Engineering Student Involvement: Comparison of Two Dissimilar Institutions

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Engineering education researchers focus on questions relating to educational and professional persistence in engineering. It is believed that increased student engagement leads to higher educational persistence. The current study focuses on one measure of student engagement – that is, involvement in student organizations at two dissimilar universities. As we identify who becomes involved with engineering organizations and how and why they became involved, we can alter support structures to promote engagement and educational persistence.

A cross-sectional study of engineering students (sophomores, juniors, and seniors) at a medium-sized, Midwestern, private institution (religiously affiliated) was conducted during the fall of 2011, and repeated at a medium-sized, Midwestern public institution (urban setting) in the fall of 2012. The study involved an on-line survey completed by hundreds of engineering students across the two institutions responding to questions about their extracurricular involvements both within engineering and across the university as a whole. The reasons for getting involved with each organization were probed and, further, students were questioned about whether they ever considered leaving engineering. The results are analyzed statistically with demographic and experiential questions serving as critical co-variants in defining differences between students that are members/participants, leader/officers, and non-participants.

Results reveal that students consider leaving engineering at the greatest proportions when the first core, discipline-specific engineering courses are introduced. Male and female students from both institution had similar experiences in terms of the factors they found to be encouraging (interest, employment opportunities, parents, and salary potential) and discouraging (time required, grades, pace of courses, and competition in courses) of their engineering educational pursuit. Women are involved in engineering, on campus, and in the community at higher rates than male students. Finally, students from the public institution indicated a higher commitment level towards engineering professional persistence.

Introduction

A large-scale, multi-institutional study of persistence and engagement in engineering by 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 vary significantly among institutions. They also reported that engineering students have the same level of engagement as students in other majors and, despite heavier course loads, report levels of satisfaction with the college experience and involvement with campus organizations and volunteer work at a level similar to students in other majors. One notable difference that emerged from that study, however, was that engineering 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 speculate that "the engineering experience may focus narrowly on content, excluding broader personal development that is necessary for life-long learning" (p. 275).[1] Smith and associates agree 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.[2] Finally, differences in terms of learning style, approaches to learning, and intellectual development throughout the entire college experience beyond academics should be recognized as growth factors that develop students personally and professionally through the entire college experience.[3]

Felder and associates reported that, although women entered engineering programs with academic credentials stronger than or equal to their male counterparts, they experienced degradation in terms of performance and confidence 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.[4] 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. The study advocates for female student participation in social enrichment activities as critical to a more positive perception of a department and the classroom environment, which consequently 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."[5]

The WECE study served as a critical underpinning for the current study. Like the WECE study, the current study used a web-based survey with similar research questions that focused on participation in activities and persistence in engineering. But, drawing on the conclusions presented by Ohland et al.[1] of comparable male and female persistence at an individual institution, our study considers all engineering students during their sophomore, junior, and senior years (when they are institutionally recognized as engineering students) to explore their degree of involvement in engineering, on campus, and in the community.

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.[8] 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 amount of: energy devoted to academic study, time spent on campus, participation in student organizations, interaction with faculty, and interaction with students. These factors are not unrelated, and in fact 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. Or conversely, 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.[9-10] The relationship of student involvement, and specifically who is getting involved, is considered in the current study in the specific context of engineering education.

Lichtenstein and associates performed a study of senior engineering students at two institutions to answer the research question "To what extent do students who complete undergraduate programs in engineering intend to pursue engineering careers?"[11] Their study consisted of surveys and interviews. They found that engineering students who completed an engineering major are not necessarily committed to careers in engineering or even in STEM. They also found that, during their undergraduate experience, students' career options could be disproportionately swayed positively or negatively by a single experience. Furthermore, institutional differences and factors contribute to levels of commitment to engineering careers. Finally, current engineering graduates entering the workforce do not consider a career choice as a lifetime commitment.

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

1. Do male and female students have similar experiences in terms of:
   a. Getting involved in engineering, campus, and the community?
   b. Taking on leadership roles in engineering?
   c. Considering leaving engineering?
   d. Do they consider the same factors to be encouraging / discouraging for continuation in engineering?
2. Do students from dissimilar institutions have similar experiences in terms of:
   a. Getting involved in engineering, campus, and the community?
   b. Taking on leadership roles in engineering?
   c. Considering leaving engineering?
   d. Do they consider the same factors to be encouraging / discouraging for continuation in engineering?

