2018 CoNECD - The Collaborative Network for Engineering and Computing Diversity Conference: Crystal City, Virginia Apr 29

Quantitative Analysis of Barriers to Completion of Engineering Degrees for Female-Identifying and Under-Represented Minority Students

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Quantitative Analysis of Barriers to Completion of Engineering Degrees for Female-Identifying and Under-Represented Minority Students

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Abstract

This study examines barriers to successful completion of undergraduate engineering degrees amongst female-identifying and under-represented minority (URM) students at Seattle University. The goal of this data-driven study is to extract characteristics that differentiate students who do or do not successfully complete degrees within engineering.

We analyze data on undergraduate students who were enrolled in the four engineering majors in the College of Science and Engineering (CSE) for any part of their time at Seattle University. We present results identifying barriers to students' successfully completing degrees in these programs, including examining the impacts of transfer versus first-time-in-college status, students' prior mathematics and science background, and pressures related to differing levels of unmet financial need.

Introduction

Despite nationwide efforts to attract and retain female and URM students to engineering disciplines, their numbers are still very low. In 2016, only 20.8% of recipients of Bachelor's degrees in engineering identified as female, and 18.2% identified as an under-represented minority [1].

Table 1 presents demographic information from the 2000 U.S. Census for individuals between the ages of 20 and 24 (age groups just above or below this age range show similar results). 48.9% of individuals between 20 and 24 identify as female [2]. 26.8% identify as an under-represented minority (URM) [3], which we define to include Hispanic or Latino, American Indian or Alaska Native, Black or African American, Native Hawaiian or Pacific Islander.

Table 1. U.S. Census demographics age 20-24.

Female- Identifying (%)	Male-Identifying (%)	URM (%)	Non-URM (%)	Female URM (%)
48.9	51.1	26.8	73.2	13.1

It is clear that both female-identifying and URM-identifying students are substantially under-represented in undergraduate engineering programs relative to the population as a whole. We use the term "barriers to access" to refer to issues relating to demographic disparities amongst those who do or do not enter engineering programs.

Even after a student enters an engineering program, there can be further disparities in how likely some students are to successfully complete an engineering degree relative to their peers. We use the term "barriers to success" to refer to issues relating to these disparities.

At Seattle University, if we analyze all students who matriculated between 2002 and 2010, and who at some point in their academic career were enrolled in an engineering program, we find that only 19.5% identified as female, and only 9.3% identified as URM.

Seattle University's mission and values statement includes a commitment to the importance of diversity in educational excellence. While we have seen an increase in the percentages of female- and URM-identifying students entering our engineering programs over recent years, there is still much progress to be made before we will reach a state of equality.

A recent grant from the Boeing Company provides resources to address the barriers to access and success currently faced by female- and URM-identifying students attending our University. Before developing and implementing new policies, we are assessing the current state of these students in our programs.

This assessment is taking place in two phases. First, in this study, we examine quantitative results from our institution to assess the magnitude of existing barriers to both access and success that our female- and URM-identifying students face. Second, this work will be followed up with focus group interviews that will allow us to hear from students as to what specific issues and experiences they have encountered that have contributed to these barriers, as well as what they have found that has been helpful to their academic success.

Seattle University's College of Science and Engineering (CSE) is comprised primarily of undergraduate programs, which are the focus of this study. We examine data on undergraduate students who were enrolled in the CSE's engineering programs (comprised of Civil and Environmental Engineering, Electrical & Computer Engineering, Mechanical Engineering, and Computer Science) for any part of their time at Seattle University. We present results identifying barriers to students' successfully completing degrees in these programs, including examining the impacts of transfer versus first-time-in-college status, students' prior mathematics and science background, and pressures related to differing levels of unmet financial need.

These findings will be used to inform the development of new policies and programs within the CSE to better support female-identifying and URM students in completing engineering degrees. This study focuses primarily on the success of students who are already enrolled in engineering degrees at Seattle University. It is part of a broader initiative at our college to examine accessibility of engineering degrees to female-identifying and URM students that will encompass both barriers to completion and the more fundamental barriers to access that prevent students from pursuing these degrees.

Previous Work

There has been considerable research on factors affecting student retention and on support services that help retain engineering students. The below works are only examples representative of the substantial body of work on women and URM students in engineering.

Reference [4] lists the most common retention techniques and institutions that implemented them. The authors divide the strategies into three groups: student-focused, faculty-focused, and institutional and department-focused strategies and provide many examples from literature and submissions from institutions.

Blaisdell and Cosgrove explain how self-efficacy (one's belief about how well they can perform given task or behavior) affects women choosing engineering as their field of study and persisting in it [5]. They advocate for interventions designed using the theory of self-efficacy and give an example of such a program. Sullivan and Davis [8] found that commitment to engineering and confidence in engineering are predictors of retention of women in engineering.

In [6], the authors study how academic performance factors and personality traits, as measured by the Hogan Personality Inventory, influence academic success and retention of engineering students. They found that ACT score and high school GPA were significantly related to second semester GPA for both genders. Personality traits measured included adjustment, ambition, sociability, likeability, prudence, intellectual curiosity, and school success. The authors concluded that higher GPAs were associated with more prudence and less sociability. Even if women had significantly higher scores on prudence, intellectual curiosity, and school success, these same academic factors and traits were significantly related to the retention of the male but not the female engineering undergraduates.

Jenkins and Keim analyzed engineering student graduation data at the University of Southern California and found that graduation rates of female students were slightly higher than those of male students [7]. On the other hand, graduation rates of under-represented minority students were found to be lower than graduation rates of non-minority students. The average semester when male students left engineering was fall semester of sophomore year while female students left during spring or summer of their freshman year. The average GPA of female students leaving engineering was lower than the GPA of male students leaving engineering.

Knight et al. analyze six questions about the experience of women who are studying engineering at CU-Boulder [8]. They used surveys and focus groups and learned that their female students were confident, interested in engineering, and felt accepted into the college. The students were not worried about failing but instead, they were concerned about not performing up to their expectations. Their most important findings include realization that first-year women are vulnerable to losing interest in engineering while in their introductory science courses especially if they are of the "weed-out" type. They are also at-risk due to disappointments over their GPA. The authors also learned that women know less about engineering careers than men before coming to college. Finally, women are more likely to seek support during their first year than men. The authors recommend that support services are increased and target women in their first year of college.

The above study was expanded in [9]. The authors conclude that women students who decide to stay in engineering continue to be interested in engineering careers and strongly believe that they will be able to obtain an engineering degree. They perceive the college climate to be friendly and accepting to women. On the other hand, women who chose to leave engineering report losing interest in engineering and find the classroom climate to be unfriendly to them. In addition, both women and men who leave engineering studies are dissatisfied with their grades and advising.

Amelink and Creamer surveyed students and conducted focus groups at 9 institutions in order to identify factors in the student undergraduate experience that positively influence satisfaction with engineering as a major and desire to work in engineering careers in the future [10]. They found that satisfaction with engineering major does not necessarily translate into wanting to pursue an engineering career especially in the case of women. The biggest impact on both gender students' satisfaction with their engineering major was getting along with other students in the major. Other factors that were important for women students were being treated with respect by other female students and instructors in their engineering classes and the quality of teaching. Male students were satisfied with their major choice if the quality of teaching was high but they also wanted to be treated with respect by their peers and instructors. Students of both genders responded to faculty who cared about their learning and success in the major. Satisfaction with the quality of teaching and the presence of effective female role models in the department were found to be influencing positively students' plans to seek careers in engineering.

