

AN EQUITY-MINDED ASSESSMENT OF BELONGING AMONG COMPUTING
STUDENTS AT CAL POLY

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ABSTRACT

An Equity-minded Assessment of Belonging among Computing Students at Cal Poly

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Creating a Computer Science and Software Engineering Department that supports students with diverse identities and backgrounds is essential to creating a computing workforce that reflects the world at large. Inspired by the work of Metcalf et al.'s survey conducted at the University of Illinois [20], we use the same methods to examine the state of our computing department with respect to issues of inclusive climate and student sense of belonging, which have been shown to be important for retention in STEM fields [7, 8, 14, 15, 16, 13, 17]. We use the four areas that contribute to belonging based on the work of Rainey et al. [22] along with a fifth category of learning environment in order to assess our students' sense of belonging.

This paper's main focus is based on results from two surveys of Cal Poly Students conducted exactly one year apart (2019: $n = 154$, 2020: $n = 122$). Both surveys were sent to all computing majors in Spring quarter, the last quarter of the regular academic year. We found that 58-68% of students felt they were not typical computer scientists, which mirrors the results of the survey conducted at the University of Illinois [20], indicating that the lack of belonging is perhaps a ubiquitous problem within the field of computing. Other salient results include identifying the presence of statistically significant differences for some groups based on gender and race & ethnicity. These differences were found when looking at students' senses of their science identity and learning environment. We also found that women had a significantly greater chance of having strong interpersonal relationships within computing. The survey results are augmented by a survey of first-quarter freshmen in Fall 2019 ($n = 44$) and student interviews conducted in Spring 2021 ($n = 15$). We

hope that the addition of these results explain and expand upon our main results and add insight as to how the student experience can evolve from a student's first quarter onward. These differences shine an important light on some positive trends as well as several concerning differences to be examined in our quest to create a diverse and equitable department.

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Chapter 1

INTRODUCTION

The field of computer science and software engineering continues to face issues with regards to a serious lack of diversity [25] and a defensive culture [12]. Through the firm efforts of faculty and students, the computer science and software engineering department at Cal Poly has made progress in gender diversity with the number of women in computer science increasing from 9% in 2009 to holding steady with close to 25% from 2014 onward (nationwide the representation is approximately 18%) [25]. However, there is clearly room for ongoing growth for gender parity. Computing also has traditionally underserved some student populations. A nationwide report shows the number of CS bachelors for BIPOC (Black, Indigenous, and people of color) averages 13% collectively [25]. Students from underrepresented and minoritized groups majoring in computing at Cal Poly is around 10%. Within the state of California, only 36.5% of the population is White alone, not Hispanic or Latino [2], and the demographics of both computing as a whole and the department at Cal Poly do not reflect the overall ethnic breakdown in the state. In order to attract and retain a diverse computing student body, we must tackle the challenge of developing an inclusive culture for teaching and research. Therefore to develop an inclusive department, it is essential to understand a department's strengths and weaknesses as they apply to diversity and as we work to develop a clear path forward.

In this work, we present the results from two large-scale surveys of computer science and software engineering students conducted at Cal Poly. The first survey conducted in Spring 2019 included 154 student responses out of a population of approximately 1100 CSSE students. The second survey was conducted in Spring 2020 during the

period of mandatory distance learning during the COVID-19 pandemic and consisted of 122 responses. Additionally, we present the results from a survey of 44 first-quarter freshmen in Fall 2019 as well as the aggregated results of 15 student interviews conducted in Spring 2021. Cal Poly is a primarily undergraduate university with a focus on hands-on education, or "learn by doing". The Computer Science and Software Engineering department offers a BS in computer science, a BS in software engineering, and an MS in computer science with a total of 1038 undergraduate and 54 graduate students. In hiring, promotion, and retention, the department places a large emphasis on teaching.

The primary surveys were based on a survey conducted by Metcalf et al. at the University of Illinois [20]. By repeating the survey from Metcalf et al. [20] at a primarily-undergraduate university, we aimed to test whether the original findings were unique to Metcalf's institution UIUC or to R1 universities. After the first survey in 2019, we found that many of the results were similar, indicating a larger systematic lack of belonging in computing, with 68% of students responding in 2019 that they feel they are not a typical computer scientist.

This led us to conclude that our community needed to continue exploring interventions to open up computing to all. We had planned to conduct the survey again among freshmen in Fall 2019 and among the whole department in Spring 2020 in order to track changes in the community. However, the sudden switch to distance learning meant that our results must be considered within this context. To address this, we added one section to the original survey about the transition to the new learning situation. We found that students felt that their learning environment suffered from the shift to online learning, and that this shift disproportionately affected minoritized students.

This paper presents a subset of the full survey data with a focus on questions related to 2018 work of Rainey et al.[22] which uses four main areas that contribute to the sense of belonging among STEM students: Interest, Competence, Interpersonal Relationships, and Science Identity. Additionally, we use the work of Garvin-Doxas et al.[12] and Cheryan et al.[7] to justify the use of a fifth category: Learning Environment. We present the results of responses to questions which are categorized using this structure to try to better understand the successes and challenges for our students with respect to a sense of belonging. Examining the survey data over the last two years allows us to highlight areas of success and need for growth as we found statistically significant differences between the sense of belonging for students groupings based on gender and race & ethnicity. We present our results in an effort to better expose the challenges for student’s identities and explore options for addressing the pressing issues of equity. Given the sudden transition to distance learning, we also explore how that has impacted students’ sense of belonging. It is our hope that this work inspires others to critically examine and reflect on their department’s path to equity by conducting and sharing similar results. By examining a primarily undergraduate public institution, we can help our discipline identify both the global and local hindrances to an equitable discipline.

1.1 Paper Overview

This thesis is structured as follows. First, Chapter 2 provides a background of work that has been done so far in the study of belonging in computer science. This includes motivation for why belonging needs to be studied and improved, as well as justification for the metrics that we used to quantify belonging. Next, Chapter 3 describes the methodology for each of the three surveys as well as the approach used for the student interviews. It also includes some potential threats to validity and how those are

addressed in this research. Chapter 4 is a presentation of the most salient results that were emergent from the surveys and is organized based on the areas of belonging identified in Chapter 2. Chapter 5 includes results from our freshmen survey and student interviews to provide additional insights into the research. Chapter 6 provides a discussion and interpretation of results. Finally, Chapter 7 is the conclusion to the paper.

Chapter 2

RELATED WORKS

2.1 Retention Rates & Computing Demographics

It is well documented that developing a sense of belonging is essential for student retention in STEM fields [7, 8, 14, 15, 16, 13, 17]. Recent work highlights how students from underrepresented groups, in general, have less of a sense of belonging than white men in the same field [22]. And perhaps more salient, recent work documented how even after 10 years of focusing on inclusivity 62% of computer science students at the University of Illinois, a large R1 school, felt that they were not “real” computer scientists [20].

2.2 Culture of Computing

The importance of culture (department or college level) with respect to sense of belonging is of particular relevance to this work. The work of Cech [6] examines the role of culture in student engagement and retention, in particular, the culture of disengagement in engineering and how that culture influences students. Recent work by Nguyen [21], presents the effects of competitive enrollment policies on students’ sense of belonging, emphasizing the importance of department policies in setting up students for success in computing.

2.3 Quantifying Belonging

We strive to use equity-minded sense making of our data. We use the analysis portion of the work discussed here, and we used the structure of the 2018 work of Rainey et al.[22] to categorize questions related to impact on sense of belonging. In the Rainey et al. paper, the authors identify four main areas that contribute to the sense of belonging among STEM students: Interest, Competence, Interpersonal Relationships, and Science Identity[22]. We categorized questions from the original Metcalf [20] survey, which represent a student’s response to the four factors identified by Rainey et al. and examine our data along gender and race and ethnicity to identify equity issues for our setting.

There are other measures of belonging that have been used to measure student belonging. For example, “Exploring Factors that Influence Computer Science Introductory Course Students to Persist in the Major” is a 2009 work by Barker et al., which studies student persistence, and states that it comes most from student to student interaction, pace/workload and student experience, and the male gender [5]. While Barker et al. do not identify student persistence as belonging, the three most important measures they identify align well with that of Rainey et al. [22]. Barker’s student to student interaction could be seen as Rainey’s Interpersonal Relationships, Barker’s pace/workload and student experience seems to align with Rainey’s Competence, and while Rainey does not have an explicit measure for the male gender, results are analyzed in gendered slices which can show emergent results that may be consistent with Barker’s work.

Other works about student belonging include Garvin-Doxas et al.’s work on “strutting” and social status in computer science classrooms. The authors found that men tended to ask pseudo-questions to emulate the high status students with experience,

which alienated students with less experience. They also found that female students who behaved like the high-status male students felt more alienated rather than accepted like their male colleagues [12]. This is not really a measure of belonging itself but rather an examination of student behaviors that can negatively contribute to belonging. Similarly, Cheryan et al. examine the effect of a student's classroom environment on their sense of fit or belonging, testing different environmental queues on a student's desire to learn computing, especially as it relates to the gender of the people in each room. They found that women felt better about studying computing when in a room with neutrally coded objects like nature paintings and dictionaries rather than objects that were traditionally associated with computer science [7]. This work on ambient belonging will be classified with the Garvin-Doxas paper as Environmental Belonging, or the effect of peers or the learning environment on belonging outcomes of students. This is more difficult to measure as our results overlap with a year of in-person instruction and one year of online learning, which may greatly skew results, however this will be discussed more in the Results chapter.

Chapter 3

METHODOLOGY

3.1 Main Surveys

In order to assess the sense of belonging of students within our Computer Science and Software Engineering department, we conducted two surveys of the student body following the work of Metcalf et al. [20]. Both surveys were sent to the entire population of CSSE students and we received about a 12% ($n = 154, n = 122$) response rate. The surveys were conducted through Google Forms and sent through email to all students, and advertised through clubs, professors, and various social media sites related to Cal Poly Computing. A sample of the surveys can be found in Appendix A. An analysis of results is presented in Chapter 4.

Similar to Rainey et al., we grouped students' racial and ethnic categories by White and minoritized students as an initial lens for equity-minded assessment of our student experience. We acknowledge that intersectional identities and fine-grained data disaggregation are a particularly important future consideration. We also acknowledge that we received 6 and 3 responses from nonbinary or gender nonconforming students in 2019 and 2020 respectively, however, there were too few responses to be included as a statistical category. The threats to validity are discussed in Section 3.4.

The first study was conducted in the Spring quarter of the 2018-2019 academic year. It consisted of 96 questions that ranged from binary response questions to Likert scale questions and short answer questions. Initially there were 175 responses and after removal of non-computing majors, computer engineering majors, and off-topic responses, 154 remained. The results consist of both graduate and undergraduate

Table 3.1: 2019 and 2020 Computer Science and Software Engineering respondents based on demographics

Variable	2019 Number	2019 %	2020 Number	2020 %
Gender				
Male	103	70.0%	79	66.3%
Female	44	30.0%	40	33.6%
Race and Ethnicity				
White	79	53.0%	55	47.0%
Minoritized students	70	47.0%	62	53.0%

computing students, and a summary of respondents' demographics can be found in Table 3.1.

The second study was conducted in Spring 2020 and was sent to all computing students in the same manner as the 2019 survey. It was nearly the same survey as the previous year with an added section that was focused on gaining insight into the students' perceptions of their educational experience while participating in distance learning. After removing non-computing, computer engineering, and off topic-responses, 122 usable responses remained. A summary of the respondents can be found in Table 3.1. Both the surveys from 2019 and 2020 were estimated to take at least 20-30 minutes to complete based on the informed consent form, and there was no incentive to do either.

3.2 Additional Studies

The additional studies will be examined in Chapter 5, as it does not provide as holistic a view of our students as the main two surveys. Nevertheless, it does provide important insights into some students' perspectives and helps us understand more in-depth potential causes for trends observed in the surveys. By surveying Freshmen, we hope to understand how students' views change through their experiences at Cal

Table 3.2: Freshmen CSSE respondents based on demographics

Variable	Number	%
Gender		
Male	31	70.5%
Female	12	29.5%
Race and Ethnicity		
White	12	27.3%
Minoritized students	32	72.7%

Poly in computing. We also hope that the interviews provide an important addition of off-the-cuff responses from students in a more casual environment. The threats to validity for both the survey and the interview are discussed in Section 3.4.

3.2.1 2019 Freshmen Survey

The study of freshmen and first-year transfers was conducted in Fall 2019. The survey was similar to the original 2019 survey, however some questions were removed because they were deemed irrelevant to new students. The population that was surveyed in this second study has no overlap with the population from the first study because it was sent exclusively to new students. A summary of these respondents can be found in Table 3.2. Initially, we received 49 responses and after disregarding results from non-computing majors, 44 remained. This survey was slightly shorter than the two major surveys, as we did remove questions.

3.3 Interviews

Student interviews were conducted in Spring 2021 completely virtually. These were conducted over Zoom and were automatically transcribed using Cal Poly’s Microsoft Streams service. Each interview was conducted by one of two researchers, and we attempted to limit the chance that either researcher knew their interviewees personally

in order to reduce bias. In general, the interviews lasted around 30-45 minutes and were structured based on a specific script that the researchers followed. The script can be found in Appendix C. The questions were developed based on the results of the surveys and were targeted to learn more about how each area of belonging contributed to a student's sense of fit within the CSSE department and computing as a whole. Between the two researchers, we conducted 15 interviews and anonymized responses will be used to add information to our results in each category of belonging.

3.4 Threats to Validity

While we think the results of these surveys are important, we do want to explicitly address potential threats to validity. The survey was advertised to students through the department email list, social media, clubs, and by some individual professors. There was no requirement or incentive to complete the survey, and we had between 10-12% of students reporting. This could lead to an amount of selection bias, which must be taken into account. Additionally, these surveys and the opportunity to be interviewed were only presented to members of the CSSE department, not to students who dropped out or changed majors, which may also skew the results. It is also important to understand the experiences of those who dropped out or switched majors, as a lack of belonging could be a major factor in their choice to stop majoring in computing, however we leave this for future work.

Chapter 4

RESULTS

In this section, we present the responses to selected questions from the 2019 and 2020 surveys of the CSSE department as a whole. We are using these two surveys as our main source of results in order to have relatively comparable sets of data. The next chapter will present supplementary results from the survey of freshmen in Fall 2019, as well as results from the interviews conducted with students in order to provide further insight into the responses we observed in these surveys. Overall, we found that 58-68% of student respondents feel they are not a “typical computer scientist”.

To better understand which factors might be contributing the most to this, we focus on a subset of the survey questions, five of which strongly relate to the categories contributing to a student’s sense of belonging according to Rainey et al [22]: **Interest, Competence, Interpersonal Relationships, and Science Identity**. According to the work of Garvin-Doxas et al.[12] and Cheryan et al.[7], we include a fifth category: **Learning Environment** which examines more external influences to a student’s sense of belonging like classroom environment or the influence of classmates or peers with which a student doesn’t have a close interpersonal relationship. Additional questions are included which added insight into student perception of the learning environment of the department, and the mental impact that distance learning was having on their education. We picked these responses to analyze specifically because they were the questions that most directly related to the categories of belonging we are focusing on. The questions and their categorization and results are presented in Table 4.1. This data as well as the supplementary freshman survey and student interview responses are analyzed in Chapter 6.

Table 4.1: Categorized questions in this chapter

Number	Question	Category
Q1	What I am learning in the department helps me solve problems that are important to me.	Interest
Q2	I have friends in the department.	Interpersonal Relationships
Q3	Do you feel like a typical computer scientist?	Science Identity
Q4	Do you feel successful at Cal Poly?	Competence
Q5	My resume or CV is just as impressive as those of my peers	Competence
Q6	Do you think that the Cal Poly CSSE department values excellent teaching?	Learning Environment
Q7	How has your sense of belonging and community within the CSSE department changed with regards to distance learning?	Learning Environment

4.1 (Q1) What I am learning in the department helps me solve problems that are important to me.

This question provides insight into the perceived match between a student’s field of study to their personal **interests** and passions. A positive sign for a student’s sense of belonging would be if the student answered that they agree or strongly agree that they felt like what they learned in the department helped them solve important problems [22]. The majority of the students rated their answer as 4 (Agree) or 5 (Strongly Agree) with this statement over both years 63.9% (2019) and 64.5% (2020). This is a positive outcome as feeling that computing helps students solve problems that are important to them can be a contributor to sense of belonging, but does indicate that there is room for improvement in terms of addressing the 35% of students who answered less enthusiastically. We found no statistically significant differences between men and women or white and BIPOC students.

