



DIVERSIFYING STEM: INCREASING WOMEN'S PERSISTENCE ON THE TRANSFER PATHWAY IN ENGINEERING AND COMPUTER SCIENCE

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ABOUT SWE

The Society of Women Engineers (SWE), founded in 1950, is the world's largest advocate and catalyst for change for women in engineering and technology. The not-for-profit educational and service organization is the driving force that establishes engineering as a highly desirable career aspiration for women. To ensure SWE members reach their full potential as engineers and leaders, the Society offers unique opportunities to network, provides professional development, shapes public policy, and provides recognition for the life-changing contributions and achievements of women engineers. As a champion of diversity, SWE empowers women to succeed and advance in their personal and professional lives. For more information about the Society, please visit www.swe.org.

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EXECUTIVE SUMMARY

As our society seeks ways to diversify science, technology, engineering, and mathematics (STEM) professions, we must recognize and support the various higher education pathways that are now open to students interested in obtaining a STEM baccalaureate degree. Many women and other underrepresented groups in STEM begin their postsecondary education at a community college, so encouraging and supporting students on the transfer pathway is critical for addressing issues of diversity in STEM.

The Society of Women Engineers (SWE) is committed to supporting and empowering women in engineering and technology. As a professional engineering society aimed at increasing diversity and inclusion in the profession, we seek to develop programs and services to meet the needs of students and professionals, wherever they may be on their educational and career journeys. SWE's desire to better support women who begin their education at a community college prompted the organization's research efforts to gain a better understanding of the transfer landscape and the experiences of women and other underrepresented groups on this pathway.

In December 2017, SWE released its first research report on the success of community college transfer students in engineering and computer science. The 2017 study showed that women who declare an engineering or computer science major are more likely than men to switch out of these majors prior to obtaining their baccalaureate degrees. This report describes a second study aimed at understanding factors that contribute to success and identifying challenges that women and other minoritized students in STEM experience prior to transfer, with the goal of informing the development of programs and services to support them along this pathway.

In collaboration with the University of Washington Center for Evaluation & Research for STEM Equity (CERSE), SWE conducted a mixed-method study of students in engineering and computer science at three different community colleges in Texas. We surveyed over 400 students to capture information on their engineering self-efficacy, motivations, and confidence. We also interviewed students and faculty to help us better understand the community college experience for students marginalized in engineering and computer science. The interviews allowed us to identify key supports that students received and the barriers they faced on the transfer pathway.

Below is a summary of our key findings and recommendations. These recommendations are aimed at institutional leaders, professional societies, industry partners, and other organizations interested in improving support for transfer students.

- **Improve advising for transfer students.** Students in our study reported feeling uncertain about the help they receive from their college advisors – over one-quarter of survey respondents were dissatisfied with advising on their campus. Faculty we spoke with expressed an expectation that students should be proactive in reaching out to the transfer institution for information about courses they should take at the community college. While a number of students interviewed indicated that they were able to find the help they need despite somewhat inconsistent advising, students who are unsure how to navigate the college environment or transfer process may be falling through the cracks.

- **Provide more financial support.** For many students, cost is the primary reason for beginning their baccalaureate degrees at a community college and continues to be a concern throughout their college career. About one-third of survey respondents reported lack of finances was likely to cause them to withdraw from classes or college. Some students in our study spoke of the impact working full-time while taking classes had on their ability to make time for school-related activities, including enrolling full-time and participating in clubs or organizations. Scholarships and other forms of financial support could help give students more time to focus on their engineering and computer science studies. Paid internships and other forms of employment that expose students to hands-on engineering projects while also providing monetary support as they pursue their education could help retain students in engineering and technology programs.
- **Provide more information about career pathways.** Over half of the students in our study expressed limited or no knowledge about the engineering profession prior to entering college. Few students indicated that parents or mentors influenced their decision to pursue engineering, while school-related experiences were cited as the most frequent form of exposure. Survey responses show that women learned less about engineering as a profession during their time at community college than men. Students we interviewed reported that learning more about the range of opportunities available within engineering and technology would help them narrow their choice of major and develop plans for their future. Fostering connections with professional engineers could be very valuable for women in community college by exposing them to the different career paths and opportunities available if they complete their degrees.
- **Strengthen interpersonal relationships, networking, and mentorship.** Students stated that they knew that involvement in extracurricular activities could benefit them academically, socially, and professionally. While a number of students we interviewed said that they were interested in joining professional societies, few were members of such organizations. Women in community college could benefit from events that allow them to engage with professional women engineers or interact with university students who have successfully transferred into engineering and computer science majors from a community college. Connections with engineers could help encourage mentorship and build professional networks, and fostering relationships with university students could help ease the transfer process.
- **Focus on boosting confidence.** Consistent with prior research, women in our survey tended to be less confident in math and science than men. Research suggests that interventions such as providing opportunities for undergraduate research and connecting women with same-gender STEM experts can counteract stereotypes and increase women's confidence. Increasing women's confidence can have a measurable impact on both performance and persistence in STEM.

INTRODUCTION

In December 2017, the Society of Women Engineers (SWE) released its first research report focused on the transfer pathway in engineering and computer science in Texas. The findings from this exploratory study of 10 years of education data were eye-opening. Three observations were of particular interest. First, more women than men transfer to complete their baccalaureate degrees, but very few women who transfer are selecting engineering or computer science as a major. Second, among those women who began their studies at a community college and declared a major in engineering or computer science at some point, a significant number were switching out of those majors and graduating with bachelor's degrees in other disciplines. Third, community college transfer students majoring in engineering or computer science have similar (or better) rates of degree completion than those students who begin their studies at a four-year institution.¹

More women than ever are entering college and obtaining bachelor's degrees in the U.S. In 2017, 56% of total undergraduates were women, and 57% of all bachelor's degrees awarded were earned by women [1]. Unfortunately, women in engineering and computer science fall far below these figures, and remain underrepresented in enrollments and degrees earned in these fields. Though the number of engineering baccalaureate degrees earned by women has almost doubled since 1995 to more than 27,000 in 2016-17, this is only 20% of the total enrollment in engineering baccalaureate degree programs in the country [1]. In computer science, the number of baccalaureate degrees earned by women declined until 2010, in both actual headcount and proportion of total. In 2016-17, the number of computer science degrees earned by women exceeded 13,000, but represented less than 20% of the total degrees earned in computer science[1].

Community colleges provide a pathway for many students interested in pursuing higher education, but who seek a more flexible and less expensive alternative to a traditional four-year university program. Among the millions of undergraduates in the U.S., 25% are older than 25 years of age, and approximately 40% work at least 30 hours per week [2]. Over 40% of undergraduates in the U.S. attended a public two-year college in 2017-18 [1]. Between 2010 and 2017, almost half of U.S. baccalaureate degree earners had done some coursework at a community college, and almost 20% had earned an associate's degree [3].

The National Academy of Engineering (NAE) has highlighted the importance of community colleges in broadening participation in engineering because of the diversity they represent [4], [5]. In fall 2017, approximately 43% of Hispanic undergraduates, 42% of American Indian/Alaskan Native undergraduates, and 35% of Black undergraduates were enrolled in two-year institutions across the United States [1]. Among women, 31% of undergraduate students were enrolled in two-year colleges in fall 2017 [1]. More support for students on the transfer pathway into engineering could yield greater diversity in the profession, given that over 80% of first-time community college students indicate that they want to complete their bachelor's degree or higher [6]. The National Student Clearinghouse [7] has also found that over 60% of associate degree earners go on to enroll in a four-year institution within the next six years, and this percentage is higher for those who were 20 years old or younger when they earned their associate degree.

¹ To read SWE's report, *Diversifying STEM: Student Success and Community College Transfer in Engineering and Computer Science in Texas*, visit <https://research.swe.org/>.

Given that (1) approximately 15% of two-year college students declare a major in engineering or computer science, (2) over 65% of students who declare an engineering major and transfer to a four-year university eventually complete an engineering baccalaureate degree, and (3) many underrepresented groups (including women and minorities) begin their education at a community college, the transfer pathway to an engineering or computer science degree shows great promise in helping us increase diversity in these fields [8], [9].

The challenge we face is that only 33% of community college students, regardless of major, successfully transfer [10]. In addition to low transfer rates, women who begin their engineering and computer science studies at a two-year institution have higher rates of switching out of these majors than their male counterparts [11]. One computer science faculty member from our current study has observed this phenomenon directly:

In my classroom, when it is an introductory course, you see among 20 students, 30 students, it's almost half and half, 50-50, and sometimes the female students are actually dominant compared to the male students at the introductory-level courses. When we get to the advanced courses in computer science, we are lucky if we have two or three female students.

Building on the findings of SWE's first report, SWE partnered with the UW Center for Evaluation & Research for STEM Equity (CERSE) to conduct a mixed-method study of community college students in engineering and computer science. This study investigates the differential rates of persistence in engineering and computer science among men and women on the community college transfer pathway, with the aim of identifying programs, services, and additional supports that could help women and other minoritized students persist to earn an engineering or computer science baccalaureate degree.

For the remainder of this report, we will refer to engineering and computer science as "engineering" to limit repetition.

METHODS

Our mixed-methods approach allows for a quantitative exploration of differences in the community college engineering experience based on gender identity. Our qualitative approach provides a deeper look into dimensions of this experience for women on the transfer pathway and their perception of factors contributing to success.

QUANTITATIVE METHODS

Survey data were collected from 414 students aged 18 or older at three community colleges in Texas between April and September 2019. The survey captured information on students' self-efficacy, motivations, and confidence in engineering using previously validated measures from the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) [12] and the Academic Pathways of People Learning Engineering (APPLES2) [13]. Scores for each multi-item measure were calculated and normalized to a 0-100 scale, and the means of these measures were compared across gender and race/ethnicity groups using independent samples t-tests. The survey items that contribute to each scale are reported in Appendix B. Respondents also provided information on their educational history, current area of study, and intentions to pursue a baccalaureate degree and career in engineering. Intentions to pursue a baccalaureate degree and career in engineering were compared between gender and race/ethnicity groups using chi-squared tests. Logistic regression was utilized to examine the relationships between intentions to pursue engineering and demographic characteristics, motivation, inclusion, and efficacy measures.

QUALITATIVE METHODS

The research team conducted eight qualitative interviews with students recruited from the pool of survey respondents. Students were contacted if they indicated a willingness to participate in an interview, identified as a woman², and expressed an intention to pursue a bachelor's degree in engineering. In order to develop an understanding of factors contributing to success for students most marginalized in engineering, recruitment efforts were primarily targeted toward students from groups minoritized in STEM (URM³: American Indian or Alaska Native; Black, African, or African American; Hispanic, Latino/a/x, or Chicano/a/x; or Native Hawaiian or Pacific Islander). Interviews were transcribed and coded using Dedoose software. A coding scheme was developed inductively based on commonly occurring themes and themes relevant to existing literature. The aim of this study was to identify factors contributing to persistence of women in engineering, so particular attention was paid to respondents' reflections on both supports received and barriers faced in their pursuit of engineering at a community college.

Four community college faculty members who teach engineering (or pre-engineering) students were also interviewed for this study. Their observations of the institutional supports and barriers were useful in helping the researchers understand the experiences of students on this pathway.

² The one respondent identifying as genderqueer/nonbinary was not recruited because they did not provide an email address for interview follow-up.