Miller et al. focus on racially diverse students and factors that affect their adjustment to studying engineering [11]. They report that students experience many academic, social, and financial challenges during their first semester such as lack of study skills, lack of support, and high tuition costs. The authors give suggestions on how to help racially diverse students in their adjustment to college by listing numerous support services that the students in their study or previous research found to be successful in such circumstances. Trautvetter et al. study programs that are successful at recruiting and retaining women engineering students [12]. According to the authors, factors that are essential for retention include campus climate, support services administered during early undergraduate years, personal connection to faculty and other students, institutional support for student organizations and activities, and learning and living communities. Reid at al. discuss institutional student engagement strategies that have been proven to facilitate success of students of color in engineering [13]. The research has been conducted by the National Society of Black Engineers in collaboration with ExxonMobil. The recommended strategies include engagement of the institutional leadership, summer bridge programs, collaborative learning and living environments, facilitated study groups, early alert systems, scholarships, positive self-efficacy development, positive identity development, and faculty development programs. The paper provides research-based explanation of why each of these strategies works as well as best practices and challenges for their implementation.

In [14], the authors perform a study of retention of students in STEM fields. They found that 48% of students at bachelor's degree level and 69% at the associate's degree level left STEM fields by either changing majors or not completing a degree. Taking less challenging math courses and lighter credit load in STEM courses in the first year were associated with higher probability of switching majors. Poor overall performance in course was, not surprisingly, associated with higher levels of dropping from college. They also analyzed other factors that are associated with leaving college such as high numbers of withdrawn or failed STEM courses and lower STEM grades.

Chang at al. studied factors that contribute to the persistence of URM students in STEM field and found that Black and Latino students were less likely to persist in STEM majors than White and Asian American students [15]. They suggest that institutions can take actions to improve the retention of URM students by providing opportunities for these students to participate in such academic experiences as studying together, participating in undergraduate research, and involvement in academic clubs or organizations.

In [16], the authors report the results of a study designed to understand factors related to persistence in engineering majors. They found that women use a wider set of resources in their classes and often discuss the lecture topics with other students but do not find study centers to be useful. Women are also less confident in their abilities to succeed in an engineering course but their GPAs are similar to those of men. When selecting a career, women rank opportunity to make a difference as a much more important factor than men. Women are also more successful at balancing studying and participation in extracurricular activities.

Fouad and Singh report their findings from surveying over 3,700 women who graduated with an engineering degree on their reasons to continue their engineering career or switch to another job [17]. Women who left the fields did so because of their dissatisfaction with working conditions including excessive travel, lack of opportunities to advance, and low salary. Some left because of workplace climate or to spend time with their family. Those who did not enter engineering career after graduation, did so because of a negative perception of engineering workplace culture as unfriendly to women or engineering being inflexible in general. Some women said that they lost interest in engineering. Those who stayed in engineering were influenced by supportive supervisors or co-workers. In addition, companies that seem to retain women value and recognize their contributions, and invest in their training and professional development.

Bowling et al., describe a successful undergraduate research program for rising sophomores and juniors that are at risk of leaving STEM [18]. Students were paid a stipend and were part of a research team. The authors found that students who participated in the research program were more likely to continue their engineering studies and were more successful in terms of learning outcomes.

Sundararajan et al. described their efforts to improve recruitment, retention, and engagement of women in their Mechanical Engineering Department [19]. The Women in Mechanical Engineering program organized social and professional development events to provide opportunities for women to interact with each other and faculty and introduce students to role models in engineering and academic professions. Creating such community in the department and expanding it to a network of professionals had a positive influence on the numbers of women enrolling in their program.

Brown et al. describe teaching strategies and behaviors that improve student success in STEM [20]. The recommendations can be categorized into those that 1) create a welcoming and supportive learning environment, 2) provide early and frequent feedback on learning, 3) encourage students to engage in the scientific method, 4) show the relevance of the course material to the rest of the field and give exposure to careers in STEM. The authors provide implementation notes for each type of strategies. Tanner focuses on biology courses and provides strategies for educators that promote equitable classroom environments with enhanced student engagement and participation in learning [21]. Similarly, Killpack and Melón provide strategies for STEM faculty on how to create an inclusive classroom environment. They discuss faculty privilege, implicit bias, and stereotype threat [22].

Seattle University

Seattle University (SU), founded in 1891, is located near downtown Seattle and it is one of the largest independent institutions in the Pacific Northwest region. Over 7,400 students are enrolled in undergraduate and graduate programs. One of the core values of Seattle University is to put the good of students first: students enjoy personal attention, small class sizes, and extensive support services. U.S. News and World Report’s “Best Colleges 2018” ranks Seattle University #7 for its undergraduate, masters and select doctoral degree programs. Seattle University is accredited by the Northwest Commission on Colleges and Universities.

The College of Science and Engineering consists of eight STEM departments including Computer Science (CS), Civil and Environmental Engineering (CEE), Electrical and Computer Engineering (ECE), and Mechanical Engineering (ME). There are over 100 full-time and part-time faculty and more than 1,100 undergraduate and graduate students. In addition to rigorous technical educations where theory is balanced with hands-on, laboratory-based work, our students experience emphasis on leadership, teamwork, and oral and written communication.

All engineering and computer science students participate in a year-long senior design project which is sponsored by local industry. Teams of students mentored by a faculty member and a liaison engineer solve real-world engineering problems. Students design, build and test their own solution, write proposals and reports, and present the result to their sponsors. By bridging the gap between academia and industry, the senior design project prepares students for their professional life.

Design projects combined with problem solving, critical thinking, teamwork, and opportunities for interdisciplinary collaboration characterize a holistic approach to the education provided to our undergraduate students. We strive to create an inclusive, supportive, and academically challenging learning environment where personal attention from faculty, peer mentoring, collaboration, and hands-on projects help our students reach their potential.

Data Set

Seattle University's Institutional Research department provided data on students admitted between summer quarter of 2002 and winter quarter of 2017. The data set provided included students who at one point "touched" the College of Science and Engineering (CSE). We define "touched" to mean any student who declared a major in the CSE or was a pre-engineering student during their time at Seattle University.

Analysis was conducted on a subset of this data, based on the following criteria:

1. Relevant program—this study primarily examines students who were at some point during their time at Seattle University enrolled in Pre-Engineering (PEGR), Civil & Environmental Engineering (CEGR), Mechanical Engineering (MEGR), Electrical & Computer Engineering (EEGR), or Computer Science (CPSC) programs. These we will refer to as "All Relevant Programs" (ARP).
2. Relevant year—this study excludes students who may be currently working on their degree. It was decided that only students who enrolled between 2002 until 2010 be examined. The original data set started at 2002 matriculation. 2010 was decided as the end year to allow a window of 6 years for degree completion.

It is worthwhile to note that some students declared double engineering majors. In this case, they were counted in both categories. Therefore, the total students for each individual program add up to slightly more than the total number of overall students.

To summarize the data used in the study, Table 2 gives counts of the number of students included, divided by major, by gender identity, and by URM status, while Table 3 provides percentage breakdowns. When considering the intersection of gender and race, percentages are reported in two different ways. "Percent URM Female" refers to the percentage, out of all students, who identified as both URM and female, while "Percent URM of Female" refers to the percentage, out of only those students who identified as female, who also identified as URM.

Table 2. Demographic breakdown of student totals.

	Total Students	URM Total	Female Total	URM Female Total	Male Total	URM Male Total
ARP	1175	109	229	20	946	89
CPSC	264	29	44	6	220	23
PEGR	165	17	44	1	121	16
EEGR	259	21	27	2	232	19
CEGR	278	25	98	9	180	16
MEGR	287	23	37	2	250	21

Table 3. Percentage breakdown of relevant student population.

