How Students’ Informal Experiences Shape their Views of Engineering and Affect their Plans for Professional Persistence

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Abstract
It is believed that increased student engagement leads to higher persistence. The current study was originally focused on one measure of student engagement – student involvement in organizations within engineering, on campus, and in the community; however, it evolved into a study of the effect of a broader range of informal experiences on student perceptions of engineering and their plans for professional persistence. A mixed method, cross-sectional study of engineering students was conducted during the 2011-2012 school year. The study involved an on-line survey completed by 240 engineering students regarding their extracurricular involvements within engineering and across the university as a whole. Follow-up interviews informed the results of the large scale survey to further probe the factors that encouraged persistence in engineering and post-graduation plans. Women and men, and white and non-white respondents, reported similar experiences in terms of when/if they considered leaving engineering and the sources of encouragement and discouragement for persisting in engineering. Students who indicated an intrinsic interest in engineering were less likely to indicate that they had ever considered leaving engineering. The experiences of male, female, white and non-white engineering students are collectively more similar than different. But the individual experiences and extracurricular involvements contribute to an engineering student’s development and are shaped by the culture of the academic institution.

Overall, the percentage difference of male, female, white, and non-white students who considered leaving engineering was not statistically significant. The peak time frame for consideration was second semester of the first year and first semester of sophomore year. This indicates that all engineering students grapple with uncertainties related to pursuing engineering at similar points in their educational paths. A student’s self-reported “interest in engineering” was statistically significant to consideration of leaving engineering (for both male and female students). Male students reported a lower rate of involvement than female students in all types of engineering organizations. White students reported lower levels of involvement than non-white students in engineering and off-campus community organizations, but higher levels of involvement in campus organizations. The same factors predictive of engineering involvements; grade level, female and plans to work in engineering related field post-graduation were also predictive of engineering leadership. Students planning to work in an engineering related field after graduation were less likely to be involved with community organizations (conversely, those who considered leaving engineering were more likely to be involved in the community).

Introduction
This mixed-method study considers undergraduate student experiences in an engineering program to better understand the relationship between student involvement in extracurricular activities (within engineering, on campus, and off campus in the broader community) and their engagement in and identification with that program as evidenced by their engineering educational persistence assuredness and engineering professional persistence plans. Student responses were considered as an aggregate and also by gender and race / ethnicity (white vs. non-white) to help understand the relative similarity and difference felt by students in their undergraduate engineering experience. Many prior studies that have considered these issues in
different ways and in different contexts served as critical foundations to the current study and are described in the following paragraphs in terms of their relationship to the current study.

Over two decades ago, Astin published the seminal work, *Involvement: The Cornerstone of Excellence*, which indicated the critical link between student involvement, engagement and success in undergraduate studies. Astin defined involvement in terms of physical and psychological energy devoted to a specific context, and went on to outline a series of factors to increase student involvement, including increasing the amount of energy devoted to academic study, time spent on campus, participation in student organizations, interaction with faculty, and interaction with fellow students. These factors are not unrelated. Thus, it stands to reason that, the more time spent on campus, the more interaction a student would have with faculty and peers, and the more opportunity a student would have to participate in student organizations and study. Alternatively, the more involved a student is with organizations, the more interaction that student would have with students and faculty, and the greater their social capital (social connections, which can be used for greater leverage within a specific context for personal benefit). The current study thus considers relationship of student involvement, and specifically who gets involved in what particular extracurricular activities, in the specific context of engineering education.

Because of the workload expectations for engineering majors, engineering students may perceive themselves as having less time for extracurricular involvements and, consequently, less opportunity for personal and social advancement. Prior studies partially support this perception. For example, in a large-scale, multi-institutional study of persistence and engagement in engineering, Ohland and associates reported that engineering students persist in engineering at levels similar to other majors at an individual educational institution, but also found that persistence rates and levels of engagement varied significantly from institution to institution. They also reported that engineering students have the same level of engagement as students in other majors and, despite heavier course loads, reported levels of satisfaction with the college experience and involvement with campus organizations and volunteer work at levels similar to students in other majors. One notable difference reported by engineering students in this study; however, was that those students rated themselves lowest in terms of personal and social development, as well as in regard to reflective and integrative learning, when compared to their peers in other majors. The authors of that study speculated that this perceived lower level of personal and social development may exist because engineering students believe that the narrow focus of engineering education on technical content has limited their opportunities for broader personal development. Other studies have provided evidence to support this contention. Smith and associates agreed that all engineering students throughout their undergraduate education require professional skill development in terms of talking through and listening to ideas with peers, knowing how to build trust in a working relationship, and leadership of group efforts. Felder and Brent studied differences in terms of learning style, approaches to learning, and intellectual development throughout the entire college experience beyond academics, and recognized these as growth factors that develop students personally and professionally through the entire college experience. Thus, when students do not have these experiences in the classroom, they may seek them through other avenues, but may still feel shortchanged in this development in the context of classroom experiences.
Felder and Brent also reported that, although women entered engineering programs with academic credentials stronger than or equal to their male counterparts, they experienced a drop in confidence and academic performance throughout their undergraduate studies. The authors went on to suggest that strengthening organizations to provide guidance and support would ultimately result in increased persistence and improved performance of women in engineering programs. Other studies support this contention, including the final report from the Women’s Experiences in College Engineering (WECE) study, which engaged in a multi-institutional, longitudinal examination of undergraduate women’s experiences and persistence in engineering programs. That study advocated for female student participation in social enrichment activities as critical to a more positive perception of a department and the classroom environment, which relates to higher persistence in engineering. Specifically, the WECE report stated that “participation in support activities is vital to many women undergraduates, who need to feel they are part of a larger community in engineering. Community allows students to build networks and to feel that their presence in engineering is important to others. Networking can counteract the isolation that women experience — providing them with information, support, and the knowledge that they’re not alone in the challenges they face.” The WECE study served as a critical underpinning for the current study, which focused on participation in activities and persistence in engineering.

Drawing on the conclusions presented by Ohland et al. of comparable male and female persistence at an individual institution, the current study considers all engineering students during their sophomore, junior, and senior years (when they are institutionally recognized as engineering students) to explore their level of involvement in extracurricular activities within engineering, on campus, and in the off-campus community. Matusovich and associates conducted a qualitative case study involving 11 students / cases (with multiple interviews each) that looked at their choices for continuing in engineering. They found that women were more likely to experience a lack of connection between their engineering-related values and their sense of self. These results supported the conclusions in Seymour and Hewitt’s study that pointed out that several high academic performers were still at risk for leaving engineering because of a lack of connection between engineering and a personal sense of self. All of these values relate to identity and the ability to identify with engineering and, thus, have implications for persistence. The authors suggested that “we can encourage a student to stay in engineering by helping them associate a perceived engineering identity with their personal identity and demonstrating the value of this association.”

Marra and associates conducted a longitudinal study exploring former engineering students’ reasons for leaving engineering. Students cited both academic and personal reasons for leaving, but a lack of identity / sense of belonging was more significant than academic issues. While they did not report any differences between male and female students, they did find a difference between majority and non-majority students, specifically that non-caucasian students indicated that curriculum difficulty / high school preparation were greater factors for transferring out of engineering. Non-caucasian students also indicated a lack of belonging in engineering at higher rates. Tonso has also studied engineering identity ethnographically, examining how students come to understand their place in a group and the interactions that support or detract from that sense of belonging and concluding that gender and “social status” were a part of a complex dynamic that influenced student experiences.
The belief that minority students may have a different undergraduate experience has also been indicated in the literature. May and Chubin speculated that minority students would be less likely to be involved in organizations with predominantly non-minority membership\(^{14}\). Trenor and associates also reported that minority students were much less likely to know an engineer, which relates to a student’s perception of the field of engineering. However, despite this difference, minority students did not differ from non-minority students in terms of perceived social supports, barriers to education, sense of belonging, or experiences in the engineering college\(^{15}\). A quantitative study of over 200 engineering programs by Harper and associates reported a significant interaction term between race and student experiences, which they contended indicates a significant relationship between race and student out-of-class experiences. Their analysis indicated that institutional climate had a greater influence on African American, Hispanic, and Asian students than did engineering program climate, suggesting that efforts to create inclusive engineering communities can be helpful, but then ultimately concluding that the institution itself must be inclusive as well. The positive influence on minority student of out-of-class experiences, such as internships and participation in design competitions, further indicates that such opportunities are key learning experiences that should be supported and encouraged by engineering program faculty\(^{16}\).

