Survey analysis of student experiences for underrepresented populations in engineering and computer science

Abstract
This study examines the experiences of students in engineering and computer science at XYZ University, and how those experiences differ for students from underrepresented or marginalized groups.

XYZ University's mission and values statement includes a commitment to the importance of diversity in educational excellence. In the fall of 2018, 1,094 undergraduates were enrolled in XYZ University's College of Science and Engineering (CSE), including 480 female-identifying students and 222 underrepresented minority (URM) students. The CSE is comprised primarily of undergraduate programs, which are the focus of this study.

This study follows previous work examining barriers to successful completion of undergraduate engineering degrees amongst female-identifying and URM students. While the goal of the original study was to extract characteristics that differentiate students who do or do not successfully complete degrees within engineering, this new study examines survey data to better understand the experiences of students from underrepresented or marginalized groups.

We examine survey data for undergraduate students who were enrolled in the CSE's engineering majors (comprised of Pre-Engineering, Civil & Environmental Engineering, Electrical & Computer Engineering, Mechanical Engineering, and Computer Science) during the spring of 2018. Results are compared for female-identifying students, URM students, LGBTQ+ students, and students with disabilities across factors including students' feelings of preparedness, sense of community, satisfaction with their academic performance, and experiences of bias from both peers and faculty/staff.

These findings will be used to inform the development of new policies and programs within the CSE to better support students from underrepresented or marginalized groups. This study is part of a broader initiative at our college to examine accessibility of engineering degrees and how our engineering programs can better support students from underrepresented populations.

Introduction

XYZ University is in the midst of a multi-year project to develop programs and policies to better support students from underrepresented populations in engineering and computer science. Previous work examined 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 XYZ University. Barriers to students' successfully completing degrees in these programs were analyzed, 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 [1].

URM-identifying students tended to show shorter time to graduation than non URM-identifying students. Female-identifying students tended to show shorter time to graduation than male-identifying students. Students who did not graduate tended to have higher levels of unmet financial need, particularly URM-identifying students. Female-identifying and URM-identifying graduates tend to have lower financial need than their male-identifying or non URM-identifying counterparts. Moderate unmet financial need did not seem to be detrimental to graduation, but large amounts might be.

Female-identifying students who began in engineering showed roughly the same chance of graduating as male-identifying students. URM-identifying students were less likely to complete engineering / computer science degrees than non URM-identifying students. Computer Science and Pre engineering showed lower completion rates than the other programs examined.

Female-identifying students appeared to primarily face barriers to access. They were less likely to pursue engineering degrees, but those who did seemed to have comparable rates of completing those degrees to their male peers. In contrast, URM-identifying students appeared to face barriers to both access and success. In addition to being less likely to pursue engineering degrees, they were also less likely to complete those degrees if they did start them.

URM-identifying and female-identifying students are disproportionately unlikely to enter engineering, both at XYZ University and nationwide. We have observed an increase in female identifying and URM identifying students over time at XYZ University, but the rate of improvement has been relatively slow.

To continue this work we studied current students in our engineering and CS programs. We are interested in discovering the kind of experiences students are having to inform the development of new policies and programs to better support students in completing their degrees.

Methods

To gain greater insights into student experiences in engineering and computer science at XYZ University, a survey was conducted. A Qualtrics survey was made available to all active students coded in any engineering field, computer science or pre engineering. Students were invited to participate via email. The survey was available over approximately 10 days. Questions were a combination of multiple choice, yes/no, and some free text boxes for comments. Questions were based on questions from several literature sources [1] [2, 3] [4] [5]. Survey was subject to University IRB review. 130 responses were received of the 560 invited students (23.2%), with 99 students fully completing the survey. Of the 99 students who completed the survey, 58 identified as male, 40 identified as female, and one identified as non-binary. 16 identified as being from an underrepresented minority group. 16 identified as being LGBTQ+. 32 identified as having some form of disability, including 22 with mental health conditions, 6 with chronic physical / medical conditions, 8 with ADHD, and 7 with an information processing or learning disability.