	Female (%)	URM Female (%)	URM of Female (%)	Male (%)	URM Male (%)	URM of Male (%)
ARP	19.5	1.7	8.7	80.5	7.6	9.4
CPSC	16.7	2.3	13.6	83.3	8.7	10.5
PEGR	26.7	0.6	2.3	73.3	9.7	13.2
EEGR	10.4	0.8	7.4	89.6	7.3	8.2
CEGR	35.3	3.2	9.2	64.7	5.8	8.9
MEGR	12.9	0.7	5.4	87.1	7.3	8.4

Students in the data set were each flagged with a binary indicator of whether they are an under-represented minority (URM). The institution defines URM for race or ethnicity to include Hispanic or Latino, American Indian or Alaska Native, Black or African American, Native Hawaiian or Pacific Islander. When "Two or More" are indicated and at least one includes the above, a URM flag is given. 51 of the students included in the data set did not report their ethnicity information, and thus are not counted in either the URM or non-URM category. Female-identifying students marked themselves as such at time of enrollment.

Additional data came from two other sources. We used data prepared for the ASEE retention reports. Those reports cover cohorts 2008-2016 for First-Time-in-College (FTIC) and 2008-2013 for transfer students. In addition, to analyze traits of students who successfully make it to graduation in engineering, we obtained reports of students who graduated in engineering from Seattle University in years 2013-2017. In the ASEE data, if a student selected “Two or More” for their race or ethnicity, information was not available for which two or more categories they identified with, and so these students could not be definitively categorized as URM or not. For comparison, “Two or More“ in ASEE data sets were treated as URM.

Results

Graduation

We define “graduated” to mean that a student completed any degree from Seattle University (not specifically that they graduated with an engineering degree). Table 4 compares graduation rates for students who started in each engineering program. Table 5 expands upon this, showing graduation rates within each program based on gender identity and URM status. Analyses later in this paper will also examine rates for students specifically graduating with a degree in engineering.

The sample sizes for both URM and female students are fairly small, and much smaller in the case of students who identify as both female and URM. Consequently, many of the differences examined do not show statistical significance. Though the data is sparse, we still find it important to report the numbers and percentages for the information we do have available.

Table 4. OVERALL graduation rates for students who started in engineering programs.

	Graduated (%)
ARP	78.0
CPSC	74.2
PEGR	70.9
EEGR	78.8
CEGR	88.5
MEGR	81.9

Table 5. PERCENTAGE breakdown of graduation rates across programs.

	Graduated of Females (%)	**Graduated of URM Females (%)**	**Graduated of Non-URM Females (%)**	**Graduated of Males (%)**	**Graduated of URM Males (%)**	**Graduated of Non-URM Males (%)**
ARP	83.8	80.0	84.2	76.5	77.5	76.4
CPSC	84.1	100.0	81.6	72.3	82.6	71.1
PEGR	81.8	100.0	81.4	66.9	68.8	66.7
EEGR	70.4	50.0	72.0	79.7	78.9	79.8
CEGR	88.8	66.7	91.0	88.3	87.5	88.4
MEGR	94.6	100.0	94.3	80.0	76.2	80.3

Table 5 shows that across nearly all programs, we see higher graduation rates for female-identifying students than male-identifying students. There is less of a clear trend in comparing URM and non-URM students, in part driven by the smaller numbers of students who identify as URM.

Financial Need

Because financial ability is a crucial factor in continuing education, we study how financial need affects graduation rates. We also analyze how financial aid is affecting specific groups. Table 6 shows graduation rates for students who have their assessed financial need met versus those who have unmet financial need. Financial aid information is collected at the start of the student's first term at Seattle University.

Table 6. PERCENTAGE breakdown of graduation rates across financial need.

	Graduated of Females (%)	**Graduated of URM Females (%)**	**Graduated of Non-URM Females (%)**	**Graduated of Males (%)**	**Graduated of URM Males (%)**	**Graduated of Non-URM Males (%)**
Unmet Financial Need	86.0	83.3	86.2	79.0	80.0	78.8
Met Financial Need	81.5	75.0	82.0	74.4	73.5	74.5

Across all groups, it appears that students with unmet financial need have a higher chance of graduating than students whose financial has been met. This information might be contrary to what one might expect. The pressures of needing to graduate and get a job to pay back loans might be a justification for this result. We plan to discuss the impact of financial need on graduation during our student focus groups in the near future.

Next, we consider the magnitude of the unmet financial need in the case of students who had unmet financial need.

Figure 1 compares the amount of unmet financial need between students who did and did not graduate. Students who did not graduate were more likely to have higher amounts of unmet financial need relative to their peers who did graduate.

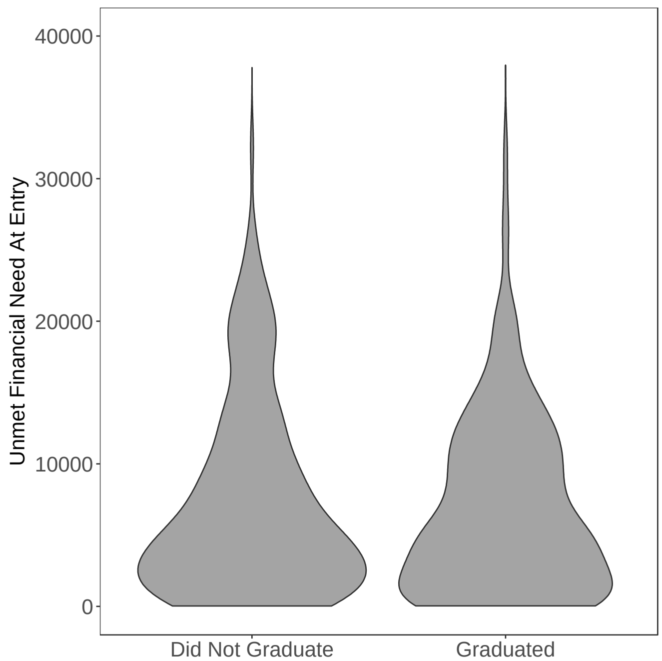

Figure 1. Amount of unmet financial need for students who did and those did not graduate.

Figure 2 compares the amount of unmet financial need between female- and male-identifying students. For both male- and female-identifying students, those who did not graduate were more likely to have higher levels of unmet financial need. Also, male-identifying students were likely to have slightly higher levels of unmet financial need than female-identifying students.

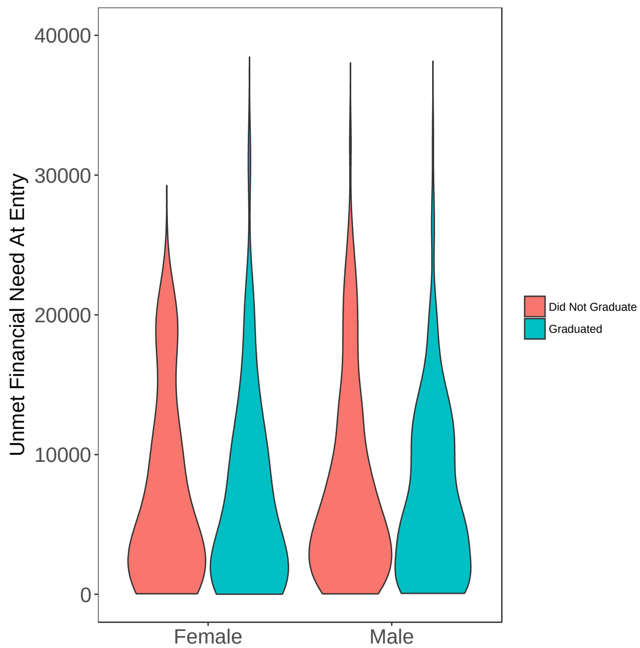

Figure 2. Unmet financial need for female- and male-identifying students.

Figure 3 compares the amount of unmet financial need between URM and non-URM students. Again, students who did not graduate tended to have higher levels of unmet need. This disparity is greater for URM students than for non-URM students. The URM students who did not graduate tended to have higher levels of unmet financial need than non-URM students who did not graduate. URM students who did graduate tended to have lower levels of unmet financial need than non-URM students who did graduate. A logistic regression model predicting probability of completing a degree based on magnitude of unmet financial need found that there was a highly statistically significant effect (p-value < .0001).