These research questions relate to the specific areas of focus posed in the survey and which are discussed in this study – there are obviously many other experiences that comprise the undergraduate experience.

Profile of the Studied Institutions

Selective Private

At the selective private institution studied in 2011, 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 and serves ~10,000 undergraduate students per year. 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 the college of engineering, students at the institution may elect to enroll in the college of science, college of arts and letters, college of business or school of architecture. The overall student body is 53% male and 47% female, while the college of engineering is approximately 72% male and 28% female. Engineering disciplines available at the selective, private institution studied include: aerospace, chemical, civil, computer, electrical and mechanical, along with computer science and environmental geosciences.

Urban Public

At the urban public institution studied in 2012, very few students complete their undergraduate studies in four years. The university serves ~13,000 undergraduate students, 86% of which come from within the state. It is a very accessible school for students of diverse academic preparations and socioeconomic status. Specifically, it guarantees admission to any student earning a high-school degree or GED equivalent (although some programs, including engineering, do have restricted admissions). The STEM College is 72% male and 28% female. Most students in the STEM College are of traditional college age (80% less than 25 years old), are full time students (85%), and live off campus and commute (90% commute). The STEM College has a total enrollment in the fall of 2012 of 2,833 students, including 184 graduate and doctoral students, and 36 non-resident aliens. Engineering disciplines available at the urban, public institution studied include: chemical, civil, electrical, industrial, and mechanical.

Structure of Pathway to Engineering Disciplines for Both Schools

Neither school uses admission criteria other than completion of the First-Year Engineering Curriculum (including: an Introductory Engineering Course Sequence, mathematics, chemistry, physics, and English prerequisites) and student interest for entry into any of the majors. For most students, during the spring of their first-year, students select which discipline they plan to pursue starting in the fall of the next year. The students begin to take courses specific to their chosen disciplines at the start of sophomore year. At both institutions, the vast majority of students that discontinue their engineering educational studies 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 survey was administered during the fall of 2011 at the selective, private institution and in the fall of 2012 at the urban, public institution. The surveys were sent to all engineering students (sophomores, juniors, and seniors) and via the web using Survey Monkey®. The differences between the surveys administered at each institution were minor, including modifications for institution specific items such as the engineering disciplines offered. 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 that included correlation, ttests (two group unpaired), and regression modeling. These methods do have a normality assumption, but this is reasonable given the large sample size.[12] The approach for analysis was progressive, beginning with correlations to explore possible relationships between variables (a measure of association), followed by ttests and chi-square tests to determine which relationships are statistically significant.[13] These tests were foundational descriptive statistics to verify the research questions. Regression models were both traditional (the response variable having more than 2 outcomes) and logistic (with the response variable having a binary outcome).

Several of the survey questions were based on the WECE study,[5] 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 survey institutions were both predominately white, with small representations from specific races/ethnicities. 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.

A Summary of Potential vs. Actual Respondents

This section compares the potential respondents to the actual respondents by grade level, gender, engineering discipline, and ethnicity. At the selective, private institution there were 364 students that started the survey, with 240 complete surveys, for an overall response rate of 24.7%. And at the urban, public institution there were 96 students that started the survey, with 85 complete surveys, for an overall response rate of 23.5%. These data are further broken down by grade level in Table 1, by gender in Table 2, and race / ethnicity in Table 3. Women as a group comprised 35.4% of respondents, with uneven response rates in different class years. (It is speculated that the under-representation of female juniors in the survey might be due to the disproportionately large segment of that group that studies abroad in the fall semester.) 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.[14]

Table 1. Summary of Participants at Each Institution by Grade Level

	Selective Private			Urban Public		
	Actual Respondents	Potential Respondents	Response Rate	Actual Respondents	Potential Respondents	Response Rate
Sophomore	92	329	28.0%	24	103	23.3%
Junior	68	331	20.5%	25	118	21.2%
Senior	80	312	25.6%	36	141	25.5%
Total	240	972	24.7%	85	362	23.5%

Table 2. Summary of Participants at Each Institution by Gender

	Selective Private						Urban Public					
	Male			Female			Male			Female		
	Actual Respondents	Potential Respondents	Response Rate	Actual Respondents	Potential Respondents	Response Rate	Actual Respondents	Potential Respondents	Response Rate	Actual Respondents	Potential Respondents	Response Rate
Soph	48	220	21.8%	44	109	40.4%	13	83	15.7%	11	20	55.0%
Junior	53	249	21.3%	15	82	18.3%	21	105	20.0%	4	13	30.8%
Senior	54	229	23.6%	26	83	31.3%	29	116	25.0%	7	25	28.0%
Total	155	698	22.2%	85	274	31.0%	63	304	20.7%	22	58	37.9%

Survey respondents also indicated their race/ethnicity. However, the number of non-white survey participants was so small (especially at the urban public) that analysis on those responses could not be considered separately.

