Mind the Gap: Exploring Differences in Student Perceptions of Belonging and Inclusion in Computer Science*

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Abstract

To aid in understanding the current climate of diversity and inclusion in the Computer Science Department at our university, we developed a survey to identify and evaluate factors related to these topics. The survey was administered before the third week of participating Spring 2024 courses, which ranged from introductory classes open to any student from any major, to advanced classes taken as part of the computer science major course sequence. Our findings show that students expressed feeling more confident in their potential for success in class versus as a future professional in the field. They reported more positive interactions with faculty than with peers. Students also indicated a desire for more structured opportunities to connect with peers, and commented positively on current departmental efforts to make our common areas more welcoming. The survey results provide a baseline that we can use in the future to evaluate the impact of curricular interventions on student perceptions of inclusion and belonging. We also plan to evaluate how enhanced support for student well-being in the department and within student groups impacts perceptions and retention of underrepresented groups.

1 Introduction and Related Work

The underrepresentation of female, Black, and other marginalized identities in the field of Computer Science (CS) is a well-known, longstanding problem [4, 7]. As an example, the latest data from the National Center for Education Statistics show that women represent only 23% of majors classified as "Computer and information sciences and support services" [12, 11]. Compounding these issues, computing graduates from underrepresented groups will enter a workforce with continuing diversity gaps. In their 2021 report, Pew Research found that while women hold 50% of STEM jobs, they represent only 25% of the computing workforce and are paid less than their male counterparts across all demographics. Black and Hispanic STEM workers also remain underrepresented in the field and earn the least of all racial and ethnic groups [4].

Undergraduate computer science education is a common trajectory for individuals who wish to become professionals in the field; however, the statistics above show that this remains a leaky pipeline for students from non-majority identity groups. This problem and potential solutions are under active examination in computer science and other STEM disciplines [10, 2, 8]. Belonging and inclusion are factors often examined with respect to retention. Research has shown that a sense of belonging in introductory computer science courses is correlated with continuation of studies in the field, particularly for "minoritized students" [10]. Specific pedagogical strategies like Culturally Responsive Teaching have been shown to result in positive learning outcomes and feelings of inclusion [1]. This pedagogy has also been studied as a tool for university STEM departments to transform their culture such that it is more supportive and inclusive of *any* interested student [6]. Peer relationships are also important. Lehman et al. examined factors related to the "persistence" of women and racially/ethnically minoritized groups in computing majors, as their retention rates are lower than those of majority groups. Based on their findings, they assert that "peer experiences" are strongly related to persistence, as when these experiences are "poor," students are more likely to leave the major [7], thus leading to lower overall retention rates within programs.

Extensive literature details various methods for surveying students to understand how their identity, other personal factors, and their current environment influence their sense of belonging and inclusion. Research and related survey instruments include those developed to understand first-year experiences and feelings of belonging [5, 9], measure how belonging is beneficial in online learning [3], and determine the validity of instruments measuring general classroom community [13]. Washington et al. developed and tested a survey instrument to measure the cultural competence of computing students, identifying this as a problem requiring longitudinal study across many institutions [15]. Preceding this work, Washington explains the importance of cultural

competence and diversity in computer science education [14], working to align goals with ABET requirements. This rich body of prior work provides the basis for our survey instrument, which is focused on the measurement of students' feelings of belonging and inclusion.

In the following sections, we describe the development and details of our survey, and present the results of administering it early in the Spring 2024 semester to students enrolled in courses across our department. We discuss key themes in survey responses and conclude with some ideas about how this instrument might be used in the future.

2 Methods

For this study, we compiled a survey instrument informed by related literature to gather information on student demographics, perceptions of inclusivity in the department and classes, and attitudes about the field of computing [5, 9, 3, 13, 15, 14]. We administered the survey at a mid-size liberal arts university in 18 sections of 10 courses across our computer science curriculum, including courses for non-majors. The survey was given in each class after the drop-add period was complete and before the third week of classes.

2.1 Survey Instrument

There are three sections to our survey instrument[1]:

- **Demographics:** The first 11 questions ask for demographic information including major, year, gender identity, race, and disability status.
- **Likert Scale Ratings:** The next 16 questions ask the respondent to what extent they agree with statements about either class climate (such as "Faculty demonstrate respect for individual difference"), personal assessment ("I feel comfortable interacting with computer science professionals"), or the field of computing ("I find the field of computer science interesting"). Respondents rated their agreement with statements as either "Strongly agree", "Somewhat agree", "Neither agree nor disagre", "Somewhat disagree", or "Strongly disagree".
- **Free-Response:** The final 6 questions ask what factors are important for inclusion and what things our department in particular is doing well or could be doing better.