Student experiences such as internships have been indicated by others as critical to professional persistence\(^{17-18}\). Lichtenstein reported that, during a student’s undergraduate experience, career options could be disproportionately swayed positively or negatively by a single experience\(^{17}\). Meyers and associates supported this research with a mixed-method study of engineering identity that found that experiences such as internships and undergraduate research were not statistically significant predictors of engineering self-identification. Student interviews indicated that those experiences were formative, but not necessarily affirmative. Students reflected on the influence of single experiences (such as research, internships, and engineering organizational involvements) on their sense of belonging, educational persistence, or professional persistence plans\(^{18}\).

Building on prior literature, this study sought to answer the following research questions:

1. Do male, female, white, and non-white students have similar experiences in terms of:
   a. Consideration of leaving engineering at the same points and with the same frequency?
   b. Consideration of the same factors to be encouraging / discouraging for continuation in engineering?
   c. Involvement in engineering organizations, campus activities, and the community?
2. How do these factors and experiences affect students’ plans for professional persistence?

These research questions relate to the specific areas of focus in the survey and are discussed in this study. Obviously, many other experiences comprise the undergraduate experience; however, limiting the scope of the study allows for meaningful interpretation of the results and makes the findings more robust.

**Profile of the Studied Institution**

At the institution studied, nearly all students complete their undergraduate studies in four years and are of traditional college age (18-22 years old). The institution is considered selective and is religiously affiliated. All first-year students are admitted to a separate First Year of Studies program, and select their majors (engineering or otherwise) near the end of the first year, when they register for classes for the sophomore year. In addition to engineering, students at the
institution may elect to enroll in programs in science, arts and letters, business or architecture. The overall student body is 53% male and 47% female, while the engineering program is approximately 72% male and 28% female.

The engineering program uses no admission criteria other than student interest for entry into any of the majors. First-year students who intend to enroll or are considering enrolling in engineering as sophomores, with few exceptions, complete a standard first-year curriculum, including the two-semester “Introduction to Engineering” course sequence, before declaring the fields of engineering that they plan to pursue. Engineering disciplines at the institution studied include: aerospace, chemical, civil, computer, electrical and mechanical, along with computer science and environmental geosciences. The students begin to take courses specific to their chosen disciplines at the start of sophomore year. Historically, 85% of students who leave engineering do so before the end of the first year, and the majority of the rest who leave do so during the first semester of sophomore year. Thus, because this study involved sophomores, juniors and seniors, it does not evaluate the extracurricular engagement of those who left, only that of those who stayed.

Methods
The primary methods for data collection were: (1) a survey assessment tool, (2) individual interviews, and (3) institutional records. Survey administration offers advantages of larger sample sizes and statistical analysis to potentially identify trends within the data, but presents a drawback in the lack of depth afforded by standardized questions. Interviews, on the other hand, provide rich data sets that give insight into the views, meanings, and experiences of engineering students beyond what a survey alone can capture. These methods, both quantitative and qualitative, were used in conjunction with one another to support and strengthen the findings of each result set through triangulation. Participation in both the survey and interview was voluntary, and was limited to students who have persisted in engineering. The defining criteria for the selection of interview participants were based on two key survey responses, both of which were statistically significant factors in the quantitative analysis: (1) whether they had indicated that intrinsic interest in engineering subject matter was a source of encouragement; and (2) whether they had reported being involved in the community. The selection strategy for interview participants is explained in further detail in the qualitative section of this manuscript. Institutional records were used for survey administration and verification of survey responses in selecting interview participants.

Quantitative
The survey was administered during the fall of 2011 to all engineering students (sophomores, juniors, and seniors), to a list generated through institutional records. It was sent out via the web using SurveyMonkey®. No reminders were sent out; responses came from only the initial invitation. Only the students who completed the entire survey were included in the study. Incomplete survey responses were dropped from the analysis because it was believed that this was due to survey fatigue rather than due to data missing on a random basis. Some of the survey questions were open response (such as what organizations students were involved with on campus or in the community). Those responses were simply coded yes/1 /involved or no/0 /not involved, with no further coding breakdown.
The quantitative analysis to the fixed-response survey questions was completed using the statistical software package STATA®. Responses were coded such that a more positive response was a higher value, and a less positive response was a lower number. The primary analysis methods are parametric evaluations including correlation, t-tests (two-group unpaired), Pearson’s chi-square, and regression modeling. T-tests, correlation, regression modeling methods do have a normality assumption, but this is reasonable given the large sample size. The approach for analysis was progressive, beginning with correlations to explore possible relationships between variables (a measure of association), followed by t-tests and chi-square tests to determine which relationships are statistically significant. These tests provided foundational descriptive statistics to address the research questions. Chi-square tests of independence in particular were used to determine when a group’s response was different than what would be expected by chance; for example male, female, white, non-white, engineering discipline, and grade-point average (GPA) could be considered relative to certain reported behaviors, feelings or experiences in terms of continuation in engineering or in terms of what factors were encouraging or discouraging. These results, in combination with the factors indicated in prior literature, were used to select the independent variables to include in the regression models. Regression models were both traditional (the response variable having more than 2 outcomes) and logistic (with the response variable having a binary outcome). Discussion of the analysis methods is further explained within the context of the results.

The survey questions are listed in the Appendix. Several of the survey questions were based on the WECE study, or adapted as appropriate for the research institution. Additional questions were posed to allow grouping of respondents by gender, race/ethnicity, discipline, grade level and grade-point average. Note that the engineering program at the survey institution is predominantly white (84%), with small representations from specific races/ethnicities (no single racial or ethnic group larger than 10% of the survey population). For the purposes of analyses, all racial/ethnic minorities were combined in a “non-white” group to compare with the majority group of “white” students.

Qualitative
The qualitative interviews in conjunction with survey responses served as a collection of case studies. Case study is the theoretical framework for this research study and is also the technique utilized for analysis. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. There were 13 individual cases analyzed both within and across cases. This approach was selected because there are clearly identifiable cases that are “bounded” within the context of undergraduate engineering students during the 2011-2012 school year; however, the contextual location of the university cannot be separated from the student experience. Case studies are typically based on multiple sources of data, which in the current study included individual interviews, surveys, and background information (specifically admissions data that indicated a student’s initial indication as being either an engineering or non-engineering intent). Having a large number of cases, as in the current study, there is concern that the overall analysis can be “diluted” because each case is explored to less depth; however, given that the current study is quite focused on questions relating to engineering student extracurricular involvements and their experiences that was not a concern. The interview protocol for all participants is included in the Appendix, but because the interviews were semi-structured, follow-up questions were unique to each participant.
Engineering students were selected as interview participants by a method of similarity and difference in sampling groupings according to gender, race/ethnicity, and extracurricular involvements to yield a cross-section of the engineering class. The selection pool of potential interview participants was limited to those who responded affirmatively to the final survey question, “Are you interested / willing to participate in a follow-up interview?” for which there were 125 affirmative responses overall (41 sophomores, 39 juniors, and 45 seniors). Potential interview participants were limited to the 39 juniors, primarily because it was believed that juniors had enough experience/opportunity in the engineering program and at the university to get involved in extracurricular activities (including professional societies for their discipline of engineering) and because their future plans beyond graduation were within view but not already determined by a prior commitment (acceptance to a company or graduate school). Two subgroups were established on the basis of their survey responses as to whether interest in engineering subject matter was a factor they found encouraging to continue their engineering studies. Those subgroups were further broken down into groups of students who indicated their involvement in the off-campus community and those who did not, as that was a statistically significant factor in student engagement with the engineering program based on the initial analysis. And across the sub-groups, a spectrum of engineering disciplines, race/ethnicity and gender that was approximately representative of the College of Engineering was achieved by cross-checking survey responses with data from institutional records (name, major, GPA, gender, and minority status). This sampling strategy is depicted graphically in Figure 1.

Each participant was individually interviewed, the interview was transcribed by a professional, and a formal coding and analysis process was conducted. Three independent engineering education researchers evaluated each interview. For each example provided by the interview participant, the response was initially coded and summarized into a tabular format as part of the within-case analysis. The researchers worked separately to evaluate the interview responses, but came together to discuss the codes assigned and come to consensus for analytic triangulation. The multiple discussions and revisions took place throughout the analysis process as part of the consensus building meetings. Once all the responses were organized for within-case analysis, the cross-case analysis began. The cross-case analysis involved a form of thematic analysis across-cases, both in terms of similarity and difference. Specifically a few key

Figure 1. Interview Selection Strategy
factors were compared: gender, engineering discipline, race/ethnicity, indication of interest in engineering subject matter as an encouraging factor, and off-campus community involvement.

A Summary of Potential vs. Actual Respondents

This section compares the potential respondents to the actual respondents by grade level, gender, engineering discipline, ethnicity, and GPA. Of the 972 students who were asked to take the survey, 364 students started the survey, and 240 completed the survey, for an overall response rate of 24.7%.