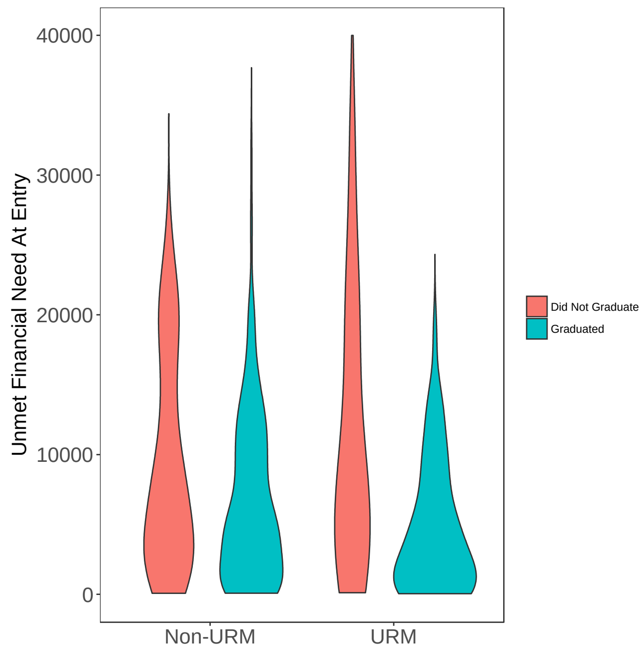

Figure 3. Unmet financial need for URM and non-URM students.

Admit Status

A large number of our students transfer to Seattle University from a prior institution. There are many factors that could differ for transfer students versus FTIC students. We compare graduation rates between the two groups in Table 7.

Table 7. Percentage breakdown of graduation rates across admit status

	Percent Graduated of Females	Percent Graduated of URM Females	Percent Graduated of Non-URM Females	Percent Graduated of Males	Percent Graduated of URM Males	Percent Graduated of Non-URM Males
Transfer	80.6	83.3	80.5	79.0	74.2	79.4
FTIC	85.9	78.6	86.8	74.7	78.9	74.2

As shown in Table 7, URM transfer students have low rates of graduation across gender in comparison to URM students who enrolled at Seattle University as their first time in college experience. It is important to note that the data sets for "URM Females" were very small—less than 20 for both transfer and FTIC students.

Age

Table 8 shows graduation rates for students in two age groups: those who were 25 years or older at the time they entered Seattle University and those who were younger than 25 years. The chance of graduation in the case of students who are older than 25 years is lower than for the general population of students in the data set. Within our data, URM female-identifying students over the age of 25 have the highest rate of graduation.

Table 8. PERCENTAGE breakdown of graduation rates with respect to age.

	Graduated of Females (%)	Graduated of URM Females (%)	Graduated of Non-URM Females (%)	Graduated of Males (%)	Graduated of URM Males (%)	Graduated of Non-URM Males (%)
Age 25 and Older	72.2	78.9	71.6	57.4	52.0	58.2
Age under 25	84.7	77.8	85.4	77.0	81.1	76.6

Characteristics of Students Graduating in Engineering Between Summer 2013 and Spring 2017

Among the students who graduated in engineering between summer 2013 and spring 2017 (total 383 students), 20.6% were women and 11% were URM. Among the 188 FTIC students in the data, 23.9% were women and 15.4% were URM. Students graduating during this period include FTIC and transfers. The large majority of these students started between 2008 and 2015. In this section, we take a closer look at students who graduated in engineering; analyzing data for student who did not graduate in engineering is part of our future work.

Mathematics is an important foundational course for engineering programs. We study how the type of the first math course impacted the likelihood of graduation. As shown in Table 9, almost 70% of FTIC students started in at least Calculus 1. Only 2 students starting in the lowest math class (Functions and Algebraic Methods) completed an engineering degree. Those two students were international students requiring additional English coursework, likely with higher math skills and English barriers affecting math. Typically, students start in Precalculus, Calculus with Algebra, Calculus 1, or higher than Calculus 1 due to Advanced Placement, International Baccalaureate, or transfer credit. Calculus with Algebra is a two-quarter course offered as an alternative to the one-quarter Calculus 1 course, aimed at students who are identified via a diagnostic test as being at risk for poor performance in Calculus 1. Over the two quarters, it covers the same calculus material as the one-quarter Calculus 1 course, but spends additional time reviewing concepts from algebra and trigonometry in tandem with the introduction of calculus material [23].

Table 9. STUDENT demographics of FTIC who graduated in engineering 2013-2017 initial math course.

X Math	Male Total Students in X Math	URM Total Students in X Math	Female Total Students in X Math	Female URM Total Students in X Math	FTIC Total Students in X Math	Percent started in X math	Percent Women who started in X math	Percent URM total who started in X math	Percent Female stared in X math (# F/FTIC tal in X)	Percent URM starts in X Math (#URM total/FTIC total in X math
pre calc	31	9	10	3	41	21.8	23.9	15.4	24.4	22.0
calc 1a	10	3	1	0	11	5.9	0	0	9.1	27.3
calc 1	46	5	15	2	61	32.5	0	0	24.6	8.2
above	52	12	17	4	69	36.7	0	0	24.6	17.4
other	4	0	2	0	6	3.2	0	0	0	0
Total	143	29	45	9	188	0	0	0	0	0

Student Retention Profile

FTIC Students (2008-2015 cohorts; **854 total students)**

2008-2015 1st year retention averaged 73.4% . However, overall, that percentage has generally increased over time. Women (216 total students) have retained in the first year at a slightly higher rate, averaging 75.3%. Notably, since 2013, the retention for women has increased significantly, averaging 69.3% in years 2008-2012 and 85.1% in 2013-2015. Retention of our engineering students moving into the third year averaged 81.1%, with women at a slightly lower rate of 79.8%. The time frame for this is a year shorter (2008-2014) because the third year for the 2015 group will be in 2018.

Using ASEE's database to compare to similar size institutions we see that for FTIC students we have room for improvement. The average first term retention is 77.4% and second term is 65.7% compared to our 73.4% and 64.8% respectively for the 2015 cohort.

Transfer students (2008-2015 cohorts; 301 total students)

Transfer students come to us at all points from freshman transfer to senior transfers. It is quite common for transfer students to only be at our university for two years, after which time they have completed their degree. As such, looking beyond first year retention for transfer students is not informative, as there is no longer an expectation of being at our university for a typical four years as there is with FTIC students. For that reason, we have compared only first year persistence for transfers. As expected, our transfers retain at a higher rate than FTIC students. Cohorts 2008-2015 average retention is 85.3%. Again, women (52 total) persisted at a slightly higher rate, with retention of 86.9% to the second year.

Compared to similar size universities we compare well according to the ASEE national database. The national average for first year retention is 79.4% overall and 82.6% for women compared with our 81.9% and 85.3% respectively.

Paths to Graduation

To study paths to graduation, we again consider those students who began between 2002 and 2010. Table 10 shows where those students who began in engineering programs ended up completing their degrees (or if they did not graduate). For each starting program, we count those who completed a degree in each engineering program, who completed a degree outside of engineering but still within the College of Science and Engineering (in math or science), those who completed a degree at Seattle University outside of the College of Science & Engineering, and those who did not complete a degree.

If a student double-majored in two engineering degrees, we count them in both. For example, two students who began as Electrical and Computer Engineering majors ended up with double majors in Electrical and Computer Engineering and Computer Science. For the EEGR row, those students are counted in both the EEGR and CPSC columns.

On the other hand, if a student double-majored in an engineering degree and a degree outside of engineering, we only count them in the engineering outcome. The "Math & Science" column counts students who did not complete an engineering degree but who still completed a degree within the College of Science & Engineering.

