortoise, and Adventurer. As discussed in
session 5.3, each archetype has unique attributes and attitudes for making decisions. The behaviors of
interview participants who fitted in one archetype are dominated by that single decision style. Moreover,
when the influence of one decision style becomes dominant, a student will be rarely influenced by
research and internship experiences. That student’s choices with that very decision style can be
predictable. For example, the decision style of one interviewee, Daniel, matches perfectly with the
Drifter. In Daniel’s undergraduate institution, most seniors entered graduate school immediately after
graduation. Moreover, Daniel’s parents believed that Daniel should stay in school as long as possible,
and so did Daniel’s peers. However, Daniel had little passion for research, even though he had one
experience in a research lab in the United States. In the interview, he mentioned that entering graduate
school would help him postpone an industrial job, since he felt unprepared for real-world jobs. Otherwise, he had no particular reason for graduate study. Daniel just drifted into graduate school.

Meanwhile, when the interview participants fit into two or more archetypes, the influence of decisions styles and research and internship experiences can be equally important. For instance, Brian, a senior in industrial engineering, fit both the Adventurer and the Planner styles. Brian loves challenging problems and prepares himself to solve those problems throughout the undergraduate study. The Adventurer’s style of decision reflects a type of personality, which is energetic, optimistic, and confident. That is exactly Brian. He joyfully explored his talents and took advantage of them as he proceeded to enter professional practice. Moreover, Brian aspired to become a future leader and make an impact in his workplace. Through internships, he realized that an industrial job could help him pay off his college debts and prepare him financially for further education in the future. Thus, Brian targeted his post-graduation plan in industry. To become a future leader in engineering, he took leadership roles in the student organizations to further sharpen his interpersonal skills. Brian’s decision process illustrates how two archetypes can co-exist in one person and guide him through choosing his post-graduation plans.

6.2 Limitations

6.2.1 Only One Institution

The University of Illinois, Urbana-Champaign (UIUC) is a large public research-orientated university, especially famous for its College of Engineering. Influenced by a rich culture of research, undergraduate engineering students in UIUC have abundant opportunities for doing research as early as their freshmen year. As a result, the percentage of UIUC engineering undergraduates who decide to enter graduate school is probably much higher than that of engineering undergraduates from other non-research-based institutions. Therefore, the results of my research on post-baccalaureate plans may not apply to other institutions, especially where an industrial culture is dominant.
Moreover, in UIUC, most of the undergraduate engineering students are registered as full-time students. Thus, engineering undergraduates are more likely to participate in student organizations, compared with institutions with a considerable number of part-time students. Since involvement in student organizations is a common practice, the factor of student organizations does not significantly influence the post-graduation plans of engineering undergraduates in UIUC. However, in the institutions where such involvement is rare, student organizations could be a significant factor of students’ post-graduation plans.

6.2.2 Survey

Originally, we expected the response rate of the undergraduate survey to be around 15%, and that the response rate of the graduate student survey would be around 10%. However, because of delays with approvals, both surveys were conducted around the time of final exams in the fall of 2011. Thus, students were more likely to skip the surveys. The actual response rates were 2.7% for the undergraduate survey and 6.5% for the graduate student survey. Although both of the survey respondents are consisted of different majors, genders, and nationalities similar to the sample population, it would still be better to have more survey respondents.
7. Conclusion

In this thesis, we gathered data using surveys and individual interviews. In the survey, we investigated six factors that may influence advanced engineering students’ post-baccalaureate plans: gender, research experiences, industrial internships, people (e.g., faculty and family members), attachment to the department, and student organizations. For three of the six factors, there were statistically significant differences in students’ decisions between industrial jobs and graduate school: research experiences, industrial internships, and attachment to the department. Students who had research experiences were more likely to choose graduate school. Students who had no research experiences were more inclined to choose industrial jobs. Meanwhile, even a single negative research experience can discourage students from considering graduate school.