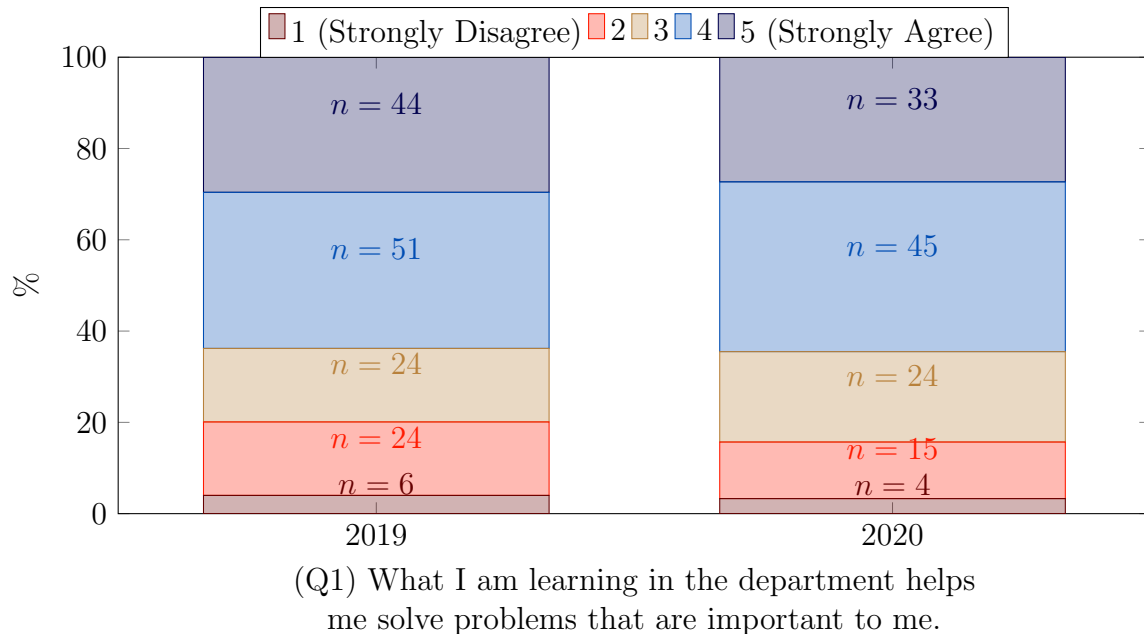


Figure 4.1: Student responses in 2019 & 2020 for (Q1).

4.2 (Q2) I have friends in the department.

This question provides insight into a student’s **interpersonal relationships** in the department. A positive sense of belonging is linked with students forming interpersonal relationships [22], and a student having friends in the department is an indication of these kinds of positive connections to others. Our department also has a handful of fairly active student-run academic clubs, which could influence students feeling as though they have friends in the department.

In both 2019 and 2020, we saw that the majority of students felt that they had friends in the department. In 2019, 70.59% of students agreed or strongly agreed that they had friends in the department and in 2020, that number increased to 80.35%, as seen in figure 4.2.

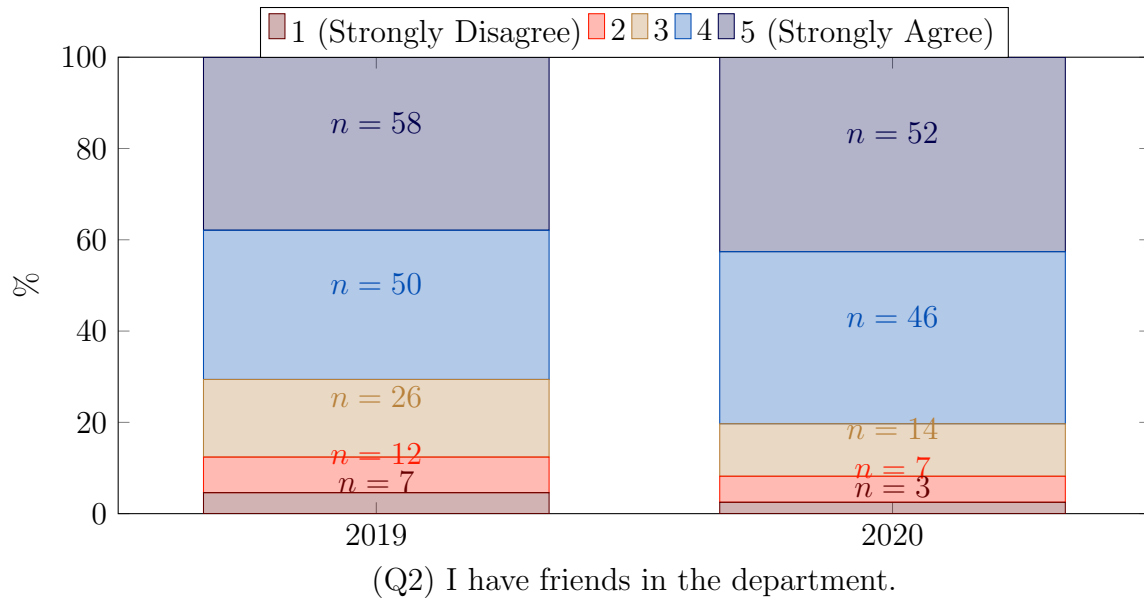


Figure 4.2: Student responses in 2019 & 2020 for (Q2).

In 2020, there was a statistically significant difference between responses based on gender. As seen in Figure 4.3, none of the 40 women who responded to the survey in 2020 responded with a 1 or 2 (Strongly Disagree or Disagree) when asked if they felt they had friends in the department, while 10% of male students responded 1 or 2. This is a significant finding based on a chi squared test, when comparing the responses of men and women in 2020, with $p = 0.043$ which is less than our α of 0.05. We attribute this difference to the presence of a very active student club focused on supporting women in computing, WISH (Women Involved in Software and Hardware), that actively matches female students with mentors and provides many opportunities for community engagement and connections. We found no statistically significant difference between white students and BIPOC students in this question.

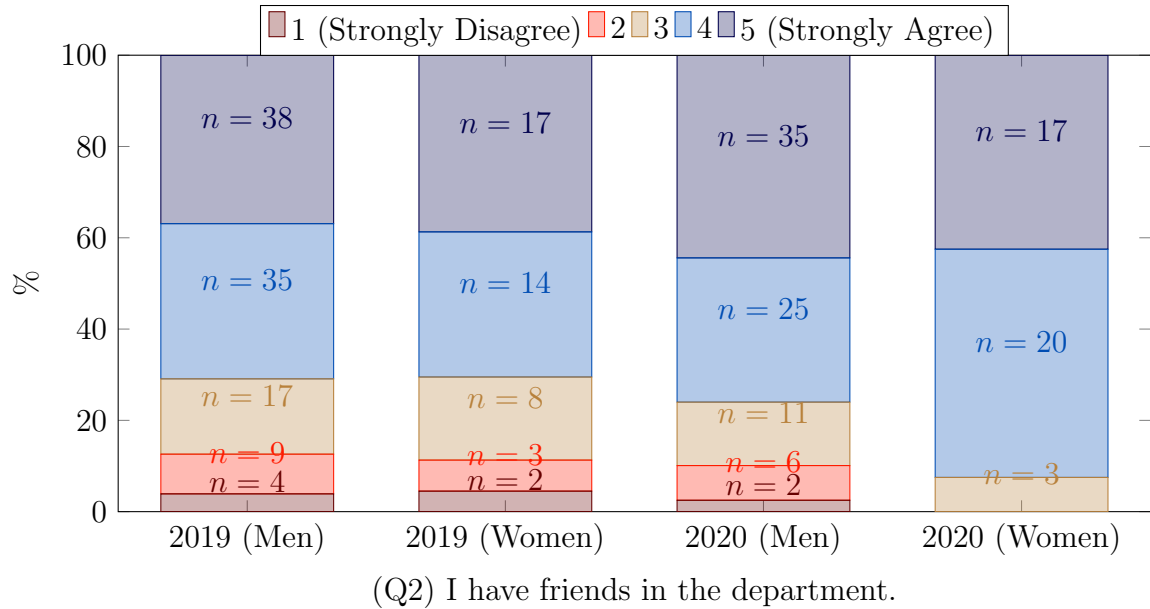


Figure 4.3: Student responses in 2019 & 2020 for (Q2) split by gender. Significant difference found in 2020.

4.3 (Q3) Do you feel like a typical computer scientist?

This question provides insight into a student’s feelings of a **science identity**, or associating their identity with their career choice. Again, as documented in Rainey et al. [22], science identity provides perspective on a sense of belonging. As seen in Figure 4.4, in 2019, 67.8% of students did not feel like typical computer scientists. In 2020, 57.9% of our students did not feel typical.

In 2020, we found a statistically significant difference between men and women. We had a p-value of 0.0021 for a chi-square test which is less than our α of 0.05. For men in 2020, 48.7% felt like they were not typical, while 77.5% of women felt like they were not typical. We note that this difference was not found in the original University of Illinois study [20]. We found no statistically significant difference between white students and students of color in the responses to this question.

To account for that, we assess a follow up question that prompted students to explain their answer. In Figures 4.6 and 4.7 below, their responses are presented with the coding into which categories were mentioned in each response, along with their response to if they felt like a typical computer scientist. Some reasons can be seen as “good,” especially when seen along with a positive response to feeling like a typical computer scientist. Additionally, if a student answered that there was no such thing as a typical computer scientist, as was the case with many students, their response is fairly neutral and could be thought of as positive even if they did not feel like a typical computer scientist. The responses were coded using similar areas of belonging to the rest of this research, as most of the responses fit into those categories. However, the category of interpersonal relationships has been replaced with a broader “social” category that captures responses about having friends within or outside of the major, or feeling more socially adept or extroverted than the student’s perception of a typical computer scientist. Additionally, many students used their demographic characteristics to assess their feeling of being a typical computer scientist or not. The “interests” category includes students who used their interests—either within computing or outside interests—to characterize their feeling of being typical. Some salient student quotations are also listed below along with their response to if they felt typical.

“When I think of a typical Computer Scientist, I envision someone who has a very specialized skillset for a specific market. I feel like my understanding of Computer Science is more broad but not very focused.” (2020, No)

“‘Computer scientist’ isn’t something that has a ‘typical’ portrayal. Maybe an old stereotype is a white male coding alone in his basement, but that isn’t the case anymore. Computer scientists can apply to anyone who has the programming background.” (2020, Yes)

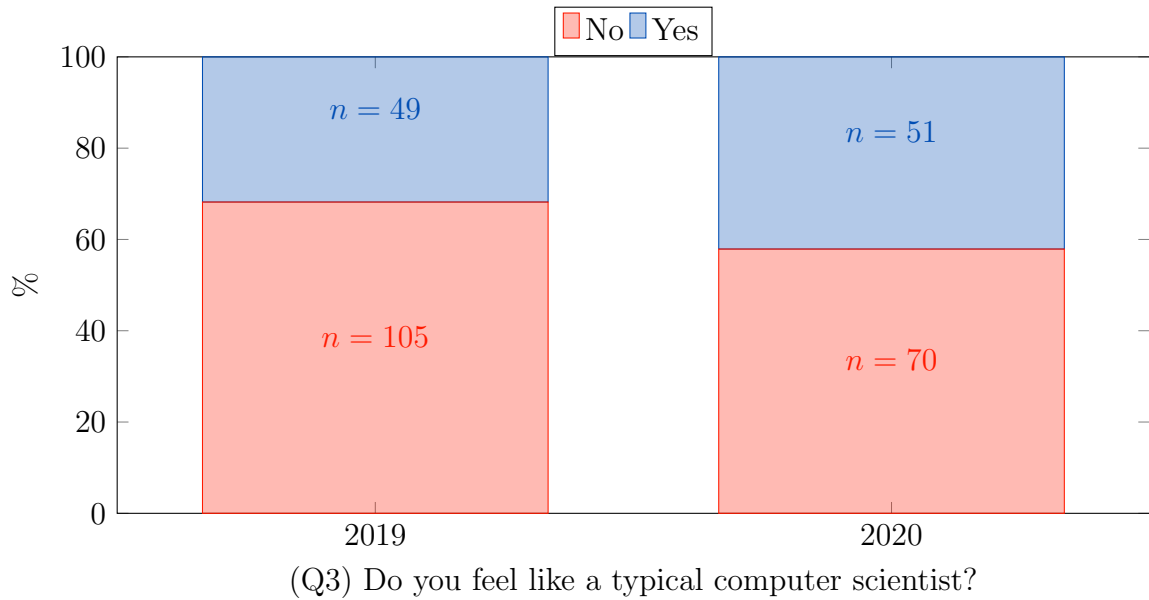


Figure 4.4: Student responses in 2019 & 2020 for (Q3).

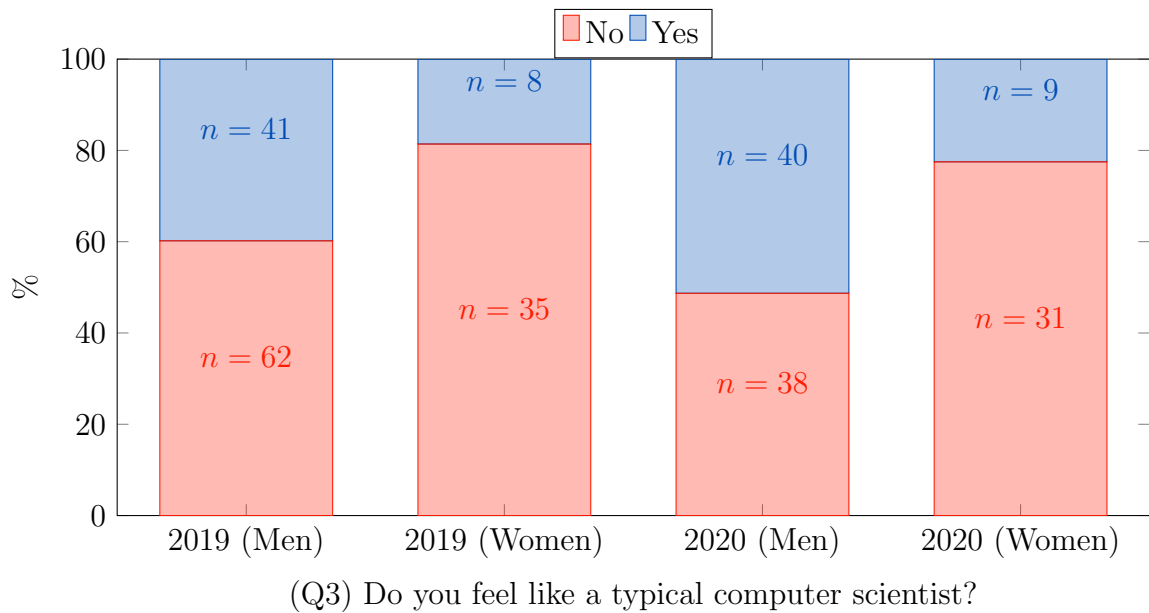


Figure 4.5: Student responses in 2019 & 2020 for (Q3) split by gender. Significant difference found in 2020.