The survey asked questions about a variety of aspects of students' experiences, including questions relating to their level of confidence, their participation in various activities and programs, as well as direct questions about their experiences with bias.

Results

Student Experiences of Unequal Treatment

Students were asked questions about their experiences related to bias with respect to ethnicity and gender. **Error! Reference source not found.** presents the percentage of students who said they "agreed" or "strongly agreed" with the following:

1) Some students treat their classmates differently based on those classmates' ethnicity
2) Some students treat their classmates differently based on those classmates' gender
3) Some faculty treat students differently based on those students' ethnicity
4) Some faculty treat students differently based on those students' gender

One student, in their survey responses, raised a concern with the phrasing of these questions. They noted that "differently" is not necessarily a negative, and that ideally faculty would treat students differently in response to the different needs that students have depending upon their backgrounds, their identity, and their current situations. This point is well taken, and we will be more careful in how we talk and think about these issues in future work. However, in this survey, it appears that students assumed the term referred specifically to negative treatments, and so we believe students' responses here are still informative.

Almost 30% of all students surveyed observed that some students treat their classmates differently based on their ethnicity and that over 46% are treated differently based on gender. The percentages increase when women, URM, LGBTQ+ and students with disabilities are considered separately. In general, greater percentages of students reported differences in treatment based on gender compared to ethnicity. The population observing the greatest difference in treatment of students by their classmates based on ethnicity was the URM with 53% observing different treatment. Furthermore, 68% female students "strongly agreed" or "agreed" that students were treated differently based on their gender.

When considering faculty treatment of students based on their ethnicity or gender, the percentage of students that "agreed" or "strongly agreed" with the statements decreases but is still significant. Considering all students, 20% observed difference in how faculty treat students based on their ethnicity and 35% reported differences in treatment based on gender. Similar to questions 1) and 2), percentages increase when women, URM, LGBTQ+ and students with disabilities are considered separately. The greatest differences with respect to faculty treatment of students with respect to ethnicity were observed by female students (40%), and with respect to gender were reported by students with disabilities (37%).

Students were asked if they had experienced differential treatment based on some personal characteristic in the following manners:
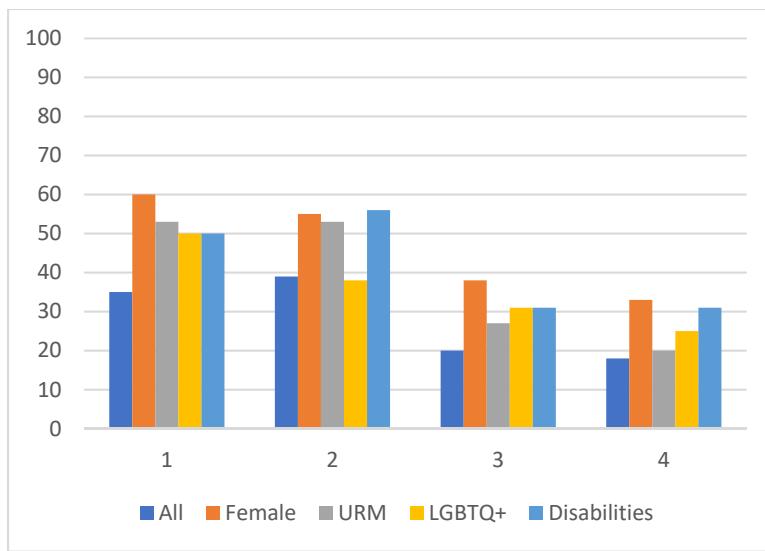
1) Directed at themselves by classmates,
2) Directed at other students by classmates,
3) Directed at themselves by faculty or staff,
4) Directed at other students by faculty or staff.

Error! Reference source not found. presents the percentages of students that reported experiencing differential treatment. Of all students, 35% and 39% reported experiencing differential treatment directed at themselves or others by classmates, respectively. A higher percentage of females, URM, LGBTQ+, and students with disabilities experienced differential treatment, all equal to, or greater than, 50% for treatment directed at themselves. Furthermore, more than 50% of the females, URM, and students with disabilities, reported experiencing differential treatment that was directed at others.