Students who had industrial experiences were more likely to work in industry after their undergraduate study. Responses from open-ended survey questions further confirmed the positive influences of industrial internships. According to the survey responses, industrial experiences also broadened students’ views on the work of professional engineers. On the other hand, very few students commented negatively on their prior internship experiences. For attachment to the department, students who felt connected with their engineering departments, when they were undergraduates, were more likely to continue to graduate study. Several students who were closely attached to their departments as undergraduates stayed in the same department for graduate study.

In the interview results, we found that students’ post-graduation plans are influenced by their decision styles. From the interview data, we constructed eight decision style archetypes: Avoider, Opportunist, Drifter, Planner, Pragmatist, Idealist, Tortoise, and Adventurer. The eight archetypes can be grouped into four pairs. The first pair is the Avoider and the Opportunist. Students who fit with those two types have opposite motivations. The Avoider avoids uncomfortable situations, whereas the
Opportunist catches opportunities that can bring benefits, even those opportunities do not match with the personal interests of the Opportunist. The second pair is the Drifter and the Planner. Those two types of students follow different principles when they make decisions. The Drifter can be easily persuaded by others’ opinions instead of insisting on her own ideas. Thus, the Drifter follows the choices of most people. In contrast, the Planner considers things in advance and organizes into a specific plan. The Planner may revise the plan if it is necessary, but the Planner will not break the plan due to what most people advocate.

The third pair is the Pragmatist and the Idealist. The Pragmatist seeks a practical career path, which can bring the Pragmatist good salary and job promotion opportunities. Meanwhile, the Idealist is interest-orientated and seeks feelings of accomplishment. The Idealist enthusiastically pursues jobs that meet his interests, even when those jobs are low-paid. Lastly, the fourth pair is the Tortoise and the Adventurer. The Tortoise aims for low risk or risk-free goals, whereas the Adventurer prepares every second for challenges.

By realizing how students fit into one or more archetypes, mentors and advisors can effectively guide students through their decision processes on post-graduation plans. For instance, mentors need to encourage students who fit with the Tortoise archetype to think of alternative post-graduation plans when they stick with only one low-risk plan. On the other hand, for students who fit with the Adventurer archetype, mentors are responsible for properly cautioning the Adventurer about risks.
References


[8] E. Smith and S. Cookie, “‘I was told it was going to be hard work but I wasn’t told it was going to be this much work’: The experiences and aspirations of undergraduate science students,” *International Journal of Science and Mathematics Education*, vol. 9, no. 2, pp. 303-326, April 2011.


Appendix A Survey & Follow-up Interview Recruitment Email

For undergraduate students:

Subject: Please participate in an online survey for engineering seniors

Body:

Seniors in engineering,

You are invited to participate in an online survey to gather research data for the undergraduate thesis project of Anwen Jiang, a senior in the College of Engineering. The purpose of this project is to learn how advanced engineering students decide their post-baccalaureate plan, and how those plans relate to the student’s identity as an engineer. Only students like you can provide the information needed for this project.

You must be at least 18 years old to participate in the survey. We expect the survey to take about 15 to 20 minutes to complete. To take this survey, click on the following link: https://illinois.edu/sb/sec/8753589. This survey will be active until November 19, 2011.

After you take the survey, you may volunteer for an OPTIONAL individual interview. The interview session will be audio recorded and will last 45 to 60 minutes. If you are selected for an interview, you will receive a $10 gift card at the end of the interview session. To volunteer for an interview, if you are at least 18 years of age, please provide your name, your academic level (undergraduate or graduate student), and available time spots between November 19 and December 9 by e-mail to undergraduate student Anwen Jiang at ajiang3@illinois.edu by November 19. She will make an appointment with you regarding the interview time and place.

Your participation in this research will remain confidential. In publications, no personally identifying information will be disclosed. If you have any questions about the project, please contact me at loui@illinois.edu. If you are concerned about your rights as a research participant, please contact the University of Illinois Institutional Review Board at (217) 333-2670 or irb@illinois.edu.