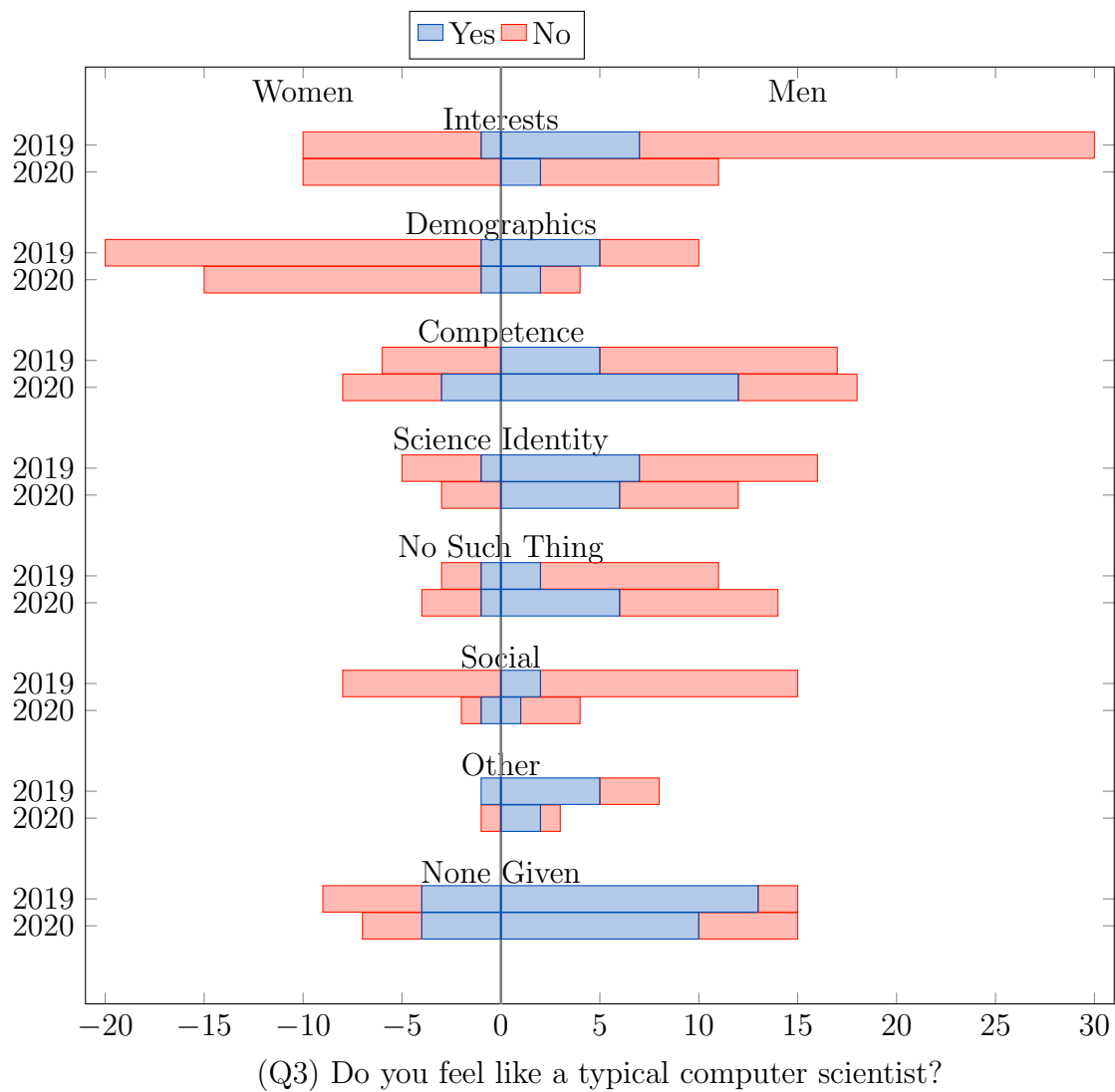


Figure 4.6: Student reasons in 2019 & 2020 for their responses to (Q3) split by gender

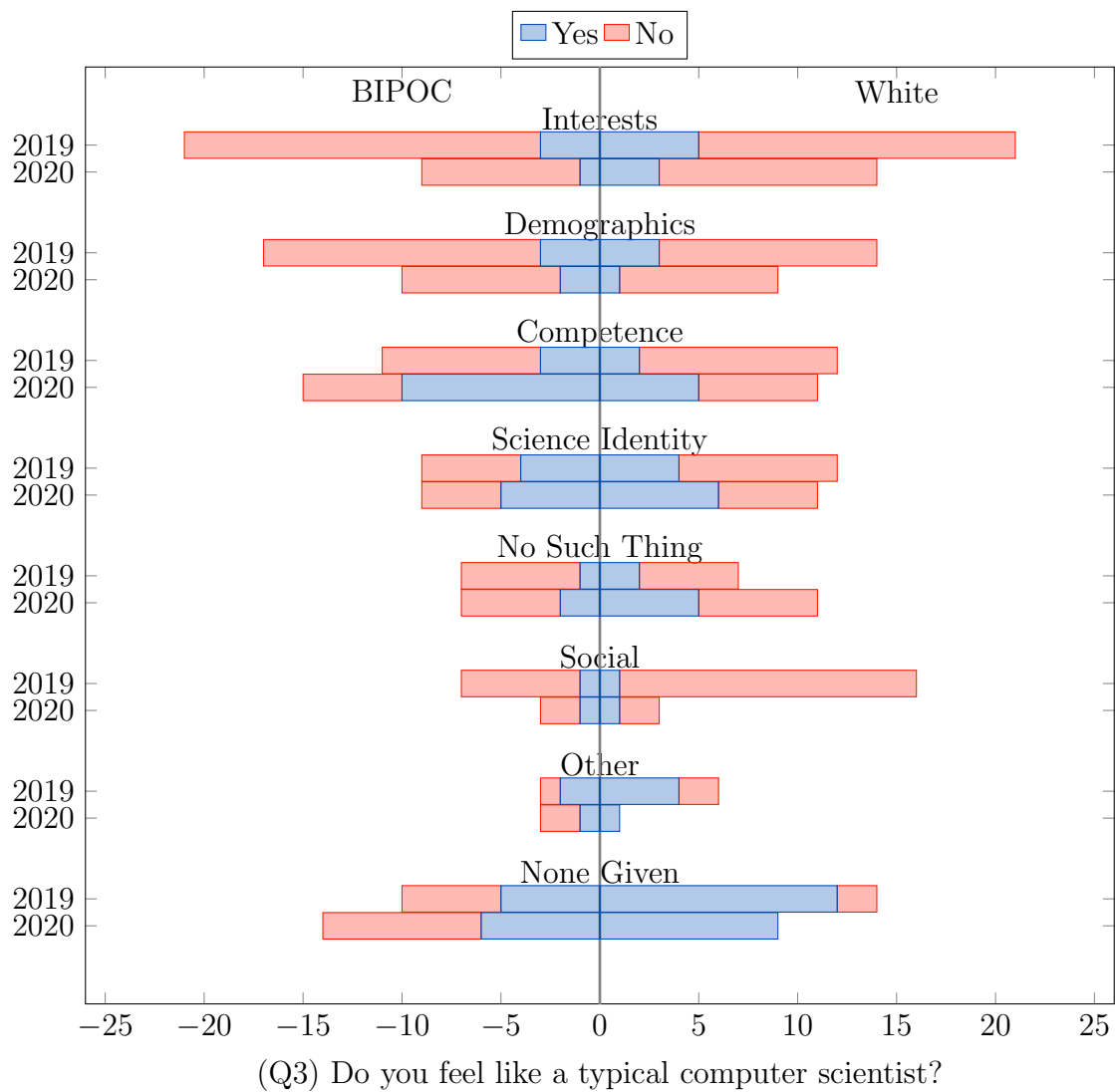


Figure 4.7: Student reasons in 2019 & 2020 for their responses to (Q3) split by race

“I don’t think I fit into the general stereotype, but after coming to Cal Poly I have met more people like me (outdoorsy, talkative, and not into video games) in the major.” (2020, No)

“I’m nerdy, I enjoy programming and video games and other computer-related things” (2019, Yes)

“I enjoy programming but I don’t live and breathe CS. I want to do other things. I exercise. I shower. I have a lot of friends outside CS.” (2019, No)

4.4 (Q4) Do you feel successful at Cal Poly?

This question provides perspective on a student’s sense of their **competency** in computing. The nature of this question is not meant to understand the actual competence of students, rather how they perceive their own competence, which has more weight when it comes to measuring sense of belonging[22].

As seen in Figure 4.8, in both 2019 and 2020, the majority of our students felt that they were successful, 56.7% in 2019 and 65.6% in 2020. Including students who answered that they felt ‘somewhat’ successful, the positive assessment is even stronger with 94% in 2019 and 95.1% in 2020. We found no significant differences between men and women or White and BIPOC students in 2019 or 2020. A potential limitation of this question is that one’s sense of ‘success’ is not necessarily only founded on their success in computing courses, as exemplified by the quotes below and examined further in the next question.

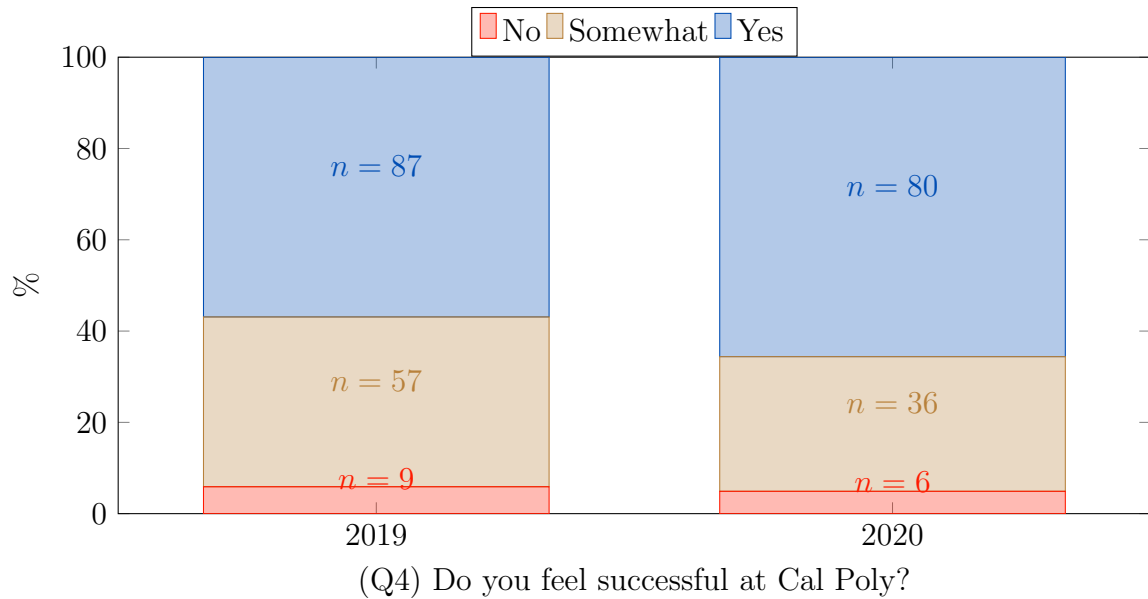


Figure 4.8: Student responses in 2019 & 2020 for (Q4).

There were many different reasons cited for why students did or did not feel successful. Some students mentioned their GPA, internships, or specific courses or coursework. Some students, like those quoted below, felt that their prior experience affected their sense of success. The quotes below are listed with the student’s year and their response to (Q4).

“Due to past experiences with software, I have some intuition as to how programming works. Paired with natural affinity with devices, I find I learn CS topics reasonably well – my Major GPA affirms this.” (2019, Yes)

“My first coding class was CPE 123. In terms of my own progress, I think I’ve been successful. But when compared to my peers who started coding in 8th grade or earlier, no, I am not successful.” (2020, Somewhat)

“I’m a freshman in computer science who came in with nearly zero knowledge of the computer science field, and through my hardwork and the support of the mentors, mentees, and connections I’ve made at Cal Poly I was able to get interviewed by engineering companies as a first year.”
(2019, Yes)

Another set of reasons students used for their feelings of success were social relationships. This could be with mentors, mentees, friends, peers, professors, or other professionals in the field of computing. As seen in the below quotes, strong positive relationships with others in computing helped these students feel a sense of success that was built through networking. Likewise, a lack of these relationships could lead to students feeling disconnected from computing and the CSSE department. Additionally, some students mentioned their demographics as a factor contributing to their ability to build relationships with other computer scientists.

“Most of the connections I’ve made with other students seem to be more of an acquaintance relationship rather than friendships. Even though I may be around them I feel disconnected from everyone in a group for the most part. I haven’t really gotten to know many of the faculty as I don’t want to bother them or take up their time. As far as understanding the material I feel like I fall behind a lot compared to those around me, and am not as competent. I also don’t feel like I am able to support those around me and become more of a burden or annoyance to them.” (2019, Somewhat)

“I enjoy the courses I’m taking, I have built relationships with some professors, I have an internship lined up for this Summer, and I have a social life outside of my schooling” (2019, Yes)

“As a woman of color in a predominantly white institution and in a major dominated by men, it’s often very difficult to feel successful when you are already so different from everyone else. I find myself struggling to feel confident in reaching out to others or participating in major/career-related activities because I already feel at such a disadvantage in comparison to my peers.” (2020, Somewhat)

“Of course, responses to the previous question will be solely based on the individual’s own world view and their interpretation of their own accomplishments. For me, I feel that I came to Cal Poly to learn, grow, and to connect with others with similar passions. To that end, I have succeeded wholeheartedly in my mission.” (2020, Yes)

“I have found the most inspiring mentors. I love the department and really feel that it has my best interest at mind. I do decent in class but the main reason I feel successful is that I have a plan for my career.” (2020, Yes)

4.5 (Q5) My resume or CV is just as impressive as those of my peers.

In addition to the previous question, this question is included in order to further measure students’ perceptions of their **competence**. We included two questions because, a student could have an impressive resume without feeling successful or likewise, they could feel successful without having an impressive resume. Including both can indicate an overall feeling of competence.

Figure 4.9 shows a different view of student’s sense of their competency. When comparing against their peers, concerns result in more of a uniform distribution across the scale, with over 30% of students responding that they ‘strongly disagree’ or ‘disagree’

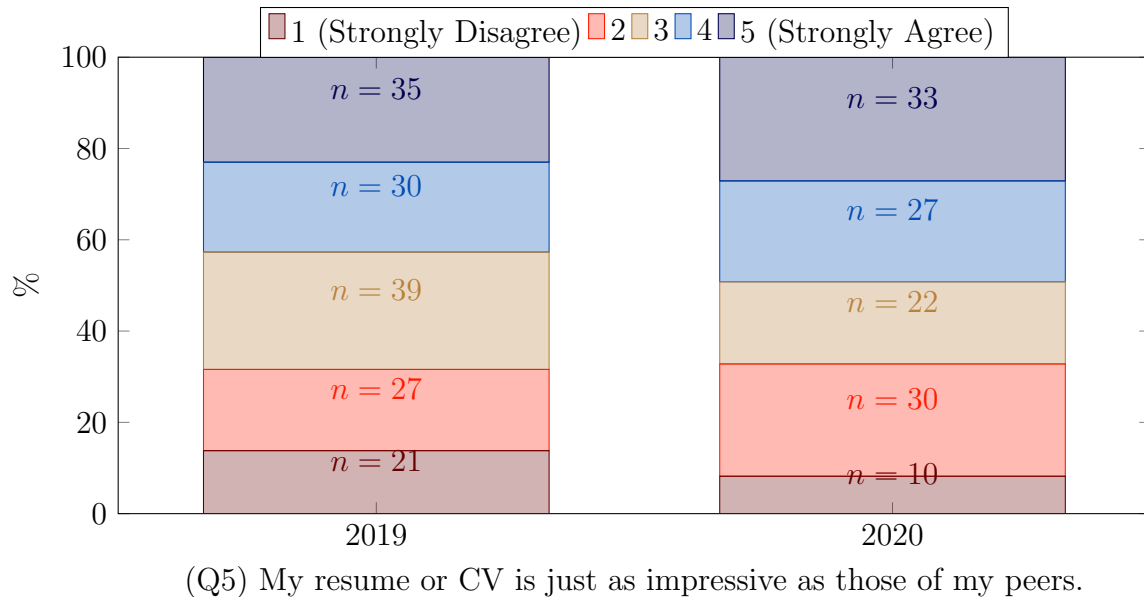


Figure 4.9: Student responses in 2019 & 2020 for (Q5).

that their resume is impressive. This measure of competence more closely matches the data reflected in (Q3) about student sense of their computer science identity. We did not find any statistically significant differences between white and BIPOC students or men and women in 2019 or 2020.