Of all students, 20% and 25% reported experiencing differential treatment by faculty that was directed at themselves or other students, respectively. The highest percentage of differential treatment by faculty was reported by female students, with 38% observing treatment directed at themselves and 33% directed at other students. In all cases, greater percentages of students observed differential treatment by classmates than by faculty.
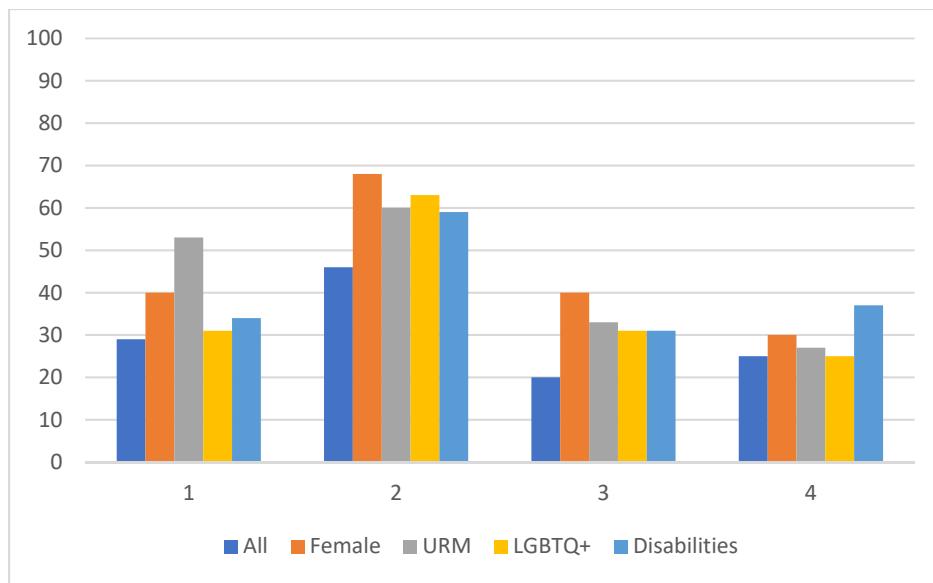
Figure 1. Percentages of students who said that they "agreed" or "strongly agreed" with the following statements: 1) Some students treat their classmates differently based on those classmates' ethnicity; 2) Some students treat their classmates differently based on those classmates' gender; 3) Some faculty treat students differently based on those students' ethnicity; 4) Some faculty treat students differently based on those students' gender.
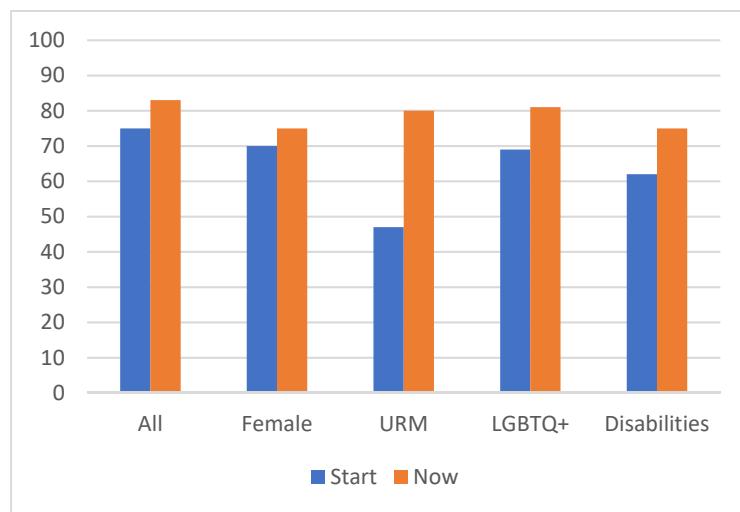

Figure 2. Percentages of students who reported that they had experienced differential treatment based on some personal characteristic in the following manners: 1) Directed at themselves by classmates; 2) Directed at other students by classmates; 3) Directed at themselves by faculty or staff; 4) Directed at other students by faculty or staff.