Table 3. Race / Ethnicity of Survey Participants at Each Institution

	Selective Private		Urban Public	
	# Respondents	% Respondents	# Respondents	% Respondents
Black / African American / African	9	3.80%	1	1.18%
Central / Southeast / East Asian	5	2.10%	1	1.18%
Hispanic / Latino	21	8.80%	0	0.00%
Indian Asian	10	4.20%	1	1.18%
Native American	1	0.40%	0	0.00%
Pacific Islander	1	0.40%	0	0.00%
Two or more	10	4.20%	1	1.18%
Other	21	8.80%	2	2.35%
White	192	80%	79	92.94%

Results / Discussion

This section presents the results of the survey along with a discussion. It begins with a summary of the survey response rates for specific questions with emphasis on gender. Finally, an identification of statistically significant factors from regression modeling is presented.

Response Comparisons by Gender

A comparison of survey responses is presented for the questions regarding consideration of leaving engineering, sources of encouragement/discouragement and involvements in student organizations (engineering, campus, and community).

Students were asked if they had ever considered leaving engineering. At the selective, private institution the peak time for considering leaving occurred between the second semester of first year and the first semester of sophomore year, while for the public institution the peak time was between the second semester sophomore year and first-semester junior year as shown in Figure 1. We believe this shift can be explained by the preparation level of the incoming students at each institution. At the private institution, all of the students begin with Calculus I and take a standard curriculum for First-Year students that also includes two semesters of Chemistry and a semester of Physics. At the public institution, in contrast, 50% of students start in a mathematics placement of Pre-Calculus or below, which also delays some of the foundational science courses required for the engineering disciplines. Further, the grade succession from year to year is much less clear at the public school in which a 4 year graduation rate is not the norm. Taken together, at both institutions, it is the time period when students hit some of the core, discipline-specific engineering requirements when students seem to question their decision to continue in engineering.