Table 1a shows the number of potential and actual respondents broken down by grade level (sophomore, junior, or senior) and gender, and Table 1b shows the parallel break down by race/ethnicity. Women as a group comprised 35.4% of respondents, with uneven response rates in different class years. Men as a group comprised 64.6% of respondents, with similar response rates by grade level. Gender has been indicated as the most significant predictive factor in survey completion. The lower response of junior women likely resulted from the fact that a disproportionately large segment of that group studies abroad during fall semester of junior year. This lower response rate likely does not indicate any particular difference in this group of women from the other classes. Multiple institutional and engineering program surveys over the years have shown very little difference in various subjects surveyed from year to year, so it is reasonable to conclude that these women were generally like the other women in the survey, despite the lower response rate.

Table 1a. Potential and Actual Survey Respondents by Gender

<table>
<thead>
<tr>
<th>Grade</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soph</td>
<td>92 (38.3%)</td>
<td>329</td>
<td>28.0%</td>
<td>48</td>
<td>220</td>
<td>21.8%</td>
<td>44</td>
<td>109</td>
<td>40.4%</td>
</tr>
<tr>
<td>Juniors</td>
<td>68 (28.3%)</td>
<td>331</td>
<td>20.5%</td>
<td>53</td>
<td>249</td>
<td>21.3%</td>
<td>15</td>
<td>82</td>
<td>18.3%</td>
</tr>
<tr>
<td>Seniors</td>
<td>80 (33.4%)</td>
<td>312</td>
<td>25.6%</td>
<td>54</td>
<td>229</td>
<td>23.6%</td>
<td>26</td>
<td>83</td>
<td>31.3%</td>
</tr>
</tbody>
</table>

Table 1b. Potential and Actual Survey Respondents by Race/Ethnicity

<table>
<thead>
<tr>
<th>Grade</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soph</td>
<td>92 (38.3%)</td>
<td>329</td>
<td>28.0%</td>
<td>62</td>
<td>253</td>
<td>24.5%</td>
<td>30</td>
<td>76</td>
<td>39.5%</td>
</tr>
<tr>
<td>Juniors</td>
<td>68 (28.3%)</td>
<td>331</td>
<td>20.5%</td>
<td>54</td>
<td>255</td>
<td>21.2%</td>
<td>14</td>
<td>76</td>
<td>18.4%</td>
</tr>
<tr>
<td>Seniors</td>
<td>80 (33.4%)</td>
<td>312</td>
<td>25.6%</td>
<td>56</td>
<td>258</td>
<td>21.7%</td>
<td>24</td>
<td>54</td>
<td>44.4%</td>
</tr>
</tbody>
</table>

The cross-section of respondents by engineering discipline is shown in Table 2. The disciplines with the highest response rates also have the highest percentage of female students: Chemical/Biomolecular Engineering and Civil Engineering/Geological Sciences.
Table 2. Potential and Actual Survey Respondents by Department

<table>
<thead>
<tr>
<th>Department</th>
<th>Actual Respondents</th>
<th>Potential Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical &amp; Biomolecular Engineering</td>
<td>63 (27.9%)</td>
<td>226 (23.3%)</td>
</tr>
<tr>
<td>Civil Engineering &amp; Geological Sciences</td>
<td>42 (27.6%)</td>
<td>151 (15.5%)</td>
</tr>
<tr>
<td>Aerospace &amp; Mechanical Engineering</td>
<td>79 (24.2%)</td>
<td>327 (33.6%)</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>23 (24.0%)</td>
<td>96 (9.9%)</td>
</tr>
<tr>
<td>Computer Science &amp; Engineering</td>
<td>33 (19.2%)</td>
<td>172 (17.7%)</td>
</tr>
</tbody>
</table>

Survey respondents also indicated their race/ethnicity, which is shown in Figure 2. In the current study, there were 48 non-white survey respondents. Non-white students – meaning those who self-identify as other than only “white or Caucasian” in institutional records – comprise 21.6% of the potential survey population in the engineering program, and 20.0% of those who participated in the survey.

Figure 2. Race / Ethnicity Breakdown of Survey Participants

For analysis purposes, students were grouped according to GPA as either above or below a 3.0. The majority of respondents reported having high grades in the 3.5-4.0 range (40.2%, compared with 37.0% in the potential survey population) or the 3.0-3.49 range (37.5%, compared with 36.6% in the potential survey population). The median GPA for students in all three grade levels is 3.33.

Qualitative Participants:

Overall, 13 students were interviewed based on the sampling strategy previously discussed. All of the interview participants were invited via e-mail with a $10 gift card as an incentive. There were 9 male and 4 female students who were interviewed (3 of the male students were non-white students). And all 5 departments within the College of Engineering were represented, with 4 students from Aerospace/Mechanical Engineering, 4 students from Civil Engineering/Geological...
Sciences, 2 students from Chemical/Biomolecular Engineering, 2 students from Electrical Engineering, and 1 student from Computer Science/Engineering. Table 3 is a summary of the interview participants listed by their pseudonym.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Gender</th>
<th>White or Non-White</th>
<th>Engineering Discipline</th>
<th>Interest in Engineering Subject Matter as a Source of Encouragement</th>
<th>Community Involvement Indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jack</td>
<td>Male</td>
<td>White</td>
<td>Civil</td>
<td>Not indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Paul</td>
<td>Male</td>
<td>Non-White (Hispanic)</td>
<td>Chemical</td>
<td>Not indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Michael</td>
<td>Male</td>
<td>Non-White (Two or more)</td>
<td>Aerospace</td>
<td>Not indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Brittany</td>
<td>Female</td>
<td>White</td>
<td>Mechanical</td>
<td>Not indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Victoria</td>
<td>Female</td>
<td>White</td>
<td>Aerospace</td>
<td>Not indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>York</td>
<td>Male</td>
<td>White</td>
<td>Electrical</td>
<td>Not indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>Kyle</td>
<td>Male</td>
<td>White</td>
<td>Mechanical</td>
<td>Not indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>Haile</td>
<td>Female</td>
<td>White</td>
<td>Computer Science</td>
<td>Indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>Steve</td>
<td>Male</td>
<td>Non-White (Two or more)</td>
<td>Civil</td>
<td>Indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>Nathan</td>
<td>Male</td>
<td>White</td>
<td>Chemical</td>
<td>Indicated</td>
<td>Indicated</td>
</tr>
<tr>
<td>Wendy</td>
<td>Female</td>
<td>White</td>
<td>Civil</td>
<td>Indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Matthew</td>
<td>Male</td>
<td>White</td>
<td>Electrical</td>
<td>Indicated</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Quinn</td>
<td>Male</td>
<td>White</td>
<td>Civil</td>
<td>Indicated</td>
<td>Not indicated</td>
</tr>
</tbody>
</table>

Results / Discussion
This section presents the results of both the survey and qualitative interviews. Initial data analysis began with variable correlations, which showed that those students who are involved in engineering organizations are also involved in other on-campus organizations (0.85). Grade-point average was moderately correlated with considering leaving engineering (-0.37), but not with plans to work in an engineering-related field post-graduation (0.03). These relationships were explored further and are discussed in the following sections, which also include a summary of the survey response rates for specific questions with emphasis on gender and race/ethnicity (white vs. non-white). It continues with a presentation of statistically significant variable relationships (t-tests and chi-square) and continues with identification of statistically significant factors from regression modeling, in which tests of statistical significance were reported for values with a threshold of p<0.05. The interview data are introduced throughout the section to help inform the survey results. There are five primary sections including:

I. Motivations and Influences for Engineering Study and Activities
II. Student Consideration of Leaving Engineering
III. Sources of Encouragement / Discouragement for Continuing in Engineering
IV. Student Extracurricular Involvements
   a. Overall
   b. Engineering
   c. Campus and Off-campus Community
V. Professional Persistence Plans
I. Motivations and Influences for Engineering Study and Activities

In the interview introductory discussions, students were asked how they came to be in the position they are in — specifically to tell their stories about how they came to be juniors in their engineering disciplines and what they enjoy most and least about engineering. This resulted in some expected responses such as excelling in math and science in high school and enjoying problem solving. But this also led to several other responses that were more insightful when considered in terms of relative similarity and difference by respondent (cross-case analysis). Two students indicated that they were unsure about engineering initially but decided to start in engineering because they already knew / understood the gates / boundaries that make transferring in more difficult – a curricular structure that Ohland and associates have encouraged changing to make a pathway in more accessible:

Kyle: “When I applied to college I thought maybe engineering. And I knew that I couldn’t just jump in late so that’s where I started.”

Nathan: “When I got to college I decided to start in engineering because I thought it was easier to start in it and if I didn’t like it leave instead of trying to come in later.”