Student Attitudes

Figure 3 presents the percentages of students who reported that they were "confident" or "very confident" that they will be able to complete their engineering degree when they started at XYZ University versus at the time of taking the survey. For all groups, the percentages of

students that were "confident" or "very confident" increases from when they started at XYZ to when they took the survey. The highest percentages are reported by all students. The smallest percentage of students reporting that they were "confident" or "very confident" when they started at XYZ was URMs, with only 47%. However, at the time of the survey, 80% indicated that they were "confident" or "very confident", only slightly lower than all students (83%).

Figure 4 presents the percentages of students who reported that: 1) They are unable to meet some or all of the workload demands of their coursework; 2) They feel high stress in their coursework; 3) They feel unsatisfied with their academic performance. Of all students, 28% reported being unable to meet some or all of the workload demands of their coursework, and 42% reported feeling high stress in their coursework. Furthermore, even higher percentages of female, URM, LGBTQ+, and students with disabilities reported being unable to meet all the workloads demands of their coursework and feeling stress in their coursework. Twenty-seven percent of URM feel unsatisfied with their academic performance and 31% of all student feel unsatisfied. More LGBTQ+ students reported being unable to meet workload demands (63%), feeling stress in their coursework (53% - tied with females), and being unsatisfied with their coursework (50%) than any other group.

Figure 3. Percentages of students who reported that they are "confident" or "very confident" in that they will be able to complete their engineering or CS degree when they started at XYZ University versus time of survey.
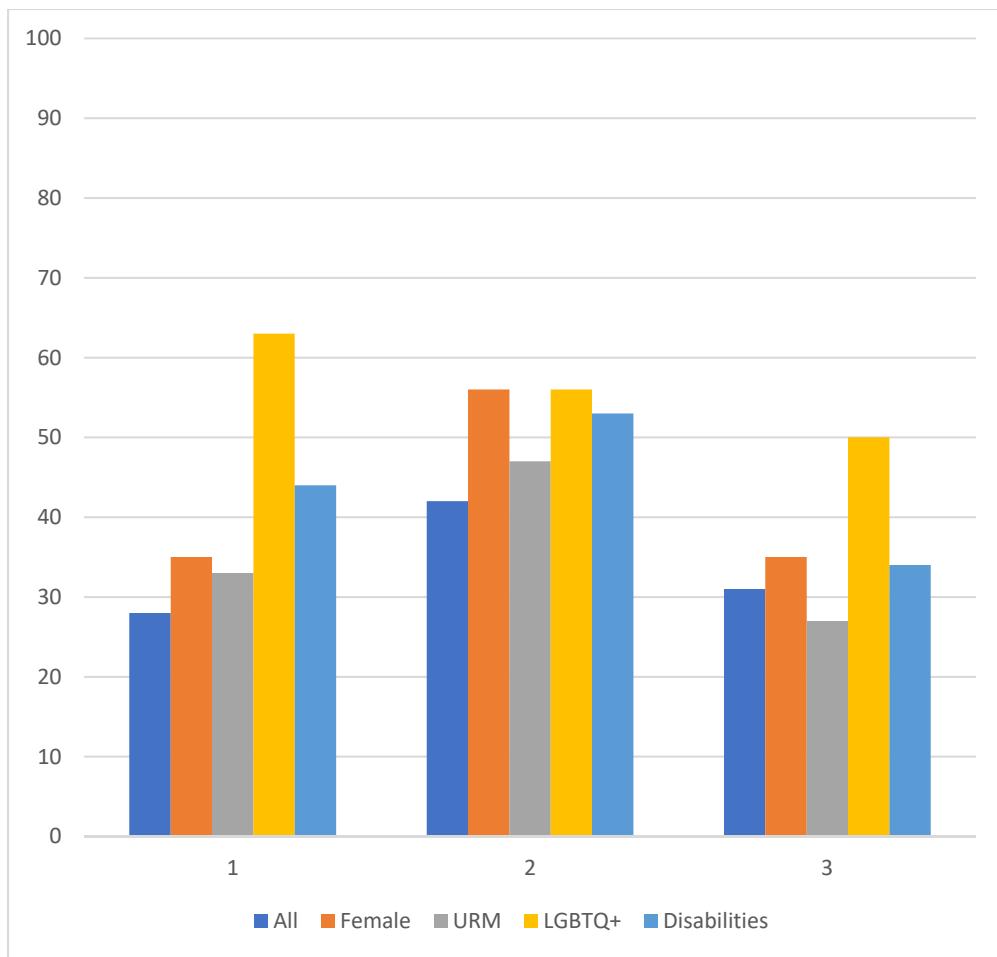
Figure 4. Percentages of students who reported that: 1) They are unable to meet some or all of the workload demands of their coursework; 2) They feel high stress in their coursework; 3) They feel unsatisfied with their academic performance.

