AC 2011-332: FIRST YEAR WOMEN ON THE ENGINEERING PATHWAY: RESEARCH STRATEGIES TO SUPPORT RETENTION

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Introduction

This research was initiated to address two disturbing trends seen in undergraduate education at the national level and an equally disturbing trend within our own university, the University of Colorado at Boulder. While women have historically been underrepresented in STEM fields, the number of women in the biological and life sciences has grown to nearly one half, and nearly one third of chemists are women; nevertheless, women compose less than 15% of the engineering population.[1] Additionally, the proportion of women over the last 20 years has merely grown 5%, despite numerous efforts including scholarships, curriculum improvements, and mentorship programs across the country.[2] The declining retention rates in universities and slow growth occurs in spite of the fact that overall, the qualifications of women tend to be equal or slightly better than their male counterparts.[3] In addition, six-year graduation rates for women within our college fell below those of men for consecutive years, the first such occurrence since at least 1990, and there is a downward trend overall in retention into the second through fourth years (See Figures 1 and 2 below). This study was designed to address these trends by investigating the following six research questions about undergraduate women in engineering.

- Do women express a loss of interest during their program?
- Is there a chilly climate for women in the college?
- Do women's self-efficacy levels change during the program?
- Do academic performance levels play a role in women's retention in engineering?
- Do women have adequate support structures in the college?
- Does the structure of the academic program support career awareness in the first year?

The first five research questions were initially investigated by a pilot women's survey of the women currently enrolled in the College of Engineering at CU-Boulder.[4] The present study expands on the previous study in the following directions. First, we obtained a larger more demographically balanced data set through a second administration of the women's survey to see if our initial findings held up with a more robust sample. Second, we conducted seven focus groups to dig deeper qualitatively into the issues brought up in the survey administrations. Third, we focused on the population with the highest attrition rate, first-year women, by comparing their responses to upper-class students on the gender survey and by comparing gender differences on a second survey of first-year students in the college.

Literature review

Volumes of research have been produced in the field of retention for both women in Science, Technology, Engineering, and Math (STEM) courses and first-year students in general. This previously conducted research provides scaffolding for this study from which new work and intervention strategies can be developed. The attitudes, experiences, and goals held by students during the transitional period known as freshman year greatly impact a student's decision to remain in engineering.[5] Numerous studies have been conducted that address women in STEM or first-year students, but there is little work has been done that combines the two.