Other students indicated more altruistic motivations for the decision to study engineering, such as a desire to use their engineering skills to serve, which was interestingly enough present in the explanations of 3 of the 4 civil engineering students who were interviewed (but not in the other engineering disciplines). There may be something intrinsically different about civil engineering and its mission to serve the public. Service and “helping people” has been reported as an important factor for specifically for women and civil engineering as a discipline tends to have one of the higher female enrollments as compared to other engineering disciplines — at the institution studied, it has the second-highest female enrollment following chemical/bimolecular engineering:

Jack: “After reading an article about Engineers without Borders, I became very struck with the idea that there are a substantial number of people in the world living without adequate and proper drinking water.”

Steve: “Coming to school I knew I wanted to [do] something with service…. and I chose Civil Engineering – or finalized it because I had talked with a senior [Civil engineering student] who was involved with NDSEED [(an engineering service organization)], and he explained to me that the classes made the most sense with a mindset of service.”

This quote is an indication of the influence that student peers have on each other. Astin’s seminal publication “What Matters in College?” stated that student-student interaction was the single greatest source of influence on all aspects of student learning and development. Beyond decisions about extracurricular activities, students also influence their peers on their selection of an engineering major as depicted in the following student quotation:

Matthew: “I chose chemical engineering by default but I wasn’t set in stone; the only reason I did that was because I liked chemistry in high school. When I came here I really didn’t know what engineering was... my next door neighbor [in the dorm] was a sophomore electrical engineer and I saw little gadgets he brought in from lab and I talked to him about his classes... And I think a lot of things came together at that time for me to decide electrical engineering was where I wanted to go.”

Two students also mentioned that they liked the role that engineers have in society:
Haile: “[I enjoy] the thought process that it involves that it’s something challenging but doable, because that is the way I think. So I found a place that I can use how I work to do a job that is specific and challenging, and has its place in society... I like that it has an application, and that I can do it but it’s not something that everyone can do."

Quinn: “I like that engineering is more like a producer in society as opposed to a businessman who is kind of a middle man, but I like that engineers put everything together in society.”

II. Ever Considered Leaving Engineering

As part of the survey, students were asked if they had ever considered leaving engineering. Not surprisingly, the peak time they considered leaving occurred between the second semester of first year and the first semester of sophomore year, as shown in Figure 3.

The WECE final report indicated that about two-fifths of student participants in all years of college reported considering leaving engineering at some point during college, with one-third of participants considering leaving during the sophomore year. In this study, the largest proportion of students considered leaving engineering during the second semester of their first year (25.8% of all respondents and 31.7% of women) and the first semester of their sophomore year (25.4% of all respondents and 33.8% of women). These results are not surprising, because it is during the second semester of the first year that students must select their intended major and decide on the college to enroll in for the start of the sophomore year. The first semester of sophomore year also represents the first time that students take courses in their chosen discipline. This perhaps represents a time that they can confirm that their choice of major is consistent with their expectations for the major.

Figure 3. Percentage of Students who Considered Leaving Engineering
Overall, the percentage difference of male and female students who considered leaving engineering was not statistically significant based on a two-group unpaired t-test. Graphically, the second semester of the first year shows the largest differential between male and female respondents and between white and non-white respondents. Looking closer at that time period, the data were considered strictly in terms of those students who indicated that they had considered leaving engineering during their second semester of their first-year, and the t-test results were not significant to p<0.05 level. Although not statistically significant, the trend does indicate that women and minorities may be at greater risk of leaving during the first few semesters in engineering. This is consistent with the work of Min and associates, who reported differences in “survival rates” by gender and minorities early in their engineering academic profession. However, our study is different in that we were asking students that had persisted in engineering if they had ever considered leaving (rather than asking those who left why and when they decided to leave). So among those who persisted, the absence of a statistically significant difference indicates that male and female students grapple with uncertainties related to pursuing engineering at similar points in their educational paths. They are likely to consider leaving engineering at the same time periods and at similar rates. That women and men behaved similarly in this regard is not entirely surprising, given the roughly equivalent retention rates of men and women at the institution studied, and given findings by Ohland and associates that reported that women engineering students persist at rates similar to male students and that found few meaningful differences in terms of matriculation and persistence. The WECE study reported 27.9% sophomore women and 26.4% of junior women who stayed in engineering had actually considered leaving engineering at some point. Reid and Imbrie’s four-year longitudinal study of student attitudinal effects also supports gender similarity hypothesis, in which they reported most differences (in terms of effect sizes) between the male and female engineering students were small or approaching zero.

Non-white students as a group behaved similarly to white students, but had a peak time of considering leaving in the second semester of first year (33.3%). There was not a statistically significant difference for white and non-white students during the first semester of the first year. This was a relatively small difference, so it is difficult to draw any conclusions, but the data do point to a need to better understand how non-white students experience the first year, and how that experience may differ from that of white students.

Tests of independence using chi-square were run to determine what variable relationships were statistically significant. Chi-square was used to further explore the relationship of grades to a student’s consideration of leaving engineering (p<0.0001). Grouping all students with a self-reported GPA of 3.0 and above and those below is shown in Table 4.

<table>
<thead>
<tr>
<th>Ever considered leaving engineering?</th>
<th>&lt;3.0 GPA</th>
<th>&gt;=3.0 GPA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>13</td>
<td>118</td>
<td>131</td>
</tr>
<tr>
<td>Yes</td>
<td>38</td>
<td>69</td>
<td>107</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>187</td>
<td>238</td>
</tr>
<tr>
<td>Percentage “Yes”</td>
<td>74.5%</td>
<td>36.9%</td>
<td>45.0%</td>
</tr>
</tbody>
</table>
The authors also speculated that interest in engineering would make a statistically significant difference in terms of engineering involvement, leadership, working in an engineering-related field post-graduation, and consideration of leaving engineering. Chi-square tests were applied to each of those relationships and indicated that only the relationship between interest in engineering and consideration of leaving engineering was statistically significant (p <0.002), and was the same for both male and female students. Table 5 summarizes the responses to this question.

Table 5. Relationship of Considering Leaving Engineering and Interest in Subject

<table>
<thead>
<tr>
<th>Ever consider leaving engineering?</th>
<th>Interested in Subject Matter (Not Indicated)</th>
<th>Interested in Subject Matter (Yes)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>36</td>
<td>95</td>
<td>131</td>
</tr>
<tr>
<td>Yes</td>
<td>50</td>
<td>57</td>
<td>107</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>152</td>
<td>238</td>
</tr>
<tr>
<td>Percentage “Yes”</td>
<td>58.1%</td>
<td>37.5%</td>
<td>45.0%</td>
</tr>
</tbody>
</table>

The authors sought to explore further the relationship between gender, ethnicity and considering leaving engineering. However, based on a chi-square test, neither gender nor race/ethnicity was statistically significant.

Finally, a regression model was evaluated that considering interest in engineering, grade level, GPA, gender, and race/ethnicity as potential explanatory variables for a student considering leaving engineering. As shown in Table 6, only interest in engineering subject matter and GPA were statistically significant predictors. Other studies have reported that students with high classroom performance are not immune to leaving engineering\(^8,11\); however, our study would indicate that, among students who have remained in engineering, lower grades are more likely to may make a student question educational plans.

Table 6. Regression Summary for Consideration for Leaving Engineering

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Ever Considered Leaving Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest in Engineering Subject Matter</td>
<td>-3.03**</td>
</tr>
<tr>
<td>Grade Level (Sophomore, Junior, Senior)</td>
<td>-0.63</td>
</tr>
<tr>
<td>GPA</td>
<td>-5.91***</td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>0.91</td>
</tr>
<tr>
<td>Race / Ethnicity (White)</td>
<td>0.59</td>
</tr>
</tbody>
</table>

\(**p<0.01, ***p<0.001\)

The qualitative feedback from student interviews supported the trend of considering leaving engineering during the first two years: 6 of 13 students said they never considered leaving engineering, while 7 of 13 students indicated that they had considered leaving engineering at some point in semesters 1-4 (first year and sophomore year). The cross-case analysis did not show any striking similarities or differences between male and female and white and non-white students. The WECE study had indicated that women were most vulnerable to leaving engineering during the first two years\(^8\). While the current survey supports the WECE study conclusion, it further extends that conclusion to say that all students (male, female, white, and non-white) are most vulnerable to leaving engineering during the first two years.
III. Sources of Encouragement and Discouragement in Engineering

Students were also asked what factors they found both encouraging and discouraging for continuing in engineering. The results show similarity in the factors considered as both encouraging and discouraging between the current study and the WECE report. In the current study, students reported the top factors that served as sources of encouragement for continuing in engineering as interest, employment opportunities, parents, and salary potential. The most significant sources of discouragement include the amount of time required for coursework, grades, pace of courses, and competition in engineering classes. As shown in Table 7, these lists are similar to those reported by WECE, but with a different ordering of significance. The current study further compared the differences in factors between men and women and found that, while the relative percentages for each factor differed, the overall list of factors and their order was the same for both male and female participants -- yet another indication that the experience of female versus male students is more similar than different. And although there were only 48 non-white survey participants, we reviewed the sources of encouragement and discouragement and found that white and non-white students cited the same top factors.