For those students who completed a degree outside of the College of Science and Engineering, we do not provide a detailed breakdown of which degrees they completed. However, we noted when examining the data that degrees in Business (including Finance, Marketing, and Economics) were common outcomes for these students.

Table 10. STARTING and ending programs.

		Graduating Program						
Starting Program	Total	MEGR	EEGR	CEGR	CPSC	Math & Science	Outside of STEM	Did not graduate
MEGR	224	130	3	5	1	3	30	52
EEGR	214	2	147	0	4	3	8	52
CEGR	229	10	4	145	1	4	33	32
CPSC	228	3	7	0	95	6	52	66
PEGR	164	27	10	20	2	10	48	47

Table 11 provides a summary in percentages, rather than counts, of where students ended up based on the program they started with. We see that for all five starting programs, there are roughly similar overall graduation rates. For those who started in MEGR, EEGR, or CEGR, a majority graduate with a degree in the major they started in. For CPSC and PEGR, a majority did not complete degrees within Engineering or STEM.

Table 11. GRADUATION programs by percentage.

Starting Program	Graduated in starting program (%)	Graduated in an engineering program (%)	Graduated in STEM (%)	Graduated (%)	Did not Graduate (%)
MEGR	58.0	62.0	63.4	76.8	23.2
EEGR	68.7	70.6	72.0	75.7	24.3
CEGR	63.3	69.9	71.6	86.0	14.0
CPSC	41.7	45.6	48.2	71.1	28.9
PEGR	N/A	36.0	42.1	71.3	28.7

Table 12 examines the same set of outcomes as Table 10, but now restricted to female-identifying students only. Table 13 again summarizes these findings in percentages. We see that numbers for female students are roughly in line with the previously considered overall numbers.

Table 12. STARTING and ending programs of female-identifying students.

		Graduating Program						
Starting Program	Total	MEGR	EEGR	CEGR	CPSC	Math & Science	Outside of STEM	Did not graduate
MEGR	20	15	0	0	0	0	3	2
EEGR	21	1	12	0	0	0	1	7
CEGR	80	6	0	45	0	3	15	11
CPSC	41	0	0	0	18	4	12	7
PEGR	43	7	1	12	0	4	12	7

Table 13. GRADUATION programs of female-identifying students by percentage.

Starting Program	Graduated in starting program (%)	Graduated in an engineering program (%)	Graduated in STEM (%)	Graduated (%)	Did not Graduate (%)
MEGR	75.0	75.0	75.0	90.0	10.0
EEGR	57.1	61.9	61.9	66.7	33.3
CEGR	56.3	63.8	67.5	86.3	13.8
CPSC	43.9	43.9	53.7	82.9	17.1
PEGR	N/A	46.5	55.8	83.7	16.3

Table 14 and Table 15 provide similar analyses again, but now for URM-identifying students. These numbers show roughly similar overall graduation rates, but lower graduation rates within STEM.

Table 14. STARTING and ending programs of URM students.

		Graduating Program						
Starting Program	**Total**	MEGR	EEGR	CEGR	CPSC	Math & Science	Outside of STEM	Did not graduate
MEGR	20	11	0	1	0	1	2	5
EEGR	18	0	11	0	0	0	2	5
CEGR	21	0	2	9	0	0	5	5
CPSC	27	0	1	0	9	0	13	4
PEGR	17	3	0	2	0	1	6	5

Table 15. GRADUATION programs of URM students by percentage.

Starting Program	**Graduated in starting program (%)**	**Graduated in an engineering program (%)**	**Graduated in STEM (%)**	**Graduated (%)**	**Did not Graduate (%)**
MEGR	55.0	60.0	65.0	75.0	25.0
EEGR	61.1	61.1	61.1	72.2	27.8
CEGR	42.9	52.4	52.4	76.2	23.8
CPSC	33.3	37.0	37.0	85.2	14.8
PEGR	N/A	29.4	35.3	70.6	29.4

Table 16 and Table 17 reduce our data set further, to consider outcomes only for students who identify as both female and URM. The sample sizes in this case are small enough that the percentages should not be considered particularly reliable estimates. However, the very small numbers in Table 2 provide a reminder of the scope of the issues being considered – over the period being considered, from 2002 to 2010, there were only a total of twenty students who identified as female and URM who entered Seattle University with a major in engineering. Of those twenty, only seven completed a degree in engineering.

Table 16. STARTING and ending programs of URM female-identifying students.

		Graduating Program						
Starting Program	**Total**	MEGR	EEGR	CEGR	CPSC	Math & Science	Outside of STEM	Did not graduate
MEGR	2	1	0	0	0	0	1	0
EEGR	2	0	0	0	0	0	1	1
CEGR	9	0	0	3	0	0	3	3
CPSC	6	0	0	0	3	0	3	0
PEGR	1	0	0	0	0	0	1	0

Table 17. GRADUATION programs by percentage of URM and female-identifying students.

Starting Program	Graduated in starting program (%)	Graduated in an engineering program (%)	Graduated in STEM (%)	Graduated (%)	Did not Graduate (%)
MEGR	50.0	50.0	50.0	100.0	0.0
EEGR	0.0	0.0	0.0	50.0	50.0
CEGR	33.3	33.3	33.3	66.7	33.3
CPSC	50.0	50.0	50.0	100.0	0.0
PEGR	N/A	0.0	0.0	100.0	0.0

Figure 4 compares graduation rates for all students versus 1) female-identifying students, 2) URM-identifying students, and 3) female URM-identifying students. Results are divided by starting major within each graph, and by graduation category (graduated in starting major, graduated in engineering, graduated in STEM, and graduated in any degree).