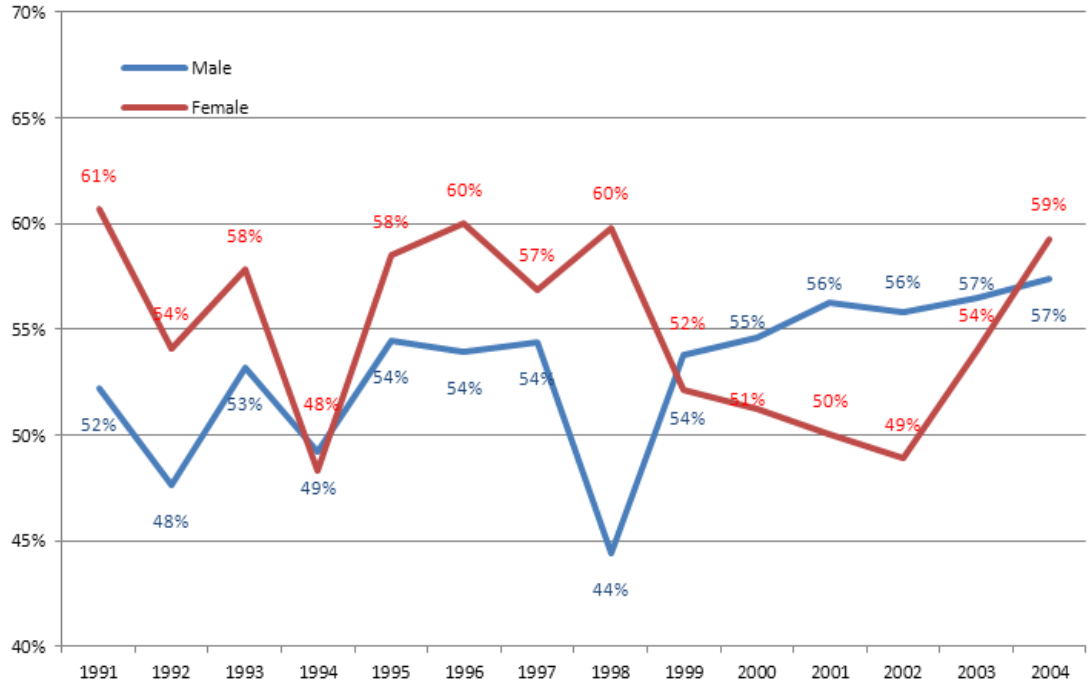

Figure 1: Six-year retention results by gender

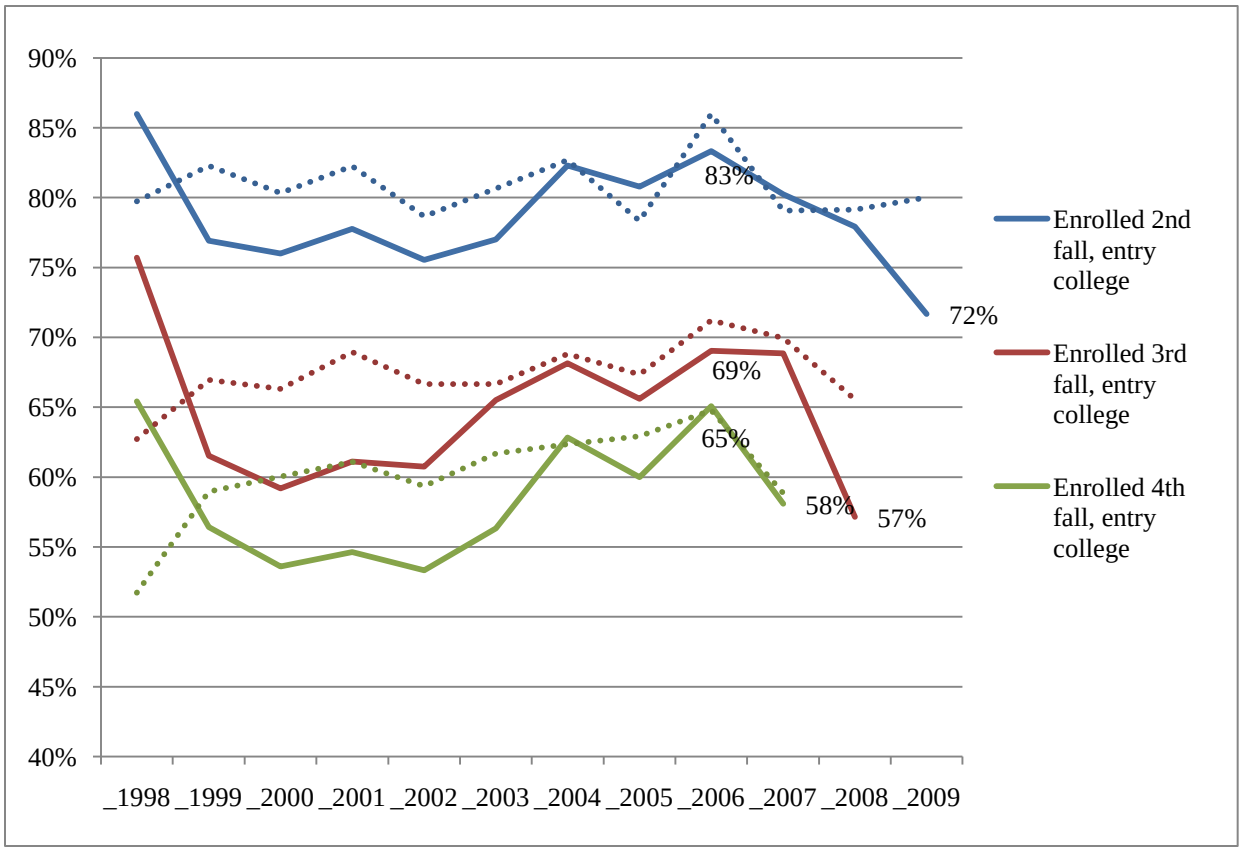

Figure 2: Women's retention rates, where the dotted lines refer to men's retention rates.

One of the most common reasons cited by women who leave engineering is losing interest in their studies, a topic that is addressed in this study's first research question. Women in science are more likely than men and women in other fields to state a "change in career interests" as a primary reason for leaving STEM fields.[6] Many students who enter engineering are often "pushed toward" engineering by a high school counselor, parents or even friends. Therefore, most students who leave do not exhibit a strong intrinsic motivation toward obtaining a degree in engineering.[7] In a study done for the Society of Women Engineers, in answer to the question, "what caused you to leave engineering," forty-seven percent, the highest percentage of responders, cited "interest in other careers" as their response.[8]

Gender-based discrimination against women can lead to what is known as a "chilly climate," which can foster a lowered sense of belonging.[6] In order to attract new and retain current women engineering students, the climate must be adapted to incorporate differing viewpoints and approaches to learning engineering. Male sexist behavior in engineering environments can be subtle and can induce social identity threat where one performs downward to stereotyped expectations, ultimately leading to underperformance on math-based exams by women engineering students. "Gender-inclusive engineering" is the practice of including women, their interests, and their learning styles, proposed as a strategy to counteract a chilly climate.

Self-efficacy, as defined by Bandura, is a "situation specific confidence in one's abilities."[9] Bandura goes on to say that: "Expectations of personal efficacy determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences." Therefore higher levels of self-efficacy will make students want to strive to not only finish their class work but do it well, and can be the foundation for greater student success. This model of self-efficacy applies to everyone in engineering, and is strongly related to women's persistence in engineering. It has been suggested that many talented women have a lower self-concept of their ability in mathematics and science which contributes to their decision to leave male dominated fields.

One's grade point average (GPA), the direct measure of academic performance, contributes to a student's decision to stay or leave a major. More specifically, the first-year GPA strongly influences student retention.[2] In a study at Central Michigan University, it was concluded that high school GPA remains the most powerful predictor of freshman-to-sophomore retention.[10] While it is believed that students leave engineering because of their grades, comparing the GPA's of women who leave and stay shows little difference between the two values.[11] This leads to the hypothesis that it is women's attitudes towards their grades rather than the grades themselves that cause the attrition.