Table 7. Comparison of Sources of Encouragement and Discouragement in Engineering

<table>
<thead>
<tr>
<th>Sources of Encouragement</th>
<th>Current Study</th>
<th>WECE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>Interest in subject matter</td>
<td>Parents</td>
</tr>
<tr>
<td>Factor 2</td>
<td>Employment Opportunities</td>
<td>Interest in subject matter</td>
</tr>
<tr>
<td>Factor 3</td>
<td>Parents</td>
<td>Employment Opportunities</td>
</tr>
<tr>
<td>Factor 4</td>
<td>Salary Potential</td>
<td>Salary Potential</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sources of Discouragement</th>
<th>Current Study</th>
<th>WECE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>Time required for coursework</td>
<td>Grades</td>
</tr>
<tr>
<td>Factor 2</td>
<td>Grades</td>
<td>Time required for coursework</td>
</tr>
<tr>
<td>Factor 3</td>
<td>Pace of Courses</td>
<td>Quality of instruction in Engineering</td>
</tr>
<tr>
<td>Factor 4</td>
<td>Competition in Engineering Courses</td>
<td>Interest in subject matter</td>
</tr>
</tbody>
</table>

Qualitatively, the most striking consistency from the interviews related to sources of discouragement for continuing in engineering, specifically the amount of time required for engineering coursework. We sought to probe this concern during the individual student interviews (based on survey responses in which 10 of 13 students interviewed indicated it as a source of discouragement). Students spoke openly about their frustrations, specifically as it compared to what they observe their peers in other majors doing. But even without asking directly if the time required for engineering coursework was discouraging, we asked students in an open-ended question what they liked least about engineering, and 8 of the 13 interview participants indicated time/workload. The following student quotes explain this frustration:

*Victoria: “I knew coming in that it [engineering] was a lot of work. And I understand that. But there are just sometimes when after two all-nighters you ask yourself, why am I doing this? I could be in Arts and Letters and write a paper and not have to be up to 3 in the morning every night.”*
Steve: “Sometimes I feel myself getting pulled in a lot of different directions. So, in that sense I would want to do more and the reason others can is because they spend less time doing homework and working on that kind of stuff. So that’s one of the things I had to wrestle with is whether I wanted to do engineering or not.”

Wendy: “It’s frustrating that we have to put in a lot of time, it’s more annoying when there are other students who only have four classes and write two papers and have two tests all semester whereas we have homeworks every week.”

Quinn: “The lack of sleep that I get with it. I don’t mind the homework, I don’t mind the work of engineering, but it definitely cuts into the social life of college as opposed to other majors.”

Students consistently compared themselves to students in other majors (although not within other disciplines of engineering) using boundary language to distinguish themselves from others. Other engineering education studies likewise reported that students demonstrated an increasing “solidarity” with other engineering students and a distancing from college students in other majors31. While engineering has long been noted for its rigor, there is a relatively simple opportunity for administrators to try to balance that workload. As several students indicated, it was not just the workload, but also that major projects and deadlines of engineering courses would fall at the same times:

Haile: “The deadlines overlapping because it’s a very project-based major that’s what causes me the most stress. Having hard material is difficult, but there are enough resources to help me. But, when deadlines overlap and I can’t do enough about moving one or the other, or just having enough time to finish them.”

Administrators could organize discussions of faculty teaching the courses that most sophomore, junior, or senior engineering students would be taking in a given semester and seek opportunities to shift deadlines and due dates to alleviate some of the stress for students.

Grades were another theme among the students interviewed. Eight of 13 students discussed grades as a discouraging factor during their interviews. And specifically, there was a consistent message that engineering students were accustomed to earning very high grades in high school and must adjust to the expectations of college / engineering:

Paul: “When you get your first exam back and the average is a 60 you question yourself as to what’s going on. But then you realize that’s just the way it is, and it turns out an average between a 60 and 70 is a pretty good split. It discourages people a little bit because a D in high school is bad. But in engineering you realize you just hit the average.”

Brittany: “It’s discouraging when your friends [in other majors] have 3.5’s or 3.8 GPA and I’m really just scraping by... if I can hit 3.0 then I’m golden.”

However, the multi-institutional study by Ohland and associates reported that many engineering students believe their grades are lower than students in other majors but the actual difference in grades was not found to be statistically significant9.

Faculty relationships are also critical. Vogt reported that the approach that a faculty member takes towards students affects achievement, and recommended that faculty strive to be more
accessible and that they try to promote opportunities for positive interactions both inside and outside the classroom\textsuperscript{32}. Umbach and Wawrzynski likewise reported that student perception of a faculty member’s level of involvement with teaching was related to higher student engagement and greater learning gains\textsuperscript{33}. Finally, Astin reported that student-faculty relationships were critical, second only to student-student relationships in defining the student experience\textsuperscript{28}.

Jack: “I don’t like it when professors are removed from the students. I guess I’ve been spoiled a little bit because there are some either younger or more personable engineering faculty in the department.”

Kyle: “I think it’s really encouraging when I see my professor and think of them as good, fun, personable people because then I look at engineering and I think okay so I’m not going to be lonely... when I see professors and advisors who enjoy discussing the material I think okay well hopefully if I go into industry then these are the people I would be working with very closely on a daily basis.”

This quotation not only shows the criticality of faculty relationships, but also shows that it is in relating to faculty that students are able to reconcile their identity. This same student at another point in the interview discussed specifically his identity concerns:

Kyle: “So sometimes it’s [engineering] pretty cool. But at the same time, I wonder if I belong in it. I really wonder if I belong in it. And I may just be over-thinking completely.”

Finally, key experiences such as internships and research as undergraduate students was also a common source of encouragement. Other studies have sited the criticality of these experiences but cautioned engineering educators of students’ “malleability” in forming views based on a single / limited experience\textsuperscript{34} or the bi-directionality of an experience as being either affirming or dissuading\textsuperscript{18}. In the current study, all student references to experiences in internships and research experiences were found to be affirming:

Jack: “A lot of it boils down to an incredibly positive experience I had over the summer with a firm that I worked for out in the Seattle area... The folks there were just really friendly; there was this camaraderie that I felt with them.”

York: “I’ve been doing research here for a professor in the biophysics department. And the more I do research the more I like it just because I like to learn.”

IV. Student Extracurricular Involvements

a. Overall

This study also sought to better understand student engagement as evidenced by extracurricular involvement within engineering organizations, on campus, and in the off-campus community. Table 8 summarizes responses for these questions. Overall, response data indicate that 57.4\% of respondents were involved with engineering organizations, and 18.3\% report being a leader or officer in an engineering organization. Beyond that, 85.5\% of students report being involved with campus organizations. And finally, 16.9\% of students report being involved with off-campus community organizations.

A subset of students – overall 29\% -- is not involved with any organizations (engineering, campus, or off-campus community). Male students reported a lower rate of involvement than female students in all types of extracurricular organizations. White students reported lower
levels of involvement than non-white students in engineering and off-campus community organizations, but higher levels of involvement in campus organizations.

The belief that students in a minority group may have a different experience has been expressed in other studies. May and Chubin, for example, stated that it would seem reasonable to suspect that minority students would be less likely to be involved in organizations having predominantly non-minority membership\textsuperscript{14}. However, we found that the non-white students were more involved than white students in terms of engineering organizations, leadership in engineering organizations and involvement in off-campus community organizations. This finding would appear to contradict May and Chubin’s speculation; however, looking closer at the responses from students in terms of what organizations they are involved with, many are actually minority-serving engineering organizations. Specifically, 68% of are involved in some form of extracurricular activity and, of those, 50% reported involvement in a minority organization.

<table>
<thead>
<tr>
<th></th>
<th>% Involved in Engineering Organizations</th>
<th>% Leaders in Engineering Organizations</th>
<th>% Involved in Campus Organizations</th>
<th>% Involved in Community Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Students</td>
<td>57.4%</td>
<td>18.3%</td>
<td>85.5%</td>
<td>16.9%</td>
</tr>
<tr>
<td>Male Students</td>
<td>56.8%</td>
<td>16.8%</td>
<td>84.1%</td>
<td>15.5%</td>
</tr>
<tr>
<td>Female Students</td>
<td>72.9%</td>
<td>20.0%</td>
<td>91.9%</td>
<td>22.4%</td>
</tr>
<tr>
<td>Non-white students</td>
<td>68.8%</td>
<td>25.0%</td>
<td>81.8%</td>
<td>20.8%</td>
</tr>
<tr>
<td>White Students</td>
<td>60.9%</td>
<td>16.1%</td>
<td>88.9%</td>
<td>17.2%</td>
</tr>
</tbody>
</table>

The qualitative portion of this study helped to inform these results, specifically in understanding how and why students become involved with organizations, and confirmed that peers have a tremendous influence. Every student interviewed -- male, female, white, non-white -- discussed openly peer influence in terms of the organizations they have chosen to get involved with, as shown in the quotes below from a female and male student:

Brittany: "I’ve only recently gotten involved with SWE [Society of Women Engineers]...My roommate this year is on listserv and for some reason I am still not on the listserv... so she fills me in all the time on when meetings are and stuff."