Sincerely yours,

Michael C. Loui
Professor of Electrical and Computer Engineering
University Distinguished Teacher-Scholar
For first-year graduate students:

Subject: Please participate in an online survey for first-year engineering graduate students

Body:

First-year graduate students in engineering,

You are invited to participate in an online survey to gather research data for the undergraduate thesis project of Anwen Jiang, a senior in the College of Engineering. The purpose of this project is to learn how advanced engineering students decide their post-baccalaureate plan, and how those plans relate to the student’s identity as an engineer. Only students like you can provide the information needed for this project.

You must be at least 18 years old to participate in the survey. We expect the survey to take about 15 to 20 minutes to complete. To take this survey, click on the following link: https://illinois.edu/sb/sec/2172151. This survey will be active until December 16, 2011.

After you take the survey, you may volunteer for an OPTIONAL individual interview. The interview session will be audio recorded and will last 45 to 60 minutes. If you are selected for an interview, you will receive a $10 gift card at the end of the interview session. To volunteer for an interview, if you are at least 18 years of age, please provide your name, your academic level (undergraduate or graduate student), and available time spots between December 7 and December 16 by e-mail to undergraduate student Anwen Jiang at ajiang3@illinois.edu by December 16. She will make an appointment with you regarding the interview time and place.

Your participation in this research will remain confidential. In publications, no personally identifying information will be disclosed. If you have any questions about the project, please contact me at loui@illinois.edu. If you are concerned about your rights as a research participant, please contact the University of Illinois Institutional Review Board at (217) 333-2670 or irb@illinois.edu.

Sincerely yours,

Michael C. Loui

Professor of Electrical and Computer Engineering

University Distinguished Teacher-Scholar
Appendix B Survey Questions

For undergraduate students:

1. What were the three most important reasons for choosing a major in engineering when you were first admitted to an engineering program?
   a) Financial support for studying in engineering
   b) Curiosity about gadgets (such as electronic devices, robots)
   c) Salary as an engineer
   d) High school counselors' advice
   e) Ability in mathematics and science
   f) Suggestions from family members
   g) Foundation for careers in other professions (e.g. law, medicine)
   h) Other

2. What was your understanding, beliefs or images of "engineer", when you initially entered college as a freshman?

3. How did you acquire those concepts about "engineer" as a freshman?

4. Do you hold the same understanding of "engineer" now, compared with your freshmen year?
   a) Yes
   b) No

5. If your answer is "yes", what people or experiences have confirmed your understanding? Please list and explain at least two factors.

6. If your answer is "no", what people or experiences have changed your mind? Please list and explain at least two factors.

7. How do you define "engineer" now? Rank the following answers. (6-most important identity, 1-least important identity) The engineer...
   a) Brings social benefits to the community
   b) Develops new products and processes
   c) Improves processes or products
   d) Makes or saves money for employers
   e) Solves problems
   f) Works within constraints

8. What kinds of skills are essential to engineers? Choose the 3 most important ones.
   a) Good communication skills
   b) Ability to use resources to solve problems
   c) Teamwork
   d) Ethical standards
   e) Life-long learning
   f) Business perspectives
9. Depending on your answer in the previous question, how well do you think you fit with the attributes of engineering? (5-Very Well, 1-Not Well at All)

5-Very Well
4-Somewhat Well
3-Neutral
2-Somewhat not Well
1-Not Well at All

10. Which of the following opinions do you agree with more? Please elaborate the reasons for your choice.

a) Engineers should have strong theoretical background.

b) Engineers should possess practical lab skills and interpersonal skills.

11. How relevant are social skills to engineers' work? (5-Very Relevant 1-Irrelevant)

5-Very Relevant
4-Somewhat Relevant
3-Neutral
2-Somewhat not Relevant
1-Irrelevant

12. What are your post-graduation plans?

a) Look for a job in engineering
b) Apply for graduate school in engineering
c) Not decided
d) Other

13. Have you had any internship or co-op experiences? How do those influence your post-graduation plans?

14. Have you had any research experiences? How do those experiences contribute to your post-graduation plans?

15. Who (individuals can be parents, mentors, faculty, friends, etc.) have influenced your post-graduation plans? In what ways?