In order to further excite and encourage students, a variety of support systems have been created, researched, and implemented in colleges and universities everywhere. Studies have shown that women who participate in STEM support systems have higher retention rates than both men and women who have not participated in such programs. It has also been shown that support programs that are rooted in viewpoints that are "institutional/structural-centered" instead of "individual/student-centered," are associated with the most positive outcomes. The implication is that changing the way business is done is more effective in increasing retention than molding student attitudes to match the environment.[6]

Finally, this research looks at the development of career awareness for women. Research has found that only 84.4% of women students believe that they will be working as an engineer ten years from now, compared to 92.4% of men who were asked the same question.[12] Other research that questioned first-year students regarding their thoughts about leaving engineering showed that most students felt "pulled" (81%) away from engineering toward another career as opposed to being "pushed" (19%) out of engineering.[13] These findings beg the question of whether students, particularly women, know what they are getting into when they decide to major in engineering.

Method

The participants in this study were all undergraduate students majoring in engineering. Data were collected from two surveys and seven focus groups. The women's survey assessment included 288 participants, comprising a 49% return rate, who were students in the CU College of Engineering during the 2009-2010 academic year.[4] Table 1 provides an example of survey questions. Respondents to this survey included women from all 12 engineering majors (see Figure 3 below) offered in the college and represent all four undergraduate years. Unlike the pilot study, this dataset was comprised of a more representative sample of GPA's with the majority of participants indicating a GPA between a 3.40 and 2.50, as can be seen in Figure 4 below.

Data were collected on a second survey of first-year students in the college. This survey assessment is conducted annually by our College of Engineering and Applied Science. Data from the most recent administration, the 2009-2010 academic year, were analyzed in this study to provide another window into the first-year experience and to compare responses between men and women students. This survey generated 239 responses from first-year students, 67 women and 172 men.

Seven focus group interviews were conducted to collect information that supported the research questions we have been investigating (see Appendix A for questions). One group included only junior and senior women who majored in aerospace engineering. A second group was a mixed gender group comprised of sophomores through seniors. The final five groups were first semester women.

Results and Discussion

This section will be organized around the six research questions for the study. Each subsection will present the main findings from the previous study, a review of these findings in light of the larger dataset for the gender study, a breakout of the first-year perspective, and supporting evidence from the focus groups.