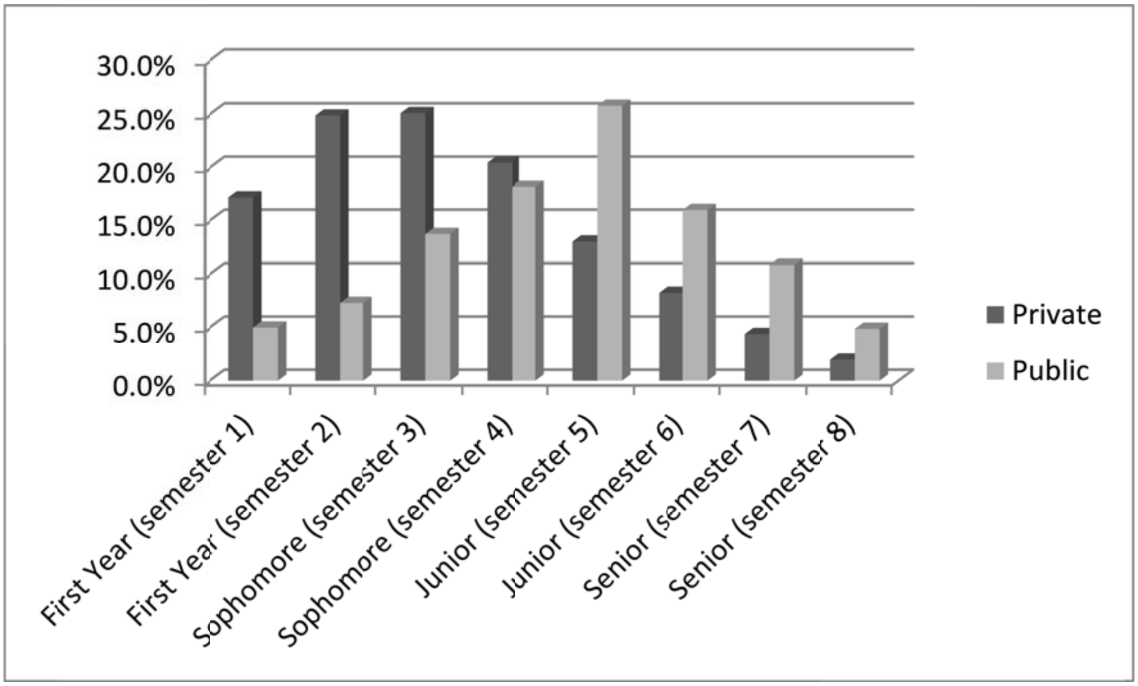

Figure 1. Percentage of Students that Considered Leaving Engineering

The percentage difference of male and female students considering leaving engineering was not statistically significant for either institution based on a two group unpaired ttest, which indicates that male and female students grapple with uncertainties related to pursing 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 surprising, given the roughly equivalent retention rates of men and women at the private institution studied, and given findings by Ohland and associates that reported that women engineering students persist at similar rates to male students and found few meaningful differences in terms of matriculation and persistence.[1] 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.

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 institutions considered in the current study, private and public, and the WECE report.[5] In terms of factors that were found to be considered encouraging towards continuing in engineering, the same top 4 factors were found in all three cases; however, the order (which is an indication of frequency) was different. The factors that students indicated were encouraging are shown in Table 4 and included interest in the subject matter, employment opportunities, parents, and salary potential. 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 was the same for both male and female participants -- yet another indication that the experience of female students is more similar than different from that of their male counterparts.

Table 4. Comparison of Sources of Encouragement and Discouragement in Engineering

	Factors Considered	**Private**	**Public**	**WECE**
Sources of Encouragement	Factor 1	Interest in subject matter	Employment Opportunities	Parents
	Factor 2	Employment Opportunities	Salary Potential	Interest in subject matter
	Factor 3	Parents	Interest in subject matter	Employment Opportunities
	Factor 4	Salary Potential	Parents	Salary Potential
Sources of Discouragement	Factor 1	Time required for coursework	Time required for coursework	Grades
	Factor 2	Grades	Quality of instruction in Engineering	Time required for coursework
	Factor 3	Pace of Courses	Grades	Quality of instruction in Engineering
	Factor 4	Competition in Engineering Courses	Pace of Courses	Interest in subject matter

This study also sought to better understand student engagement as evidenced by extracurricular involvement within engineering organizations, on campus, and in the community. Figure 2 summarizes responses for these questions. Overall, response data indicate that over 50% of students are involved with engineering organizations (at both the private and public institution studied), but only about 20% report being a leader or officer in an engineering organization (although women from the public institution indicate being leaders at a higher rate). Students at the private institution reported being involved on campus at a much higher rate than at the public institution, this is likely linked to the percentage of students who live on campus (almost all students at the private institution live on campus, while only 10-20% at the public institution live on campus). Approximately 15% of students at both the public and private institutions reported involvements in the community. Overall, male students reported the lower percentages of involvement than female students in all types of extracurricular organizations (and at both institutions).