16. Have you been involved in any on-campus student organizations or off-campus community organizations, in the past 4 years?

a) Yes
b) No
17. How actively have you participated in those organizations?
   1. Very Active---served in leadership positions
   2. Active---frequently attended/helped out with events
   3. Neutral---occasionally attended/helped out with events
   4. Not that active----rarely attended/helped out with events
   5. Not active at all----never attended/helped out with events

18. How do these experiences, in student or community organizations, affect your post-graduation plans?

19. Have you joined any kind of study group in the past 4 years?
   a) Yes
   b) No

20. If your answer is “yes” in the previous question, how well does the study group help you feel connected to the engineering community?
   a) Very helpful
   b) Somewhat helpful
   c) Neutral
   d) Somewhat not helpful
   e) Not helpful

21. How closely do you feel you are connected to your engineering department? How does that affect your post-graduation plans?

22. Major

23. Your academic standing
   a) Junior
   b) Senior
   c) First-year graduate student

24. Gender
   a) Female
   b) Male

25. Are you an international student or domestic student?
   a) Domestic student
   b) International student
**Follow-up Interview**

After the survey, we will be interviewing individuals to examine in-depth how upper-class undergraduate students decide their graduation plans, and why first-year graduate students chose graduate study. The interview will last 45 to 60 minutes. Each interviewed student will receive a $10 gift card for participating in an interview. If you are willing to participate in an interview, please email undergraduate researcher, Anwen Jiang, at ajiang3@illinois.edu. Thank you!

**For first-year graduate students:**

1. What were the **three most important** reasons for choosing a major in engineering when you were first admitted to an engineering program?
   a) Financial support for studying in engineering
   b) Curiosity about gadgets (such as electronic devices, robots)
   c) Salary as an engineer
   d) High school counselors' advice
   e) Ability in mathematics and science
   f) Suggestions from family members
   g) Foundation for careers in other professions (e.g. law, medicine)
   h) Other

2. What was your understanding, beliefs or images of "engineer", when you initially entered college as a freshman?

3. How did you acquire those concepts about "engineer" as a freshman?

4. Do you hold the same understanding of "engineer" now, compared with your freshmen year?
   a) Yes
   b) No

5. If your answer is "yes", what **people or experiences** have confirmed your understanding? Please list and explain at least two factors.

6. If your answer is "no", what **people or experiences** have changed your mind? Please list and explain at least two factors.

7. How do you define "engineer" now? Rank the following answers. (6-most important identity, 1-least important identity)  The engineer...
   a) Brings social benefits to the community
   b) Develops new products and processes
c) Improves processes or products
d) Makes or saves money for employers
e) Solves problems
f) Works within constraints

8. What kinds of skills are essential to engineers? Choose the 3 most important ones.

a) Good communication skills
b) Ability to use resources to solve problems
c) Teamwork
d) Ethical standards
e) Life-long learning
f) Business perspectives

9. Depending on your answer in the previous question, how well do you think you fit with the attributes of engineering? (5-Very Well, 1-Not Well at All)

5-Very Well
4-Somewhat Well
3-Neutral
2-Somewhat not Well
1-Not Well at All

10. Which of the following opinions do you agree with more? Please elaborate the reasons for your choice.

a) Engineers should have strong theoretical background.
b) Engineers should possess practical lab skills and interpersonal skills.

11. How relevant are social skills to engineers' work? (5-Very Relevant 1-Irrelevant)

5-Very Relevant
4-Somewhat Relevant
3-Neutral
2-Somewhat not Relevant
1-Irrelevant
12. Have you had any internship or co-op experiences? How did those influence your decision to pursue graduate study?