Student Activities and Support Services

59% of male respondents reported some involvement with social activities sponsored by their department, versus 75% of female respondents. 10% of male respondents reported some involvement with humanitarian engineering activities, versus 30% of female respondents. However, male students were more likely to participate in design competitions or hack-a-thons: 41% of male respondents reported involvement in these activities, versus 30% of female respondents. 17% of male respondents reported involvement in undergraduate research, versus 28% of female respondents. 31% of male respondents reported involvement in the university's maker space, versus 23% of female respondents.

20% of URM respondents reported involvement in design competitions or hack-a-thons, versus 40% of white respondents. 13% of URM respondents reported involvement in the maker space, versus 30% of white respondents.

14% of LGBTQ+ respondents reported involvement in undergraduate research, versus 23% of straight students.

For students who identified as having some sort of disability, 86% reported involvement with social activities sponsored by their department.

Female students were more likely than male students to attend departmental orientation during welcome week (38% versus 21%), more likely to reach out to family members or close friends about difficulties with school (63% versus 35%), and receive tutoring (40% versus 14%).

URM students were more likely than white students to receive tutoring (33% versus 21%), to participate in learning strategies workshops (27% versus 9%), and to seek assistance from disability services (33% versus 16%).

LGBTQ+ students were more likely than straight students to reach out to family members or close friends about difficulties with school (64% versus 43%), to get advice from a mentor outside of the university (64% versus 32%), to receive tutoring (43% versus 21%), to seek help from the career center (43% versus 29%), and to seek assistance from disability services (29% versus 12%).

Students with disabilities were also more likely to reach out to family members or close friends about difficulties with school (69%). While students with disabilities were also more likely than other students to seek assistance from disability services (44%), the majority of students who identify as having a disability did not report seeking assistance from disability services.

Student Persistence

When we examine factors that students say are significant in influencing their decision to continue with their engineering or computer science degrees, we see that for students from underrepresented or marginalized groups, factors relating to a sense of community and their inclusion within that community are often rated as more significant, while students from more highly-represented populations report a greater influence from factors related to personal achievement.

For example, 38% of female respondents said that faculty and staff showing an interest in them was a significant influence in their continuing with their degree, versus 28% of male respondents. 38% of female respondents said that a friendly climate in their classes was a significant influence, versus 23% of male respondents. 21% of female respondents said that positive experiences in design teams or other collaborative learning experiences were a significant influence, versus 14% of male respondents.

In contrast, when asked about the influence of their satisfaction with their grades, 33% of female respondents identified this as a significant influence, compared to 44% of male respondents. 33% of female respondents said that their personal abilities and talents fitting the

program requirements was a significant influence in their continuing with their degree, versus 48% of male respondents.