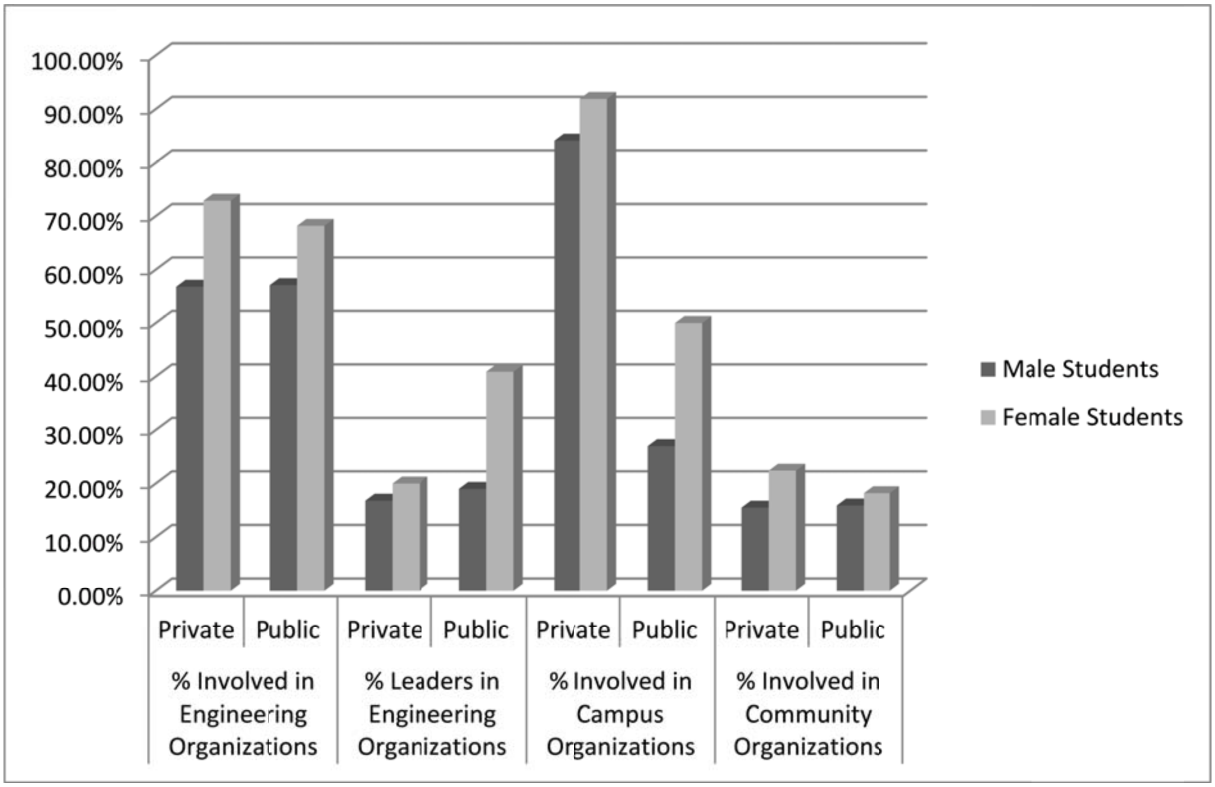

Figure 2. Summary of Male and Female Student Involvements

Plans for Professional Persistence

Lichtenstein and associates surveyed senior engineering students, asking how likely it was that they would be working in an engineering-related field three years post-graduation.[11] 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). 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.[11] Lichtenstein's results fell between the public (80%) and the private (58.5%) institutions, as shown in Figure 3. 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.[5] And in comparing the public and private institutions, overall the responses are shifted towards more affirmative plans for professional persistence at the public institution. Without qualitative feedback from students we can only speculate about this difference, but we suspect that this shift may be explained by the fact that many of the students at the private institution may have plans for further professional study post-graduation (business, law, medicine) that is not necessarily engineering related.