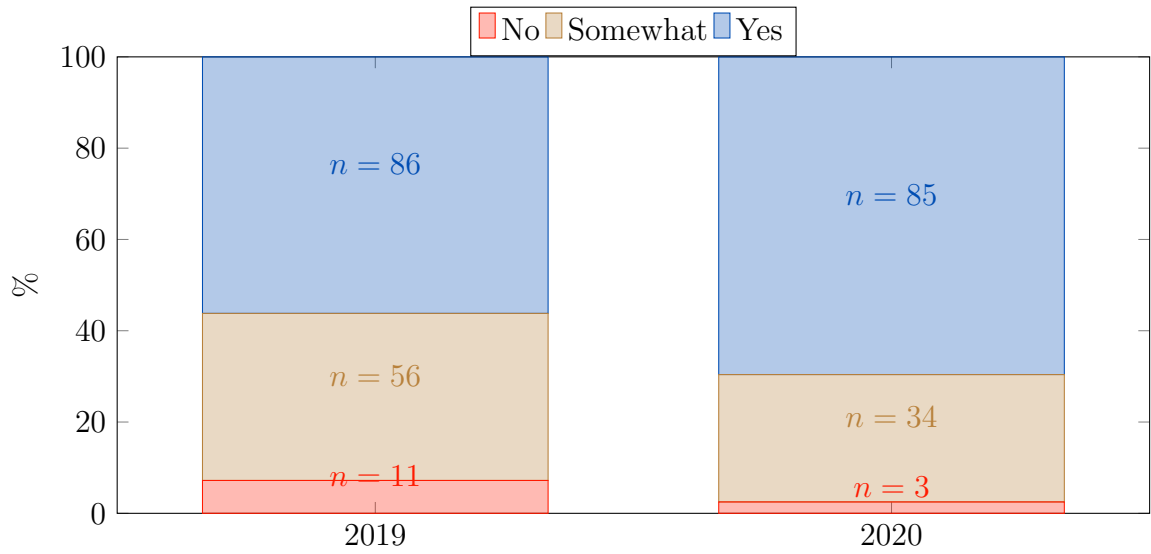
4.6 (Q6) Do you think that the Cal Poly CSSE department values excellent teaching?

We included the analysis for this question to contextualize our understanding of student’s sense of belonging with respect to their perception of the department as a whole (specifically with a lens on the quality of their education). As it relates to the student’s perception of the department, we feel that it belongs in the **learning environment** category.

Figure 4.10 shows that in 2019 and 2020, most of our students felt that the CSSE Department valued excellent teaching (56.2% in 2019 and 69.7% in 2020 responded with “Yes” and 36.6% in 2019 and 27.7% in 2020 responded with “Somewhat”). Cal Poly is a primarily undergraduate institution with an emphasis on undergraduate teaching in hiring, promotion, and retention. Despite this internal emphasis in teaching, 30 – 40% of students did not feel the department valued excellent teaching. This question allows us to understand that the majority of students feel positively about the teaching environment, but that we have room for improvement.

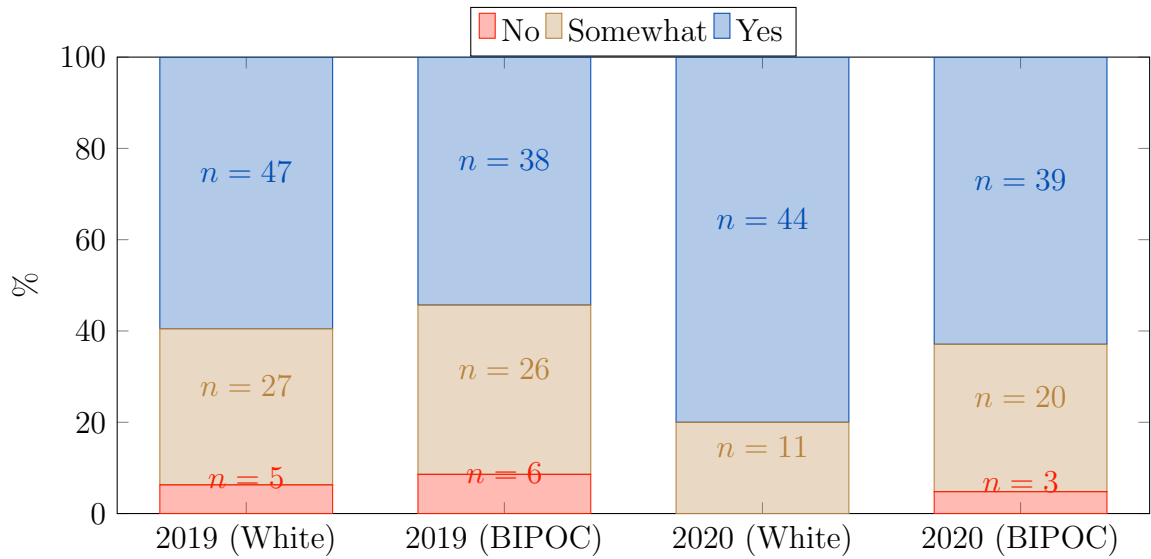
There was a statistically significant difference between men and women’s perceptions in 2019. With a p value of $p = 0.016$ and an α of 0.05, there seems to be a difference in perception between how men and women perceive the teaching quality of the department. In 2019, 62.14% of men felt that the department values excellent teaching while only 45.45% of women felt the same. See Figure 4.12. Additionally, in the 2020 survey we found that there was a statistically significant difference between white students and minoritized students with $p = 0.0352$ and $\alpha = 0.05$. While 80% of white students felt that the department values excellent teaching, and all white students thought that the department at least somewhat valued excellent teaching. In contrast, 62.90% of minoritized students felt that the department valued excellent teaching. See Figure 4.11. We did not find a significant difference between men and women in 2020 or between white and BIPOC students in 2019. Despite these shifts in significance, there is clearly a difference in perception that is absolutely something we want to track and address as a department.

Almost every student mentioned something about instructor or teaching quality in their response explaining their answer. Many students mentioned the impact that instructors can have on their educational experience. Students recognized that this can sometimes be an effect from differences between preferred teaching and learning



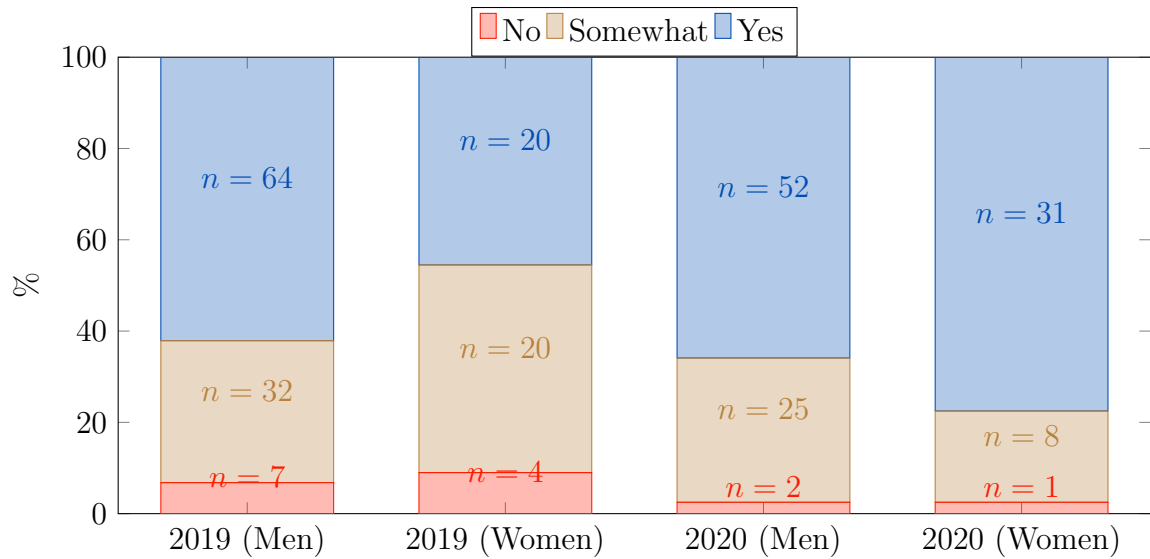
(Q6) Do you think that the Cal Poly CSSE department values excellent teaching?

Figure 4.10: Student responses in 2019 & 2020 for (Q6).



(Q6) Do you think that the Cal Poly CSSE department values excellent teaching?

Figure 4.11: Student responses in 2019 & 2020 for (Q6) split by race and ethnicity. Significant difference found in 2020.



(Q6) Do you think that the Cal Poly CSSE department values excellent teaching?

Figure 4.12: Student responses in 2019 & 2020 for (Q6) split by gender. Significant difference found in 2019.

styles, and how prepared they felt for further curriculum or jobs after taking courses. Other students felt that connections with specific instructors (or lack thereof) impacted their opinion of the values of the department.

“I think the department values excellent teaching. But not all professors are going to teach in a way that is helpful to me. In part it is my job to find professors that will create a good environment for me, and I need to go to office hours to clear up questions. I have regrets about taking classes with professors I knew I would struggle with, because my preferred sections were full, and getting low grades or failing those classes. I have purposely failed classes to take them again with professors that I would better understand. For each class within CS that I’ve failed, I gained a much better, more thorough understanding of the subject matter the second time around. There are some classes I barely passed, and now I still struggle with the subject matter. I almost wish I had failed these

classes, so I could attempt them again with a different professor and learn more.” (2019, Yes)

“Some of the professors are incredibly passionate and hard-working [...]. Some are disconnected from their students, hard to communicate with, or seem more interested in ”defeating” their students than challenging them [...].” (2020, Somewhat)

“The department seems to take student evals done at the end of the quarter seriously. There are certain teachers that students actively avoid because they aren’t known for good teaching, but for the most part excellent teaching seems important to the department.” (2020, Yes)

“I feel like there’s a bit of a paradox with professor’s involvement with students. I feel like many are involved in student oriented groups, projects and research which is great for involved students. However it also makes me more hesitant to reach out to professors classes / guidance because I’m worried I’d interfere with their already busy schedules. It feels like I haven’t been able to grow a close relationship with any of the professors at Cal Poly and that feels very disappointing as a student. It makes me feel less motivated and a bit directionless. I guess I wish there were more professors that are dedicated to instruction / guidance of students who might not yet be involved in a CS project.” (2020, Somewhat)

Another common theme that students mentioned related to impacted classes and hiring instructors. Students seemed frustrated by not being able to get into classes they were interested in, and frustrated when they felt that courses were taught by instructors that did not meet their expectations.

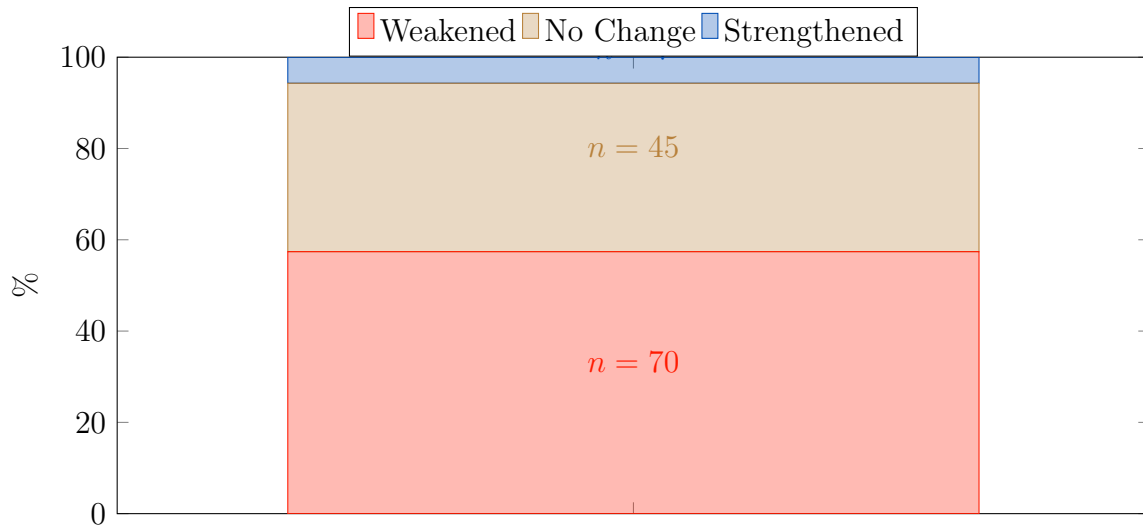
“I believe that most professors in the department try their best to teach their students. Most of the professors I’ve had have been very willing to provide help and feedback to their students. My main issue is that classes get full very quickly and can cause some students to feel neglected when they can’t get a class they want or need.” (2019, Yes)

“The department does not have the resources to the hire only excellent instructors, and as a result hires many mediocre or poor instructors in order to offer enough course sections” (2019, No)

“I feel that the CSSE program is very academically rigorous, and lots of the professors I’ve had have been very knowledgeable about the material, and most of the professors have real world experience in the field. I think this is because the CSSE department takes the professor hiring process very seriously, because they care about their students’ education.” (2019, Yes)

4.7 (Q7) How has your sense of belonging and community within the CSSE department changed with regards to distance learning?

Given our goal to understand student’s sense of belonging over time in our department, we could not survey a second year without also acknowledging the impact of distance learning. For this paper, we consider **(Q7)** in order to provide us with some context for how students’ sense of belonging was being shaped by the **learning environment** created by distance learning. Because of the timing of all the surveys, we only have data from the Spring 2020 survey.

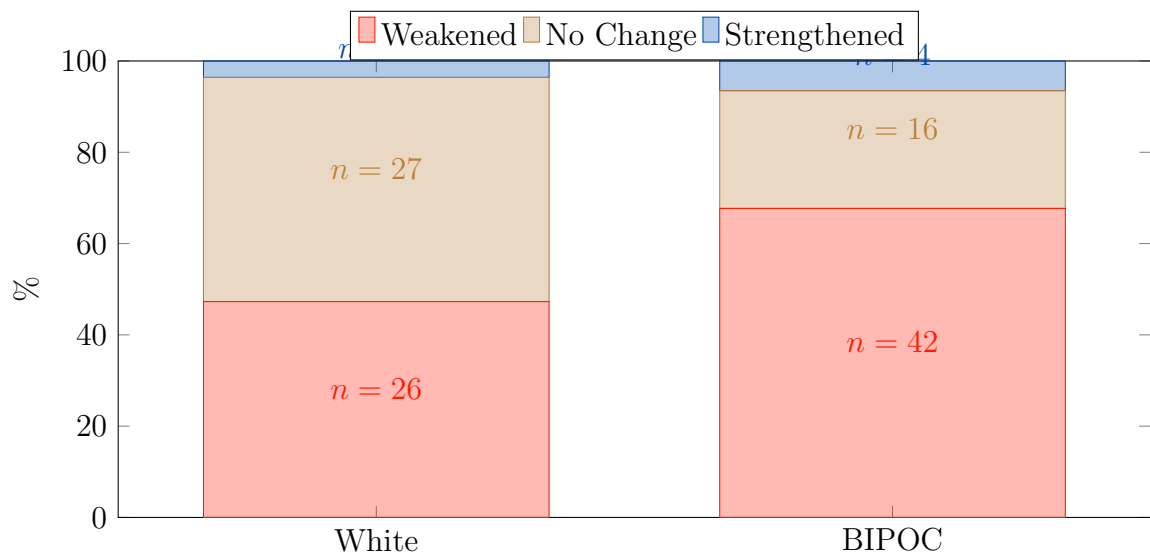


(Q7) How has your sense of belonging and community within the CSSE department changed with regards to distance learning?

Figure 4.13: Student responses in 2020 for (Q7).

As shown in Figure 4.13, a slight majority, 57.38%, of students reflected that their sense of belonging had weakened since the beginning of distance learning, while 36.9% reported no change in their sense of belonging and 5.7% reported that their sense of belonging had strengthened. The majority of students experiencing a weakened sense of identity was not surprising given the loss of access to campus academic and social life.

We found statistically significant differences between white students and minoritized students with respect to their change in sense of belonging during the distance learning period. Figure 4.14 shows this difference. For minoritized students, the majority, 67.7%, felt that their sense of belonging was weakened and only 25.8% reported no change. Among white students, 47.3% of students reported a weakened sense of belonging and 49.1% of students reported no change. For this statistic, $p = 0.0316$ which is less than our α of $\alpha = 0.05$. We did not find any significant difference between the reported change in sense of belonging between men and women.



(Q7) How has your sense of belonging and community within the CSSE department changed with regards to distance learning?

Figure 4.14: Student responses in 2020 for (Q7) split by race and ethnicity. Results were statistically significant.

Chapter 5

ADDITIONAL STUDIES

In this section, we present the results of two additional studies conducted at Cal Poly. The goal of this analysis is to add additional information to the main results to help explain some of the trends there. We continue to use the areas of belonging from previous sections that are **Interest, Competence, Interpersonal Relationships, Science Identity, and Learning Environment**. A discussion of the results can be found in Chapter 6.

5.1 Fall 2019 Freshmen Survey

The Fall 2019 survey of freshmen gives us an idea of how students feel when they first start at Cal Poly and could help us to understand what students expect when embarking on their computer science journey. This cohort of students as a whole is the same cohort that appears as freshmen in the Spring 2020 survey, however we cannot analyze the two surveys as matched pairs because there is no guarantee that the same students answered both surveys. In fact, in the survey of freshmen alone, there were 44 respondents. Only 12 students, or 27% of respondents were White or Caucasian, and 13 students (29%) identified as Female. In contrast, in the Spring 2020 survey there were 18 first-years, split evenly with 9 White students and 9 BIPOC students, and 10 Female students (56%). Due to the different number of respondents as well as the different demographics between the respondents, we can be relatively sure that the two groups are not the same. The questions to be analyzed in this chapter can be seen in Table 5.1.