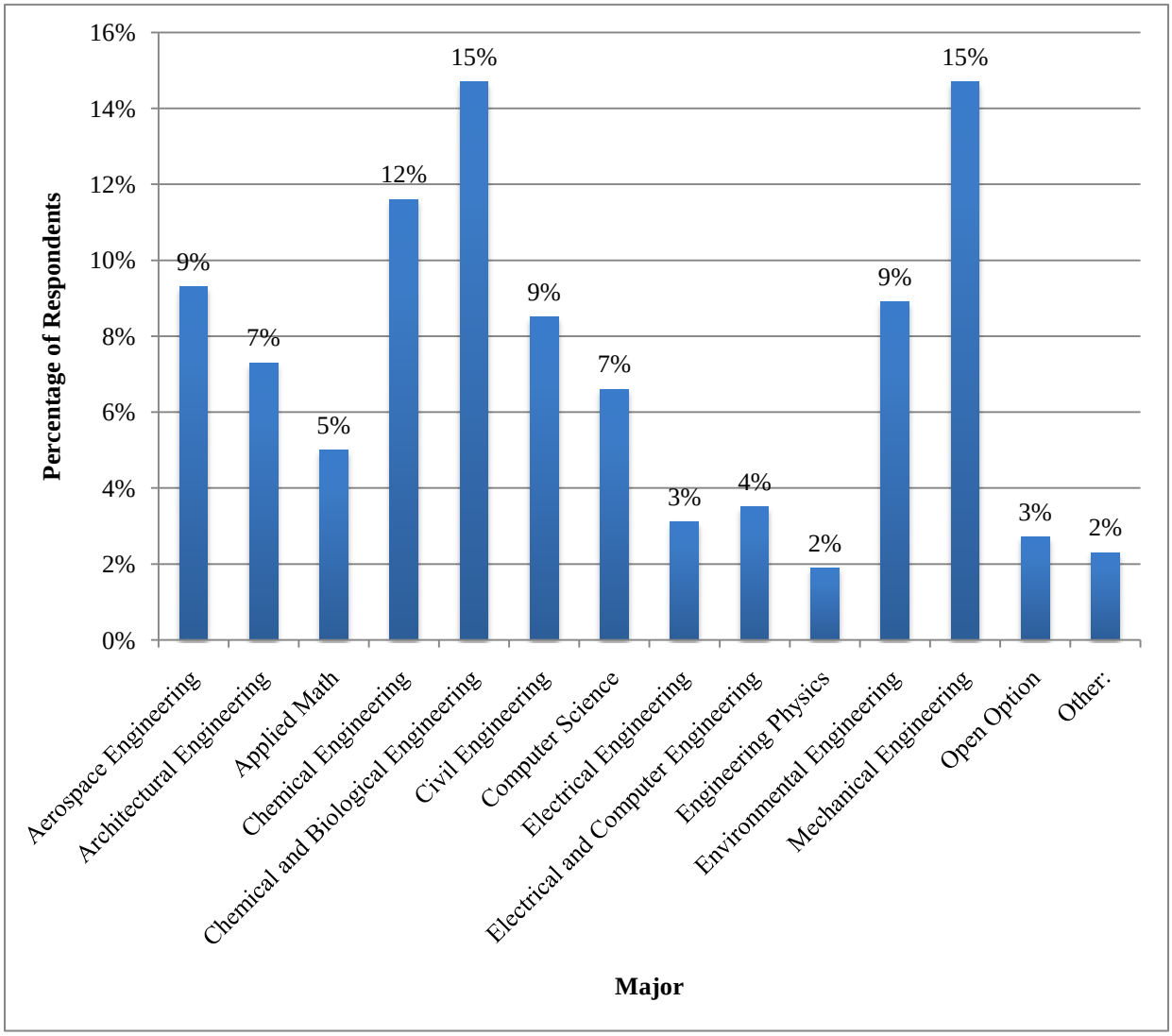

Figure 3: Distribution of majors of participating students

Table 1: Representative Survey Questions

Scale Used	Purpose	Representative Question
AWE	Inclusiveness	To what extent do you agree? (e.g. I have a lot in common with other students in my classes.)
AWE	Self-Efficacy	To what extent do you agree? (e.g. I can succeed in an engineering curriculum.
APPLES	Motivation	We are interested in knowing your main reasons for choosing engineering as your major. Please indicate below the extent to which each of the following reasons apply to you: (e.g. I think engineering is interesting.)
APPLES	Satisfaction	Please rate your satisfaction with this institution on each aspect of campus life listed below> (e.g. Academic Advising.)

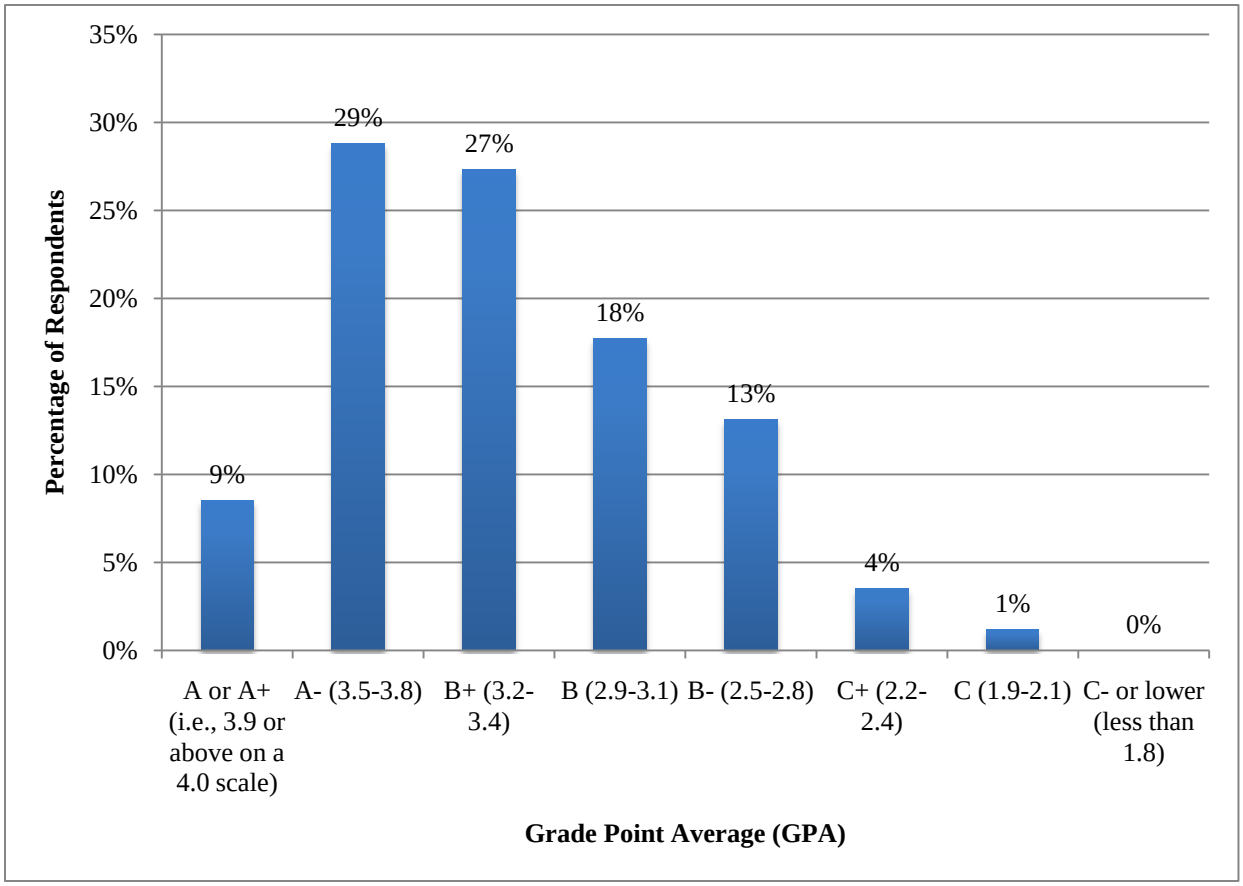

Figure 4: GPA percentages of participating students

Q1: Do women express a loss of interest during their program?