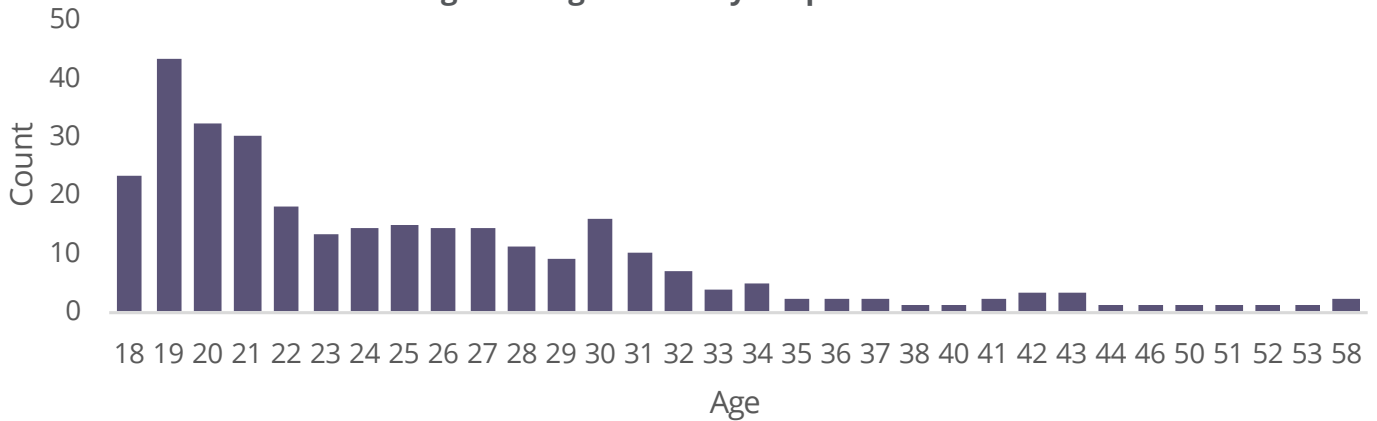
³ For the purposes of this report, we use the term "underrepresented minority" (URM) as a shorthand to describe racial/ethnic groups minoritized in STEM while acknowledging that the term overlooks the social/historical processes that result in the underrepresentation of some groups.

Table 1: Survey Respondent Characteristics

	Frequency	Percent
Institution:		
School A	225	54.3
School B	24	5.9
School C	165	39.9
Total	414	100.0
Gender:		
Women	106	32.8
Men	210	65.0
Genderqueer/nonbinary	1	0.3
I prefer not to answer	6	1.9
Total	323	100.0
URM status:		
Non-URM students	160	49.1
URM students	157	48.2
I prefer not to answer	9	2.8
Total	326	100.0

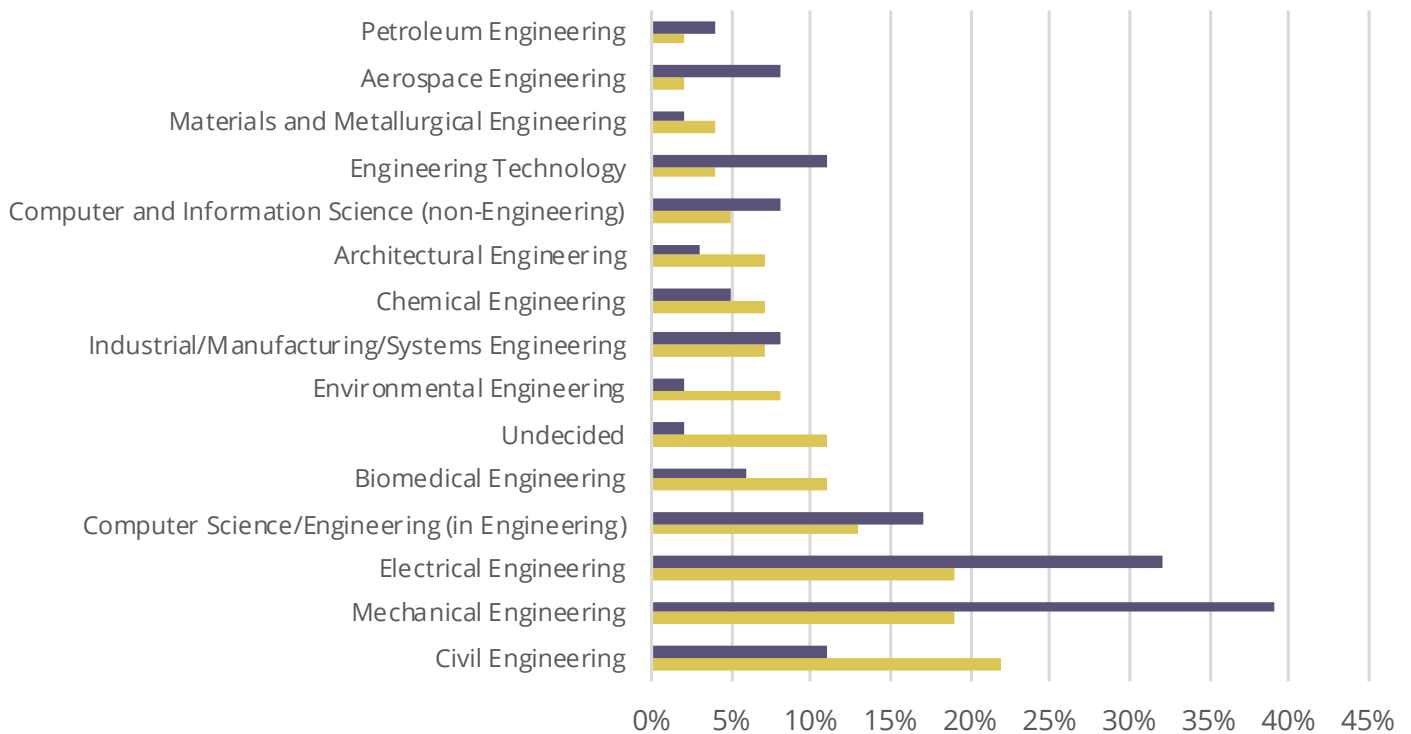
As shown in Table 1, the majority of survey respondents attended School A (54.3%), with another 39.9% from School C and 5.8% from School B. Of the participants who provided gender information, 32.8% were women. Students who responded to the race and ethnicity items were evenly split between groups minoritized in STEM and groups that are represented in STEM at rates proportional to their representation in the United States more broadly (non-URM: White or European-American; non-black Middle Eastern, North African, or of Arab Ancestry; or Asian). The mean age of respondents in years was 25, with a minimum of 18 and a maximum of 58 (Figure 1). On average, students participating in interviews were slightly older than survey participants. Interview participants were also more likely to be from racial/ethnic groups minoritized in STEM due to intentional recruitment efforts. Detailed demographic characteristics of survey and interview respondents are reported in Appendix A.

Figure 1: Age of Survey Respondents



As shown in Figure 2, there were differences between women and men survey respondents in their choice of major within engineering. Women were more likely than men to be interested in pursuing civil engineering, biomedical engineering, and to be undecided about their major. Men were more likely to be interested in pursuing mechanical engineering and electrical engineering. The distribution of engineering majors among interview respondents was similar to that among women responding to the survey. Differences in gender diversity across disciplines found in this study are similar to other studies that have shown that men are most overrepresented in mechanical engineering, electrical engineering, and computer engineering. There tends to be greater representation of women in bioengineering, civil engineering, industrial engineering, and chemical engineering, due to both individual preferences and cultural/institutional factors [14], [15].

Figure 2: Academic Major of Interest by Gender



Note: Survey respondents were permitted to choose more than one major of interest.

FINDINGS

KNOWLEDGE OF ENGINEERING AS A PROFESSION

In general, survey and interview findings illustrate the value of providing opportunities for learning about engineering as a profession at community colleges, particularly for women. Tables 2 and 3 display knowledge of the engineering profession by gender. When examining students' self-reported knowledge of the engineering profession, we found that about half reported limited knowledge before starting college, and almost three-quarters have gained a moderate or extensive amount of knowledge in the course of their studies. When comparing the two groups' responses using a chi-square test, women and men were not significantly different in their reports of their knowledge about engineering when starting college, but women reported gaining less knowledge than men since entering college ($p < .01$).

Table 2: Knowledge About the Engineering Profession Before College

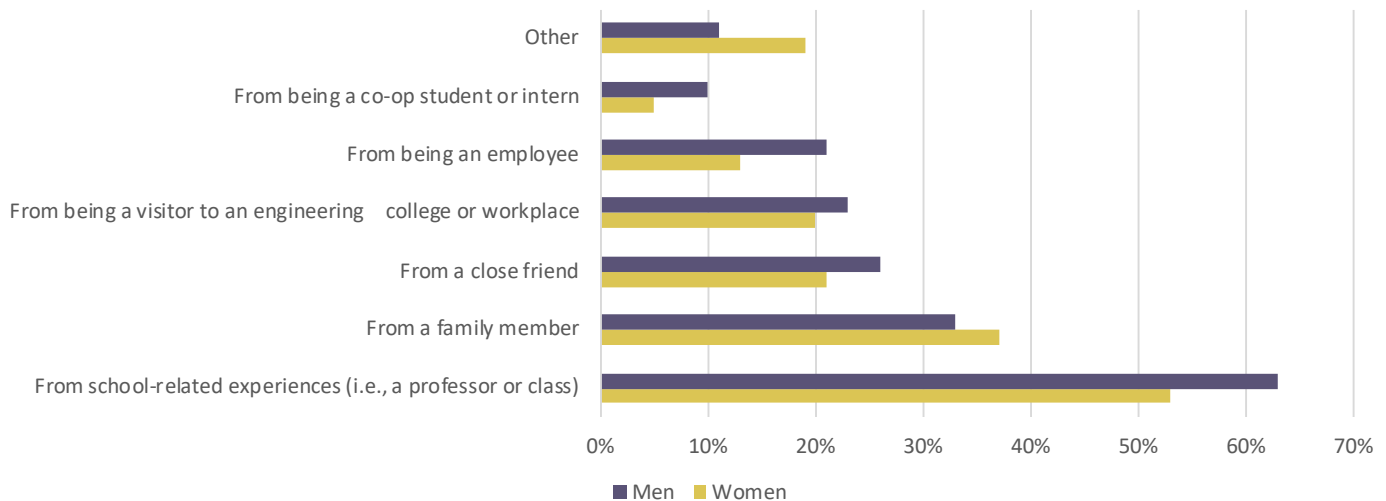
	Women	Men	Total
<i>No knowledge</i>	20%	13%	16%
<i>Limited knowledge</i>	42%	52%	49%
<i>Moderate knowledge</i>	33%	27%	29%
<i>Extensive knowledge</i>	6%	8%	7%

Table 3: Knowledge Gained About the Engineering Profession Since Starting College

	Women	Men	Total
<i>No knowledge</i>	4%	6%	5%
<i>Limited knowledge</i>	31%	18%	22%
<i>Moderate knowledge</i>	44%	58%	53%
<i>Extensive knowledge</i>	21%	18%	19%

Figure 3 displays survey respondents' sources of information about engineering. When ranking the top sources of information about the engineering profession by gender, women and men both identified school-related experiences as the most common source of information, followed by family members, close friends, and visiting engineering colleges and workplaces. The internet was cited as the top "other" source of information on the engineering profession by both groups, with 7 men and 8 women mentioning it directly. Personal research was the next most common, mentioned by 5 men and 3 women. Other mentions included television programming, previous schooling, and talking with other people, including spouses and mentors. These findings are consistent with findings from the APPLES study, which examined the engineering experience of undergraduate students at four-year universities. First-year engineering students in the APPLES study reported that personal relationships and school-related experiences helped them gain an understanding of engineering [16].

Figure 3: Sources of Information about the Engineering Profession by Gender



Note: Survey respondents were instructed to select all that apply.

While over half of all survey respondents had limited or no knowledge about engineering as a profession prior to starting college, most interview respondents reported that they had some exposure to engineering before entering college. Counter to the survey findings, most of these respondents discussed learning about engineering from friends or family members more than from school-related experiences. Five respondents mentioned friends or family members who were engineers or had taught them about engineering. For example, one student explained that her uncle inspired her to go into engineering:

I have an uncle who is an electrical engineer, and I really, really adore him. He kind of helped me decide, or have the desire for pursuing that, so that's really what I wanted to do.

Another student said that her best friend's father, while not an engineer himself, worked in the oil industry and provided her with some knowledge about engineering prior to entering college. However, most of her knowledge about engineering was gained from an engineering professor who connected her with an internship opportunity at a nearby university.