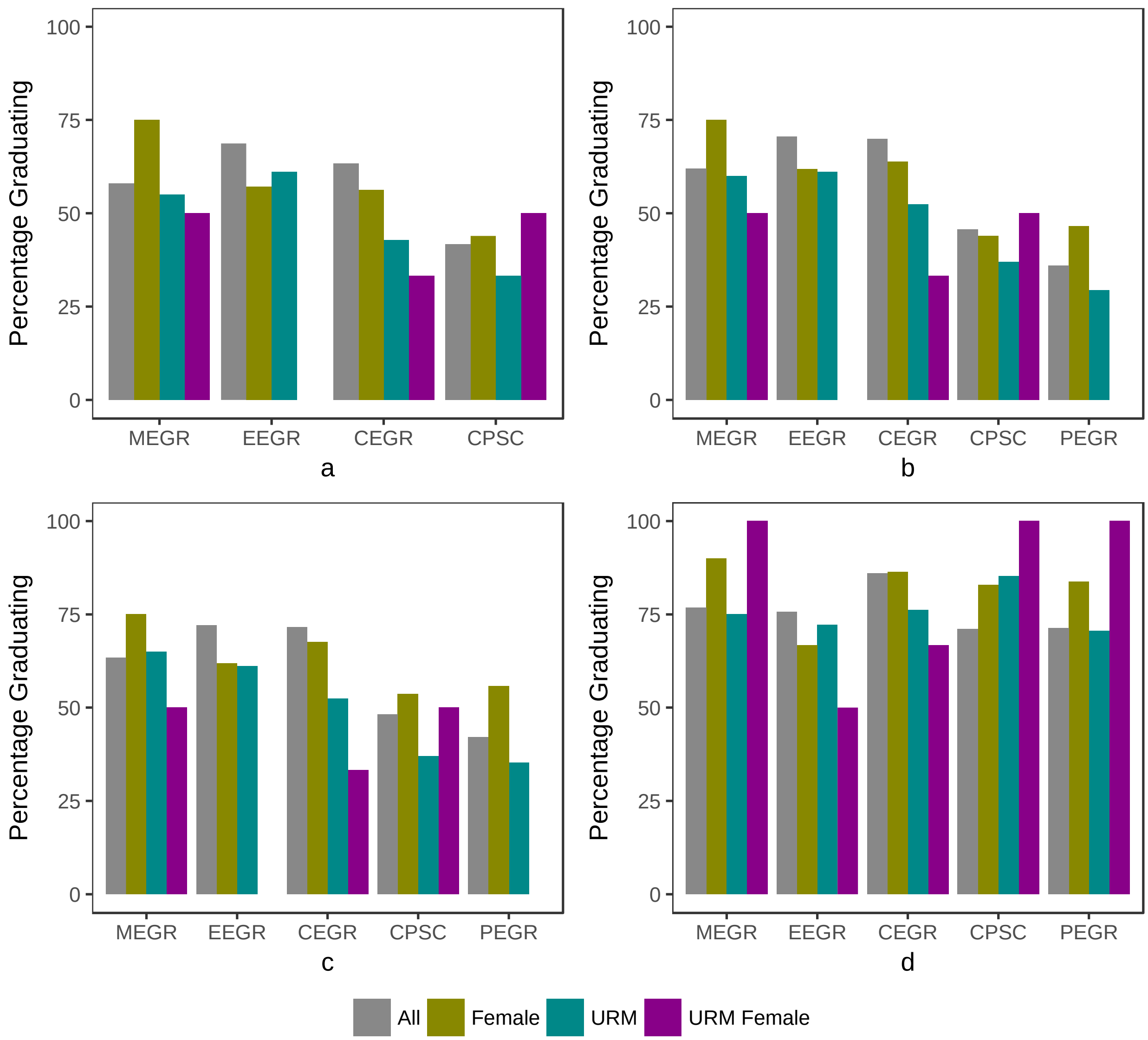

Figure 4. Graduation rates for all students. a) Graduating in starting major, b) Graduating in engineering, c) Graduating in STEM, d) Graduating in any degree.

We also examine the starting majors for all students who graduated in engineering majors. Table 18 and Table 19 show results for all students who completed a degree in engineering. While there is some movement between engineering majors, it is extremely uncommon for a student to graduate with an engineering degree if they did not begin as an engineering major.

Table 18. STARTING and ending programs of graduated population.

		Starting Program						
Graduating Program	**Total**	MEGR	EEGR	CEGR	CPSC	PEGR	Math & Science	Other
MEGR	193	130	2	10	3	27	11	10
EEGR	189	3	147	4	7	10	8	10
CEGR	194	5	0	145	0	20	7	17
CPSC	129	1	4	1	95	2	12	14

Table 19. STARTING and ending programs by percentage of graduated population.

Graduating Program	**Began in graduating program (%)**	**Began in an engineering program (%)**	**Began in STEM (%)**	**Began outside STEM (%)**
MEGR	67.4	89.1	94.8	5.2
EEGR	77.8	90.5	94.7	5.3
CEGR	74.7	87.6	91.2	8.8
CPSC	73.6	79.8	89.1	10.9

Table 20 and Table 21 provide similar summaries for female-identifying students. It was quite uncommon for female-identifying students to graduate with an engineering degree if they did not begin in an engineering major.

Table 20. STARTING and ending programs of graduated population among female-identifying students.

		Starting Program						
Graduating Program	**Total**	MEGR	EEGR	CEGR	CPSC	PEGR	Math & Science	Other
MEGR	32	15	1	6	0	7	1	2
EEGR	17	0	12	0	0	1	1	3
CEGR	63	0	0	45	0	12	2	4
CPSC	21	0	0	0	18	0	2	1

Table 21. STARTING and ending programs among female-identifying students by percentage of graduated population.

Graduating Program	**Began in graduating program (%)**	**Began in an engineering program (%)**	**Began in STEM (%)**	**Began outside STEM (%)**
MEGR	46.9	90.6	93.8	6.3
EEGR	70.6	76.5	82.4	17.6
CEGR	71.4	90.5	93.7	6.3
CPSC	85.7	85.7	95.2	4.8

Table 22 and Table 23 consider students who identified as URM. Once more, it is very unusual for these students to complete an engineering degree if they did not begin as engineering majors.

Table 22. STARTING and ending programs of graduated URM student population.

		Starting Program						
Graduating Program	**Total**	MEGR	EEGR	CEGR	CPSC	PEGR	Math & Science	Other
MEGR	14	11	0	0	0	3	0	0
EEGR	14	0	11	2	1	0	0	0
CEGR	13	1	0	9	0	2	0	1
CPSC	11	0	0	0	9	0	1	1

Table 23. STARTING and ending programs by percentage of graduated URM student population.

Graduating Program	**Began in graduating program (%)**	**Began in an engineering program (%)**	**Began in STEM (%)**	**Began outside STEM (%)**
MEGR	78.6	100.0	100.0	0.0
EEGR	78.6	100.0	100.0	0.0
CEGR	69.2	92.3	92.3	7.7
CPSC	81.8	81.8	90.9	9.1

Finally, Table 24 and Table 25 provide summaries for students who identify as both female and URM. These are the same seven students discussed previously to have completed an engineering degree in our data set. We see that all seven of these students began in the same majors they ended up completing their degrees in.

Table 24. STARTING and ending programs of graduated URM and female-identifying student population.

		Starting Program						
Graduating Program	**Total**	MEGR	EEGR	CEGR	CPSC	PEGR	Math & Science	Other
MEGR	1	1	0	0	0	0	0	0
EEGR	0	0	0	0	0	0	0	0
CEGR	3	0	0	3	0	0	0	0
CPSC	3	0	0	0	3	0	0	0

Table 25. STARTING and ending programs by percentage of graduated URM and female-identifying student population.

Graduating Program	Began in graduating program (%)	Began in an engineering program (%)	Began in STEM (%)	Began outside STEM (%)
MEGR	100.0	100.0	100.0	0.0
EEGR	N/A	N/A	N/A	N/A
CEGR	100.0	100.0	100.0	0.0
CPSC	100.0	100.0	100.0	0.0

Time to Graduate

In total, we have data on 512 first-time in college students who enrolled between 2002 and 2010 who successfully graduated (with any degree). 11 of these students were female URM, 45 were male URM, 105 were female non-URM, and 351 were male non-URM. For each student we analyze their time to graduate, in years, allowing for fractions of years based on the quarter in which they graduate. For these students, the median time to graduation was 3.75 years (corresponding to graduating the spring quarter of the fourth year after starting in fall quarter). While this median was the same for each possible subdivision of students based on gender and URM identification, the overall distributions showed some differences, as can be seen in Figure 5. Three male non-URM students took over ten years (in each case, the student began at Seattle University, took an extended leave of absence, and then later returned and completed their degree). To make the graph more easily viewable, these three students are not shown in this graph.

We see that URM students tend to show a shorter time to graduate than non-URM students, and that female students tend to show a shorter time to graduate than male students.

For female URM students who did graduate, 90.9% graduated within four years, and 100% graduated within six years. For male URM students who did graduate, 66.7% graduated within four years, and 97.8% graduated within six years. For female non-URM students who did graduate, 64.8% graduated within four years and 98.1% graduated within six years. For male non-URM students who did graduate, 61.8% graduated within four years and 97.7% graduated within six years.