In the previous study, 87% of women maintained or gained in interest in getting a degree in engineering while in the present sample 78% maintained or gained in interest as shown in Figure 5. For the first-year students, this number was 76% and interest did not vary between women and men. All of these numbers are higher than previous research which found that 31% of women had lost interest in engineering after the first year. Focus group data found women developing their interests as they progressed into more discipline-specific courses, but general courses during the first year were particularly hard on students' interest in engineering. One first-year woman opined about her general chemistry class, "I loved chemistry in high school, but this class is killing my passions. I haven't met anyone who likes chemistry; the 400 person lecture class has shrunk to half, and everybody has lost respect for that class. It's obvious that this is a weed-out class. I'm glad I don't have to take another general chemistry class."

Q2: Is there a chilly climate for women in the college?

Results indicated an accepting climate with 77% from the pilot group and 77% from the new gender survey dataset in agreement. Results from the first-year survey did not indicate any difference between genders on the climate issue. During the focus group discussions, the majority of women did not feel treated differently as a woman, although a few pointed out subtle indicators. One commented, "Guys don't realize if they are making sexist behavior; sometimes they make assumptions or have stereotypes ingrained in them."

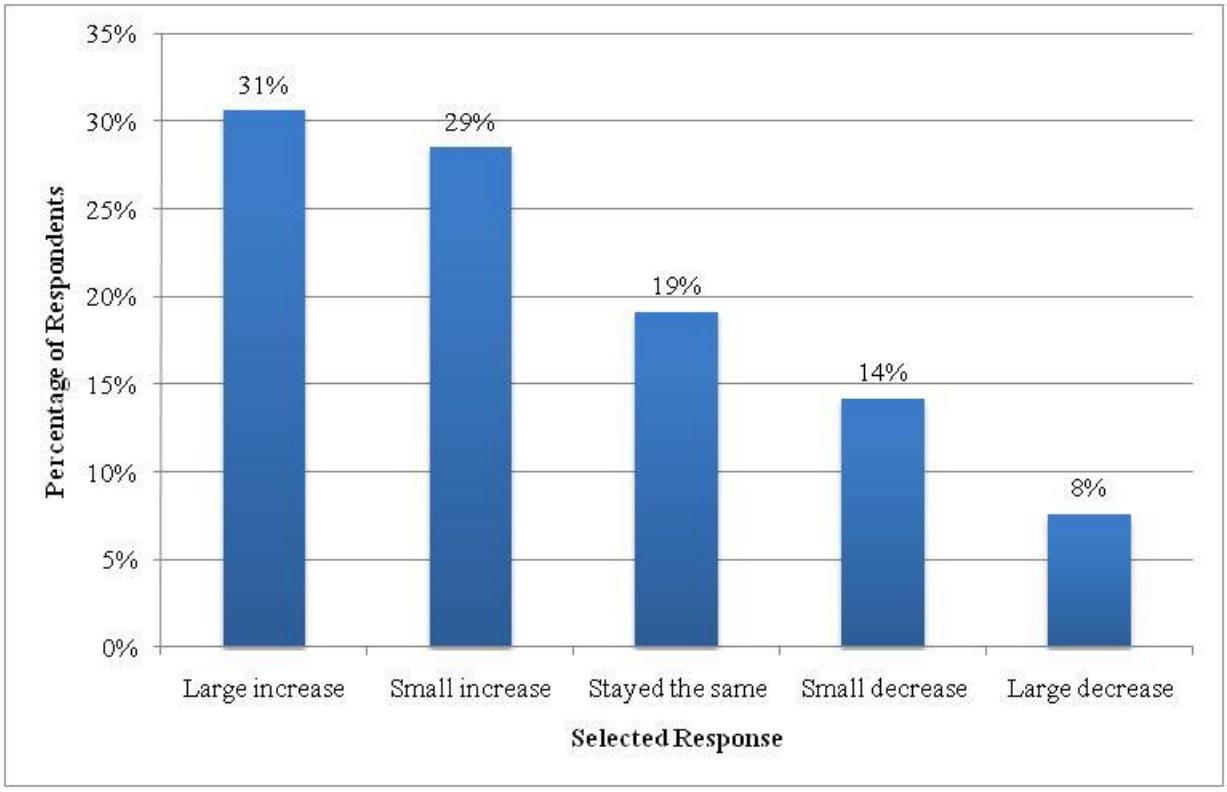

Figure 5: Response to the question: "To what extent has your interest in getting a degree in engineering increased or decreased since entering engineering?"

Q3: Do women's self-efficacy levels change during the program?

Similar to the first study, women scored quite high on the self-efficacy scale with 94% of women overall and 93% of first-year women confident that they can succeed in an engineering curriculum. As with the first study the main deviation from this pattern is the scale item referring to being able to succeed without giving up one's outside interests with only 60% of women overall and 62% of first-year students believing they can study engineering and maintain outside interests. It should also be noted that men scored significantly higher ($p < .05$) than women (mean = 4.19/5 vs. 3.82/5) on the first-year survey question, "How certain are you that you will stay in engineering until graduation." Focus groups confirmed that women see their extracurricular activities as crucial, with one stating they allow her to "keep my sanity when the course work gets really difficult," and another stating, "they're a much needed break in the midst of all the never-ending work."