Three of the respondents who had learned about engineering from friends or family also mentioned exposure to engineering through their workplace. Two had already been in the workforce for several years before returning to school to get an engineering degree. Both of these students said that their primary reason for pursuing an engineering degree was to advance further within their firm. One worked at a government agency that's "primarily filled with civil engineers" and the other worked with teams of engineers at a private industrial corporation. One respondent who was working in an engineering-related field while going to college expressed that she acted as a career resource for her peers who had less exposure to engineering as a profession prior to entering college.

MOTIVATION TO STUDY ENGINEERING

Research indicates that about 70% of students who complete bachelor's degrees in engineering intended to do so as early as their senior year in high school, and that motivations for studying engineering remain relatively stable throughout college; so understanding what motivates students to pursue an engineering career is important for developing strategies to engage students early in their community college pathway [16], [17].

Our study suggests that men and women have similar motivations for studying engineering. Survey respondents indicated that they were most motivated by intrinsic behavioral and psychological factors: students study engineering because they like to build things, and find engineering fun and interesting. When asked about why they wanted to go into engineering, over half of the students interviewed said that they were excited about solving problems and creating innovative ways of doing things, or that they excelled in math and science so engineering seemed like a natural path. One student described her switch from architecture to engineering as follows:

... You can draft up a beautiful design, but then you still have to hand it off to an engineer to know if it's going to be possible to build it at all. I just really like the idea of ... knowing how things work.

Students also reported a high degree of social good motivation (i.e., a belief that technology and engineering skills contribute to the good of society). Echoing previous research using the same survey instrument with undergraduate students at four-year universities [16], women and men in the current study were similarly inclined to express social good motivation. Three interview participants mentioned wanting to go into engineering so that they could make the world a better place, including one who discussed her desire to help people:

I did electrical engineering because I want to, in the future, work with the electrical wiring in prosthetics.

The other two were interested in working to solve environmental problems:

I just kept digging into things about how much waste we're producing as a society, and how much goes into a landfill and how many products are recycled. So, as I started getting into that, I really wanted to do something in the environment in order to change our systems and how we treat waste management.

Both survey respondents and interview participants were less strongly motivated by financial factors, such as the belief that engineers are well-paid. Only one interview respondent explicitly mentioned financial motivations:

I have six children. They like to eat. I want to make the money.

While this dimension of motivation was not captured in the survey, three students mentioned that they found the status associated with being an engineer appealing. Two of these students had already been in the workforce and stated that an engineering degree will open up opportunities and change the way others perceive them. As one student explained:

[It] sometimes gets a little frustrating ... being overlooked for a certain assignment or maybe not qualifying for a certain job because I'm not an engineer, even though I have the experience.

The lowest-ranking motivations in our survey were parental influence and mentor influence. There were no statistically significant differences by race/ethnicity or gender in financial, mentor, or parental motivations (Figures 4 and 5). There was also no statistically significant association between motivations and intention to pursue a bachelor's degree or career in engineering. Items used to construct motivation scales are presented in Appendix C.

Figure 4: Motivations to Study Engineering by Gender

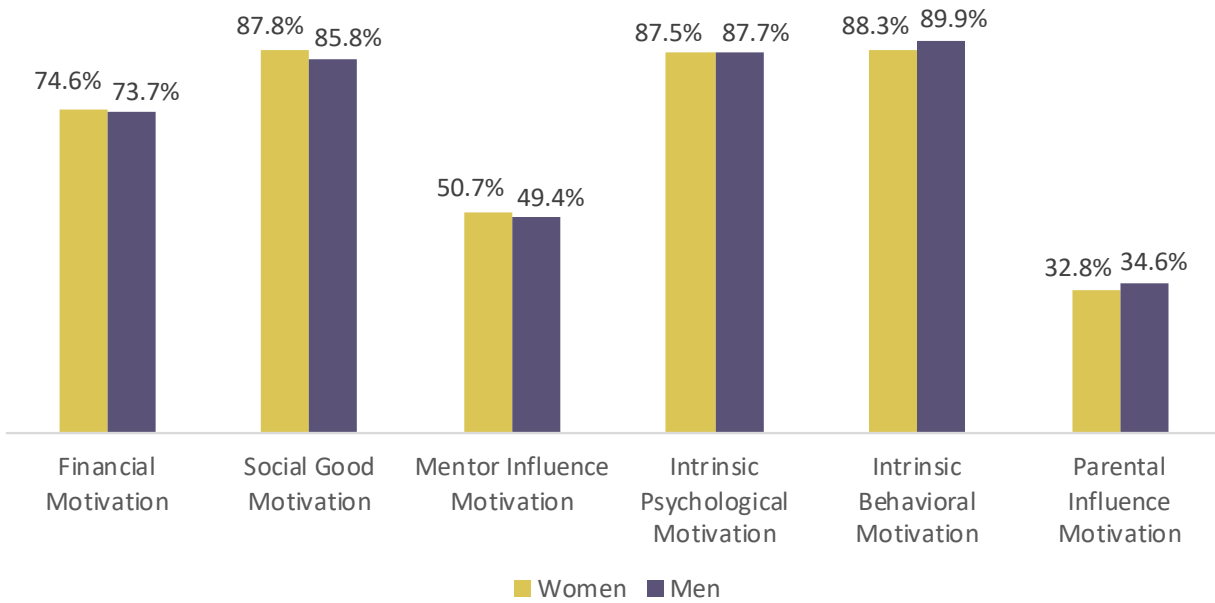
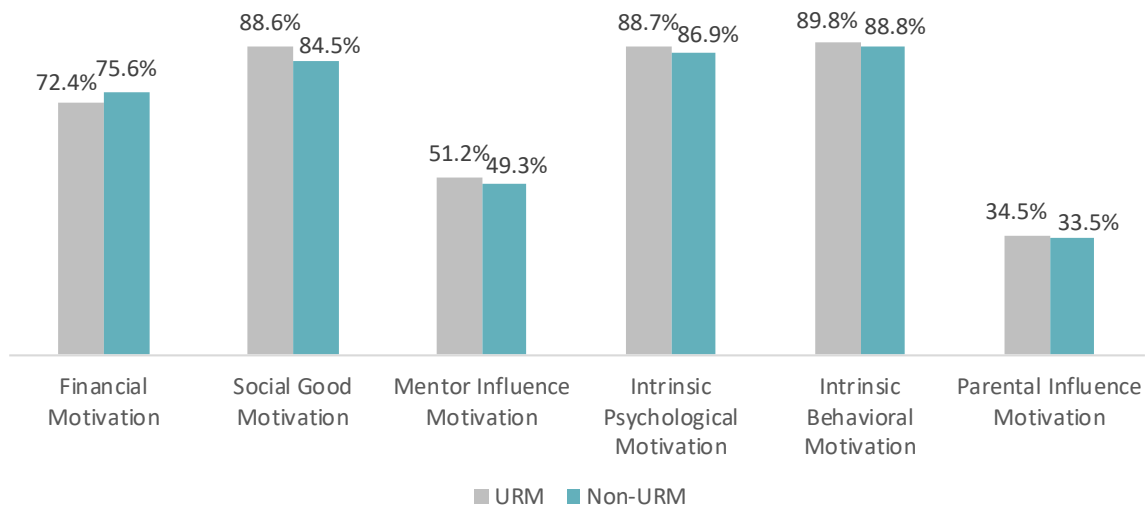


Figure 5: Motivations to Study Engineering by Race/Ethnicity



CONFIDENCE AND SELF-EFFICACY

Survey data showed no statistically significant association between demographic characteristics (gender or racial/ethnic identity) and engineering self-efficacy (Figures 6 and 7). However, there were some associations between demographic characteristics and confidence in skills related to careers in engineering. Confidence in professional and interpersonal skills did not vary by gender according to our survey, but interviews revealed that some women students are concerned with others' perceptions of their leadership capability. One woman reported:

... the biggest challenge that I would say I worry about, since I do want to be some kind of team manager or team leader, is just going to be female management. ... I hope that someday I can be respected but not feared.

Students who were older tended to be more confident in professional and interpersonal skills. Age was also associated with greater confidence in solving open-ended problems, as was lower income. An older interview respondent discussed the association between age and confidence in problem solving:

I find that being an older student and having lived in this world here of civil engineering; I think just being older helps me work through some problems using life experiences even if I don't know a problem. Like I've got a physics problem, I can maybe work my way, reason through it, because of the experience.

Consistent with other research, our survey findings show that men are more confident in math and science skills than women, when controlling for other background characteristics. While the relationship between confidence and intention to persist in STEM was not statistically significant in our findings, recent studies show that cultural stereotypes of men's superiority in math are related to increased confidence for men in math and the "overpersistence" of men in STEM [18]. For women, confidence rather than ability in math contributes to higher rates of attrition from STEM – women are less confident, even when performance is equal or superior to men's [19].

While men responding to the survey reported more confidence than women in math and science, some students interviewed expressed that they were driven to engineering because they had done well in math and science in high school and were confident in their ability relative to their peers:

Yeah, I'm generally one of the top students in almost all my classes.

Another student felt confident in her own abilities, particularly given her minoritized status within engineering, but acknowledged that confidence could be a problem for some women:

I don't think I'm very easily intimidated by being a minority in engineering ... I would just hope that other girls have the same confidence. Be confident in what you want to do.

Figure 6: Confidence and Self-Efficacy by Gender

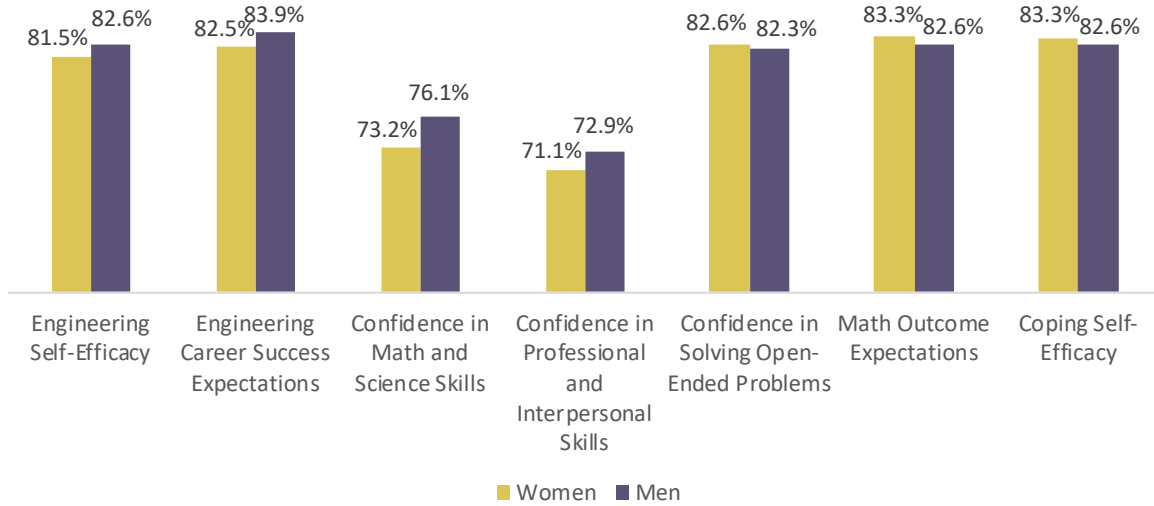
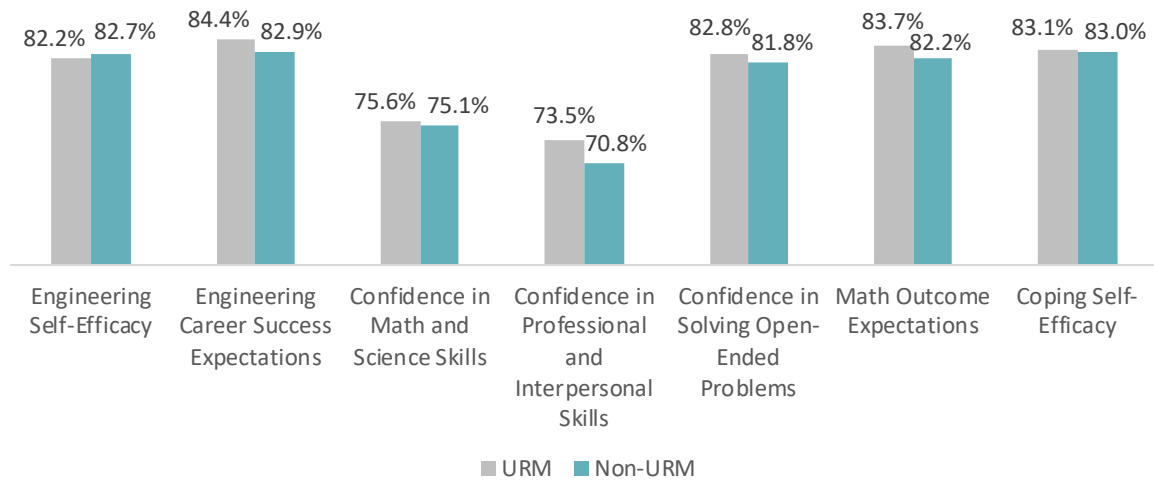