Similar patterns were observed when comparing URM students to white students. 43% of URM respondents said that a friendly climate in their classes was a significant influence in their continuing, versus 25% of white respondents. 36% of URM respondents said that faculty helping them to understand what practicing engineers or computer scientists do was a significant influence, versus 21% of white respondents. 43% of URM respondents cited effective advising as a significant influence, versus 23% of white respondents. When asked about positive interactions with other students, only 27% of URM students said that this was a significant influence in their continuing with their degree, versus 43% of white respondents. 29% of URM respondents said that their personal abilities and talents fitting the program requirements was a significant influence in their continuing with their degree, versus 48% of white respondents.

For LGBTQ+ respondents, 50% identified faculty showing an interest in them as a significant influence, versus 29% of straight respondents. 29% of LGBTQ+ respondents said satisfactory grades were a significant influence, versus 43% of straight respondents.

Student Free Responses
In addition to the multiple choice survey questions, students were given an opportunity to write short answers describing their experiences of bias, directed at themselves or others, coming from classmates, faculty, or staff. We identified ten primary themes in these free response sections. Below, we list these ten themes, along with quotes from students pertaining to each of these themes.

1) Perception among men it will be easier for women to get jobs

"One student would make me and other females feel uncomfortable by making comments such as: 'It's going to be easy for you to get a job since you're a girl. You won't need to try'."

"Some says female CS students are so much more privileged and have more opportunities (when it's clearly not so, we struggle a lot to have to prove we belong here)."

2) Need for training for faculty and students about microaggressions

"We NEED more microaggression and social training in engineering. Some of my white male classmates will disregard my questions or will disregard the struggles that women/people of color have in engineering disciplines."

"Faculty misgendering students."

3) Women and minority students are more likely to have their work and comments questioned or talked over, their questions ignored

"My answers and contributions in class constantly get questioned by my peers (mostly white males)."

"Women are often talked over. It's a small thing and unintentional but done when younger male engineering students get excited."

"The boys just take over the class so the profs don't always acknowledge the girls. Professors could put more effort into seeing we are here."

"Professors not wanting to continue answering questions when it is the female students who are asking them."

4) Feelings of isolation

"As an undocumented student faculty does not know how to properly support me. This adds to the already high levels of anxiety that I experience on a daily basis and makes me feel hopeless."

"I'm an older student and sometimes it is isolating when there are a lot of very young students."

"As a woman in stem, men in my classes assume I don't know what's going on because I am a girl. I am also bisexual, and group partners have been uncomfortable and become offstandish if it comes up in conversation."

5) Accents are a source of stigma

"Some are just not willing to study with international students due to their (potential) accent."

"In a study group sometimes people neglect you because you are not born in USA or have an accent."

6) Faculty show more connection to white & male students - listen to their questions, engage them in casual conversation

"A professor seemed to favor the men in the class by listening to their voices and acknowledging them over the girls. A professor was lenient toward a white student's late homework, but not towards an Asian student's homework."

"Some faculty do not make as much of an effort to connect with their female students. A faculty member connects with male students through talking about sports but has never made an effort to learn about MY interests."

7) Female students treated less professionally

"One thing that is super noticeable that tutors and faculty do to female students is they decide it's alright to tease them constantly and in front of other students. I

understand it's often meant in friendly jest but it's not something the teachers do to their male students and they act much more professionally with male students."

8) Faculty do not intervene when students make inappropriate comments (or may even laugh along with comments)

> *"Unfortunately, but not surprisingly, there are a lot of sexist and misogynist comments from students. These comments are often enforced by faculty laughing at the comments."*

> *"When a boy made sexist comments towards me (female) and I called the boy out on it, the teacher tried to brush the situation under the rug and quickly move on without acknowledging that the remarks the boy made were inappropriate."*

> *"I have witnessed people making fun of others for asking questions that are relevant to class and professors not making any comments about it. Also multiple times faculty has failed to address misogynist, sexist, racist, and other offensive comments that create a hostile environment in the classroom."*

9) Female students report feeling more likely to be accused of cheating

> *"Professors have accused my female classmates of cheating in multiple situations and haven't questioned their male friends."*

10) Need for greater diversity in faculty

> *"I strongly suggest hiring more faculty/staff of color. This way students like myself don't feel trapped and alone throughout their years here. It's nice being able to have other students I could relate to (even though it was only 2) but having a professional in the room that looked like me or came from a similar background would've made me feel safer in the classroom."*

> *"I have peers who are uncomfortable to see their professor in office hours because they are black and their professor is white and treats them differently from other students."*

Conclusions

These survey results show that a significant number of our students experience bias in their time at XYZ University, from both other students and from faculty and staff. Students from underrepresented or marginalized groups are more likely to report having observed incidences of bias. Free response sections of the survey allowed students to report many of the specific ways in which they have experienced bias and marginalization.