Q4: Do academic performance levels play a role in women's retention in engineering?

With the high performing demographic in the previous study, academic performance did not emerge as a significant problem. While GPA is more rounded in the present study, still very few students are in danger of failing out. What have emerged instead are the higher standards that women hold themselves to and the retention risk that emerges for women if they don't live up to their own expectations. In the present study, only 53% of women were satisfied with their academic performance (see Figure 6), 44% had thought about dropping out because of a grade they received, and 41% found their academic performance to be different from what they expected coming out of high school (see Figure 7). This trend worsens for first-year students

with 42% satisfied with their grades, 50% who thought about dropping out because of a grade and, 67% finding their performance different from their expectations. One woman expressed concern after receiving a grade lower than a C- (required for progressing on to the next course in engineering majors) and stated, “I didn't receive a C- my first time taking Thermodynamics and seriously considered changing my major.”

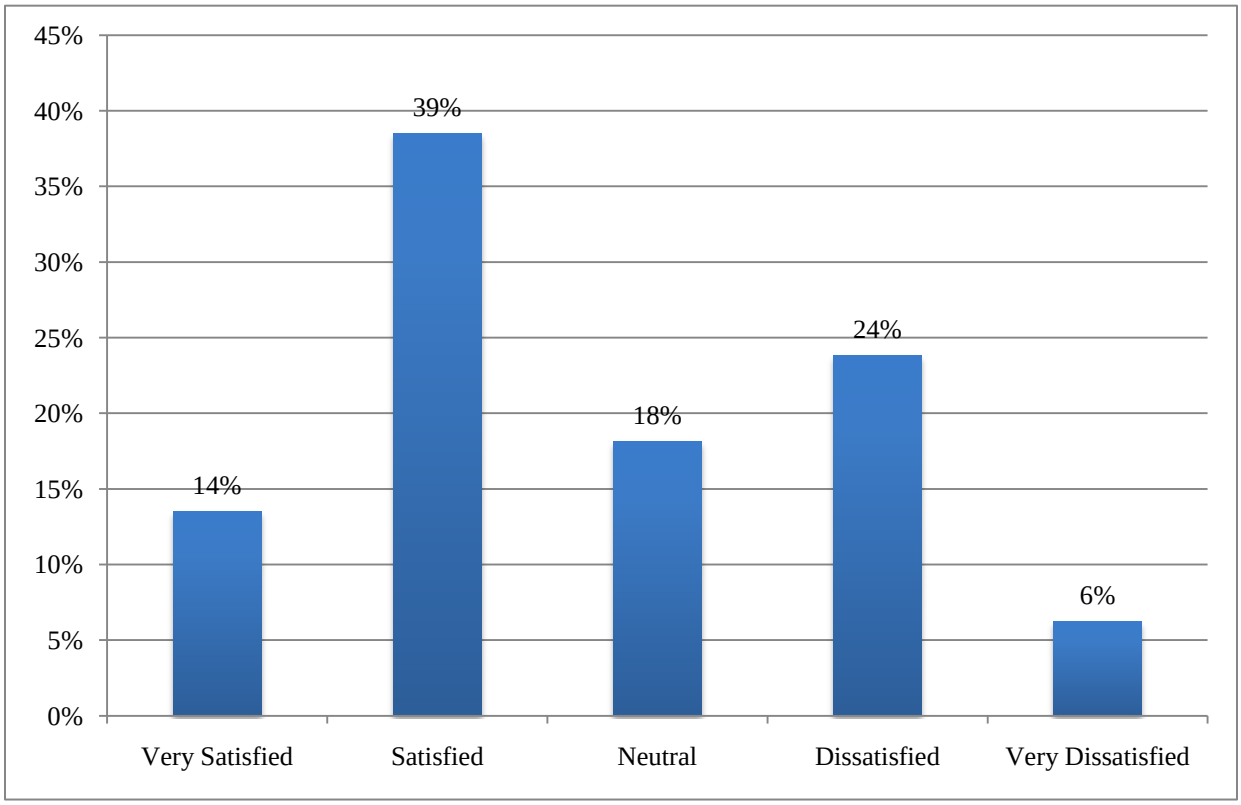

Figure 6: Response to the question: "How satisfied are you with your academic performance?"

Q5: Do women have adequate support structures in the college?

This area emerged as a problem area for women in the previous study with mentoring, advising and financial aid all found lacking. These concerns held in the broader sample with the majority of women expressing dissatisfaction with their advising (51%) and mentoring (61%). Similar concerns were found at the first-year level where 49% were dissatisfied with advising and 58% were dissatisfied with mentoring. Similarly 77% of women were on financial aid, but 67% found the aid inadequate. Results from the first-year survey did not find differences between the genders on dissatisfaction in these areas, but two other interesting differences emerged. One difference was that women found their housing situation more supportive than men (mean = 4.05/5 vs. 3.61/5) and first-year women were more likely to seek assistance from a TA or professor outside of class (mean = 3.72/5 vs. 3.02/5). This last finding suggests a greater importance of support structures for women. Overall, these findings were supported during the focus groups where women were largely unaware of mentoring and its benefits. Other women in the focus groups felt certain that they knew more about the requirements of their major than their advisor.