13. Did you conduct any independent research during your undergraduate study? How did undergraduate research experiences contribute to your decision to pursue graduate school?

14. Who (individuals can be parents, mentors, faculty, friends, etc.) have influenced your decision to pursue graduate school instead of working in the industry? In what ways?

15. Were you involved in any on-campus student organizations or off-campus community organizations, during your undergraduate study?

16. How actively did you participate in those organizations?

17. How did these experiences, in student or community organizations, affect your decision to pursue graduate school?
   1. Very Active—served in leadership positions
   2. Active—frequently attended/helped out with events
   3. Neutral—occasionally attended/helped out with events
   4. Not that active—rarely attended/helped out with events
   5. Not active at all—never attended/helped out with events

18. Did you join any kind of study group during your undergraduate study?
   a) Yes
   b) No

19. If your answer is "yes" in the previous question, how well did the "study group" help you feel connected to the engineering community?

20. How closely did you feel you connected to your engineering department, during your undergraduate study? How did that affect your decision to pursue graduate study?

21. Were you employed (not including internship or co-op) before you entered graduate school?
   a) Yes, I have
   b) No, I was admitted to graduate school directly after I finished undergraduate study.

22. Are you pursuing a master’s degree or a PhD degree?
   a) Master’s Degree
   b) PhD Degree
If you are pursuing a master degree, are you doing a thesis for your master?

23. If you are pursuing a master’s degree, does your degree program require a thesis?
   a) Yes, my master’s degree program requires a thesis
   b) No, my master’s program does not require a thesis

Demographic information:

24. Department/Program

25. Your academic standing
   a) Junior
   b) Senior
   c) First-year graduate student

26. Gender
   a) Female
   b) Male

27. Are you an international student or domestic student?
   a) Domestic student
   b) International student

Follow-up Interview

After the survey, we will be interviewing individuals to examine in-depth how upper-class undergraduate students decide their graduation plans, and why first-year graduate students chose graduate study. The interview will last 45 to 60 minutes. Each interviewed students will receive a $10 gift card for participating in an interview. If you are willing to participate in an interview, please email undergraduate researcher, Anwen Jiang, at ajiang3@illinois.edu. Thank you!
Appendix C Individual Follow-up Interview Consent Form

How Advanced Engineering Students Decide Their Post-Baccalaureate Plans

Michael Loui and Anwen Jiang
University of Illinois at Urbana-Champaign
October 14th, 2011

Purpose and Procedures

This research study is being conducted by Professor Michael Loui and undergraduate student Anwen Jiang. The purpose of this research is to research learn how advanced engineering students decide post-baccalaureate and how those plans relate to the student’s identity as an engineer.

You are invited to participate in an interview for about 45 to 60 minutes. The interview will be audio recorded and transcribed.

Voluntariness

Participation in this research is voluntary. You are volunteering to allow an audio recording and transcription of your interview to be used for research purposes. You may refuse to participate or may discontinue participation at any time. During the interview, you may skip questions that you prefer not to answer. Participation will not affect your grade in a course, status as a student, or future relationship with the University.

Compensation

In return for participation, you will receive a $10 gift card at the end of the interview session.

Benefits and Risks

Risks are expected to be minimal, no more than in everyday life. The College of Engineering will benefit from accurate information about what influences students’ decisions to pursue graduate study. Participants may benefit from reflecting on their experiences.

Confidentiality

The data to be used in this research are limited to the interview text with associated demographic information. When the interview is transcribed, your name will be replaced by an identifying code. All collected data will be kept confidential and will be discarded one year later the final journal publication of this research. Copies of audio transcripts will be kept in Professor Loui’s locked office for a minimum
of three years. Audio recordings will not be disseminated, but instead will be erased after transcription. No names will be revealed in any publications.

**Whom to Contact with Questions**

Questions about this research should be directed to Professor Michael Loui (phone 217-333-2595, e-mail loui@illinois.edu). Questions about your rights as a research participant should be directed to the campus University of Illinois Institutional Review Board (phone 217-333-2670, e-mail irb@illinois.edu); you may call collect.