Figure 7: Confidence and Self-Efficacy by Race/Ethnicity



INCLUSION

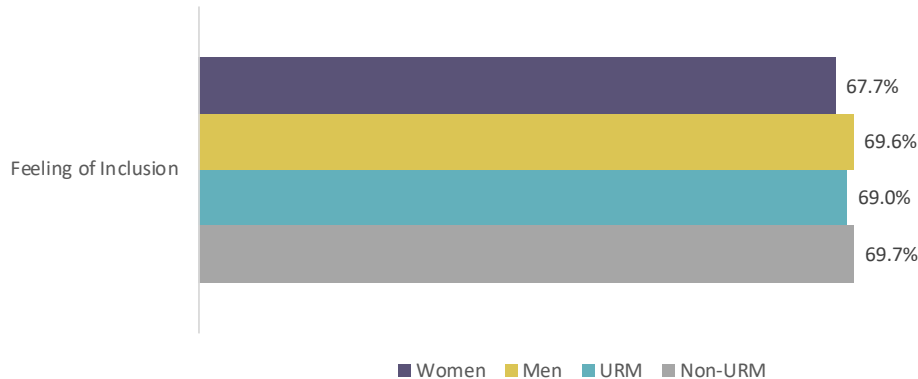
Contrary to previous research on gender inequity within engineering, survey respondents reported a similar sense of inclusion in engineering regardless of their gender or race/ethnicity (agreeing at similar rates to items such as “I can relate to the people around me in my class” and “I have a lot in common with the other students in my classes”⁴ (Figure 8). However, interviewees expressed that the lack of women in engineering classes and professions sometimes causes doubts about whether they belong in the field; one student summarized:

... compared to my classmates, I am the most feminine ... Sometimes it makes me wonder if I belong a little bit. I know that femininity and engineering has no correlation, but it does make me feel like, because I stand out, maybe I don't belong.

⁴Sense of inclusion was measured using LAESE multi-item variables as reported in Appendix C.

Another noted that there were gendered expectations in her engineering workplace, whereby she was expected to be extra friendly and personable in addition to working competently because she was a woman. About half of interviewees mentioned the lack of women in engineering and the need for more women engineers. Furthermore, one student said that she anticipates that her Mexican heritage might affect her throughout her career.

Figure 8: Feeling of Inclusion by Gender and Race/Ethnicity



Age more than gender, race, or ethnicity arose as a theme that set some interview respondents apart from their peers. Our sample included three women who were considerably older than the average community college student, and in some cases this age gap caused a disconnect between study participants and their peers. One woman remarked:

Most of my classmates are 20-year-old boys and they're really awkward ... I've made friends with some people that are older, mostly people who are about my age. The younger people, not so much.

Another mentioned that coming to engineering later in life has made her more committed than her peers.

Generally, older students reported that their younger peers look to them as a resource, with one explaining:

I've found that people tend to listen to what I say because I'm older and I know that just from talking to other women who are engineers, that's not often the case.

and another saying:

They actually look to me because they're like, 'Oh well you already have a job ...' So they kind of look up to me like, 'Hey ... is your job hiring?' And things like that.

Some respondents expressed that due to the pressures of busy schedules, they do not interact much with their peers socially. Overall, though, there was a sense that the drive to complete engineering degrees was a quality shared by interviewees and their peers.

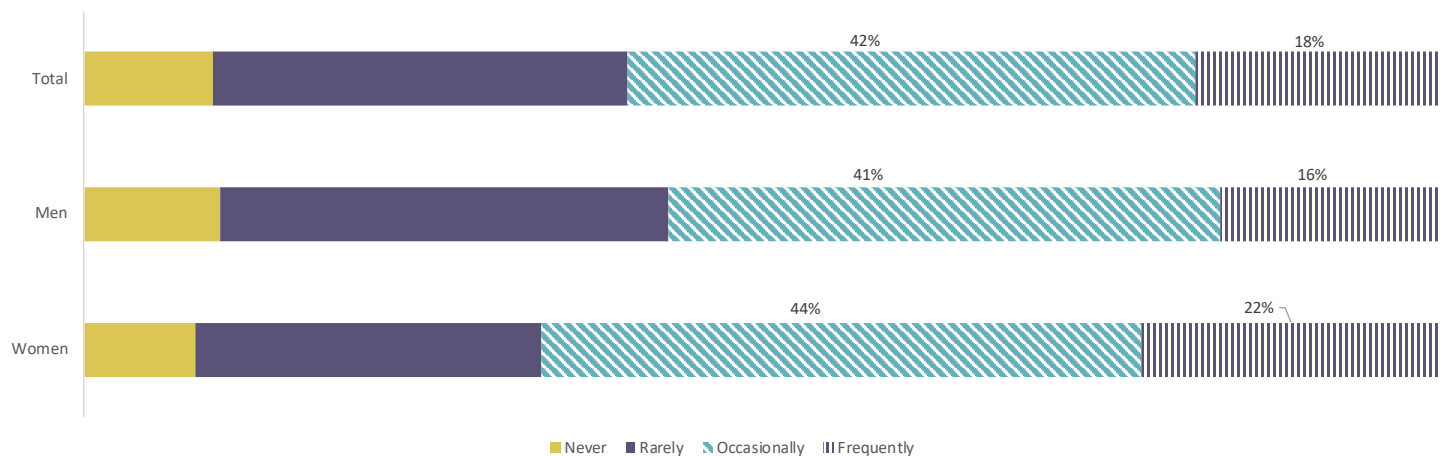
INVOLVEMENT IN ACADEMIC AND EXTRACURRICULAR ACTIVITIES

Research shows that students in STEM are more likely to persist when they engage in activities such as studying with others and involvement in academic clubs and organizations, particularly those from underrepresented racial groups in STEM [20]. As shown in Table 4, survey respondents participated in a variety of academic activities outside of class. Respondents were most likely to report that they participated in study groups, followed by honor societies and activities sponsored by their department. In addition to academic activities, 66% of women and 57% of men said that they occasionally or frequently participated in extracurricular activities such as hobbies, civic or church organizations, campus publications, student government, or sports (Figure 9).

Table 4: Academic Activities Participated in at Least Once During the Past Year

	Women (N=63)	Men (N=120)	Total (N=183)
Study groups	75%	80%	78%
An honor society (such as Phi Theta Kappa)	29%	20%	23%
Activities sponsored by your department or major	25%	15%	19%
Peer Mentoring Program	11%	18%	15%
An engineering society (such as American Society of Mechanical Engineers)	8%	12%	10%
SWE (Society of Women Engineers)	24%	3%	10%
SHPE (Society of Hispanic Professional Engineers)	3%	5%	4%
NSBE (National Society of Black Engineers)	2%	4%	3%

Figure 9: Frequency of Involvement in Extracurricular Activities



Over half of the interview respondents were involved in some sort of extracurricular or academic club/activity or had plans to join. While several mentioned that it was difficult to fit these extracurriculars into their busy schedules, they saw them as beneficial academically, socially, and professionally. These extracurricular activities included a Christian student organization, two engineering clubs, two volunteer positions, and a leadership training organization. When asked why they chose to take part in clubs and activities outside of their coursework, students said that they were fun, helped develop leadership skills, provided academic support, built networks, and provided social support.

While students generally benefitted from these activities when they chose to participate, several students mentioned that they didn't have time or energy to do much beyond school and work. Faculty who were knowledgeable about the clubs and organizations available to engineering students at their colleges also indicated that the clubs often struggle to maintain active membership and leadership, precisely for these reasons:

... it's very difficult to get these members when there is a meeting, when there is a workshop, it's very difficult to get them to be active, actually.

... there is a pretty good percentage of community college students who are here part-time, ...they are married, have families, have jobs, things of that sort. Getting them involved in college activities becomes a little bit more difficult because they have other things to do outside of classrooms and exams and their college life.

INVOLVEMENT IN ENGINEERING PROFESSIONAL ORGANIZATIONS

While only two interviewees had been involved in engineering-related clubs, several discussed the utility of joining a professional engineering organization. Whether they were affiliated with a professional engineering organization or not, students described the following aspects that are useful about professional organizations:

Learning and professional development

Interview respondents noted that professional organizations can be a great source of information, both directly and through other students involved. One commented:

It's sometimes hard as a student to see the other side into the professional world, because you're just at such a ground level of taking classes and learning things. You don't really get to see how any of it's going to be implemented in the future.

Another said:

"I know for a fact that I would probably want to do [more than] meet and greet at conferences ... Tell me about technologies that people are coming up with, jobs that are available."

A third wanted to hear people talk about different jobs:

"I don't think I've really had much exposure at all to career things that are actually specific to my major beyond how to write a resume or something like that."

Professional networking

Students frequently discussed a desire to connect both with other engineering students and with professionals working in the field:

I don't really know anyone else who's doing what I'm doing ... I guess it would be nice to be involved in something like that just to hear what other people are interested in or what other people are getting involved in.

They expressed that more connections with professional engineers could help them better understand their career options; one mentioned:

It would be very cool to just get some kind of a window into [the tech software area]. ... Either just like work life, or just exposure to how tech companies operate.

Related to networking, mentorship appears to be an important piece missing from several students' experiences, and could be a clear way for professional organizations to influence the next generation of engineers.

Career opportunities

Interviewees were as interested in connections to job opportunities as they were in information related to engineering in general, and about making connections to other engineers. This benefit of professional organizations was usually discussed in conjunction with learning, professional development, and networking. As one student put it:

You never know, you might meet someone that can give you your next seven-figure, six-figure job just because of the fact that they want someone that's in the same organization as them versus someone off the street they have no idea about.

Inspiration and encouragement

Students mentioned that identity-based organizations (such as the Society of Women Engineers or the National Society of Black Engineers) can be useful in this arena, by "show[ing] the presence of women engineers" and connecting them with "people ... who know what I'm going through in my career because they're going through it, too."

EDUCATIONAL AND CAREER ASPIRATIONS

As shown in previous studies that examine the relationship between aspirations and persistence in STEM, our survey findings suggest that aspiration does not likely contribute to the higher rate of attrition for women in engineering [19]. When comparing women's and men's intentions to pursue a baccalaureate degree or a career in engineering, women were more likely to respond "definitely yes" to both items (Figure 10). The two groups were similarly likely to respond with "definitely not," "probably not," and "not sure." When asked about their future plans, 76.5% of women said that they would definitely work in an engineering job compared to 66.7% of men, and 28.2% of women said that they would definitely go to graduate school in an engineering discipline compared to 25.1% of men (Figure 11).