Paul: "My roommate freshman year had joined [Ultimate Frisbee Club]. And then sophomore year a lot more guys from the dorm had joined. I was just throwing the friz around the quad for fun with a bunch of really nice guys and I decided to stay."

Given that peer influence is such a strong factor in student development\textsuperscript{28} and, as we have discussed here, in getting involved in various activities, this could be an indication to administrators that using peers to encourage each other may be an effective way to increase student engagement and persistence. One area that seems to be an opportunity for engineering educators is to promote professional societies. In fact, several interview participants had indicated on the survey that they were involved with professional societies in some way. But when their involvement was probed during the interview, the depth of experience was minimal in most cases, with a common reason for joining being résumé builder.

Paul: "AIChE I joined this year. It’s kinda’ quiet... I don’t honestly know what they’re supposed to be doing but they’re not."
Interviewer: “So what was your first reason for getting involved with AIChE?”
Paul: “Sadly résumé.”

Interviewer: “You’re in AIAA, is that right?”
Michael: “Yes I am, but my level of involvement there is fairly minimal. I’m in it because, for one thing they’re an engineering club but they don’t necessarily put on all that many events... more of it is that AIAA is connected to the US Allied Project and Design, Build, Fly. And so I signed up for it because, well for one thing all the guys who do that project pretty much are in that. And so they kind of signed me up anyway...they’re pretty involved in the design competitions.”

Interviewer: “Would you say that it had a direct influence on your experience in engineering?”
Michael: “I honestly could not say that.”

b. Engineering Involvements

Chi-square tests show that involvement and leadership in engineering organizations for different engineering disciplines was statistically significant (p<0.002). Table 9a summarizes the responses: students in Aerospace/Mechanical, Chemical/Biomolecular, and Civil/Geological Sciences are involved with engineering organizations at a higher rate than expected, while students in Computer Science/Engineering and Electrical Engineering are involved at a lower rate than expected. Some of these differences may be explained by the fact that the Chemical/Biomolecular and Civil/Geological programs have a higher enrollment of women, so a higher level of participation in relevant extracurricular organizations is not unexpected. But when exploring students in leadership roles in these organizations, students in Civil/Geological Sciences and in Electrical Engineering were involved at a higher rate than expected (p<0.003), as shown in Table 9b. This could be explained by the comparatively small sizes of each of these programs, so a higher proportion of students would be needed to staff a similar number of leadership positions in each organization.

Table 9a. Relationship of Engineering Involvement and Engineering Discipline

<table>
<thead>
<tr>
<th>Engineering Involvement</th>
<th>Aero / Mechanical</th>
<th>Chemical</th>
<th>Civil</th>
<th>Computer Science</th>
<th>Electrical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>21</td>
<td>22</td>
<td>14</td>
<td>21</td>
<td>12</td>
<td>90</td>
</tr>
<tr>
<td>Yes</td>
<td>58</td>
<td>40</td>
<td>28</td>
<td>12</td>
<td>10</td>
<td>148</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>62</td>
<td>42</td>
<td>33</td>
<td>22</td>
<td>238</td>
</tr>
<tr>
<td>Percentage “Yes”</td>
<td>73.4%</td>
<td>64.5%</td>
<td>66.6%</td>
<td>36.4%</td>
<td>45.4%</td>
<td>62.1%</td>
</tr>
</tbody>
</table>
### Table 9b. Relationship of Engineering Leadership and Engineering Discipline

<table>
<thead>
<tr>
<th>Engineering Involvement</th>
<th>Aero / Mechanical</th>
<th>Chemical</th>
<th>Civil</th>
<th>Computer Science</th>
<th>Electrical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Involved</td>
<td>21</td>
<td>22</td>
<td>14</td>
<td>21</td>
<td>12</td>
<td>90</td>
</tr>
<tr>
<td>Participant / Member</td>
<td>46</td>
<td>30</td>
<td>17</td>
<td>11</td>
<td>5</td>
<td>109</td>
</tr>
<tr>
<td>Leader / Officer</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td>1</td>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>62</td>
<td>42</td>
<td>33</td>
<td>22</td>
<td>238</td>
</tr>
</tbody>
</table>

| Percentage “Leader”    | 15.2%             | 16.1%   | 26.1% | 3%               | 22.7%      | 16.4% |

In terms of engineering involvement, the following quote by Matthew explains that he did not get involved in engineering organizations because he felt that extracurricular activities are outlets for other interests (other students expressed similar reasons):

*Matthew:* “Engineering is kind of my job, or I guess at school it’s my job, it’s what I need to be serious about and I spend so much time in engineering with these engineering people that would I get involved or do something else outside of the engineering that’s not at school, it’s nice to do something different. And also surround myself with a different sort of people and just because it’s a change of pace.”

Regression modeling for “engineering leadership” as the dependent variable was traditional since there were three potential outcomes (not involved / participant or member / leader or officer). But applying the same independent variables showed that the same factors predictive of involvement -- grade level, female, and plans to work in an engineering related field post-graduation -- were also predictive of engineering leadership as shown in Table 10.

### Table 10. Regression Summary for Engineering Leadership

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Engineering Involvement</th>
<th>Engineering Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level (Sophomore, Junior, Senior)</td>
<td>0.55**</td>
<td>0.18***</td>
</tr>
<tr>
<td>GPA</td>
<td>0.20</td>
<td>0.04</td>
</tr>
<tr>
<td>Female</td>
<td>1.03**</td>
<td>0.28**</td>
</tr>
<tr>
<td>White</td>
<td>-0.47</td>
<td>-0.15</td>
</tr>
<tr>
<td>Consider leaving Engineering</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td>Work in engineering related field 3 years post-graduation</td>
<td>0.38**</td>
<td>0.11***</td>
</tr>
</tbody>
</table>

**p<0.01, ***p<0.001

Civil engineering and participation in ASCE’s concrete canoe was an exception, although it was still recognized as a low time commitment:

*Wendy:* “ASCE. So I’m just a member. Last year I did some stuff with the concrete canoe… I helped with the mix design. This semester I haven’t been able to do as much because JEC [another engineering organization] has taken up so much time that I don’t really have time for anything else.”

*Interviewer:* “So what was your first reason for getting involved with ASCE?”
This quote is indicative of engineering identity development through a sense of belonging, which is influenced by both internal and external factors stemming from the culture of the institution. Theoretically speaking, from a multiple-identities framework, Gee indicates four major identities: (1) nature (a state), (2) institution (a position), (3) discourse (an individual trait) and (4) affinity (experiences). This research specifically focuses on (4), the affinity/experiences of an individual that contribute to engineering identity. An example of common student experiences mentioned previously is the challenging workload pointed out by several engineering students in the current study, which may bring students together as part of a shared experience or a pride expressed by students over the difficulty of taking engineering as an educational or professional path. And while some of the factors indicated by students in the current study are similar to the experiences reported by students at other institutions, there are also differences stemming from campus culture. For example, the current study was conducted at an institution which has a mission directly related to service and the betterment of the community, which we would expect to influence a student’s expectations of personal involvement in service, as explained further in the next section.

c. Campus & Off-Campus Community Involvement

Students who were not involved with the off-campus community indicated that time (or lack of time) was a factor. When asked if students felt an expectation for being involved with service:

Paul: “It’s [community involvement] not really a big part of what I did. I feel bad about it....No it’s true. Sometimes I’ve felt like I should be trying to and then I’d talk myself into the I’m busy speech... I’ve honestly never had too much motivation towards community service. It’s always been something that I thought about that I needed to do, but never did.”

Interviewer: “More because it’s the thing that everyone talks about that you should be doing?”

Paul: “Exactly.”

Haile: “That’s kind of a culture here at ND”

And students also cite the importance of volunteering to achieve a personal goal – for example, that it is a desirable thing for a résumé in some circumstances:

York: “I know a lot of my friends do feel expected to do it. And a lot of them just do it for the applications and stuff, or over-commit themselves because of med-school applications or you know what have you.”