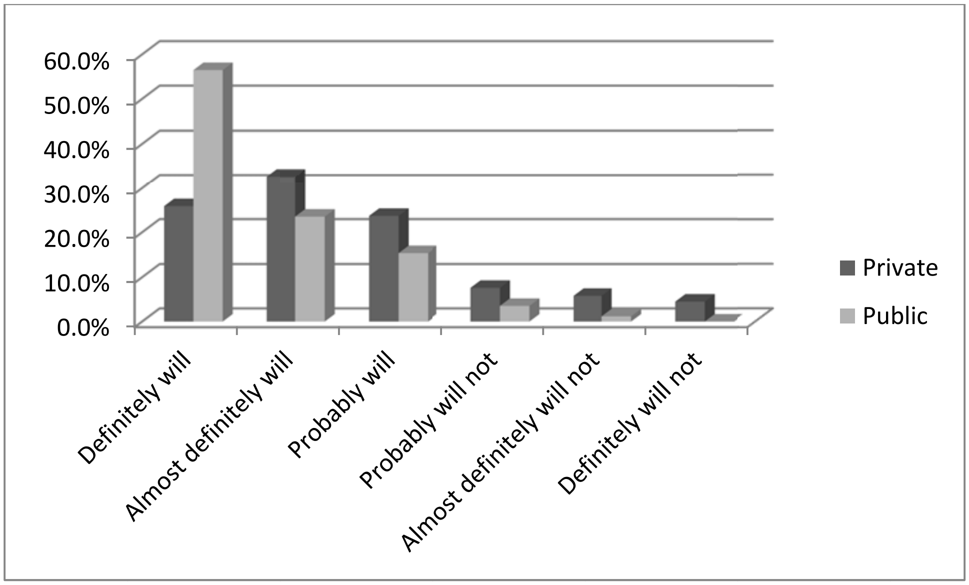

Figure 3. Professional Persistence Plans

Regression Models

Regression models were evaluated to try to understand the factors predictive of being involved in organizations within engineering, on campus, and in the community. A logistic regression model (with a binary outcome of either involved or not involved) was also developed for factors predictive of leadership in engineering or campus involvements. All models were based on the following independent variables: grade level, GPA, female, white, ever considered leaving engineering, and plans to work in engineering three years post-graduation. Statistically significant factors were identified. Table 5 summarizes the statistically significant regression model coefficients for both the private and public institutions studied. The models did not show the same factors to be predictive of involvement.

For the private institution, 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). The predictive factors for being involved with engineering and campus organizations were similar, but those for being involved in the community involvement were different. Specifically, the study identified a statistically significant correlation between both considering leaving engineering and planning not to work in an engineering-related field after graduation and involvement in off-campus community organizations. 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.

For the public institution, grade level was the only statistically significant factor in predicting engineering involvement. The campus involvement model also had one statistically significant factor, with those students with a higher GPA being more involved on campus. One potentially confounding factor is that a low percentage of students live on campus (10-20%), but of those who do live on campus many are Honors / Scholar students (on academic scholarship) and, consequently, are likely to have high GPA's. Finally, none of the factors included in the model were able to adequately predict community involvement.

Table 5. Regression Summary for Engineering, Campus, and Community Involvement

Independent Variables	Engineering Involvement		Campus Involvement		Community Involvement	
	Private	**Pubic**	**Private**	**Pubic**	**Private**	**Pubic**
Grade Level (Sophomore, Junior, Senior)	0.55**	2.12*	0.38*	-1.35	0.10	0.12
GPA	0.20	1.25	0.19	4.28***	0.13	0.44
Female	1.03**	1.05	1.02**	0.82	0.38	0.48
White	-0.47	-0.09	-0.15	1.53	-0.41	0.96
Consider leaving Engineering	0.08	0.73	-0.05	0.66	0.91*	1.03
Work in engineering related field 3 years post-graduation	0.38**	0.77	0.26*	-0.54	-0.26*	0.04

***p<0.05, **p<0.01, p<0.001**

Regression models for holding (past or present) a leadership role in an engineering organization were considered based on the same independent variables are summarized in Table 6. For the private institution, 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. For the public institution, grade level and GPA were predictive of engineering leadership. Previously we noted a relationship that women at both the public and private schools were more likely to be in engineering organizational leadership roles, but when controlling for all the other factors in the regression model it is not statistically significant.

Table 6. Regression Summary for Engineering Leadership

Independent Variables	Engineering Leadership	
	Private	**Public**
Grade Level (Sophomore, Junior, Senior)	0.18***	2.07*
GPA	0.04	2.47*
Female	0.28**	1.88
White	-0.15	-1.33
Consider leaving Engineering	0.01	0.73
Work in engineering related field 3 years post-graduation	0.11***	1.31

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

Conclusions:

An on-line survey was administered to engineering sophomores, juniors and seniors at two medium-sized, Midwestern, institutions one of a selective, private and one an urban, public. There were differences by institution, specifically the factors predictive of involvement in engineering, on campus, and in the community were not consistent (regression models); however, there were some commonalities including:

- The majority of students consider leaving engineering when they are faced with the first primary engineering courses in their major. There is believed to be both a transition to college and engineering as a first-year student, and again as students are integrated into their engineering department. It is early in the departmental experience that many students seem to question their educational path.
- Women and men (even from dissimilar institutions) have are similar experiences in terms of the factors they find encouraging (interest, employment opportunities, parents, and salary potential) and discouraging (time required, grades, pace of courses, and competition in courses).
- Women are involved in engineering, on campus, and in the community at higher rates than male students (even at dissimilar institutions).
- Students from the public institution indicate a higher commitment level towards engineering professional persistence.

Limitations of the current study include the survey design, which is based on self-reported data. Only students that have persisted in engineering were invited to participate in the survey. A study that seeks feedback from students that have not persisted in engineering is an opportunity for further research. Finally, the interpretations of collective survey responses would be strengthened if it were informed by qualitative feedback from each institution – this is an opportunity for future work.

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