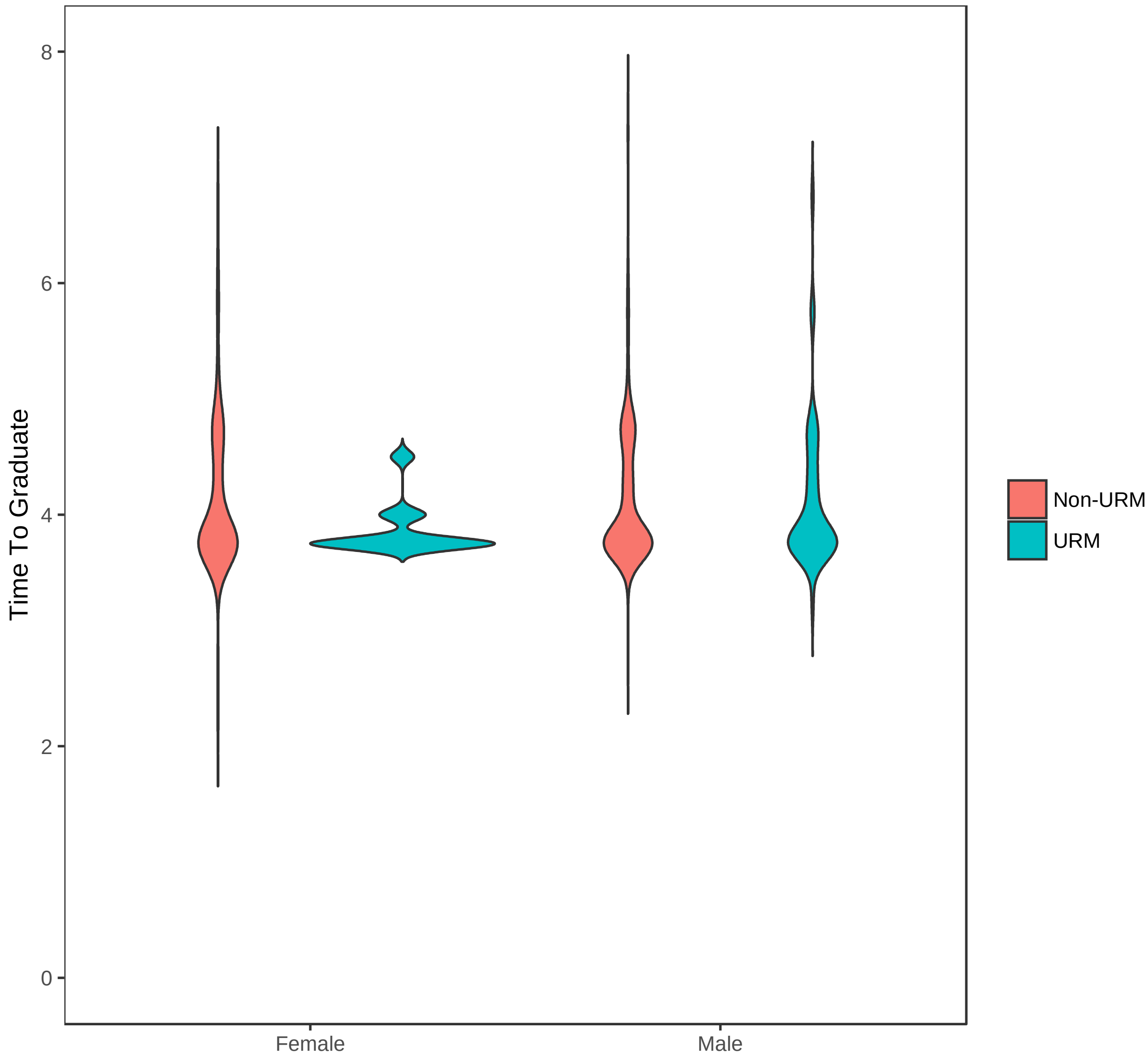

Figure 5. Time to graduate for FTIC students by gender and race identification.

Demographics over time

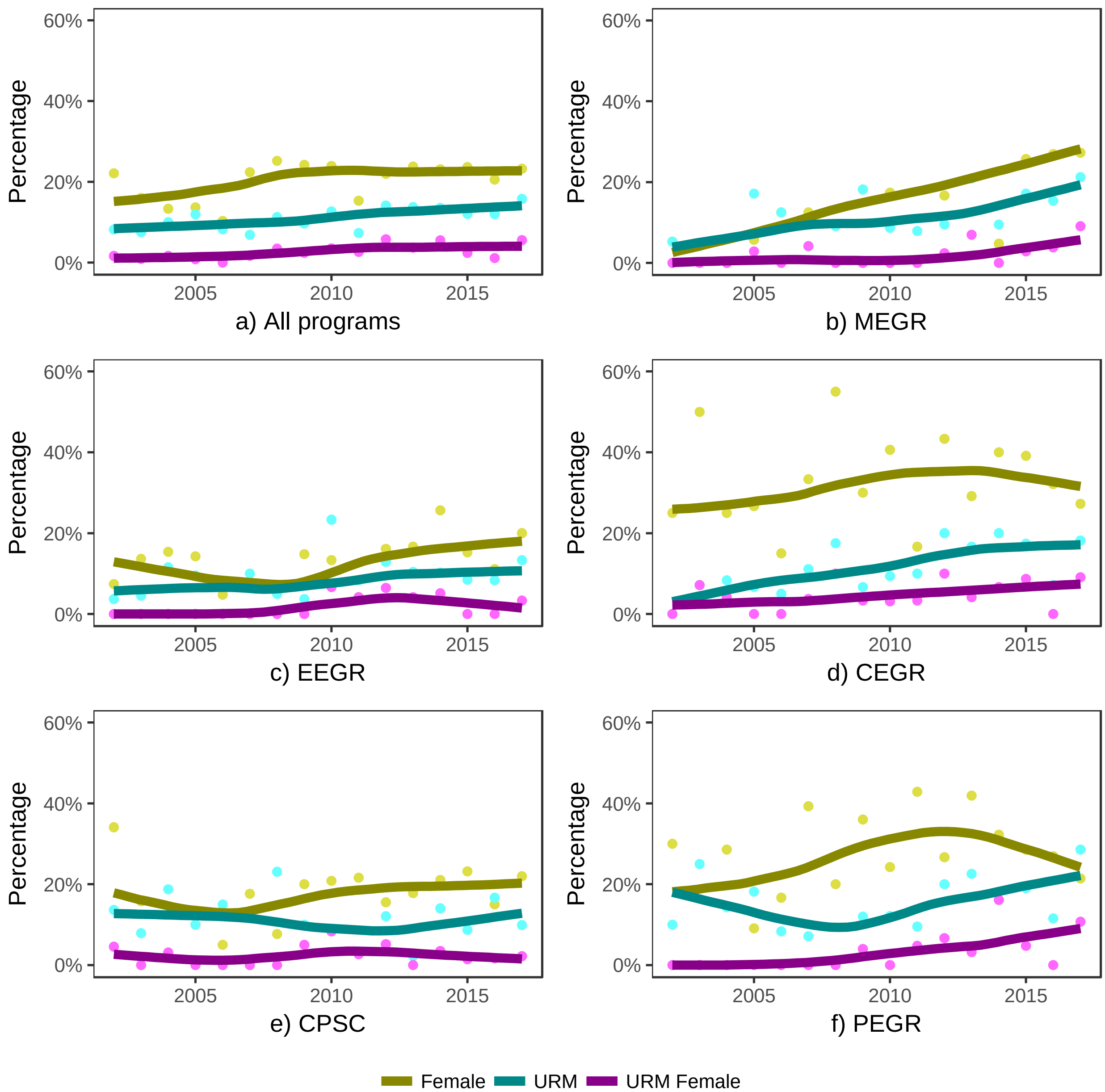

Figure 6 shows the demographics of students in the five engineering programs and for all engineering students. It is clear that overall, there have been an increase in the number of female-identifying and URM students. However, these increases are very small.

Mechanical Engineering has seen the clearest upward trends for percentages of both female- and URM-identifying students over time. Civil engineering also shows a clear upward trend in the percentage of URM-identifying students. Other programs, while showing some evidence of upward trends in these percentages, are not as clear-cut, and show more variability from year to year.

Across programs, the percentages of URM-identifying students seem to be fairly consistent, while the percentages of female-identifying students differ, most notably in civil engineering, which has a higher percentage of female-identifying students than other programs.