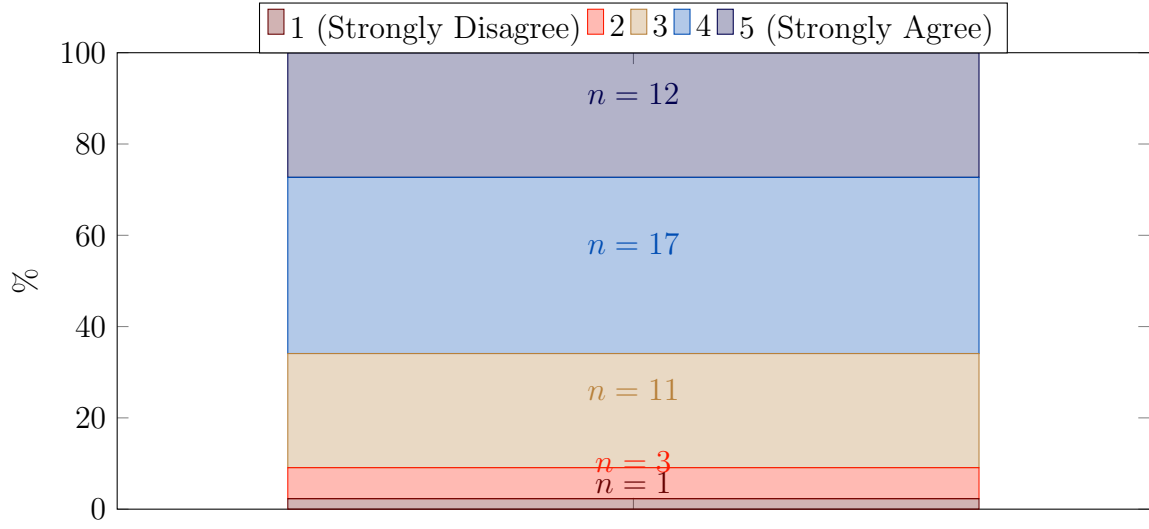
Table 5.1: Categorized questions from the Fall 2019 Freshmen Survey

Number	Question	Category
Q1	I enjoy working as a computer scientist as much as my peers.	Interest
Q2	I am academically as successful as my peers.	Competence
Q3	From whom do you get the most support you need to be successful?	Interpersonal Relationships
Q4	Do you feel like a typical computer scientist?	Science Identity
Q5	What motivated you to come to Cal Poly's Computer Science Department for your undergraduate degree?	Learning Environment

5.1.1 (Q1) I enjoy working as a computer scientist as much as my peers.

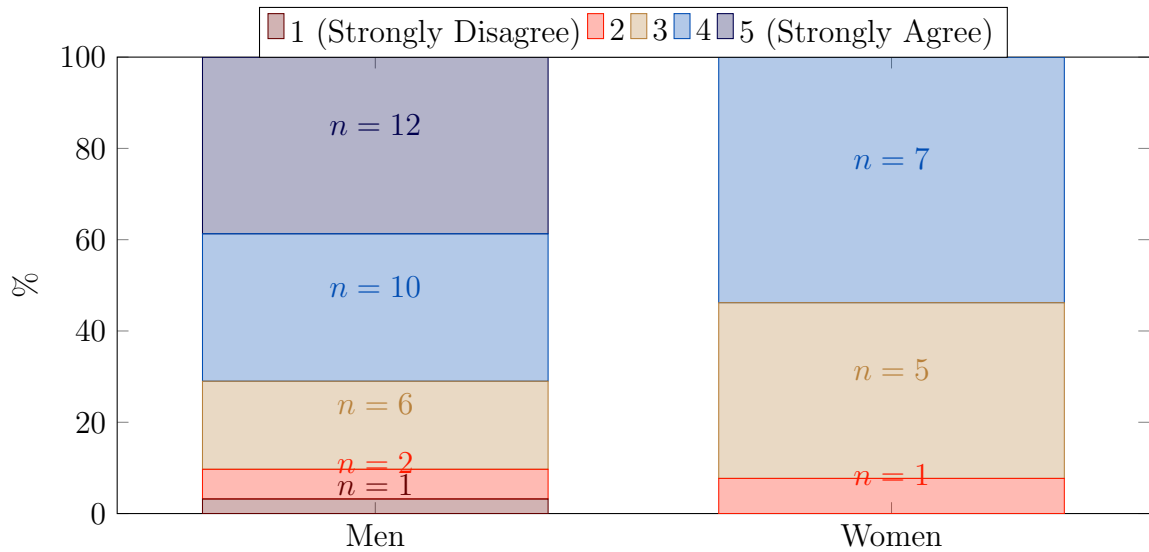
In order to understand students' **Interest** in computing, we can use their enjoyment as an analogous metric. As these students were first quarter freshmen at the time of the survey, they presumably were interested enough in computing to pursue the major. However, to understand if they remained interested through the first few weeks of course material, we can look at their enjoyment of computing.

In Figure 5.1, we can see that most students agreed or strongly agreed that they enjoyed computing. However, it is important to note in Figure 5.2 that none of the women strongly agreed, indicating that there may be a gap based on gender with regards to who has more positive experiences with computing early on in their computing careers. Figure 5.3 implies that BIPOC students and White students have closer to similar experiences in computing as freshmen. When we examine this result along with the results from Section 4.1, it seems that students maintain the same amount of interest as a whole.



(Q1) I enjoy working as a computer scientist as much as my peers.

Figure 5.1: Freshmen responses for (Q1).



(Q1) I enjoy working as a computer scientist as much as my peers.

Figure 5.2: Freshmen responses for (Q1) split by gender.

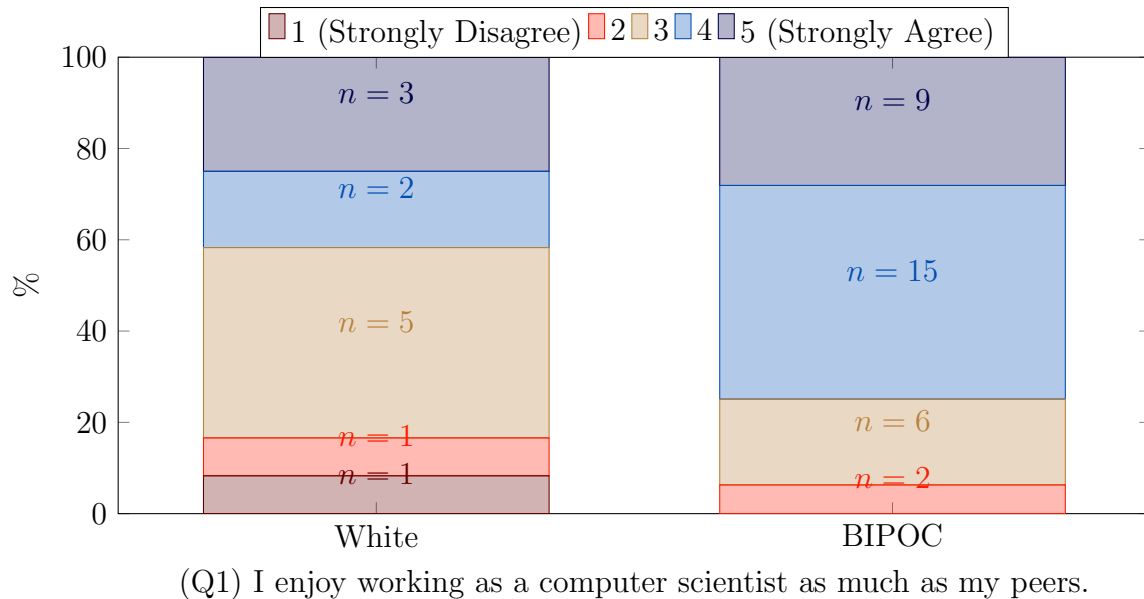


Figure 5.3: Freshmen responses for (Q1) split by race.

5.1.2 (Q2) I am as academically successful as my peers.

For this section, we chose to analyze this question for the **Competence** category as it allows newer students to evaluate their perceived competence compared to other students rather than to analyze it in the abstract. Since newer students may not have a reference for success in the long term or in industry, it is more useful to understand how they feel about their success compared to other students that they know.

In Figure 5.4, we can see that most students agreed or strongly agreed that they enjoyed computing, although the largest single proportion of students felt neutral about their competence. Additionally, no students strongly disagreed with the question, indicating that nobody felt extremely far behind their peers in terms of success. As in Q1, we can see in Figure 5.5 that none of the women strongly agreed, further indicating that there could be a gap between the experiences and perceptions of male and female students. Figure 5.6 shows the difference between White and BIPOC students' perceptions of their competence, which are very similar. While these re-

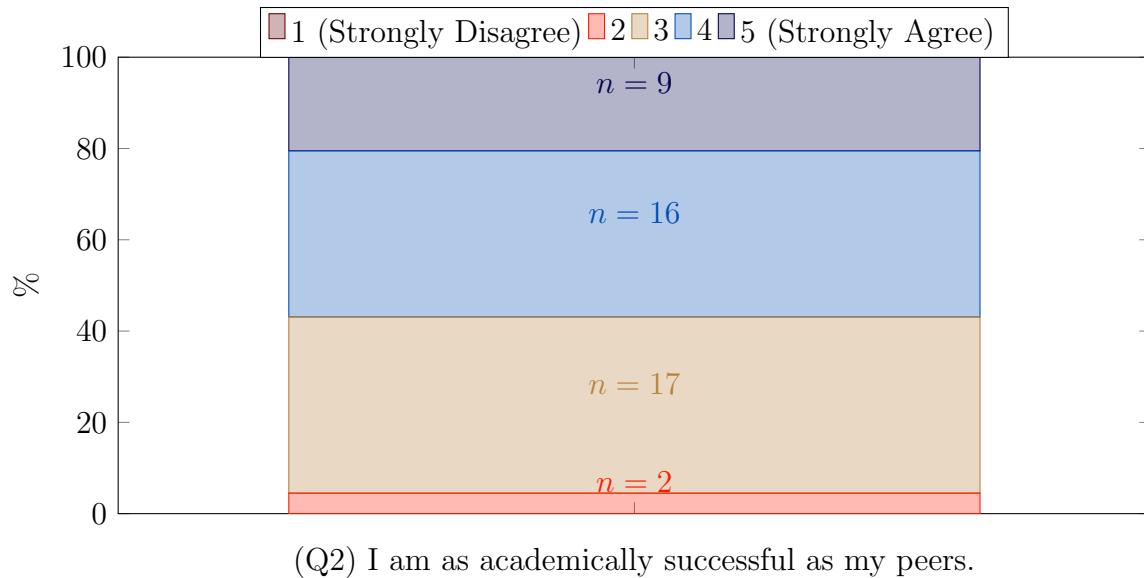


Figure 5.4: Freshmen responses for (Q2).

sults skew more positive, the main results found in Sections 4.4 & 4.5 show that the students as a whole are spread more evenly.

5.1.3 (Q3) From whom do you get the most support you need to be successful?

While this question may seem similar to **Q2**, we aim to understand a student's support system rather than their actual competence in computing. In terms of **Interpersonal Relationships**, we would like to see most students developing support within computing either with their peers, friends, or staff. This question was in a free-response format, but almost every answer could be coded into some combination of Family, Friends, Peers, Staff, and a few other options, so the responses are analyzed based on those categories.

As seen in Table 5.2, the most common supporters were family members or friends. As first year students, these responses make sense as students may not have had much

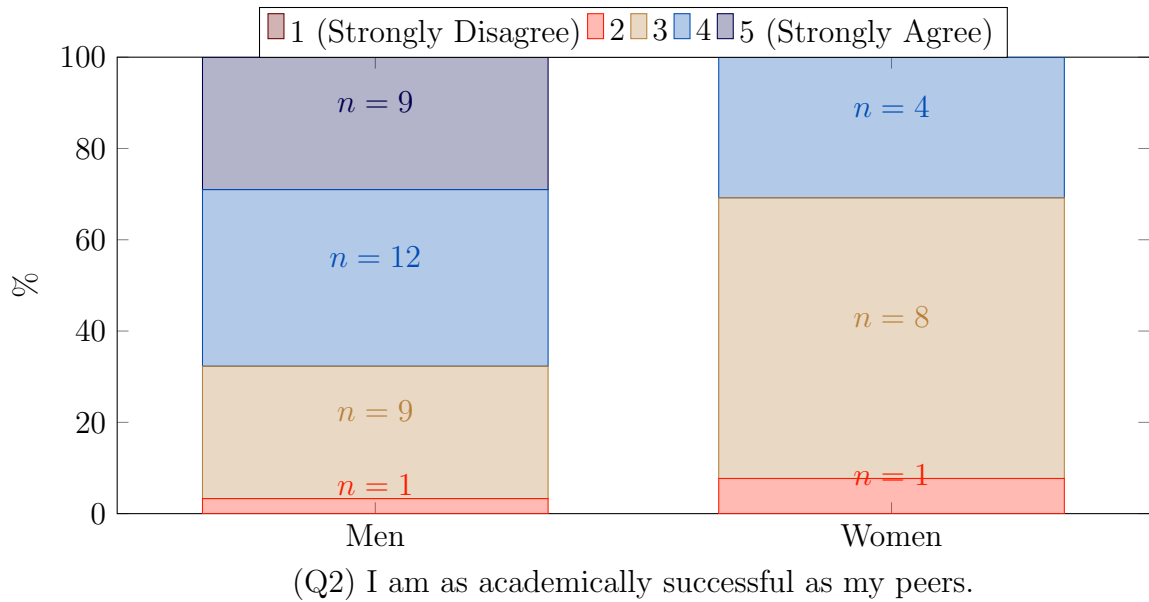


Figure 5.5: Freshmen responses for (Q2) split by gender.

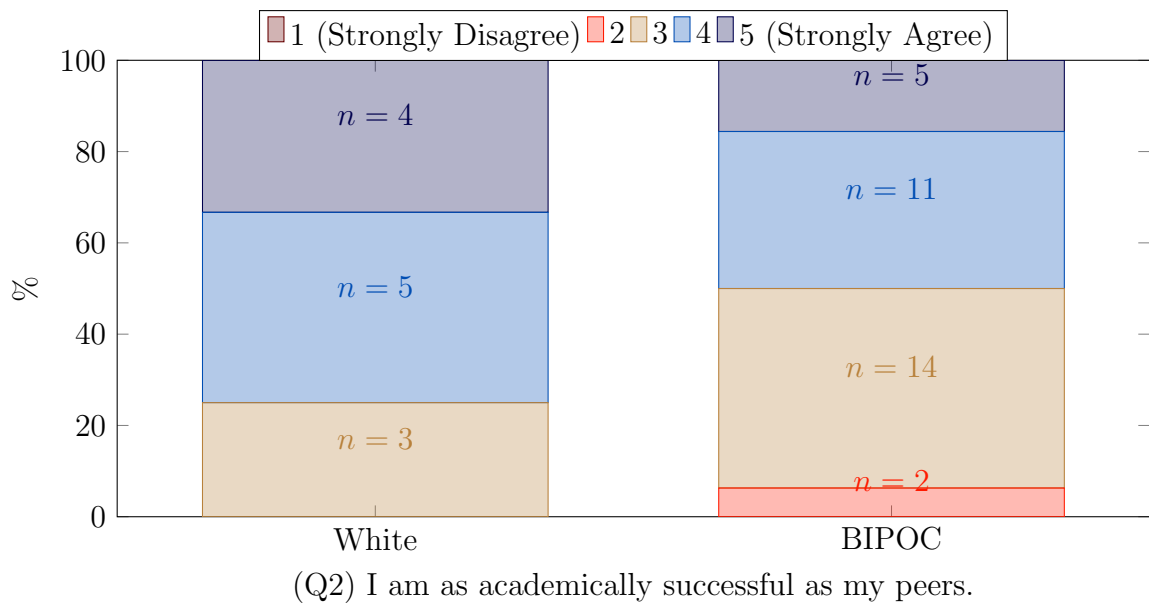


Figure 5.6: Freshmen responses for (Q2) split by race.

Table 5.2: Responses to (Q3) From whom do you get the most support you need to be successful?