Students from underrepresented or marginalized groups reported feeling less confident about their ability to complete their degree when they started. They are more likely to report that they do not feel able to fully meet the demands of their academic programs. They report higher levels of stress, and less satisfaction with their academic work.

Students from underrepresented groups appear to engage with their degree and with academic life in different ways than their peers – they are more likely to be involved in social events and department activities, but less likely to participate in events aimed at individual accomplishment such as hack-a-thons and maker spaces. They are more likely to seek out help, in the form of tutoring, disability services, outside mentors, and talking with friends and family about difficulties with school.

Similarly, students from underrepresented groups are more likely to emphasize communal and social aspects of their academic life as being influential in their decisions to continue to pursue their degrees, while their peers give more emphasis to individual factors.

Attempts to provide greater support for students from underrepresented and marginalized groups in engineering and computer science need to be developed with an understanding of how these students experience bias and marginalization. It must also be informed by the differing ways in which these students engage with their academic life.

Survey results showed that students from underrepresented groups attempt to engage more with their academic programs as a community than their peers do. Their responses indicate that, frequently, the issues that they run into are systemic issues with the university's culture. Many student responses highlighted the lack of intentionality on the part of those creating a hostile academic environment; these students from underrepresented and marginalized groups see other faculty, staff, and students not putting the same attention into being part of an academic community as they themselves do.

These students' negative experiences are, frequently, not a result of students, faculty, and staff creating a deliberately hostile environment, but rather of students, faculty, and staff acting within accepted norms of a campus culture that lacks awareness of the experiences, needs, and perspectives of students from underrepresented groups. Improving these students' experiences cannot simply be a matter of addressing isolated hostile incidents, but rather must involve a conscious effort on the part of the university to create a culture of awareness, inclusivity, and consideration.

Future Work

To further understand the experience of an engineering or CS student at XYZ University and to study barriers to successful completion of undergraduate engineering or CS degrees amongst

female-identifying and underrepresented minority (URM) students at XYZ University, we will conduct multiple focus groups with current engineering and CS students. We are planning six focus groups and invite the following student populations to join the group that they most associate with: 1) US-born women 2) URM women (including South East Asian and Pacific Islanders but not Asian); 3) URM men (including South East Asian and Pacific Islanders but not Asian); 4) international students (mix of men and women); 5) mixed group; and 6) strugglers and leavers – students who are still at XYZ University who have left engineering and computer science or students still enrolled in any engineering program but with with a GPA currently below what is required to graduate. We are interested in hearing from students who have been in the program for at least one year (i.e. sophomores, juniors, seniors, and transfer students who have been in residence at least one year). We would like to have an even distribution of students among our four academic programs: Computer Science, Mechanical Engineering, Electrical and Computer Engineering, and Civil and Environmental Engineering.

During the focus groups, we are planning to ask questions about students' experience doing group work with other students and about being treated differently in their program because of their gender or skin color. We will also discuss if students feel respected by their peers and faculty, and if they ever felt like leaving the program. Finally, we will ask what they would change about their departments and if their motivation to study engineering or computer science changed over time.

The information gathered from our data analysis, surveys, and focus groups will be used to design and implement student support services. Among services that we are considering are microaggression and anti-bias training sessions for faculty, staff, and students; math preparation courses during the summer before students join XYZ in the fall; and establishing inclusive hiring practices. We will assess the support services and continuously improve the offered services based on students' feedback.

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