Figure 10: Intention to Pursue a Bachelor's Degree in Engineering or Computer Science

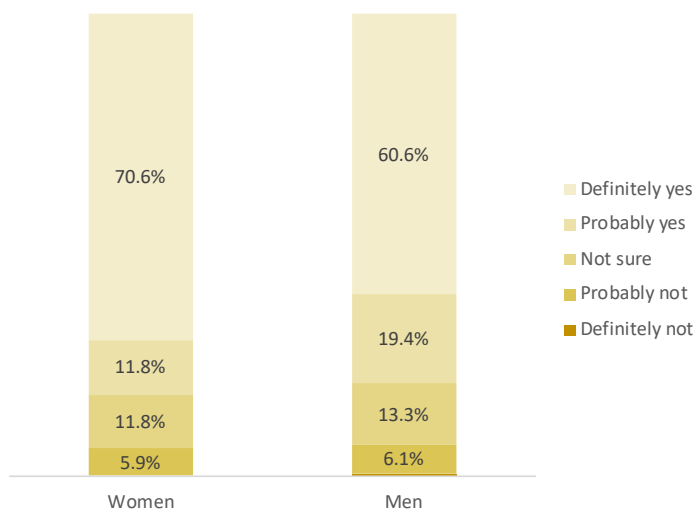
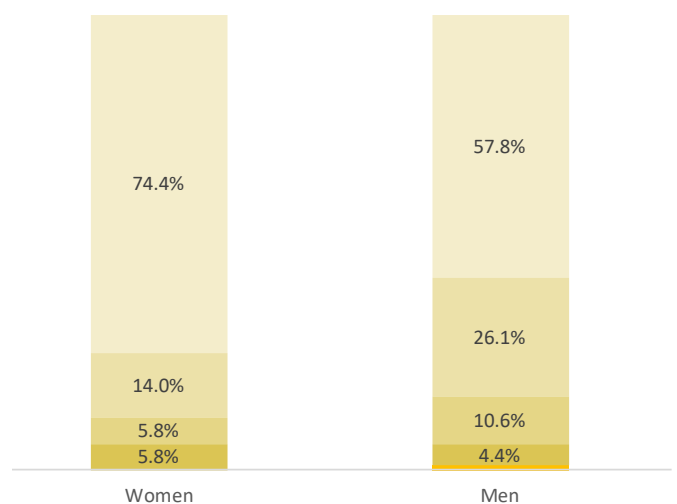


Figure 11: Intention to Pursue a Career in Engineering or Computer Science



Note: Survey responses of "Definitely not" were <=1% for men and women.

All interview participants said that they were planning to transfer to a four-year university, though some suspected that they might have to take some time off to work and earn money to pay for it first. While a higher percentage of women survey respondents expressed firm convictions to persist in engineering, gender did not have a statistically significant relationship with the intent to pursue an engineering bachelor's degree or career in engineering when controlling for confidence, self-efficacy, sense of inclusion, and motivation. Age was associated with both a stronger intent to pursue a bachelor's degree and a stronger intent to pursue a career in engineering. Degree intentions were negatively associated with being a non-native English speaker and with caring for dependents.

Interview participants were asked to discuss their education and career plans in more detail. Most planned to enter industry after they receive their bachelor's degree. While only one student expressed a firm desire to pursue graduate studies in engineering, others mentioned that they wanted a career in research:

I think research would be really interesting, being able to work in one of the national research labs would be really cool.

I love researching and presenting oil and gas and so I just want to be a materials engineer at an oil and gas energy company. And honestly, it doesn't have to be oil and gas. I love energy, solar, anything. I haven't narrowed it down from that part yet. I love energy. I love it, that's just what fascinates me. And I want to be there to present and be involved with global leaders. ...

Other students wanted to go into more hands-on/applied fields, such as construction: "like a civil construction engineer, like buildings, houses, that's my main focus." Another student hoped to double major in engineering and Chinese, and use those degrees for a career in business:

What I would love to do is be able to work with American companies who want to branch into China, or make Chinese apps, or something like that. It seems like a really, I don't know, a unique asset to be an American person who understands American business, but also be able to communicate with Chinese businesses. Something in that realm.

Overall, students appeared to have positive expectations of a career in engineering (tending to agree with survey items like "Someone like me can succeed in an engineering career" and "I expect to be treated fairly on the job")⁵. Mirroring these positive expectations, some interviewees anticipated no particular challenges as women engineers, but others expressed concern about how they will be treated and perceived based on their gender. One respondent reported:

Being a woman, a lot of people don't believe that I know what I'm talking about.

INSTITUTIONAL FACTORS IMPACTING THE EXPERIENCE OF WOMEN IN ENGINEERING

A 2011 study found that there are certain institutional supports that can influence women's persistence in STEM, including faculty inspiration to pursue STEM careers, peer academic support, and helpful transfer advising [21]. A number of institutional supports were mentioned as important factors in helping students in our study as they progressed with their studies, including partnership programs, college centers, faculty support, and quality advising.

Partnership programs

Though there are few studies that have looked at STEM partnership programs, there is evidence that community college transfer retention is higher for students who have participated in partnership programs that include resources specifically for transfer students and offer coordinated academic advising, peer mentoring, and support for the development of social and professional networks [22]–[24].

In Texas, state-level efforts to improve academic transfer pathways from two-year to four-year institutions are underway. The Texas Success Center coordinates Texas Pathways⁶, a strategy focused on designing and implementing structured academic and career pathways for all community college students. While the strategy is much broader than STEM transfer, Texas Pathways is open to participation by all 50 Texas community college districts working to establish alignment of pathway courses with transfer institutions and supporting strong transfer advising.

In addition, four-year universities in Texas are seeking to do more to smooth the transition from two-year to four-year institutions through special co-enrollment programs with community colleges around the state. For example, Texas A&M University's Engineering Academies are now available to students at seven different community college districts in Texas. The engineering academies allow students to take mathematics, science, and core curriculum courses at the community college while also taking engineering courses from Texas A&M faculty on the community college campus. Faculty interviewed stated that engineering academy students are treated as a cohort, so they get to know each other and develop a peer support network. The students can then transition to Texas A&M University after one or two years to complete their bachelor's degrees. However, students must meet the admissions requirements of the university to be accepted into the engineering academy. The university also has collaborations in place with community colleges to accept computer science students.

Another type of partnership program in Texas allows students to pursue an Associate of Science in Engineering Science degree at a participating community college with guaranteed transfer to a partnering four-year institution. For example, after receiving an ASES degree, a student is prepared to transfer to The University of Texas at Tyler. For students in Houston, UT Tyler has set up an engineering center to offer the coursework necessary to complete a bachelor's degree in engineering, so students do not even have to move to Tyler to complete their degrees. Cost is also a big draw. As one faculty member stated, it is "the cheapest engineering degree in the United States."

⁵Confidence and self-efficacy were measured using LAESE and APPLES2 multi-item variables as reported in Appendix C.

⁶To learn more about the Texas Success Center and the Texas Pathways project, visit <https://tacc.org/tsc>.

Two students described meaningful opportunities they had through partnerships with four-year universities. One student received an internship at a prestigious university that helped her decide on her major and gave her valuable hands-on experience. She said that this made her feel better about starting out at a community college:

... a lot of people tend to think community college doesn't have as many opportunities as university or whatever, but actually what's kind of cool is a big school ... they do want community college students involved in their universities and I think it helps them look good. It makes them look nice.

Another student had the opportunity to take classes from university professors on her community college campus, which she said was a wonderful and less expensive alternative to enrolling at the four-year university.

One faculty member noted the difficulties some students who do not participate in these partnership programs face when they transfer:

... they are usually delayed one to two years. Just because not all classes transfer and they can't take any [upper-level] classes, so then they're stuck. And then when they get to [the university] usually then they can't take a full load because they need so many prerequisites.

Community college offices and centers

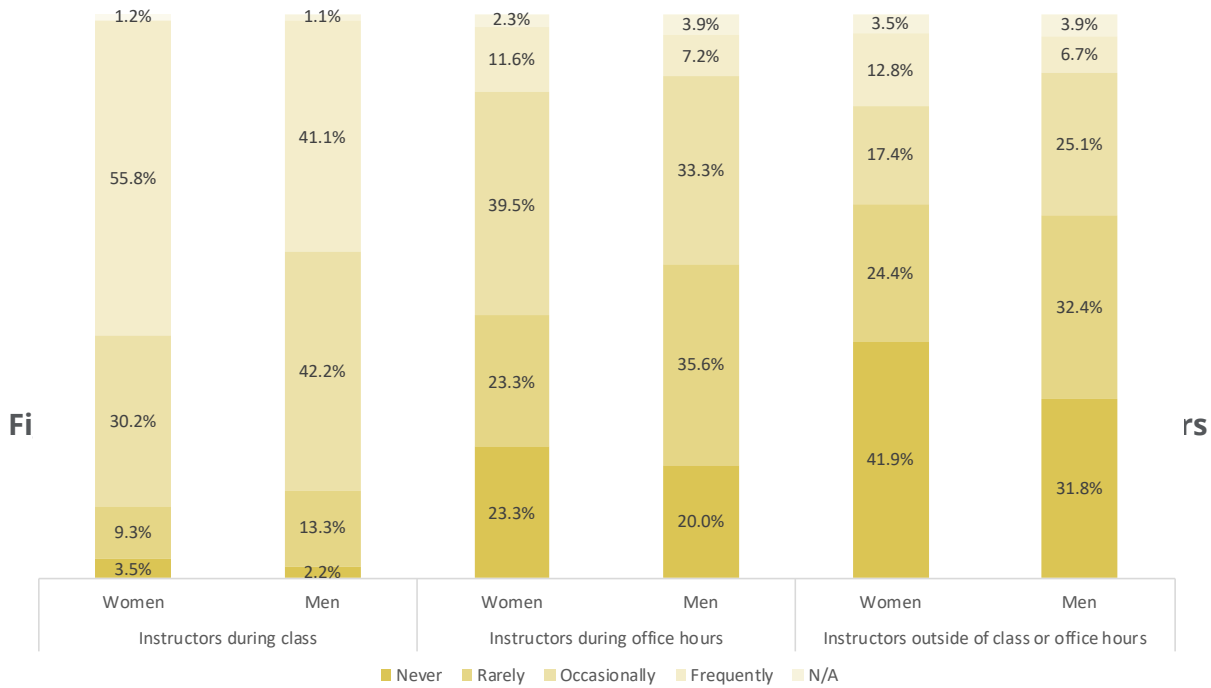
Some students mentioned specific centralized resource hubs geared toward students with specific needs or backgrounds that supported their studies by providing a broad range of supports. For example, one student relied on the mathematics, engineering, and science center on her campus for tutoring, computer access, and connecting with a community of peers. Other students relied on the veterans' office or international students' office to receive advising and get connected with other resources.

Faculty members interviewed also mentioned some of the resources that community colleges offer students. For example, one college offers free tutoring labs for students in mathematics, science, and engineering classes that are manned by experienced professors in these subjects.

Research shows that when students gain positive learning and study skills, including time management and problem solving skills, at a community college, it can have a positive influence on students' academic transfer adjustment [25], [26]. Three-quarters of the interview respondents discussed utilizing tutoring resources on-campus. Students appreciated the availability of tutoring centers with flexible hours and online tutoring options. For many, tutoring was a more accessible and often more helpful option than reaching out to instructors.