Matthew: “It’s for selfish reasons, I can practice my Spanish, and it looks good to see that you have some sort of volunteering, or are involved in the community too...I guess as an engineering major I don’t know if it’s necessary, but I feel where companies, when they come and give their spiel they always talk about community involvement... I do feel pressure [to do community service].”
Off-campus community involvement was found to be a negative predictor of working in an engineering-related field three years post-graduation (result shown later in Table 11). It is possible that those students who are getting involved with the off-campus community are not as interested in engineering related jobs anyway – they may be pursuing other professional studies such as medical school.

York: “Yeah, especially because medical schools expect community service. I think that a lot of students do feel like we’re at ND, we’re kind of expected to be better than everyone else. I think there is a certain expectation, but at the same time it’s very, very easy to get involved and do community service.”

Students with large time commitments to campus activities such as marching band and ROTC tended to be less involved with engineering organizations as well (1 of 4). It was very notably a time issue, but the researchers also hypothesize that it is because these students may more closely identify with students in those campus activities:

Haile: “I’m not as interested in engineering groups, clubs, and societies as I am in things outside of engineering. So, if I would have more time, if I weren’t in band, I would probably be involved in other things outside of academic clubs is my guess. Probably just because I am involved in clubs to get my mind off of things, you need a break from it.”

Interviewer: “Describe your involvement in marching band.”

Haile: “So band is like a fraternity/sorority in itself... because we hang out together, we travel together, and we’re at practice together every day, so it’s more of the dedication to my family than it is to a club.”

Finally, regression models were evaluated to try to understand the factors predictive of being involved in non-engineering organizations on campus and in the off-campus community. A logistic regression model (with a binary outcome of either involved or not involved) was also developed for factors predictive of campus and community involvements. All models were based on the following independent variables: grade level, GPA, gender, race / ethnicity, ever considered leaving engineering, and plans to work in engineering three years post-graduation. These factors were selected based on the results of the prior chi-square tests as well as prior literature. Table 11 summarizes the statistically significant regression model coefficients and shows that being involved with engineering organizations and campus organizations share the same statistically significant prediction factors. These factors include grade level (higher grade levels more likely), female (more likely), and plans to work in engineering post-graduation (more likely).

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Engineering Involvement</th>
<th>Campus Involvement</th>
<th>Community Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level (Sophomore, Junior, Senior)</td>
<td>0.55**</td>
<td>0.38*</td>
<td>0.10</td>
</tr>
<tr>
<td>GPA</td>
<td>0.20</td>
<td>0.19</td>
<td>0.13</td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>1.03**</td>
<td>1.02**</td>
<td>0.38</td>
</tr>
<tr>
<td>Race/Ethnicity (White)</td>
<td>-0.47</td>
<td>-0.15</td>
<td>-0.41</td>
</tr>
<tr>
<td>Consider leaving Engineering</td>
<td>0.08</td>
<td>-0.05</td>
<td>0.91*</td>
</tr>
<tr>
<td>Work in engineering related field 3 years post-graduation</td>
<td>0.38**</td>
<td>0.26*</td>
<td>-0.26*</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01
Table 11 also reveals that, while the predictive factors for being involved with engineering and campus organizations were similar, being involved with the off-campus community was different. Specifically, the study identified a statistically significant relationship between considering leaving engineering and the likelihood that a student will be working in an engineering-related field three years after graduation (negative relationship). This certainly merits more study, especially in regard to the question of whether students lose interest in engineering because they become more interested in broader, community-based issues, or whether they become more interested in community issues after they lose interest in engineering. Perhaps some efforts to show students how engineering can provide solutions for community problems would yield stronger commitment to engineering study and practice among these students. Astin and Sax conducted a study of undergraduate student’s participation in service and reported that participation “substantially enhances the student’s academic development, life skill development, and sense of civic responsibility.”

**Plans for Professional Persistence**

Lichtenstein and associates asked senior engineering students how likely it was that they would be working in an engineering-related field three years post-graduation\(^7\). We asked all of the engineering students in our survey a similar question (response choices were on a similar Likert type scale, but with 6 options instead of 5). The summary of responses is shown in Tables 12a-d. Lichtenstein reported that 66% of the seniors surveyed indicated that they would definitely or probably continue in an engineering-related field three years post-graduation\(^7\). Although the response choices were not directly equivalent, our study showed a similar result at the upper bound. Specifically, 60.1% of seniors said that they definitely will or almost definitely will continue in an engineering-related career three years post-graduation. By comparison, the WECE study asked students about their plans to persist in an engineering related field seven years post-graduation and reported affirmative responses from 80% of seniors\(^8\).

<table>
<thead>
<tr>
<th>Table 12a. Professional Persistence Plans by Grade Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sophomores</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Juniors</strong></td>
</tr>
<tr>
<td><strong>Seniors</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 12b. Professional Persistence Plans by Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Female</strong></td>
</tr>
</tbody>
</table>
Table 12c. Professional Persistence Plans by Race / Ethnicity

<table>
<thead>
<tr>
<th></th>
<th>Definitely Will</th>
<th>Almost Definitely Will</th>
<th>Probably Will</th>
<th>Probably Will Not</th>
<th>Almost Definitely Will Not</th>
<th>Definitely Will Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>24.3%</td>
<td>32.8%</td>
<td>24.3%</td>
<td>7.3%</td>
<td>6.8%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Non-white</td>
<td>31.9%</td>
<td>31.9%</td>
<td>21.3%</td>
<td>8.5%</td>
<td>2.1%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

Table 12d. Professional Persistence Plans by Department

<table>
<thead>
<tr>
<th>Department</th>
<th>Definitely Will</th>
<th>Almost Definitely Will</th>
<th>Probably Will</th>
<th>Probably Will Not</th>
<th>Almost Definitely Will Not</th>
<th>Definitely Will Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace / Mechanical Engineering</td>
<td>27.4%</td>
<td>34.2%</td>
<td>21.9%</td>
<td>6.8%</td>
<td>5.5%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Chemical / Biomolecular Engineering</td>
<td>14.0%</td>
<td>28.1%</td>
<td>35.1%</td>
<td>7.0%</td>
<td>8.8%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Civil Engineering / Geological Sciences</td>
<td>22.5%</td>
<td>32.5%</td>
<td>22.5%</td>
<td>12.5%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Computer Science / Engineering</td>
<td>35.5%</td>
<td>38.7%</td>
<td>16.1%</td>
<td>6.5%</td>
<td>0%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>43.5%</td>
<td>30.4%</td>
<td>13.0%</td>
<td>4.3%</td>
<td>8.7%</td>
<td>0%</td>
</tr>
</tbody>
</table>

A progressive regression model was built to understand the factors that contribute to a student’s plans for professional persistence (3 years post-graduation). As summarized in Table 13, Model 1 began with indication of interest in engineering subject matter (either indicated or not indicated) and with that as the only explanatory factor it is statistically significant. However, once the next factor, if a student has ever seriously considered leaving engineering, is included in the model (Model 2) it is no longer significant. Model 3 included leadership in an engineering organization as an explanatory factor and it was also statistically significant. Models 4 through 7 added grade point average, grade level, female, and white – none of which were statistically significant factors.

Table 13. Regression Summary for Professional Persistence

<table>
<thead>
<tr>
<th>Model #</th>
<th>Interest in Engineering Subject</th>
<th>Ever Considered Leaving Engr</th>
<th>Leadership in Engineering Organization</th>
<th>GPA</th>
<th>Grade Level</th>
<th>Female</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.05*</td>
<td>-3.84***</td>
<td>3.01**</td>
<td>-1.24</td>
<td>-0.69</td>
<td>-0.93</td>
<td>-0.67</td>
</tr>
<tr>
<td>2</td>
<td>1.30</td>
<td>-3.73***</td>
<td>3.02**</td>
<td>-1.12</td>
<td>-0.69</td>
<td>-0.93</td>
<td>-0.67</td>
</tr>
<tr>
<td>3</td>
<td>1.27</td>
<td>-3.89***</td>
<td>3.09**</td>
<td>-1.08</td>
<td>-0.69</td>
<td>-0.93</td>
<td>-0.67</td>
</tr>
<tr>
<td>4</td>
<td>1.23</td>
<td>-3.91***</td>
<td>3.39***</td>
<td>-1.21</td>
<td>-0.97</td>
<td>-1.92</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.22</td>
<td>-3.79***</td>
<td>3.31***</td>
<td>-1.04</td>
<td>-0.93</td>
<td>-1.88</td>
<td>-0.67</td>
</tr>
<tr>
<td>6</td>
<td>1.21</td>
<td>-3.76***</td>
<td>3.31***</td>
<td>-1.04</td>
<td>-0.93</td>
<td>-1.88</td>
<td>-0.67</td>
</tr>
<tr>
<td>7</td>
<td>1.20</td>
<td>-3.76***</td>
<td>3.31***</td>
<td>-1.04</td>
<td>-0.93</td>
<td>-1.88</td>
<td>-0.67</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01, ***p<0.001
Based on these regression results, a student’s consideration of ever leaving engineering seems to be a strong indicator of professional persistence plans. Further exploration of that factor was pursued based on the chi-square tests, which indicated that interest in the subject and GPA were significant factors independently, so a model was analyzed to try to understand their influence. Of the interview participants, all six of the students who indicated that interest in engineering subject matter was an encouraging factor for continuing in engineering also planned to work in an engineering related field post-graduation. But of the seven students who did not indicate that engineering subject matter was an encouraging factor, three definitively plan to continue down an engineering path while four did not.