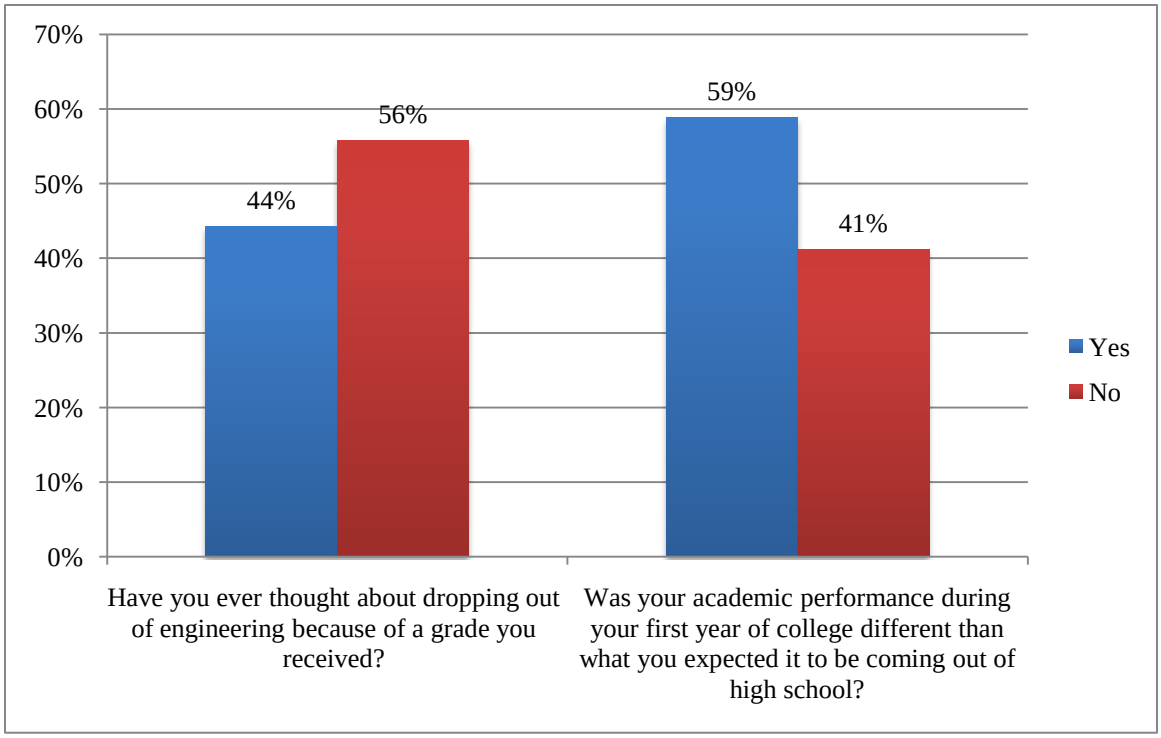

Figure 7: Views held about academic performance.

Q6: Does the structure of the academic program support career awareness in the first year? This research question was added this year with the additional focus on the first year. This question is assessed via a Likert-style, 1-5 response format survey question on the first-year survey. Figure 8 presents the results.