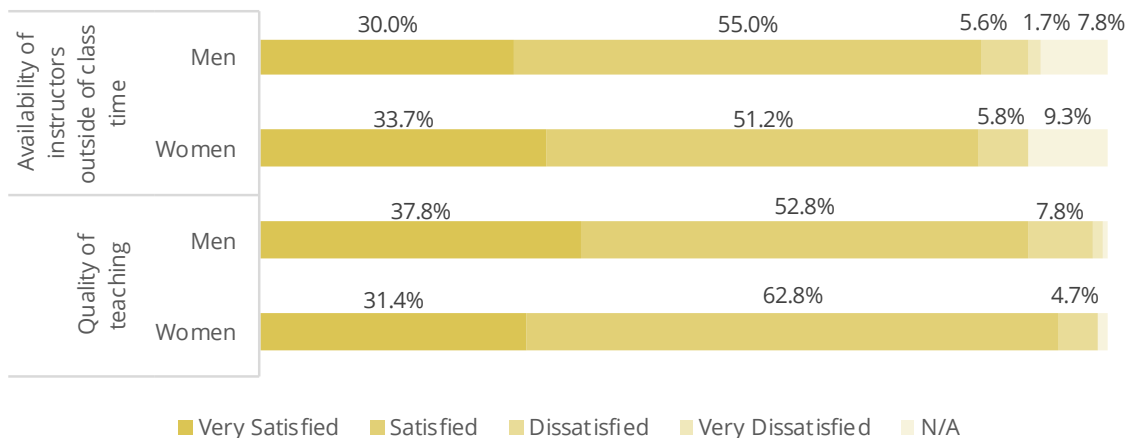
Faculty

Research has found that helpful professors and advisors after transfer were key to keeping students from switching out of their STEM major [21]. But faculty can have a great impact on students' success prior to transfer as well. Among our survey respondents, women were more likely to report interacting with faculty in class, but men were more likely to interact with faculty outside of class. The majority of survey respondents reported that they interact with instructors frequently or occasionally during class time, and women were more likely than men to report that they frequently interact with instructors during class (Figure 12). Women were also more likely than men to report frequently or occasionally interacting with instructors during office hours, and more likely to report never interacting with instructors outside of class or office hours.



In terms of satisfaction with instructors, most survey respondents reported being satisfied or very satisfied with both the availability of instructors outside of class time, and with the quality of teaching at their institution (Figure 13).

Figure 13: Satisfaction with Availability of Instructors and Quality of Teaching



Three-quarters of the interview respondents described the close connections they had made with instructors that provided them with opportunities and encouragement. For example, one student received an internship at a local university due to the information and encouragement provided by a faculty in engineering at the community college. Another student said that the small class sizes at the community college allowed her to interact with professors in a way that she might not have been able to at a large university, and that she had developed relationships with faculty members that she could trust to provide her with career guidance and recommendation letters in addition to academic help.

Students also discussed supportive faculty members who were flexible and understanding with regard to demands that community college students face outside of school. However, some students felt that faculty did not make themselves very available outside of the classroom, or were otherwise unsupportive. For example, some faculty would hold office hours at times that conflicted with students' other classes or work commitments.

While positive connections with faculty helped to keep students engaged in engineering, some interview respondents had issues with the way they or other students were treated by faculty. For example, one student stated:

I have an instructor that ... plays a little bit of favorites and I am not in his favorite little group, so it's difficult to get answers out of him because of that.

Another student said that an instructor told them "this is a piece of cake" in front of the whole class, in response to a question she had asked. Though she was able to brush it off, she felt like actions like that on the part of instructors made some of her peers resistant to asking questions in class out of fear of "looking stupid." However, she said:

I would rather look stupid and get an A than not ask and get a C.

Another student talked about navigating different personalities and approaches to teaching among faculty – she said that she had some professors who were excellent teachers but not very personable, and other teachers who were great at working with students but weren't great at teaching the material. She said it was hard to find faculty who were a balance of both.

Faculty members commented on the lack of diversity among engineering faculty:

... We don't match what the [city] demographics look like, and we don't match what our student population's demographics look like. ... The rest of [the] engineering faculty are all males. The majority of them are naturalized citizens. That's to say they didn't start their lives in the United States. We have 30% Hispanic students here, and we don't have a single Hispanic engineering faculty member.

Advising

Quality academic advising can have a positive impact on student retention and satisfaction [27], [28]. For community college students in STEM, discipline-specific advising can be especially helpful because students can see the roadmap they need to follow to complete their degree [4]. A study by Laanan et al. [25] found that students' academic counseling experiences at a community college can negatively influence the academic adjustment of students after transfer. Inadequate advising, counseling, and tutoring can also factor into students' decisions to switch out of STEM majors [27].

In our study, students described advising as really hit or miss. Some students said that they had made great connections with advisors, particularly advisors within a specific focus such as STEM or international students:

Usually when I want advising I just go to international students' office and I have one single assigned advisor and she is amazing. She really is a lot of help so I'll always feel secure about talking to her.

The handful of students who said that their college advising had been helpful indicated that they felt like they were receiving the information they needed to successfully transfer to a university. Other students said that they relied more on transfer advisors from their target four-year university rather than advisors at the community college to help them develop their academic plan:

I'm enrolled in a four-year college to start in the fall. I'm finishing up my community college work this summer and I have a new advisor there who's actually very good. She seems to know what she's talking about a lot more. At community college it wasn't really good.

Most students in our study had a relatively negative impression of their college advisors. One student indicated that she felt she got better help from her friends than from advisors, stating:

They never put themselves in the student's shoes. So the explanation is really uncaring, I guess? It's not like they are, you know, being mean to us or anything. But they don't understand us at all.

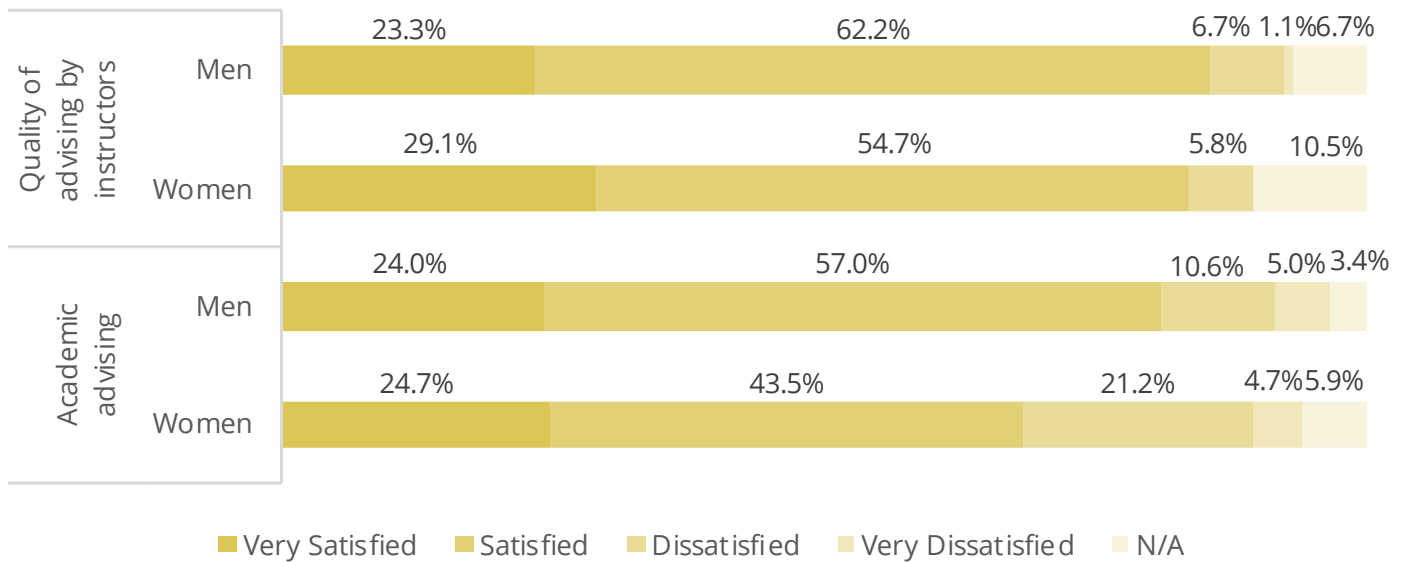
Another student said that the advising she received at more remote branch campuses was better than the advising she received at her central campus. She theorized that it may be due to the distance required to reach those campuses, resulting in fewer people making the drive out there.

One concerning issue that arose was about receiving incorrect information about transfer requirements from an advisor at the community college:

I think partly it's because they don't deal with that many people who already have bachelor's degrees at [School A] because I've actually gotten a lot of wrong information from them when I'm talking to counselors. They tell me, "Oh your credits won't count," or you have to do this or you have to do this, and it just hasn't turned out to be true a lot of the time. I kind of stopped going. I had an advisor and I met with them once and I haven't been to them since.

Reflecting the feelings of the interviewees, survey respondents were more divided on their satisfaction with academic advising than their satisfaction with other aspects of campus life (such as the quality of teaching), and women reported being less satisfied than men. About one-quarter of women respondents said they were dissatisfied or very dissatisfied with academic advising, and only 24.7% reported that they were very satisfied. In contrast, 15.6% of men responded that they were dissatisfied or very dissatisfied with academic advising (Figure 14).

Figure 14: Satisfaction with Advising



Faculty interviewed noted that transfer advising is a big issue, not just locally, but nationwide. One individual said that her college has a number of transfer agreements in place, but advising over 3,000 students about them can be a challenge:

... Every semester engineering tries to train all the STEM advisors but still stuff falls through the cracks. We still get students taking things they don't need to take and whatever, so basically we just try in our classes to give a consistent message about advising. It's up to the university that you're going to transfer to that has the ultimate authority as to whether to accept a course or not. Then, it's up to you to go and find out all that information. We try to grease the pathway. We have names. We have agreements and that kind of thing. It's still seems to me it could be easier.

Some of the faculty interviewed expressed positive views about the advising tools offered to students. For example, one individual spoke about an online degree program mapping tool offered through their college that allows students to check their progress toward a certain degree, including transfer degrees. Online tools at the state level were also mentioned, but these tools were not mentioned by students we spoke with, so it is unclear how much students are utilizing these tools.

PERSONAL AND RELATIONAL FACTORS CONTRIBUTING TO PERSISTENCE IN ENGINEERING

When discussing their success in engineering or the struggles they faced in pursuing their degree, students frequently mentioned aspects of their personality, other individual characteristics, and meaningful relationships that helped them to progress on their pathway and overcome challenges.

Individual assets

In addition to confidence and belief in innate academic abilities described above, the primary individual assets that students described as contributing to their success in engineering were perseverance and being proactive. Half of the interview respondents described themselves as persistent and resilient when faced with challenges and unwilling to give up on reaching their goals. For example, one student described an experience she had in a chemical engineering class she sat in on while on a university tour:

[The professor] told the class that when you look to your left and right, by the time you graduate, there was going to be none of them. Because a lot of people will have dropped. Honestly, I loved that ... that sounds challenging ... I like challenges, and I was determined to be one of those few who survived.

Over half of the respondents also described their ability to be proactive and seek the help they need if (or even before) they're struggling. One respondent said that she tended to do really well in her engineering-related coursework, and she attributed her success to her willingness to ask questions:

I find that a lot of the guys in my classes don't want to look dumb so they never ask questions and then they don't do well in the classes and it's totally baffling to me. I would just say if you feel like you got a question then just ask.

When asked about whether she interacts with instructors outside of class, another said "Yes, I am always after them."

Support from family, friends, and peers

Several students discussed ways in which personal connections had influenced their experience in engineering. For many, individual personal connections were key for their success in engineering at the community college, whether this be family and friends providing encouragement, faculty mentors providing opportunities and guidance, or school peers providing academic and social support where faculty support was lacking. This is consistent with research showing that STEM pathways are influenced not only by the educational institution, but also by relationships [29], [30]. Research shows that women of color in particular rely on family and community support to help encourage them to complete their STEM degrees [31]. Here, we describe ways that interpersonal relationships helped shape engineering experiences for students in our study.

Students discussed receiving a variety of types of support from their families to pursue their engineering education. For some, support was instrumental or informational. One student described two brothers who were also in school for engineering and a sister who was in school for business – all three of these siblings were able to provide information on how to navigate college life. Another respondent discussed how her father instilled in her a love of math at an early age, which has continued to help her on her engineering path.

Other respondents emphasized the emotional support their family provided. For some, family provided both emotional support and guidance:

I didn't have anyone in my corner other than my husband to tell me, 'Hey, you're doing great.'
... My husband right now is the only person I can kind of bounce those ideas off of.

Students also receive both instrumental/informational and emotional support from friends. One student discussed the career guidance she received from her best friend's father, and another mentioned the validation she received from friends:

I have my family who support me and my friends who believe in me more
than I believe in myself.