I certify that I have read this form, I have received a copy of this form, I am 18 years of age or older, and I volunteer to participate in this research study.

Please print official name:

Signature: Date:
Appendix D Individual Interview Questions

For undergraduate interviewees:

1. (a) What is your major?
   (b) What are you going to do after you graduate from U of I?

2. Why do you choose a major in engineering in your undergraduate study?

3. (a) What was your first impression about the profession of engineering in your freshmen year?
   (b) How do you think about the profession of engineering now? What has changed your mind?

4. (a) What do you think is the role of engineers in society?
   (b) What would you think your role when you enter engineering practice?

5. What kind of skills do you think an engineer should have?

6. Should engineers have a strong theoretical background?
   Should engineers have practical lab skills and interpersonal skills?
   Which opinion do you agree with more Why?

7. In your opinion, how relevant are social skills to the work of engineers?

8. How would you define the following terms in the context of engineering practice?
   (a) Teamwork   (b) Analytical Thinking   (c) Problem Solving   (d) Communication

You mentioned your graduation plan is......

9. (a) How strongly do you view your intended graduation plan as your own calling?
   (b) Could you imagine yourself doing something else at this stage of life?

10. (a) Have you ever thought of other post-graduation plans seriously?
    (b) When you were unsure about your post-graduation plans, what did you do?

11. Who has influenced you, in the past four years, regarding your post-graduation plan? (Optional: individuals can be parents, relatives, mentors, faculty, friends, etc.)

12. Think about some of your academic or technical project experiences. How have those experiences influenced your post-graduation plan?
13. (a) Have you participated in any student or community organizations?
   (b) What motivates you to be involved in those organizations?
   (c) How do those experiences influence your post-graduation plan? (Affinity identity)

14. What is something special about your personality that contributes to your post-graduation plan?

15. Do you have reasons for deciding your post-graduate plan other than technical interests, prior academic or internship experiences?

16. What role has your family played in your post-graduation plan?

17. How has your own social network affected your post-graduation plan?

For first-year graduate interviewees:

1. What is your major?

2. Why do you choose a major in engineering in your undergraduate study?

3. (a) What was your first impression about the profession of engineering in your freshmen year?
   (b) How do you think about the profession of engineering now? What has changed your mind?

4. (a) What do you think is the role of engineers in society?
   (b) What would you think your role be when you enter engineering practice?

5. What kind of skills do you think an engineer should have?

6. Should engineers have a strong theoretical background?
   Should engineers have practical lab skills and interpersonal skills?
   Which opinion do you agree with more? Why?

7. In your opinion, how relevant are social skills to the work of engineers?

8. How would you define the following terms in the context of engineering practice?
   (a) Teamwork  (b) Analytical Thinking  (c) Problem Solving skill  (d) Communication

As a first-year graduate student:

9. (a) How strongly do you view pursuing graduate study as your own calling?
   (b) Could you imagine yourself doing something else at this stage of life?
10. (a) Have you ever thought of other post-graduation plans seriously, in your undergraduate study?

(b) When you were unsure about your post-graduation plans, at that time, what did you do during your undergraduate study?

11. Who has influenced you, during your undergraduate study, to pursue graduate study? (Optional: individuals can be parents, relatives, mentors, faculty, friends, etc.)

12. Think about some of your academic or technical project experiences. How have those experiences influenced your decision to pursue graduate study?

13. (a) Have you participated in any student or community organizations?

(b) What motivated you to be involved in those organizations, in your undergraduate study?

(c) How did those experiences influence your decision to pursue graduate study?

14. What is something special about your personality that contributes to your decision to pursue graduate study?

15. Did you have reasons for pursuing graduate study other than technical interests or prior academic experiences?

16. What role has your family played in your decision to pursue graduate study?

17. How has your own social network affected your decision to pursue graduate study?
Appendix E Supplementary Bibliography