Response	# Answers
Family	20
Friends	12
Self	5
Staff	5
Peers	3
Other	4

time to develop interpersonal relationships with staff members or peers outside of their friend groups. However, as time progressed we would want to see more students finding support from staff and peers or mentors. There is also a question about how this may have changed with regards to distance learning as it could be more difficult for newer students to build and maintain friendships with other students in the department, and how we can support those students once classes return to a largely in-person format.

5.1.4 (Q4) Do you feel like a typical computer scientist?

As in the previous chapter, this question provides insight into students' feelings of **science identity** and how much their personal identity is associated with their career choice.

Figure 5.7 shows that first years as a whole responded similarly to the other cohorts about their feelings of science identity, with about 61% not feeling like typical computer scientists, which is very similar to the results seen in Section 4.3. Within Figures 5.8 & 5.9, we do see a pronounced difference between minoritized students and non-minoritized students, where White students and male students both had close to a 50% split between students feeling typical or not. In contrast, among BIPOC students, 65.6% did not feel typical and almost 84.6% of female students did not feel

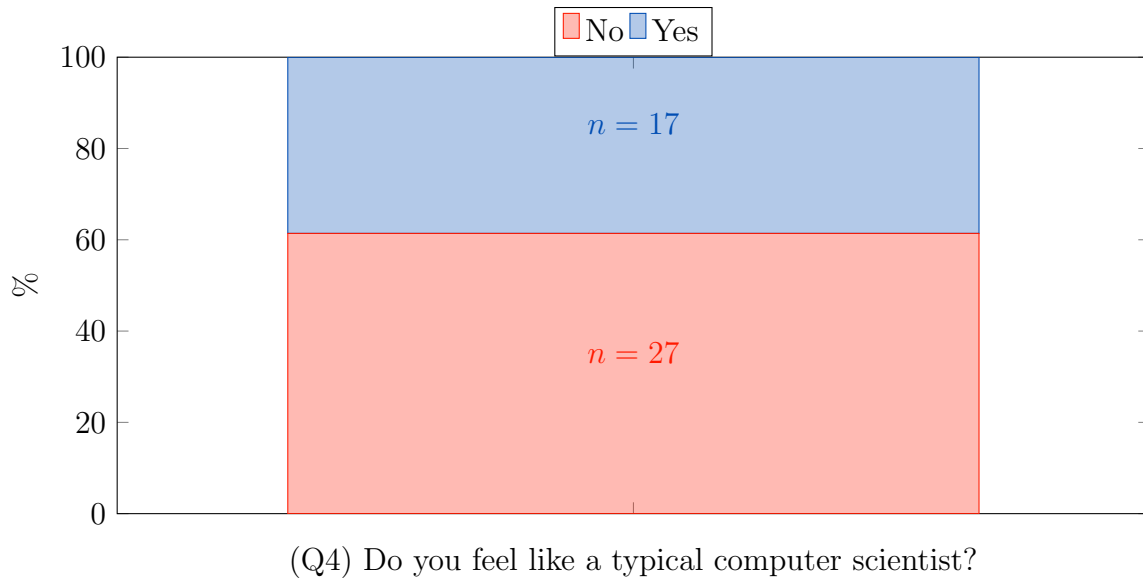


Figure 5.7: Freshmen responses for (Q4).

like typical computer scientists. As we can see in Figures 5.10 & 5.11, the most cited reason for this was because of competence. More specifically, first quarter freshmen did not feel like typical *computer scientists*, rather they felt like typical *computing students*. This makes sense, but is useful to note that through education and experience, students can increase their sense of belonging through improving their confidence. It is important to note that demographics and interest in computing as well as outside interests are still prominent reasons students gave for why they felt atypical. This can show that stereotypes about who counts as a “typical” computing student are still prominent among first quarter freshmen.

5.1.5 (Q5) What motivated you to come to Cal Poly’s Computer Science Department for your undergraduate degree?

In order to understand the impact of the **learning environment** on students’ perceptions of the CSSE department, we want to understand why students chose to come

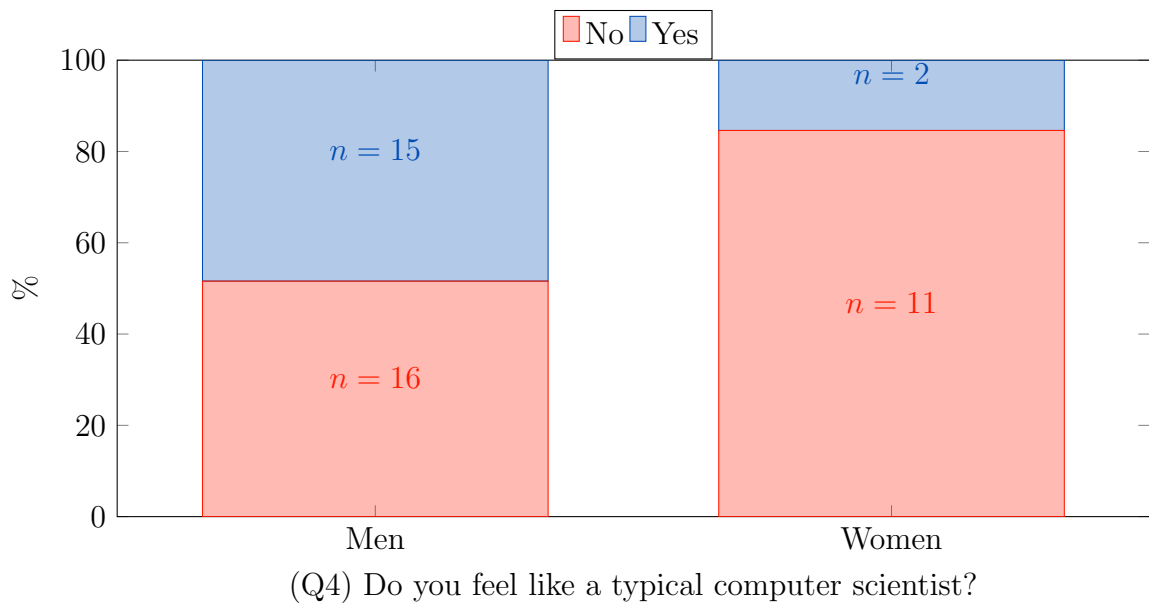


Figure 5.8: Freshmen responses for (Q4) split by gender.

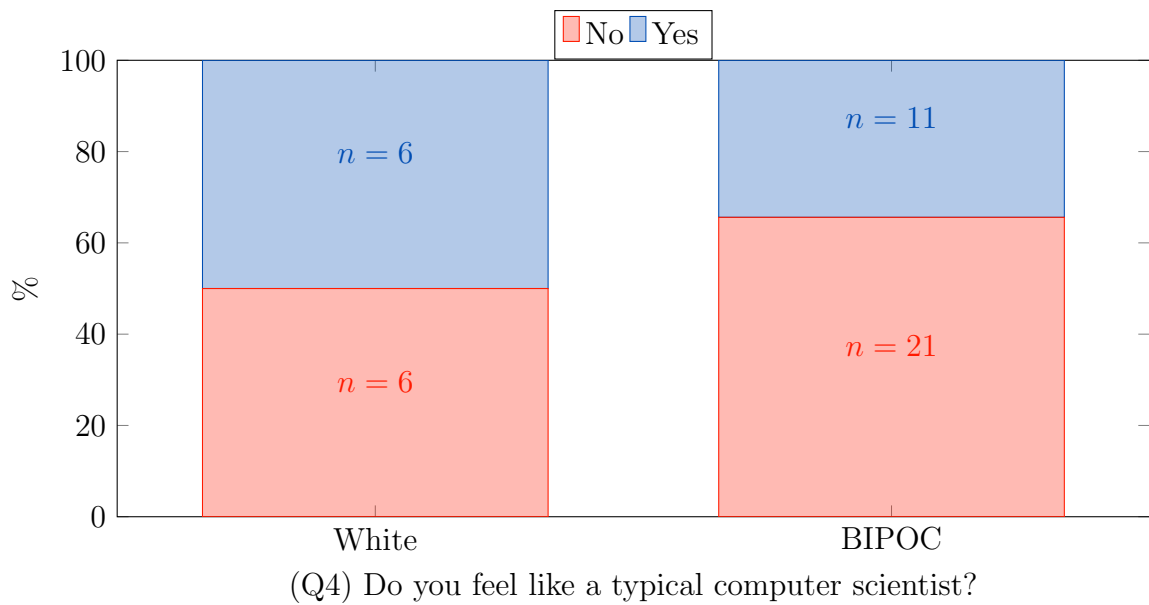


Figure 5.9: Freshmen responses for (Q4) split by race.

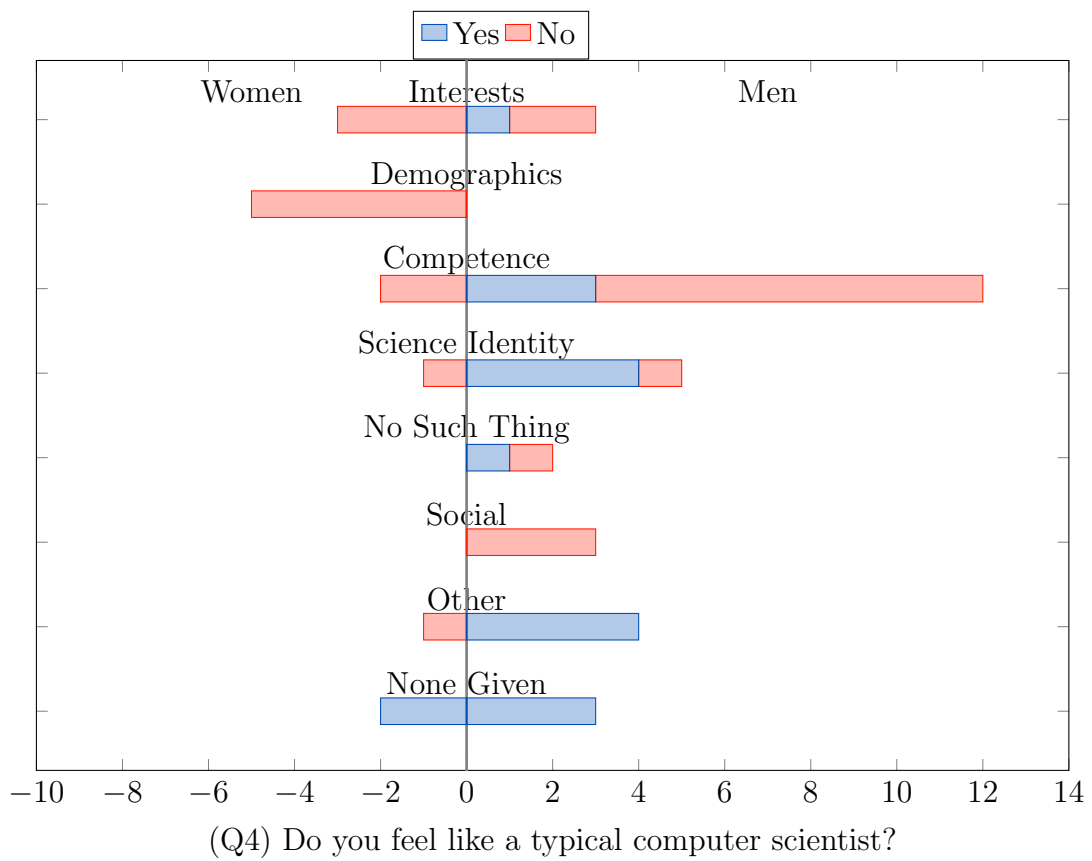


Figure 5.10: Freshmen reasons for (Q4) split by gender

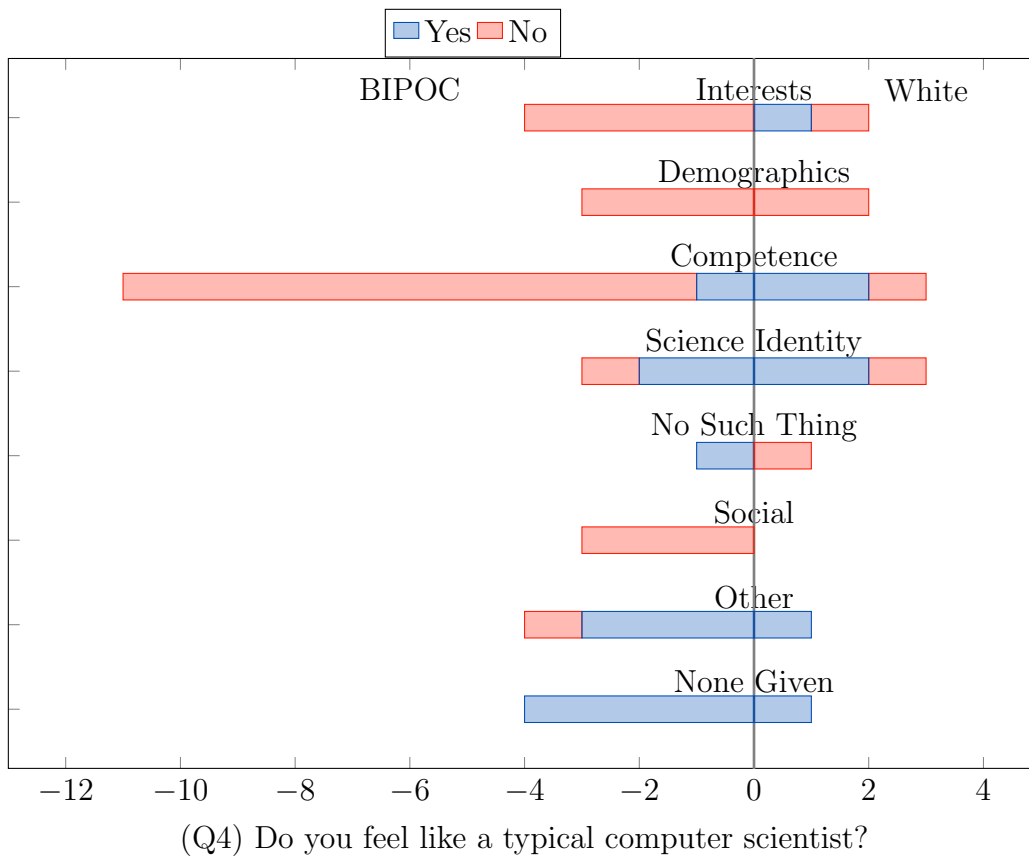


Figure 5.11: Freshmen reasons for (Q4) split by race

Table 5.3: Responses to (Q5) What motivated you to come to Cal Poly’s Computer Science Department for your undergraduate degree?

Response	# Answers
Cal Poly is a really good university in computer science	39
Cal Poly is an affordable school	26
It was the best school to which I was accepted	18
I had a family member/friend who encouraged me to attend	14
During a prospective student visit, I felt that I fit within the department and the university	9
During a prospective student visit, I felt that I fit in with the other students	6
Other	3

to Cal Poly specifically. By looking at why students chose Cal Poly, we can examine what they expected out of their learning environment and if the experience of other students as they progress through the curriculum lines up with these expectations generally. This question allowed students to select multiple options from a list or to provide their own other option.

As seen in Table 5.3, the most impactful reason students chose Cal Poly was because of the prestige of the computing program, with 88.6% of students feeling that it was an important reason for attending this university. Additionally, its affordability (presumably as a state school) was another important factor when it came to why students selected this university. Many fewer students chose the department because they felt that they fit with the department, university, or other students. This can help us understand what students are expecting out of their learning environment when they start at Cal Poly in CSSE—a good computing education at a comparatively low price—however a good education alone will not improve retention. Students still need to feel that they fit in within the department in order to continue in computing long-term, without sacrificing the educational quality that brought them to Cal Poly in the first place.

5.2 Spring 2021 Student Interviews

The student interviews present a very useful addition to the data in that they let students present more informal and off-the-cuff responses to questions targeted at each of the categories of belonging that we are studying. Between two interviewers, we conducted 15 interviews of students within different years at Cal Poly who were both computer science and software engineering majors. These interviews provided important insights into what students identified as the most important factors that contributed to their sense of belonging. The students' responses were generally consistent with the responses from the responses from the surveys.

There were some common themes that appeared that aligned closely with prior results. One in particular is that students generally identified closer with feeling like a computing student rather than a computer scientist or software engineer. Students felt less belonging within the major in their first few courses and quarters of computing, but once they started taking electives or upper division classes they felt more passion and understanding. As students progressed through the curriculum, students felt that they had more passion for computing and more of an understanding of what they wanted to do with their degree, which increased their sense of belonging dramatically. The quotes below are some examples from some of the students who mentioned these factors to their belonging.