School peers were also mentioned frequently as a source of support for interview respondents. Students made connections with other students in engineering, and used these connections to form study groups, receive academic help, and commiserate/discuss their shared struggles. For example, one student said that there was a group of students who shared several of the same classes with her, and she leaned on that network for help with her coursework:

If we have questions we can email the class. The class is very supportive. I've always found out that I can reach out to the class and say, 'you know I missed this day, what do we have for homework?' Or 'I'm stuck here, before I reach out to the professor, can anybody tell me something?' You know, we have a really good network.

Another felt that it was more productive to get help as a team rather than reaching out to an instructor individually:

It's usually easier going to office hours together to talk to the professor in a larger group because it, I don't know, it's easier to ask questions and stuff when there's other people who have the same question as you. We do that a lot. Getting together in groups on the weekends to go over homework problems or a review for tests.

Other students found social/emotional support by participating in other organizations across campus. For instance, one student helped to start a religious organization on campus where she developed a close network of friends.

Support from professional colleagues and mentors

The two respondents who were already working in engineering-related industries talked about the support they had received from colleagues at their work. This support took the form of encouragement:

... there's no women engineers, there's very few women engineers, even in my company. And so being a black woman, they were like, 'hey, this would be great if you would learn some of this stuff.'

financial support:

My agency currently pays for my school, so by December of next year I should have completed the Associate of Engineering and then from there the obligation to my agency will be met with a year servage from that time.

and flexibility:

I do make sure I take off from work, and I am very fortunate, not just because they are paying for my courses, but they're very understanding of the course load and type of courses that I'm taking. As long as I'm caught up with my work or can make it up, then they allow me the flexibility I need to see the professors during office hours that are maybe during my normal working hours.

Over half of our interview respondents described the importance of mentors (even if not identified as such) in encouraging them to pursue engineering or providing them with guidance and opportunities. A 2007 literature review of research on effective strategies to increase diversity in STEM discussed the important role that mentoring plays in the educational progress of underrepresented students, noting that a combination of both faculty and peer mentors is likely the best way to meet the needs of students seeking mentorship [27]. While mentorship is known to be important for success, students interviewed for our study had little knowledge of how or why to find a mentor. When asked whether they had a mentor, only two out of the eight respondents said yes. One identified her best friend's father as a mentor, the other said there were a handful of engineers in her workplace that she would consider mentors. In both cases, these mentors provided primarily professional/career guidance and encouragement:

... in high school I also found out that I am good at chemistry and so my mentor told me about engineering ... my mentor is also my best friend's dad, and he works at a big oil company.

I do, definitely, talk to a handful of engineers whose opinion I value. I would say that yes there is a handful of folks that keep me going. In fact there is one who actually convinced me to just begin in the program, who is not an engineer.

While these respondents are the only two who used the term mentor to describe this type of relationship, an additional three respondents discussed similar relationships they had with helpful peers or faculty who could be considered mentors. Two of these respondents explicitly said that these trusted advisors were not mentors.

A friend of my parents is the CEO or some very high up person in an engineering firm ... He's given me some advice about books to read and places to look for internships in the past.

Interviewer: Would you say that you have a mentor in engineering either at your school or outside of school?

Student: No. I think I have one professor that I've had three different times for engineering related classes. He's the only engineering professor I've had, so if I needed to talk to something, career related or something, I can just talk to him probably, but I wouldn't really say that he's a mentor.

... there was at least one lady ... we follow each other on LinkedIn and we discuss some things together. But I wouldn't say she's my mentor. But if I wanted one, she would be a good one actually.

Among students who didn't describe having a mentorship-like relationship, two said that they had not received any sort of guidance or information on how to find or approach a mentor:

I haven't been told how to find a mentor and what to expect.

Another student said that there was no time to seek out and meet with a mentor:

... when do I have the time to actually sit down, discuss what my goals are with someone else?

This same student said that there was a person at her company she had been connected with as a mentor, but he did not respond to her when she reached out.

Research on the importance of mentorship and our findings that students have a hard time articulating the how and why of finding a mentor illustrate a need for more focus on mentorship for students on the community college pathway in engineering.

BARRIERS TO COMPLETING A BACHELOR'S DEGREE IN ENGINEERING

Research on the experience of students on the community college pathway frequently discusses the additional demands on time and finances that these students experience alongside their education. Students interviewed for this study were no different. In addition to time constraints and finances, there were other factors mentioned that students felt could also hamper their progress toward a degree.

Financial barriers

Students frequently mentioned commitments and challenges outside of school that sometimes took attention away from their schoolwork. When asked what issues might cause them to withdraw from class or college, Table 5 shows that women's top responses were lack of finances (with 31.8% responding that this was likely or very likely), working full-time (27.9%), and being academically unprepared (24.4%). Men's top responses were lack of finances (42.7%), caring for dependents (30%), and working full-time (25.6%).

Table 5: Likelihood of Withdrawing from Class or College, by Issue Experienced

		<i>Very Likely</i>	<i>Likely</i>	<i>Somewhat Likely</i>	<i>Not Likely</i>	<i>N/A</i>
Women	1. Lack of finances	22.4%	9.4%	35.3%	32.9%	0%
	2. Working full-time	12.8%	15.1%	22.1%	41.9%	8.1%
	3. Being academically unprepared	10.5%	14.0%	25.6%	46.5%	3.5%
	4. Caring for dependents	9.4%	10.6%	17.6%	48.2%	14.1%
Men	1. Lack of finances	21.9%	20.8%	25.8%	27.0%	4.5%
	2. Caring for dependents	13.3%	16.7%	27.2%	33.3%	9.4%
	3. Working full-time	11.1%	14.4%	26.1%	43.9%	4.4%
	4. Being academically unprepared	6.1%	17.8%	25.6%	47.2%	3.3%

Finances play an important role in students' decisions to enroll in a two-year institution. Educational costs vary depending on the program a student selects, with courses in engineering and science being more expensive than those in the humanities and social sciences [32]. A 2006 study of STEM students found that those who completed their degrees were from higher income families, and those who did not complete their degrees were more likely to work 15 or more hours per week [33].

Most respondents in this study discussed financial challenges they faced and the necessity of working while in school. For these students, financial strain was the primary reason why they chose to attend community college rather than starting at a four-year university. Many still struggled to pay for community college, even though it was the less expensive alternative. These respondents described the difficulty of balancing work and life demands, particularly when unexpected issues arose at work:

... we went through a massive exodus so nobody was here and I was working like 60 to 70 hours a week.

or when they had to learn new strategies for time management:

... as I grew up in my country I never worked before, and when I came to live here I actually had to find a job to help me with my bills. So it's a new experience for me having to work and worry about school at the same time.

Some cope with balancing work and school demands by taking only one or two classes a semester.

Three other students also discussed family commitments that placed a considerable demand on their time. These students were all older, and one of them discussed the challenge of balancing her educational goals against the needs of two career-driven people:

... [I'm] just trying to make my career work with my wife's career cause we both, she has a career that she's not going to leave and ... I try to balance the priorities of two people that are both really career-oriented or will not give up their career interests. I think that's probably going to be pretty tough, especially geographically. It's been okay when I'm at a community college, but I'm actually moving away for four-year college, not super far away, but I'm going to be living apart from my wife, which we've never done before. That's going to be pretty strenuous, I think. Then having to deal with that on top of actual engineering school, hard classes and stuff, it's definitely going to be a challenge.

Women typically take on more child care and household responsibilities than men, which can make a successful completion of a STEM degree challenging [34]. Two students in our study mentioned the impact that having partners and children has had on their educational trajectory. Both of these mothers discussed starting college later in life because they started families young. One of these mothers talked about how she copes with the demands on her time by keeping a very rigid schedule:

When I get home sometimes, depending on what time I get home, I'll say, "Okay, family, I have 30 minutes," and I set the timer, as in like, "Okay bye," and I go upstairs and go sit down and start studying.

Though she has family, work, and school demands, this mother also discussed finding time to volunteer at local schools.

Two students discussed health issues that impact their attendance and attention to school at times. Another student explained that she had to drop out of high school and get a GED, losing her potential place as valedictorian of her high school class. Dropping out of school has been a continued source of financial strain, leading to her decision to start at a community college rather than a four-year institution.

While financial strain can be an obstacle to degree completion, one student described how this struggle was something shared between her and her peers and contributed to solidarity:

... we have that financial thing that is very common among us. And that can bring a strong connection. You know, we might have different sports teams, he might like bicycles, I might like, I don't know, boats, but I think it really brings us together. Because we all know that we need to work hard to have a better situation ... having a few things that we hold dearly to our heart that's common I think really brings us together.

Personality factors & academic preparation

Student shared some of the challenges they have faced, or are concerned about, as they work toward their engineering degrees. Some students expressed concerns related to their own individual personality or characteristics that they believe may be hindering their success. For some, it was apprehension about math and science preparation as they got ready to take classes in these subjects at the community college:

In high school I was in regular math and science classes, and that's not a bad thing, but ... [these classes] didn't have the best resources like they did in pre-AP and AP classes. So I thought because of that I wouldn't be ready to take on this major.

Another student mentioned that the length of time between when she graduated from high school and when she started college made her lose a lot of her fundamental math skills, so it was a steep learning curve to return to school.

For others, it was concern about their level of academic preparation prior to transferring to a university to complete their degree:

I am a little nervous to go to four-year college in the fall. I don't really feel like I'm super prepared because I haven't really been challenged that much in community college, and I have a feeling it's going to be overwhelming and a lot harder than what I'm used to.

One faculty member interviewed indicated a need to improve communication skills among community college engineering students, particularly oral communication skills. She said that her college works very hard to give students opportunities to stand up in front of the class to give oral presentations.

Other personality traits mentioned by those in our study that they felt made their academic journey more difficult included indecisiveness, procrastination, and a lack of confidence.

Lack of family support

While families were generally supportive of students pursuing an engineering degree, one student said that people in her network had expressed skepticism about her ability to balance school and family:

When people find out, [they say,] “oh yes, the children, are you sure you really want to do this?”

This same respondent said that people had also questioned her ability:

Oh wow, that’s a lot of math. Are you sure that’s what you want?

Faculty also noted instances of students expressing a lack of support from their families, particularly among first-generation college students. They indicated that some students think college is hard, that engineering is hard, and they believe it stems from not knowing anyone in college:

[First-generation college students] have no idea what real college, or transfer, or transition or anything is going to be, because no one’s told them before what it’s like to be in college before because no one in their family’s done it. And it goes on further where they’re actually talked to negatively about college.

Another faculty member observed gender differences in how students’ families sometimes reacted to their decision to major in engineering:

I’ve had women come in and tell me that, you know, “My parents won’t pay for me to study engineering because it’s just not an appropriate occupation for a woman. It’s okay for my brother, but it’s not okay for me.”

Additional barriers

There were a few additional challenges mentioned by those interviewed for this study. One faculty member we spoke with noted that a community college district’s size can be a challenge for students:

... we have our size going against us because the students ... take courses all over town, basically driven by their schedule. They choose the ones that work with their life. They go to different locations.

Two students mentioned difficulty understanding instructors or tutors and teaching assistants at their colleges. One had a hard time understanding tutors because they had strong accents, while the other had a hard transition to community college because she’s an English language learner.

This research was conducted to gain a better understanding of the challenges and barriers facing women on the transfer pathway in their pursuit of an engineering or computer science baccalaureate degree, and to identify factors that contribute to success from the perspective of women preparing to transfer. Our aim was to determine areas where additional supports from institutions and professional societies can help reduce women’s high attrition rates observed in our first study of transfer success in Texas. What we discovered is that many factors affect both men’s and women’s progress in these programs, and that the gender differences are not as stark as we had expected.

We present recommendations to suggest ways to better support women on the transfer pathway in engineering and computer science, but our findings indicate that students of all genders would benefit from these improvements.