Conclusions
The results of a mixed-method study considering undergraduate student experiences at a medium sized, Midwestern, private institution during the 2011-2012 school year were presented in this paper. This study yielded some critical findings for engineering education researchers and administrators, relating the findings back to the original research questions:

1. Do male, female, white, and non-white students have similar experiences in terms of:
   a. Consideration of leaving engineering at the same points and with the same frequency?
      ➢ Overall, the percentage difference of male, female, white, and non-white students who considered leaving engineering was not statistically significant. The peak time frame for consideration was second semester of the first year and first semester of sophomore year. This indicates that all engineering students grapple with uncertainties related to pursuing engineering at similar points in their educational paths.
      ➢ A students self-reported “interest in engineering” was statistically significant to consideration of leaving engineering (for both male and female students)

   b. Consideration of the same factors to be encouraging / discouraging for continuation in engineering
      ➢ While the relative percentage of the factors studied for each factor differed for male and female participants, the overall list of factors and their order was the same for both male and female participants, yet another indication that the experience of female versus male students is more similar than different.
      ➢ White and non-white students cite the same top factors as sources for encouragement and discouragement in engineering.

   c. Involvement in engineering organizations, campus activities, and the community?
      ➢ Male students reported a lower rate of involvement than female students in all types of engineering organizations.
      ➢ White students reported lower levels of involvement than non-white students in engineering and off-campus community organizations, but higher levels of involvement in campus organizations.
      ➢ Involvement and leadership in engineering organizations for different engineering disciplines was statistically significant.
      ➢ The same factors predictive of engineering involvements; grade level, female and plans to work in engineering related field post-graduation were also predictive of engineering leadership.
2. How do these factors and experiences affect students’ plans for professional persistence?

- Students planning to work in an engineering related field after graduation were less likely to be involved with community organizations (conversely, those who considered leaving engineering were more likely to be involved in the community).
- Interviews reveal that many students feel some level of obligation / pressure to do service, although it may be students who plan to continue in professional studies such as law or medicine and feel they need it for their application.

In addition to these findings, the following are potential approaches for engineering education researchers and administrators to consider for increased student involvement, engagement, and persistence:

1. Exploit student-student influence through student organizations to encourage involvement. This could be done by allowing current members of an engineering organization to “nominate” other students to become involved and could be specifically invited to participate.

2. Exploit faculty-student influence:
   a. Remind faculty that they serve as role models for the engineering profession. Students evaluate their own thoughts and views of themselves as engineers and develop their engineering identity through observing others engaged in the profession. If they see faculty enjoying their profession, they will begin to believe that they will enjoy the profession as well.
   b. Set an expectation that class attendance and participation are recognized and encouraged to promote regular interaction.
   c. Ask faculty to nominate students they observe as having leadership potential to be invited to participate in engineering organizations or serve in leadership roles.
   d. Encourage student-student interaction in class
   e. Encourage actual involvement / participation in Engineering Professional Societies – they are an untapped resource that could be used to encourage educational and professional persistence

3. Reduce unnecessary stress for students- help organize the standard courses taken by students of each grade level such that projects and exams are spaced out as best as possible to alleviate unnecessary burdens on students.

While this survey provided insight into the involvement of the engineering students, it also identifies several opportunities for additional research. The question of whether students lose interest in engineering because they become more interested in broader, community-based issues, or whether they become more interested in community issues after they lose interest in engineering, merits further study – a question that can be particularly important for understanding minority-student engagement. Additionally, this study was conducted at a single institution; and recognizing the institutional / cultural influence on student experiences, expansion to other dissimilar institutions is an opportunity for future work.

Limitations of the current study include the survey design, which is based on self-reported data. And further, respondents of sophomore women were slightly over represented, while junior women were underrepresented. The author’s speculate that a smaller pool of female survey respondents may have influenced results in a minor way; however, they do not believe it is significant because differences in responses by grade level (of female students compared to sophomores and seniors) were not significant. While this may have reduced the interview pool,
there were still four junior women interviewed in accordance with the interview design strategy -
- and several others that conformed to the selection requirements but were not selected due to
limitations in the number of interviews conducted. Finally, only students who have persisted in
engineering were invited to participate in the survey. A study that seeks feedback from students
who have not persisted in engineering is an opportunity for further research.

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APPENDIX: Survey Questions

Hello, and thank you for taking the Engineering Student Involvement Survey. The purpose is to understand Engineering Students Involvements (1) Within the College of Engineering (2) On campus, outside the College of Engineering and (3) within the community. Thank you in advance for participating in this SHORT survey...

1. Are you involved with any engineering organizations? Yes or No
2. For any of the following engineering organizations, please indicate your level of involvement. (participant / member, leader / officer)
3. Please indicate when you first became involved with each of the organizations.
4. Why did you get involved with this / these organizations? Please explain.
5. Are you involved with any ND sponsored organizations that are non-engineering related?
6. Please indicate what non-engineering organizations you are involved with.
7. Describe the nature of your involvement in each of the non-engineering organizations as either a participant / member or leader / officer.
8. Are you involved with any off campus organizations? (Community involvements)
9. Please indicate what community organizations you are involved with.
10. Describe the nature of your involvement in each of the community organizations you are involved with as either a participant / member or leader / officer.
11. Which involvements (engineering, campus, or community involvements) did you get the most out of personally?
12. Which involvements (engineering, campus, or community involvements) did you get the least out of personally?
13. Did you ever seriously consider leaving engineering in any of the academic years below?

First Year  First Year  Sophomore  Sophomore  Junior  Junior  Senior  Senior
(semester  (semester  (semester  (semester  (semester  (semester  (semester  Super
1)   2)   3)   4)   5)   6)   7)   8)   Senior

14. Please explain what factors contributed to your decision to stay in engineering.
15. To date, which are the THREE most significant sources of encouragement to continue in engineering? (Parent / Sibling / Significant Other / High School Teacher, Counselor, or Peers / College Professor, Advisor, or Peers / Someone who works in Science, Math, or Engineering field / College Faculty Member / Employment Opportunities / Salary Potential / Interest in the subject matter / Quality of teaching instruction in engineering / Grades / Internship Experience / Research Experience / Amount of time required for engineering coursework / Competition in engineering courses / Pace of engineering courses / Number of women in engineering courses / Number of women faculty in engineering courses / Number of ethnic minority students in engineering courses / Number of ethnic minority faculty in engineering
16. To date, which are the THREE most significant sources of discouragement? (see above)
17. Which of the following best describes your college standing? (Sophomore / Junior / Senior)
19. Overall GPA (<2.0 / 2.0-2.49/ 2.5-2.99 / 3.0-3.49 / 3.5-4.0)
20. Gender
21. How do you describe your ethnicity?
Black-African American-African/Central/Southeast/East Asian (e.g., Chinese, Taiwanese, Vietnamese, Korean)/
Hispanic-Latino/Indian Asian (e.g., Indian, Pakistani)/Native American, American Indian, Alaskan Native, or First Nation/
White/Pacific Islander/Two or more/Other
22. How likely is it that you will be working in an engineering related field 3 years post-graduation? (Including engineering graduate studies)
Definitely Will / Almost Definitely Will / Probably Will / Probably will not / Almost Definitely will not / definitely not
Appendix: Interview Protocol

1. Can you tell us what led you to study engineering?
   What do you enjoy most about engineering?
   What do you enjoy least about engineering?

2. Please tell us about the factors that have encouraged you to continue in engineering?
   On your survey you indicated:
   ___________________ ___________________ ___________________ ___________________

3. Please tell us about the factors that discouraged you from continuing in engineering?
   On your survey you indicated:
   ___________________ ___________________ ___________________ ___________________

4. Tell us about your decision to continue in engineering?
   On your survey you indicated considering leaving engineering during the following semesters:
   1       2    3   4  5  6  7  8

5. Tell us about your involvements in the College of Engineering?
   On your survey you indicated: ____________________________________________________

6. Tell us about your involvements on campus?
   On your survey you indicated: ____________________________________________________

7. Tell us about your involvements in the community?
   On your survey you indicated: ____________________________________________________

8. What do you envision for your future work plans (3 years post-graduation)
   On your survey you indicated:
   Definitely Will / Almost Definitely Will / Probably / Probably will not / Almost definitely will not/ Definitely will not

9. Anything else we should know