“I am more of a software engineering student rather than a software engineer position itself”

“Yes, I believe I do. I think that I have the right mindset for it. And that if anything, I'm being well trained to do the best I can when I actually enter the real world after graduating”

Another common theme that was prevalent in the interviews was the impact of competence on a student's confidence and sense of fit. Students with internships in general felt that they belonged more when compared to students who did not have internships or jobs in computing. In fact, when students compared their success to others, internships were one of the most common metrics that they mentioned. Students mentioned that feeling successful was difficult to define on its own, and therefore used their number of internships and GPA as proxies for their perceptions of competence. They also mentioned that they can judge their success based on more casual conversations with peers and friends, and were able to get a better idea of how they were doing when talking with close friends. Additionally, most students interviewed tended to feel that they were slower than their peers at coding and solving problems, which is an interesting comparison as it is not as specific as internships or GPA and yet was still mentioned often. The feeling of success among computing majors relied heavily on their ability to attain internships or opportunities or getting good grades.

“I haven't struggled too much with like tests and like assignments and usually I'm able to meet like the grade marks that I want to reach”

The idea of a “typical” computer scientist or software engineer also mirrored some of our survey results. Initially, many respondents described the “typical” computer scientist as someone who fits a nerdy persona. Students often identified similar stereotypes from a physical or diversity perspective as the surveys, with nerdy white males being seen as more typical. As one student stated, the typical computer scientist was “more academic nerdier side” than they felt. Another student identified the experience of feeling external pressure whenever they felt like a “diversity hire,” and that they had to work harder to fit in than others in the majority. However, as students had more of an ability to meet other students, work and code more, they identified

to relate more to feeling like a typical computer scientist, and their idea of what a typical computer scientist was shifted to someone who could succeed in the field.

In general, the feelings of belonging among the interviewees was mostly positive. Competence was one of the main reasons that students didn't feel that they belonged, conversely interpersonal relationships was one of the biggest cited contributors to a positive sense of belonging. When their peers openly flaunted their knowledge or quick programming skills, students felt less of a sense of belonging, a trend similar to the one identified by Garvin-Doxas & Barker [12]. Additionally, when a student felt that they needed help or fell behind, they were discouraged and felt less of a sense of belonging. Many students also stated that they really fit in when they found their own group of friends, especially if they had friends within computing. Again, we see that interpersonal relationships and connections to others in computing can really impact belonging in a positive way. Unfortunately, the move to online learning has made many students feel disconnected, especially younger students and transfers. As these younger students did not have as much time on campus – if any – before the move to distance learning, they felt that it was much harder to make friends and maintain connections while online. One student stated “Shifting online has hindered my ability to do group work.” As group work is one major way that students in computing can meet and collaborate with each other, a poor ability to participate in group work could really harm the ability to form interpersonal relationships.

Chapter 6

DISCUSSION

The original survey of the culture of a computing department at UIUC demonstrated a lack of belonging in computing. One could posit that this lack of belonging was unique to UIUC or a condition of similar research-intensive universities. By replicating the original UIUC study at a primarily undergraduate institution we have demonstrated that the lack of belonging is not unique in the field of computing. We have attempted to structure a more detailed and equity minded understanding of our students' sense of belonging in order to better direct our efforts to create an inclusive department. The data is mixed, showing some shifts in statistically significant differences along with indications of both successes and of challenges for student's sense of belonging. Overall, we feel this indicates the importance of this ongoing equity-minded work to examine aspects of department culture and student experience to create an inclusive department.

As a primarily undergraduate teaching institution, we were initially shocked when our first survey revealed that 67.8% of the respondents reported that they did not feel like a typical computer scientist. As we have continued our assessment over time and added other forms of research projects, we hoped to measure how this sense of belonging might be evolving especially as we work as a department to be inclusive. With the onset of emergency distance learning, we needed to address this as we contextualized our work, which was even more present when conducting interviews with students who had spent little time on campus about their experiences over Zoom. This has helped us learn some important lessons about our department and the work we have to do.

We used the four categories identified in Rainey et al. as contributing to a student's sense of belonging and this organization helped expose strengths and weaknesses for our department [22] as well as a fifth category that includes a student's learning environment.

6.1 Interest

As a department, we seem to be doing well in terms of maintaining students' **interest** in computing. Over both the 2019 and 2020 surveys, students felt that they could use computing to solve problems that are important to them. Within the survey of first-years, most students stated that they enjoyed working as a computer scientist. Interest is a very important pillar of belonging as it is an essential part of continuing in the major. Moreover, if a student is no longer interested in computing, they have less incentive to continue learning and working as a computing professional. It seems that through the curriculum and the many different paths that we present to students, they feel that they are able to apply computing to their interests. As a department, we are providing students with the tools they need to stay interested in computer science.

6.2 Interpersonal Relationships

We see that, in terms of students' **interpersonal relationships**, female students are doing statistically significantly better than male students. This is a positive indication of the benefit of our largest computing club WISH, which is focused on women in computing and includes a strong mentoring program. Additionally, this gives us an indication of the importance of expanding our mentoring options for young men in the department because of the impact that mentorship seems to have on the women in the

department. If we look at the results from the survey of freshmen, the data confirms that when students start at Cal Poly, their main source of support is from family members or friends, but we could help add to a students' support network with this addition of mentorship which could help students have a stronger connection to others within the department. During the interviews, students very commonly mentioned that they felt the most positive impact on their sense of belonging once they found a group of friends, especially if some of their friends were computing majors. This can further support the idea that clubs such as WISH can have a positive impact on student's sense of belonging as they provide a way for students to connect with each other early on in their college careers, and mentorship programs give students a way to meet each other more naturally.

6.3 Science Identity

The data also shows that we have more work to do, which we can see when examining students' sense of **science identity**. Students gave various reasons for not feeling like typical computer scientists: interests outside of computing/interest in computing, demographic differences, perceived competence, science identity, no such thing as a typical computer scientist, or social reasons. Among freshmen and younger students in general, lack of competence or prior experience was a major reason for their lack of science identity.

Despite female computing students being more likely to have friends in the department, friends are not enough to outweigh the statistically significant difference we see of fewer female students having a strong affinity for their computer science identity, with a smaller number feeling like a typical computer scientist. It is important to note that this difference was not found in the Metcalf et al. survey conducted at

UIUC [20]. We can see that even as first years, female students are less likely to feel a strong connection with their computer science identity, indicating that this is a larger issue that persists throughout female students' whole careers at Cal Poly. For these female computing students, their demographics were the main reason cited for not feeling typical. While anyone can be a computer scientist, the idea that the typical computer scientist is male proves to be a main detractor from our female students' sense of belonging. The same stereotype was prevalent among student responses to the interviews, but there was a shift as students spent more time getting to know others in the major who were not typical. Of course, the demographic makeup of the field of computing shows that the majority of computer scientists in the US are male [26]. However, the stereotype that any non-male is then not a typical computer scientist can be damaging to everyone in the field. We can see that men also generally felt that they do not belong because they are less interested in computing or more interested in activities outside of computing than they perceive their peers to be. Ironically, many of the interests listed as outside interests not shared among their peers were common like physical activities, outdoor activities and sports. This indicates that students' science identity is not defined in a vacuum, rather it is at least partially defined by the role models and peers in the field. By having a set of role models and peers that students can see and identify with, they may identify with a much broader definition of who is a computer scientist.

6.4 Competence

If students do not feel confident in their abilities as a computer scientist, they are less likely to persist in computing. Students may judge their **competence** more harshly than their actual grades, so the questions that we posed to students tried to capture that perception of their abilities. Most students in both 2019 and 2020 felt that they

were successful at Cal Poly and very few students felt that they were not successful, which is a very positive sign. Within the first year survey, the results were largely similar in that very few students felt less academically successful than their peers. In the freshmen survey, we did see that no female students strongly agreed that there were as successful as their peers, but we saw no statistical difference in either of the two major surveys which may indicate that students feel less of a disparity in competence as they go on—either from less of an impact from prior experience or from specialization in technical electives.

In surveys and in interviews, students did give many different reasons explaining how successful they felt. Some students felt that having many friends and connections within the CSSE department or in computing in general made them feel successful, others who didn't have those connections said that that lack of a network contributed to their feeling less success. Others noted that their GPA, internships, side projects, or general ability to complete labs affected their idea of their success. Much of student perceptions in this area will rely on what each individual student values, but it seems that again social connections and ensuring students have support in any area of computing they may find interesting could have a positive impact on students' ideas of their competence. Among students who were interviewed, the sense that other students were more knowledgeable than them and were showing off during office hours or in classes negatively affected their sense of belonging. This idea is consistent with the research from Garvin-Doxas & Barker about the negative effect that student strutting can have on computing students [12]. Additionally, students felt that needing help was a sign of lack of competence and indicated that it led to a decrease in their overall sense of belonging. As much of computing relies on building upon preexisting systems, reading documentation, and collaborating with other programmers, it is important to normalize asking for help. Asking for help should

not be a detriment to a student's sense of belonging, as it is an important skill for professionals to have.

When we look at how students feel about their resumes rather than their coursework, we see a different picture. In terms of students' perceptions of their abilities *outside* of class, there is effectively a uniform distribution. This may be a result of the competitive internship process but as a department culture, we could make more of an effort to emphasize the value of more varied types of experience. When interviewed, one of the main reasons students stated for their sense of belonging was their internships. This can be in a positive or negative way, but students who had internships largely felt that they belonged more than those who did not have internships. These student responses further confirm the impact that the competitive internship process can have on students. As a department, we could mitigate this impact by emphasizing the value of more varied types of experience and reassuring students that internships are not the only way to find success in computing.

6.5 Learning Environment

Similarly, this data reflects an important perspective about minoritized student's experiences in the **learning environment** that is present within our department. Both female and minoritized students have a more negative perspective about our department's commitment to excellent teaching. This begs some difficult questions: Why? Are our classes better designed for white male students? And how can we counteract this experience? We can see through the first year survey that students were motivated to come to Cal Poly largely because it has a good reputation for computing. Additionally, we saw in an earlier question focused on perceived competence that students do largely feel academically successful at Cal Poly. The responses

to this question help show the divide between how female and minoritized students define a quality computing education when compared to students in the majority. Students largely stated their perceptions of their learning environment with regards to instructors. Some felt that connections with instructors whose teaching style they understood or whose curriculum they found interesting made them feel supported. Others felt that a lack of connections within the department gave the impression that the department did not value excellent teaching. Impacted classes made some students feel “neglected” by the department, yet hiring teachers to fill those courses sometimes made some students feel that the quality of their education was no longer up to par. Each student needs different support and every student learns in their own ways, but ensuring that students feel that their instructors are approachable and value student success is important to ensuring that computing majors feel good about the learning environment in the CSSE department.

Finally, as noted in other publications [11], distance learning has the potential to exacerbate inequities in education and has been very isolating for some. We cannot ignore that more minoritized students feel a decline in their sense of belonging with distance learning. In interviews, it was noted that this shift to the distance learning environment has impacted students’ abilities to maintain connections with other students and participate in group projects. This impact was particularly prevalent among younger students and transfer students who have not had as much time to spend on campus to develop relationships with their peers. This is a further call to attend to the culture in general computing classrooms. In particular, recognizing how that culture might be emphasized with distance learning as a modality of classes, especially as distance learning will continue past the end of the pandemic.

6.6 Future Work

The surveys that have already been run consist of a lot of data, not only Lichert-scale questions but also free response questions. Because of this, we have a rich fabric of data that could be used for further analysis of elements not covered in this paper thus far. For example, natural language processing could be applied to the free response questions to generate a less biased understanding of students' general responses and identify trends. Other approaches could also be applied to slice the data in different and potentially interesting ways, for example slicing by responses to Lichert-scale questions or by whether or not a student has a mentor, internships, or other job experiences. These slices could show interesting emerging trends about underlying factors that could correlate strongly to a student's sense of belonging. Additionally, this data set would be a very useful one to examine through the lens of intersectionality. In our exploration of the data, we found the sample size of respondents in intersectional categories raised concerns about the anonymity of the data. Therefore in this work, we focus on slicing in one dimension only (race & ethnicity and gender), however it would be beneficial to explore the impact that intersectionality could have on how students experience computing culture.

Another potentially useful area of future work could be to continue to administer the same survey to students at Cal Poly in order to facilitate a longitudinal study of the sense of belonging at Cal Poly's CSSE department. This could either be done to examine changes over time in the general psyche of Cal Poly computing students or the current data could be used as a baseline before implementing interventions to try and improve the sense of belonging among students. The survey instrument could then be used in order to understand the impact of the intervention and on which areas of belonging it had the most impact.

As mentioned briefly among the threats to validity, this thesis only examines students who were computing students at the time of the surveys. It does not capture the responses or reasons for students who dropped out or switched majors away from computing. If the goal is to increase retention among computing students, it is important to examine not only from current students but also to hear from those who didn't have successful learning outcomes. A future study would be to interview or survey students who left the major and compare their responses to those in the main surveys to understand what areas of belonging were lacking for those students who left the major.

6.7 Summary

In several ways, the less than positive response from students is hard to acknowledge. We would like to believe our department is a welcoming and inclusive place of learning, focused on excellent teaching with students who feel like they are growing and fitting in as computer scientists. The process of surveying our students over two years shows us some positives, but also indicates areas of concern. We can see that overall, students do not feel like "typical" computer scientists but that this is more pronounced among female and BIPOC students. We can also note that those same students have a more negative impression of their learning environment, and we need to develop ways of improving the educational experience for these students especially given the disparate impact of distance learning on minoritized students.

One silver lining in this data is that it is helping to show that current interventions are working. Looking at female students' increased strength of interpersonal relationships, we can infer that groups like WISH or mentorship groups focused on community engagement in computing can have a positive impact on students. Hopefully, we can

look to groups like Color Coded to further help BIPOC students feel welcomed in computing and develop more support within the department. Moreover, connections and interpersonal relationships do not have to only be built between current students, they could be with former students, staff members, internship mentors, or any other professional in the field of computing. In fact, students cited each of these groups as positive influences on their sense of belonging. Therefore we could also look to other areas that are underutilized sources of potential mentors or networks of professionals, like alumni networks, faculty advisors, any general computing club like ACM, or the Industrial Advisory Board. The most impactful interventions would focus on improving students' sense of science identity and their learning environment. By introducing different projects or people who work outside of large tech companies, we may help students feel more like their path through computing is valid.

As another note, it is clear that while categorization of areas of belonging can be extremely helpful, the areas are deeply connected with each other. We can see this especially when we look beyond the surface at the reasoning behind many students' answers. For example, a student could feel disconnected from a science identity because they experience a lack of interpersonal relationships, or vice versa. This interconnectedness can make it more difficult to pinpoint specific areas of belonging where students need support, however it also underscores the importance of improving belonging across the board. By increasing a student's perceptions of their competence, we may also help them feel more like a computer scientist. To give another example, by connecting students with like-minded students, professors, or professionals, that student could feel more confident that small mistakes or a poor experience in class does not reflect on their personal overall competence. It is therefore imperative that we support students in any way we can, because it could be helpful to students in more ways than one. Mentors or advisors should focus on supporting students however they are most comfortable, because any support is helpful.

Chapter 7

CONCLUSION

Research has shown that a sense of belonging is crucial to student retention rates [7, 8, 14, 15, 16]. Other surveys have shown us that overall only about 30% [20] of students feel they are typical computer scientists. This work examines the data from two years of student surveys as well as a survey of first year students and student interviews. Additionally, while there has been mandated social distancing and distance learning, we included questions that examined shifts in attitudes that students experienced during the year.

We found data that further emphasises the less positive experiences that affect women and minoritized students and areas to focus on while working on improving their educational outcomes. More specifically, we found that women and BIPOC students had a significantly more negative sense of both science identity and of their learning environment. We also found that women had a significantly better sense of interpersonal relationships, indicating that some of the interventions like mentorship or affinity groups like WISH can work to improve how students feel about their sense of fit. We hope this work inspires our faculty and other departments to continue the work of examining student sense of belonging to improve computing for all.

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APPENDICES

Appendix A

MAIN SURVEY

CSSE Student Survey

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT:

"CSSE Student Survey"

INTRODUCTION

This form asks for your agreement to participate in a research project on the sense of belonging among students in the Computer Science and Software Engineering Department. Your participation involves taking part in a survey and allowing the use of your anonymous answers in research and analysis. It is expected that your participation will take approximately 20-30 minutes. There are some minimal risks anticipated with your participation. You may personally benefit from this study and others may benefit from your participation. If you are interested in participating, please review the following information.