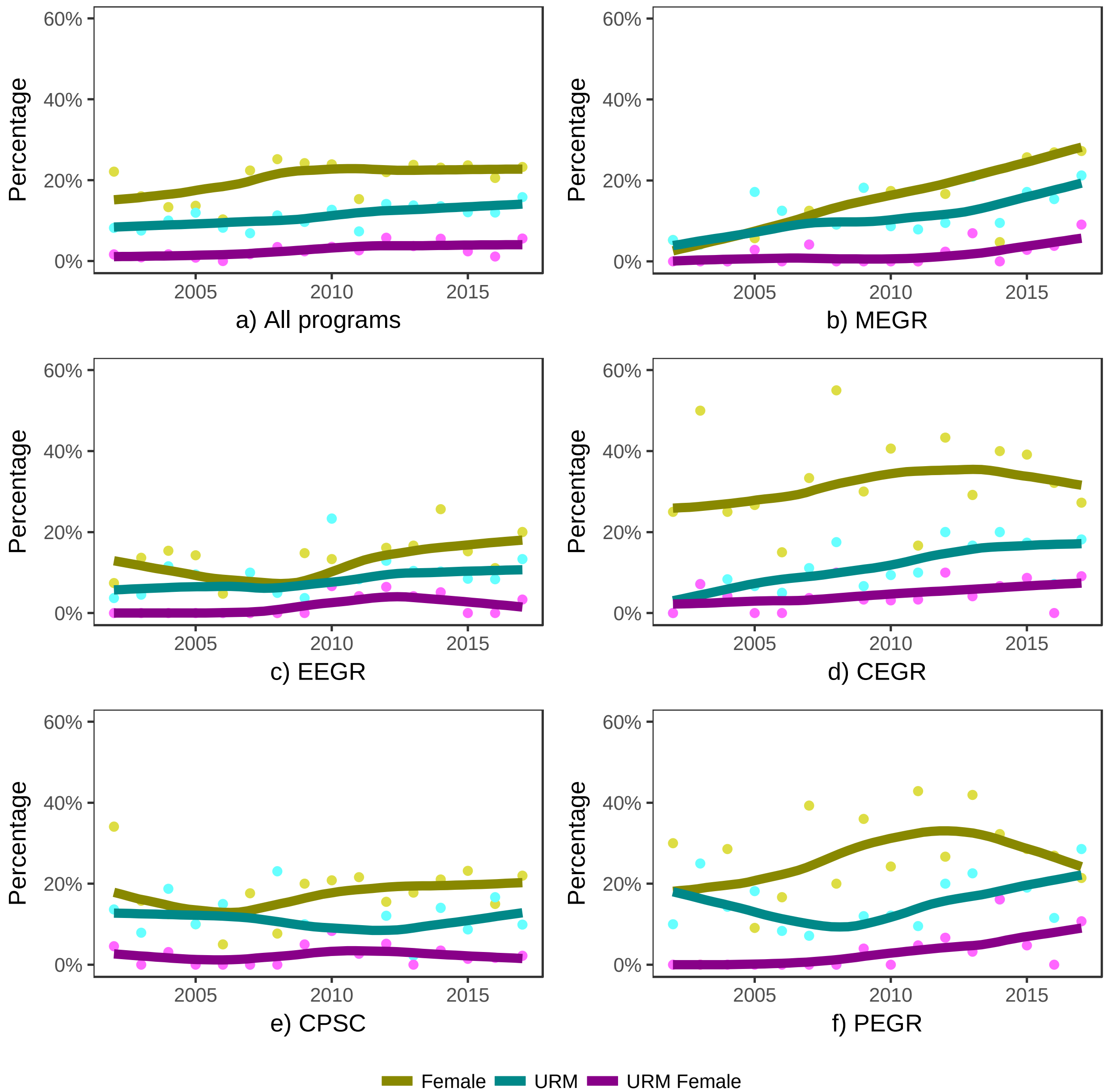

Figure 6. Demographics of female-identifying and URM students over time.

Discussion

When comparing levels of unmet financial need, we see evidence that those students who did not graduate tended to have higher levels of financial need. We saw that this was particularly true of URM students.

We also see that for both female-identifying and URM students who did graduate, their levels of financial need tend to be lower than their male or non-URM peers. Moderate amount of unmet need seems not to be detrimental to graduation (in fact this could motivate students to move through more efficiently), but a large amount of unmet need can prevent students from graduation.

This may be due to the availability of scholarships specific to their demographics.

While the overall trend in the percentages of female- and URM-identifying students is increasing, the growth is not as rapid as we would have hoped to see. This points to the importance of both additional recruitment and retention of female and URM students in engineering.

We notice a relatively high percentage of URM students starting in Precalculus. While it does not appear to affect the ability to graduate relative to other students, we do not know if those students always require additional time. We do know that they require an additional mathematics course and without summer courses they may experience some challenging course loads because many courses are only offered once a year. It is important to consider ways to provide necessary support to students who start in Precalculus with the goal of graduating in engineering.

The completion rates for computer science and pre engineering are lower than those for electrical and computer, civil and environmental, and mechanical engineering. Students often enter pre engineering less committed to that career path and in some cases less academically prepared. The lower completion rate of computer science students is surprising. It could be that students choose 'computer science' because it is more familiar to them than 'engineering', maybe even something they took in high school. Although not presented in this paper, we see similar completion rates for students in other non-engineering STEM degrees such as Math as we see here for Computer Science. Students have probably heard that there are jobs in CS, but once they get started, they may find it is not really the right fit for them and move in another direction. Future work will include focus group interviews of students, which should allow us to better understand what is causing this difference.

We see that, consistent with previous literature [6], female-identifying students who begin degrees in engineering show roughly the same chance of graduating with a degree in engineering as their male-identifying peers, while URM-identifying students who begin in engineering are, on the whole, less likely to complete an engineering degree than non-URM-identifying students. We also see that, overall, out of all students who pursue an engineering degree, the percentages of female- and URM-identifying students are lower than the overall national percentages of Americans in that age range who identify as female and/or URM.

Combined, these results suggest that female-identifying students primarily face barriers to access. They are less likely to pursue an engineering degree, but those who do choose to do so tend to be as successful as male-identifying students. On the other hand, URM-identifying students appear to face both barriers to access and barriers to success; they are less likely to pursue an engineering degree, and if they do choose to pursue an engineering degree they are less likely to successfully complete their degree.

We noted that both female- and URM-identifying students tended to report slightly lower levels of unmet financial need. We also observe that female- and URM-identifying students who complete their degrees are somewhat more likely to complete their degrees within four years. This may be a consequence of constraints placed upon them by their financial aid.

Future work:

From the data analysis presented here, we are getting some insight into what may be the barriers to the success of our engineering students. To further clarify this picture, we have immediate plans to do the following:

- Analyze first term and first year GPAs of our transfer students. This will let us understand barriers to their success since, typically, transfer students do not take their mathematics courses at Seattle University.
- Conduct student focus groups, particularly for URM and women. We will study the reasons why Seattle University students stay in engineering and why they are leaving. We will try to discover what the barriers that students have experienced are.
- Investigate the math placement and success of FTIC students who have not been successful in graduating in engineering.
- Compare profiles of our graduates with our peer institutions with respect to URM and female populations using the ASEE database.

Our numbers for URM, especially female URM, were low enough that statistically meaningful data was difficult to obtain. Recruiting more URM FTIC and transfer students should have the effect of helping them feel a better sense of belonging and hopefully increase retention. We will establish goals for URM recruitment and retention.

Since our overall goal is to increase the success of women and URM students in engineering, we will continue to study the literature and investigate programs implemented to improve recruitment and retention of engineering students, particularly URM and women. We will determine the key pieces for a recruitment and retention strategies specific to Seattle University and create plans for both FTIC and transfer students.

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