IMPROVE ADVISING FOR TRANSFER STUDENTS

Both students and faculty in our study indicated that advising for transfer students needs to be improved. While efforts are being made at local, regional, and state levels to provide more information to students about what courses are needed for their chosen major, as well as what courses will be accepted at their prospective transfer institution, the concerns expressed indicate that a lack of information is not the problem. Rather, there is a need for students to be advised by someone who can help them navigate through the information and help them solidify their transfer plan. Unfortunately, our findings indicate that students often feel uncertain about the help they receive from advisors at their colleges.

Faculty interviewed expressed an expectation that students should be proactive in reaching out to the transfer institution to find out what courses they should take at the community college. And while some students in our study indicated that they had done so, many others shared their frustrations about the lack of quality advising at their college to adequately prepare them for transfer.

Given the student-to-advisor ratio that many colleges face, it is not surprising that some students find it difficult to gain quality time with their assigned advisor. Proactive students are able to find the help they need, either through other departments or from their prospective transfer institution. It is those students who are unsure how to navigate the college environment, and who are in most need of guidance, who may be falling through the cracks.

PROVIDE MORE FINANCIAL SUPPORT

Students shared the financial challenges that they face as they pursue their college education. For some, the cost of attending college was the primary reason for beginning their bachelor's degree at a community college. Others spoke of the impact that working while taking classes had on their ability to make time for school-related activities, including their ability to enroll full-time.

Faculty also expressed concerns about the need for more financial support for students:

[Some engineering students may say], "Well, I can't be in a study group because I have to go to work afterwards. I got to go to class and I have to go to work." Maybe [offer] more financial aid ... so the student can reduce the number of hours they work ... If they reduce the number of hours by 10, then those are 10 hours spent focusing on their engineering courses.

A study in California found that only about 10% of transfer students received financial aid while enrolled at a community college [28]. Scholarships and other forms of financial support could help provide students more time to focus on their engineering studies. Paid internships and other forms of employment that expose students to hands-on engineering projects while also providing monetary support as they pursue their education could help encourage students to stay in engineering majors through transfer and graduation.

For example, the City University of New York (CUNY) offers a program called the Accelerated Study in Associate Programs (ASAP). ASAP offers students free tuition, textbooks, and transportation, in addition to smaller classes, flexible schedules, and help finding internships and research opportunities – an expensive initiative, but one that other colleges across the country are beginning to adopt because of the huge increase CUNY has seen in graduation rates of students participating in the program.

PROVIDE MORE INFORMATION ABOUT CAREER PATHWAYS

Over half of the students in this study expressed limited or no knowledge about the engineering profession prior to entering college. Survey results showed that school-related experiences were the most frequent form of exposure to engineering for students on the community college pathway, with few students indicating that parents or mentors influenced their decision to pursue engineering. Survey responses also indicated that women learned less about engineering as a profession during their time at community college than men. Students interviewed for this study reported that learning more about the range of opportunities available within engineering helped them narrow their choice of majors and plan for their future. Therefore, providing more information about engineering career paths and opportunities to connect with professional engineers could be very valuable for women in community college.

STRENGTHEN INTERPERSONAL RELATIONSHIPS, NETWORKING, AND MENTORSHIP

In this study, students mentioned that involvement in extracurricular activities could benefit them academically, socially, and professionally. Students who had received mentorship indicated that this was an important source of guidance and encouragement. Some students also said that they were interested in joining professional societies, but very few students in our study were members of such organizations.

Because research shows that extracurricular involvement, particularly academic and professional activities, is tied to students' persistence in STEM, making it easier for students to participate in these activities would be beneficial. Some faculty interviewed for this study shared ways in which they try to help students develop the types of professional networks that can lead to internships and mentors. A couple of them provided examples of activities and events that they have developed to bring in engineers and IT professionals to interact with students. Events that allow female professionals to talk about their career path or the jobs they do seem popular with students.

One faculty member noted the importance of including student organizations at area four-year universities in these networking activities:

I want my community college students to be talking to the [university] students ... they can get the lowdown on what the campus life is about. How is the department that they want to transfer into? All of the stuff that an advisor won't tell you.

Another suggestion was to try to introduce community college students to university students who have successfully transferred in engineering majors. This helps students to see and understand the transfer pathway better. It also helps students develop relationships with students at the universities that they are considering transferring to, building their support network.

Faculty interviewed did express concerns about the way in which certain networking activities are currently managed. One common challenge expressed was that a lot of this work falls to individual faculty members. They are tasked with finding resources, identifying professionals to participate, and marketing to students. While they may receive support from their department or college, they indicated that this work is reliant on the individual faculty member to lead, placing it at risk of ceasing if the individual decides to stop.

RECOMMENDATIONS

FOCUS ON BOOSTING CONFIDENCE

Our survey findings were consistent with other studies showing that women tend to be less confident in math and science, despite having equal abilities in these areas. Decreased confidence among women (or over-inflated confidence among men) contributes to differential rates of persistence. Research suggests that interventions intended to counteract stereotypes and increase confidence of women in math can have a measurable impact on both performance and persistence in STEM. These interventions can include strategies such as explicitly stating in a testing context that women and men are known to perform equally well [35], providing opportunities for undergraduate research [36], and connecting women with same-gender expert in STEM [37].

APPENDIX A: DEMOGRAPHICS

	Frequency	Percent
English as first language:		
Yes	192	58.5
No	136	41.5
Total	328	100.0
First-generation student:		
Yes	128	39.3
No	195	59.8
I prefer not to answer	3	.9
Total	326	100.0
Student status:		
Full-time student	225	68.6
Part-time student	96	29.3
I prefer not to answer	7	2.1
Total	328	100.0
Employment status:		
Working full-time	77	27.5
Working part-time	102	36.4
Not employed	101	36.1
Total	328	100.0
Family income:		
High income	8	2.5
Upper-middle income	49	15.0
Middle income	108	33.1
Lower-middle income	84	25.8
Low income	62	19.0
I prefer not to answer	15	4.6
Total	326	100.0
Married/live with partner:		
Yes	95	29.1
No	223	68.4
I prefer not to answer	8	2.5
Total	326	100.0
Primary caregiver:		
Yes	43	13.2
No	274	84.0
I prefer not to answer	9	2.8
Total	326	100.00
International student:		
Yes	60	18.3
No	261	79.8
I prefer not to answer	6	1.8
Total	327	100.0
Age	302	25 (mean)

INTERVIEW RESPONDENTS:

	Age	Race/Ethnicity	Discipline
StudentA1	35	Black	Computer Engineering
StudentA2	30	White	Environmental or Bio-Agricultural Engineering
StudentA3	25	Latina and White	Computer or Software Engineering
StudentA4	51	Native American, Latina, and White	Electrical Engineering
StudentB1	22	Native American, Latina, and White	Civil or Environmental Engineering
StudentC1	19	Black	Electrical Engineering
StudentC2	20	Black	Civil or Mechanical Engineering
StudentC3	20	Black	Chemical or Materials Engineering

APPENDIX B: MEAN CONSTRUCT RESULTS BY GENDER AND RACE/ETHNICITY⁷

Construct	Mean (scale of 0 - 100)				Mean (scale of 0 - 100)		
	Women	Men	Sig.		URM	Non-URM	Sig.
Feeling of Inclusion	67.65	69.9	0.229		68.97	69.72	0.679
Engineering Self-Efficacy	81.56	82.74	0.466		82.21	82.73	0.730
Engineering Career Success Expectations	82.52	83.87	0.287		84.38	82.87	0.193
Math Outcome Expectations	83.33	82.58	0.674		83.66	82.22	0.391
Coping Self-Efficacy	83.26	82.62	0.677		83.10	83.03	0.959
Confidence in Math and Science Skills	73.25	76.29	0.068		75.56	75.09	0.763
Confidence in Professional and Interpersonal Skills	71.06	72.70	0.385		73.49	70.82	0.126
Confidence in Solving Open-Ended Problems	82.35	82.43	0.963		82.84	81.83	0.492
Financial Motivation	74.61	73.70	0.694		72.39	75.62	0.134
Social Good Motivation	87.84	85.78	0.289		88.62	84.54	0.029*
Mentor Influence Motivation	50.68	49.44	0.647		51.15	49.25	0.449
Intrinsic Psychological Motivation	87.55	87.69	0.944		88.72	86.86	0.313
Intrinsic Behavioral Motivation	88.25	89.90	0.425		89.77	88.84	0.627
Parental Influence Motivation	32.79	34.55	0.348		34.49	33.46	0.579

⁷ Mean scores on each construct were compared by gender and race/ethnicity using independent samples t-tests. A resulting probability value, or p-value, of less than .05 is typically considered statistically significant and indicates that the two groups are likely to be different.

APPENDIX C: APPLES2 AND LAESE ITEMS USED IN THIS STUDY

APPLES2 MULTI-ITEM VARIABLES

- **Motivation: Financial**
 - Reason: Engineers make more money than most other professionals
 - Reason: Engineers are well paid
 - Reason: An engineering degree will guarantee me a job when I graduate
- **Motivation: Parental Influence**
 - Reason: My parents would disapprove if I chose a major other than engineering
 - Reason: My parents want me to be an engineer
- **Motivation: Social Good**
 - Reason: Technology plays an important role in solving society's problems
 - Reason: Engineers have contributed greatly to fixing problems in the world
 - Reason: Engineering skills can be used for the good of society
- **Motivation: Mentor Influence**
 - Reason: A faculty member, academic advisor, teaching assistant or other university affiliated person has encouraged and/or inspired me to study engineering
 - Reason: A non-university affiliated mentor has encouraged and/or inspired me to study engineering
 - Reason: A mentor has introduced me to people and opportunities in engineering
 - Agree/disagree: A mentor has supported my decision to major in engineering
- **Motivation: Intrinsic Psychological**
 - Reason: I feel good when I am doing engineering
 - Reason: I think engineering is fun
 - Reason: I think engineering is interesting
- **Motivation: Intrinsic Behavioral**
 - Reason: I like to build stuff
 - Reason: I like to figure out how things work
- **Confidence in Math and Science Skills**
 - Confidence: Math ability
 - Confidence: Science ability
 - Confidence: Ability to apply math and science principles in solving real-world problems
- **Confidence in Professional and Interpersonal Skills**
 - Confidence: Self-confidence (social)
 - Confidence: Leadership ability
 - Confidence: Public speaking ability
 - Confidence: Communication skills
 - Confidence: Business ability (not included in this study)
 - Confidence: Ability to perform in teams
- **Confidence in Solving Open-Ended Problems**
 - Agree/disagree: Creative thinking is one of my strengths
 - Agree/disagree: I am skilled at solving problems with multiple solutions
 - Confidence: Critical thinking skills

LAESE SUBSCALES

- **Engineering career success expectations**
 - Someone like me can succeed in an engineering career
 - A degree in engineering will allow me to obtain a well-paying job
 - I expect to be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter engineering
 - A degree in engineering will give me the kind of lifestyle I want
 - I expect to feel “part of the group” on my job if I enter engineering
 - A degree in engineering will allow me to get a job where I can use my talents and creativity
 - A degree in engineering will allow me to obtain a job that I like
- **Engineering self-efficacy**
 - I can succeed in an engineering curriculum
 - I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g., extracurricular activities, family, sports)
 - I will succeed (earn an A or B) in my physics courses
 - I will succeed (earn an A or B) in my math courses
 - I will succeed (earn an A or B) in my engineering courses
- **Feeling of inclusion**
 - I can relate to the people around me in my class
 - I have a lot in common with the other students in my classes
 - The other students in my classes share my personal interests
 - I can relate to the people around me in my extra-curricular activities
- **Coping self-efficacy**
 - I can cope with not doing well on a test
 - I can make friends with people from different backgrounds and/or values
 - I can cope with friends’ disapproval of chosen major
 - I can cope with being the only person of my race/ethnicity in my class
 - I can approach a faculty or staff member to get assistance
 - I can adjust to a new campus environment
- **Math outcome expectations**
 - Doing well at math will enhance my career/job opportunities
 - Doing well at math will increase my sense of self worth
 - Taking math courses will help me to keep my career options open

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