PURPOSE OF THE STUDY AND PROPOSED BENEFITS

- The purpose of the study is to gauge how computing students' interactions with their peers, faculty, and staff affect their sense of belonging.
- Potential benefits associated with the study include a better understanding of how education affects student morale and how to improve pedagogical techniques associated with belonging

YOUR PARTICIPATION

- If you agree to participate, you will be asked to take part in a survey that will assess your current sense of belonging in the department and how the department impacts your feelings.
- Your participation will take approximately 20-30 minutes

PROTECTIONS AND POTENTIAL RISKS

- Please be aware that you are not required to participate in this research, refusal to participate will not involve any penalty or loss of benefits to which you are otherwise entitled, and you may discontinue your participation at any time. You may omit responses to any questions you choose not to answer.
- There is a minimal risk to your reputation or status should your data be disclosed along with your identity. There also is a minimal possibility of emotional distress should any of the questions trigger unpleasant thoughts or feelings.
- Your responses will be provided anonymously to protect your privacy, however, your anonymity can only be protected to the extent allowed by Google forms which is not a secure survey platform. You should not write your name on the survey in order to remain anonymous, but your anonymity cannot be guaranteed due to the possibility of breach of security.

RESOURCES AND CONTACT INFORMATION

- If you should experience any negative outcomes from this research, please be aware that you may contact campus Psychological Services at 805.756.2511, for assistance.
- This research is being conducted by Zoë Wood, PhD. Professor; Bruce DeBruhl, PhD. Assistant Professor; and Kylan Stewart, Student, in the Department of Computer Science and Software Engineering at Cal Poly, San Luis Obispo. If you have questions regarding this study or would like to be informed of the results when the study is completed, please contact the researcher(s) at Dr. DeBruhl at bdebruhl@calpoly.edu, Dr. Wood at zjwood@calpoly.edu, or Ms. Stewart at knstewar@calpoly.edu.

- If you have concerns regarding the manner in which the study is conducted, you may contact Dr. Michael Black, Chair of the Cal Poly Institutional Review Board, at (805) 756-2894, mblack@calpoly.edu, or Ms. Trish Brock, Director of research Compliance, at (805) 756-1450 or pbrock@calpoly.edu.

AGREEMENT TO PARTICIPATE

If you agree to voluntarily participate in this research project as described, please indicate your agreement by completing the attached survey. Please retain a copy of this form for your reference, and thank you for your participation in this research.

CSSE Information

1. What is your major?

Mark only one oval.

- CS
- SE
- Other: _____

2. If you have a concentration, please add it here

3. How many years have you been attending Cal Poly?

Mark only one oval.

- 1
- 2
- 3
- 4
- 5
- 6+
- Other: _____

4. How many years have you been in a computing major at Cal Poly?

Mark only one oval.

- 1
 2
 3
 4
 5
 6+

5. I am a...

Check all that apply.

- Traditional 4-year student
 Transfer student
 Non-traditional student
 Grad Student

6. What motivated you to come to Cal Poly's Computer Science Department for your undergraduate degree?

Check all that apply.

- Cal Poly is a really good university in computer science.
 Cal Poly is an affordable school.
 It was the best school to which I was accepted.
 I had a family member/friend who encouraged me to attend.
 During a prospective student visit, I felt that I fit in with the other students.
 During a prospective student visit, I felt that I fit within the department and the university.
 During a prospective student visit, a faculty member expressed interest in my attending Cal Poly.
Other: _____

Courses

7. How often do you interact with your instructors outside of class?

Mark only one oval.

	1	2	3	4	5	
Never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Frequently

8. How important is it that your instructors are the same race or ethnicity as yourself?

Mark only one oval.

	1	2	3	
Not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very important

9. How important is it that your instructors are the same gender as yourself?

Mark only one oval.

	1	2	3	
Not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very important

10. Do you think that the Cal Poly CSSE Department values excellent teaching?

Mark only one oval.

- Yes
 Somewhat
 No

11. Please explain your answer to the previous question.

Department Resources

12. I have interacted with the department staff within this academic year?

Mark only one oval.

True

False

13. Think about your interactions with the staff in the Department Office. On what topics do you seek their help or advice?

Check all that apply.

- Degree requirements and assessing progress
- Getting into a closed course
- Planning a course schedule
- Understanding academic policies and procedures
- Getting academic support (eg tutoring)
- Anticipating teaching styles of various faculty
- Day-to-day struggles with college
- Transferring coursework from other institutions
- Understanding the various areas of computer science specialization
- Finding employment, volunteer, scholarship, or financial aid opportunities
- What to do when someone makes unwelcome comments, jokes, or gestures to you or about you
- Getting into graduate school
- Getting letters of recommendation
- Interpersonal issues you are experiencing within the department

Other: _____

14. The staff in the Department Office are invested in my success

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

15. What other kinds of help do you wish you could get from the department staff?
Feel free to reference the list in the previous question.

Mentoring

16. Do you have any mentors?

Mark only one oval.

- Yes *Skip to question 17*
 No *Skip to question 26*

Skip to question 27

Mentorship Questions

17. Who are the people you consider your mentors?

Check all that apply.

- Other students in organizations institutionalized at the departmental, college level, or university level on campus
 Other members of off-campus organizations in which I participate
 Other students elsewhere in the Cal Poly CSSE Department
 Other students outside of the Cal Poly CSSE Department
 My Faculty Advisor
 A faculty member in the Cal Poly CSSE Department
 A faculty member outside the Cal poly CSSE Department
 A staff member in the Cal Poly CSSE Department

Other: _____

18. If you have found mentors through any registered student organizations, off-campus organizations, or other informal groups, please list them here.

19. Consider the people you were thinking about for the previous questions. When you interact with them for mentor-like discussions, what topics do you discuss?

Check all that apply.

- Degree requirements and assessing progress
- Getting into a closed course
- Planning a course schedule
- Understanding academic policies and procedures
- Getting academic support (eg tutoring)
- Anticipating teaching styles of various faculty
- Day-to-day struggles with college
- Transferring coursework from other institutions
- Understanding the various areas of computer science specialization
- Finding employment, volunteer, scholarship, or financial aid opportunities
- What to do when someone makes unwelcome comments, jokes, or gestures to you or about you
- Getting into graduate school
- Getting letters of recommendation
- Interpersonal issues you are experiencing within the department

Other: _____

20. How important is mentoring to you, whether it is acting as a mentor or having a mentor?

Mark only one oval.

	1	2	3	
Not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very Important

21. How important is it that your mentor is the same gender as yourself?

Mark only one oval.

	1	2	3	
Not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very important

22. How important is it that your mentor is the same race or ethnicity as yourself?

Mark only one oval.

	1	2	3	
Not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very important

23. Have you been satisfied with the level of mentoring you've received from the Cal Poly CSSE Department?

Mark only one oval.

	1	2	3	4	5	
Very unsatisfied	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very Satisfied

24. Do you think that the Cal poly CSSE Department values mentoring?

Mark only one oval.

- Yes
- Somewhat
- No

25. Please explain your answer to the previous question.

Skip to question 27

Mentor: No Mentor

26. Why don't you have a mentor?

Check all that apply.

- I am not aware of any mentoring programs in the Cal Poly CSSE Department
- I am having trouble finding a mentor
- I do not have time for mentoring activities
- I am uncomfortable seeking out a mentor
- I do not want a mentor
- I do not need a mentor
- My Faculty Advisor provides all the mentoring I need

Other: _____

Skip to question 27

Success and Fit

27. What do you consider necessary to be a successful student at Cal Poly's CSSE Department?

28. Do you feel successful at Cal Poly?

Mark only one oval.

- Yes
- Somewhat
- No

29. Please explain your answer to the previous question.

30. Do you consider yourself a typical computer scientist?

Mark only one oval.

- Yes
- No

31. Please explain your answer to the previous question.

32. How does your role as a computer scientist affect your own gender identity?

Sense of Fit

33. I value engaging in extracurricular and social activities

Mark only one oval.

	1	2	3	4	5	
Much less than my peers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Much more than my peers

34. With the current California shelter-in-place order, please explain how you feel about your current level of engagement in extracurricular and social activities.

35. I relate well to my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

36. I am as academically successful as my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

37. I can be myself and still fit in in the department

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

38. I have overheard discriminatory (eg. sexist, racist, or homophobic) comments from my professors, instructors, or departmental staff

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

39. I have overheard sexist comments from other students

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

40. I have overheard racist comments from other students

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

41. I have overheard homophobic comments from other students

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

42. I have witnessed or experienced inappropriate behavior in the department

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

43. When working on group-based course projects or research projects, I am able to contribute to the team in ways that are important to me

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

44. I have had my contributions minimized because of my gender, gender identity, race, or sexual orientation.

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

45. I have friends in the department

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

46. I have been called on in a professional or classroom setting to offer perspective on behalf of my race, gender, or sexual orientation

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

Sense of Fit

47. I enjoy working as a computer scientist as much as my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

48. My life experiences prior to coming to the department are similar to my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

49. I have as many responsibilities outside of school as my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

50. My educational background prior to coming to the department is similar to my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

51. My resume or CV is just as impressive as those of my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

52. I am able to do work that matters to me in the department

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

53. I have a healthy balance between my academic and personal responsibilities

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

54. I am interrupted before I can contribute to discussions

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

55. I am given credit for my work

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

56. I can work collaboratively with others effectively and successfully

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

57. I am treated as an equal among my peers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

58. I am given less valuable aspects of team projects

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

59. What I am learning in the department helps me solve problems that are important to me

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

60. What I am learning in the department will help me get the career I want

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly agree

Future Plans

61. What kind of job would you like to get after graduating?

Check all that apply.

- Obtain a professional science/engineering-related job
- Obtain a professional job in industry, unrelated to science or engineering
- Apply to a graduate school in a science/engineering-related field
- Apply to graduate school in a field unrelated to science or engineering
- A professional job in industry
- A professional job at a start-up company
- A job at a non-profit institution
- A job at a government-affiliated institution
- An academic job at a community college
- An academic job at a four-year university
- An academic job at a research university
- A research position at a private institution
- Start my own company

Other: _____

62. What is your dream job?

Distance Learning

63. How has your sense of belonging and community within the CSSE Department changed with regards to distance learning?

Mark only one oval.

- Strengthened
- Weakened
- No Change

64. Has your experience in CSSE classes been better, worse, or neutral in a distance format?

Mark only one oval.

- Better
- Worse
- Neutral

65. How have you been staying in touch socially with your peers and friends in the CSSE Department?

Check all that apply.

	Video Chat	Audio Chat	Text Chat
Personal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Club	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

66. Does this make you more or less likely to take distance learning or online classes in the future?

Mark only one oval.

- More Likely
 Less Likely
 No change

67. Does this make you more or less likely to take flipped or partially flipped classes in the future?

Mark only one oval.

- More Likely
 Less Likely
 No change

68. Have you ever taken online classes before?

Mark only one oval.

- Yes
 No

69. Are you staying in SLO, at your family home, both, or neither?

Mark only one oval.

- SLO
 Family Home
 Both
 Neither

70. Has your self-concept as a computer scientist changed because of your current situation?

Mark only one oval.

Yes

No

71. Please explain your previous response.

72. Do you have any other thoughts or comments you'd like to share?

Gender

73. What is your gender

Check all that apply.

- Male
- Female
- Gender nonconforming
- Genderqueer
- Pangender
- Transgender
- Prefer not to say

Other: _____

74. I identify as:

Check all that apply.

- Asexual
- Bisexual
- Gay
- Heterosexual or straight
- Lesbian
- Man Loving Man
- Pansexual
- Queer
- Questioning
- Woman Loving Woman
- Prefer not to say

Other: _____

75. Do you identify as a person with a disability?

Mark only one oval.

- Yes
- No
- Prefer not to say

76. I first became interested in computer science through:

Check all that apply.

- A parent (man)
- A parent (woman)
- A parent (gender nonconforming, genderqueer, or pangender)
- A teacher (man)
- A teacher (woman)
- A teacher (gender nonconforming, genderqueer, or pangender)
- A friend (man)
- A friend (woman)
- A friend (gender nonconforming, genderqueer, or pangender)
- A partner, spouse, or significant other (man)
- A partner, spouse, or significant other (woman)
- A partner, spouse, or significant other (gender nonconforming, genderqueer, or pangender)
- My own discovery
- A class in elementary, middle, or high school

Other: _____

Citizenship & Ethnicity

77. Citizenship

Check all that apply.

- Native US Citizen
- Naturalized US Citizen
- Permanent Resident
- Temporary Resident
- Prefer not to say

Other: _____

78. Are you a citizen of more than one country?

Mark only one oval.

Yes

No

79. Do you identify with any of the following US-based Racial and Ethnic categories?

Check all that apply.

Asian or Asian American

Black or African American

Hispanic, Chicanx, or Latinx

Native Alaskan

Native American or American Indian

Native Hawaiian

Pacific Islander

White or Caucasian

Prefer not to say

Other: _____

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Appendix B

INTERVIEW INFORMED CONSENT FORMS

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT:

“CSSE Student Belonging Interviews”

INTRODUCTION

This form asks for your agreement to participate in a research project on understanding student sense of belonging in the Computer Science and Software Engineering Department. Your participation involves participating in a one on one interview with a student where you will be asked about your experiences in the department. It is expected that your participation will take approximately an hour. There are no risks anticipated with your participation. If you are interested in participating, please review the following information.

PURPOSE OF THE STUDY AND PROPOSED BENEFITS

- As computer science is a growing field with historic diversity issues, it is important to work towards helping students feel like they belong in the major. To work towards helping people feel more at home, we are interviewing computing majors at Cal Poly. The purpose of the research is to assess the current sense of belonging among computing majors at Cal Poly. We would like to analyze the interviews to improve pedagogical techniques.
- We hypothesize that students will feel a better sense of belonging after the improvement.

YOUR PARTICIPATION

- If you agree to participate, you will be asked to complete an interview with a student researcher.
- Your participation will take approximately an hour.

PROTECTIONS AND POTENTIAL RISKS

- Please be aware that you are not required to participate in this research, refusal to participate will not involve any penalty or loss of benefits to which you are otherwise entitled, and you may discontinue your participation at any time. You may omit responses to any questions you choose not to answer.
- The possible risks or discomforts associated with participation in this study may include loss of anonymity should the responses be disclosed with identities.
- Student confidentiality will be protected by allowing students to skip any questions that make them uncomfortable, allowing students to turn off their cameras to protect their identity. All findings will be reported with the name and other identifiable information redacted so that no student would be able to be uniquely identified in the reported results.

Appendix C

INTERVIEW SCRIPT

- What first got you interested in studying computing?
- What excites you most about computing?
- Can you tell me about your experience in the program so far / or what your experience has been like thus far?
- Have you made friends with students in the department? How?
- Do you feel like you have friends...
 - Inside of class?
 - Outside of class?
- How has it been different during the pandemic?
- Do you feel still connected to students in your major?
- How have your classes been going?
- Do you feel successful in your major?
- How has the shift to online learning impacted you?
- Do you feel like you are doing well in your courses?
- Do you feel like you are being prepared for the job market?
- Do you feel like you are as successful in your major classes as your peers?
Why/Why not? What makes you feel that they are more/less successful?

- What do you feel are your strengths? and weaknesses? as a computer scientist?
- Have you had an internship or job during your time at Cal Poly?
 - Tell me about it.
 - How did you get it?
 - What did you do?
 - What did you learn?
 - Were you good at it?
 - Did it make you want to do better / more passionate about your major?
- Do you feel like you are as successful in internships or jobs outside of class as your CSSE peers? Why/why not?
- Do you consider yourself to be a computer scientist? OR Do you consider yourself to be a software engineer?
- Tell me about what a typical computer scientist is to you.
- Do you consider yourself to be a typical computer scientist?
- Can you tell me about your favorite class in CSSE? What made it your favorite?
- Tell me about your least favorite course? Why didn't you enjoy it?
- Do you think the Cal Poly CSSE department values excellent teaching? Why/Why not?
- Do you feel like you belong in the field of computing? Please explain.
- Can you think of a time when you didn't feel like you "fit" in the major or "belonged" in a class?
- who/what has made you feel welcomed / supported ?

- What would improve your sense of belonging within the CSSE department?
- How can we best support you during online learning?