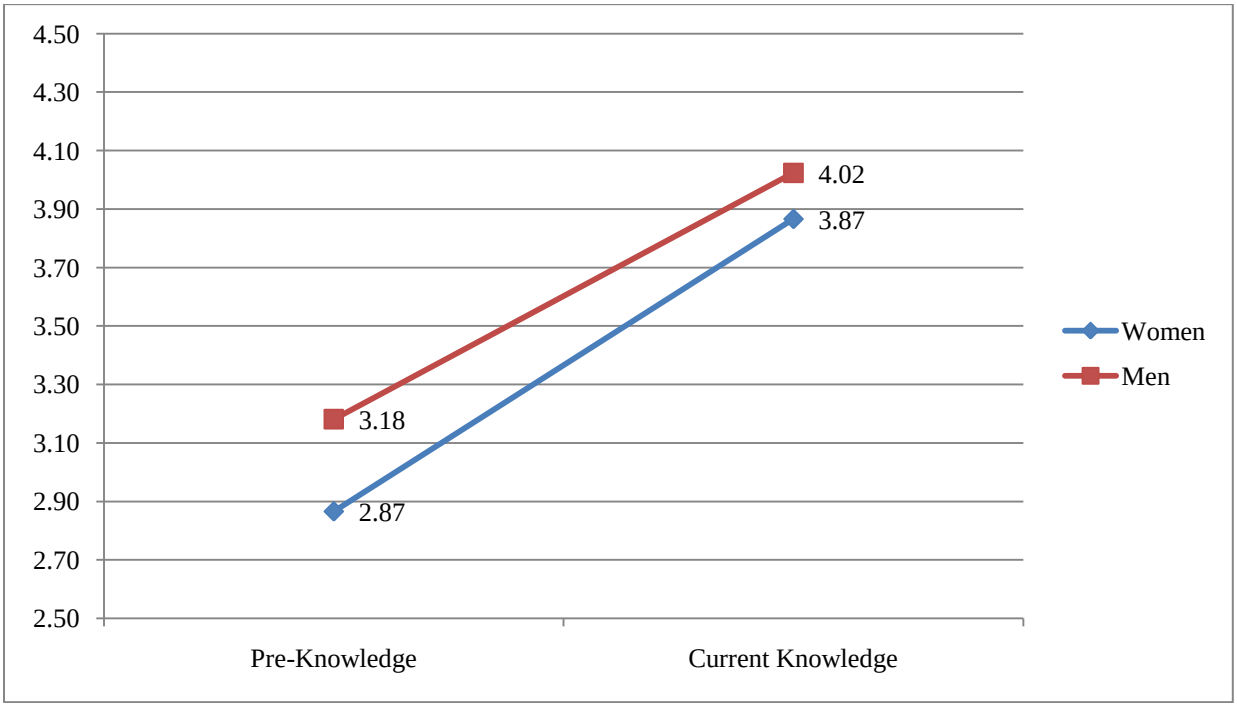

Figure 8: Gains in knowledge of engineering as a career for first-year women and men

This question asks students about their level of career awareness before enrolling in the College of Engineering and then asks them for their current level of awareness at the end of the first year. T-test analyses found a significant difference ($p < .05$) at the pre-assessment with women less aware of engineering as a career than men. This difference became non-significant ($p > .05$) at the post-assessment indicating a closing of the gap in career awareness between women and men during the first year

Conclusions

Results from the expanded sample for the women's survey largely supported findings from the pilot assessment. Our women were interested, confident and felt accepted into the college and engineering. They did not struggle with concerns about failing out, rather they thought about leaving the college for failing to live up to their own high expectations. In general, women again found advising, mentoring and financial aid to be below expectations.

New findings did emerge with a focus on the first-year population. First-year women appear vulnerable to losing interest in engineering during their introductory science classes. These "weed out" classes take a heavy toll on women who have often developed a personal connection with course content. Another finding is that first-year women are more at-risk due to disappointments over their GPA, presumably due to the jarring contrast between their current and high school performance. A third finding is that women have less awareness of engineering as a career than males before they arrive at the university. Finally, there is a greater likelihood that women will seek out additional support outside of the classroom.

The fourth finding, that first-year women are more likely to seek support than men, sets the stage for the main implications for this study, the need to increase support structures for women, especially during the first year. To that end, a first-year mentoring program is being piloted this year. It is hoped that this program will help first-year students modify their expectations about initial academic performance and survive the dreaded "weed out" classes. Future research will evaluate the impact of this program.

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Appendix A: Focus Group Question Route

Questions:

1. Warm-up Question (~5 min): How have you found friends so far in the college of engineering?
    - *Probe:* Do you do extra-curricular activities with your friends? If you had infinite time on your hands, what sorts of things would you do? What is preventing you from doing these things now? What about a job during school?
    - *Purpose:* Dig deeper on disturbing trend where women reported a smaller confidence to succeed in engineering if extracurriculars were involved. Also will attempt to understand the importance/lack of importance of extracurriculars.
2. Defining "Success" Question (~10 min): What does "success" look like in engineering to you or your friends?
    - *Probe*: How do you feel about that definition of success? Do you think your definition of success is different from other people's definitions in the college? What do you think success looks like for students in other fields or colleges?
    - *Purpose*: The survey often asks about evaluating "success", but never asks the respondents to identify what success looks like for them.
3. Climate Question (~10 min): How welcoming has the college and/or your department been to you as a woman?
    - *Probe*: What kinds of groups are you involved in which are supportive of you as a woman? How important is it for you to have groups which support you as a woman? Have you ever felt treated differently because you are a woman?
    - *Purpose*: To identify if women like programs which acknowledge their gender, or if it further isolates them? Also can be used to evaluate the impact of services provided by the BOLD Center, SWE, and other groups.
4. Mentor Question (~10 min): What is a mentor to you as an engineering student?
    - *Probe:* Describe mentoring experiences you have had since entering college or before college? What do you talk about with them? How did you find them (e.g. university, family, industry)? If the university were to initiate a mentorship program for women in the college, what kinds of qualities would be important to you for matching you with a mentor (is gender an important quality)? How important or not important is it for you to have a mentor?
    - *Purpose*: Our survey data reveals that very few female students are connected to university mentors. Mentorship is also strongly correlated to overall retention.
5. Course-Specific Question (~10 min): Are there any courses or professors that are currently impacting your decision to continue in your program.
    - *Probe:* What aspects of the course or professor were most impactful? What about the intro to engineering courses, (GEEN 1400, Departmental intro courses, math, science, computing)? In particular, what are your opinions about

the Calculus courses? Discuss any impact of your courses on the development of your knowledge of the engineering profession?
    - *Purpose:* Provide departments with targeted feedback which can guide their curriculum changes.
6. Supportive Housing Question: Tell us about your current housing situation.
    - *Probe*: How would you compare yourself to your roommates? Where, in terms of location, do you like doing your school work?
    - *Purpose*: The survey revealed that many women do not find their housing situation supportive of their school work. This question attempts to dig deeper on what aspects of their housing are supportive or not supportive of their success in engineering.
7. Open-Ended Question (~10 min): Is there anything we did not cover that would you like to talk about?