[1]Full survey: `https://github.com/muniravb/CS_UndergradSurveyBelongingInclusion`.

2.2 Questions of Note

For the remainder of this paper, we will focus on insights derived from the following subset of questions:

Likert Scale Rating:

1. Faculty in Elon's Computer Science department demonstrate respect for individual differences.
2. I feel comfortable interacting with computer science majors.
3. I feel comfortable interacting with computer science professionals.
4. I have the potential to succeed in a computer science class.
5. I expect to make important contributions in my computer science class or classes.
6. I have what it takes to become a computer science professional.

Free-Response:

7. What, if anything, makes you feel included or excluded in your computer science or STEM courses?

3 Results and Discussion

Figure 1 details the aggregate responses for Questions 1-6. For simplicity, we have combined Strongly Agree and Somewhat Agree, and Somewhat Disagree and Strongly Disagree, to "Agree" and "Disagree" respectively. This figure shows that in general, a large majority of respondents feel that faculty in our department are respectful of differences, and that they have the potential to succeed in our classes. Fewer (but still a majority) feel comfortable interacting with the student majors within our department, or are confident they have the potential for success in the tech industry beyond college.

Table 1 details student characteristics and demographics in our responses ($n = 246$).[2] The majority of our respondents (67%) were computer science majors, and all four years of study are represented. The remainder of this section breaks down the responses to determine differences between identity groups.

3.1 Finding 1: Confidence of Future Success

As shown in Figure 1, students from all demographics combined felt more confident of their success in the computer science classroom than as a computer

[2]Note that while the demographic categories of "Diagnosed Disability" and "Cognitive Condition" are intended to allow students to make a distinction between cognitive and physical conditions, there may be some overlap in responses.

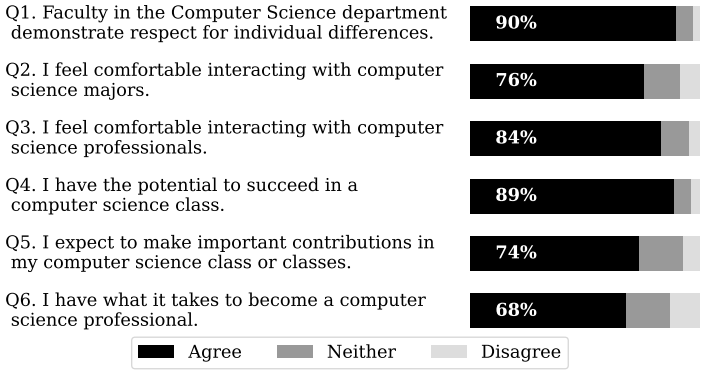

Figure 1: Student responses for selected Likert-scale questions.

Table 1: Summary of Survey Respondent Characteristics and Demographics

Factor		**Number**	**Percent**
Major	CS	149	67
	Non-CS	72	33
Year	First-Year	47	21
	Sophomore	62	28
	Junior	66	30
	Senior	46	21
Course Level	1XXX and 2XXX	115	52
	3XXX and 4XXX	106	48
Race	White/Caucasian	160	72
	African American/Black	17	8
	Hispanic/Latinx	15	7
	Asian	13	6
	Other, or prefer not to respond	16	7
Gender	Male	144	66
	Female	61	28
	Non-binary, transgender, or not listed	14	6
Diagnosed Disability	No	169	80
	Yes	42	20
Cognitive Condition	No	172	88
	Yes	23	12

science professional in the future. Overall, 89% agreed that they had potential to succeed in class, and 74% expected to make important contributions in class, but only 68% agreed that they had "what it takes" to become a computer science professional. Figure 2 shows that when these results are broken down by demographic, female-identifying students have the sharpest decline, with 90% confirming their potential for classroom success, and only 59% expressing potential for success as a professional. However, when we consider only those with a declared major in computer science, the gender difference is negligible. This means that females taking an introductory course in computer science are much less likely to believe they have the potential for success in the field at large.

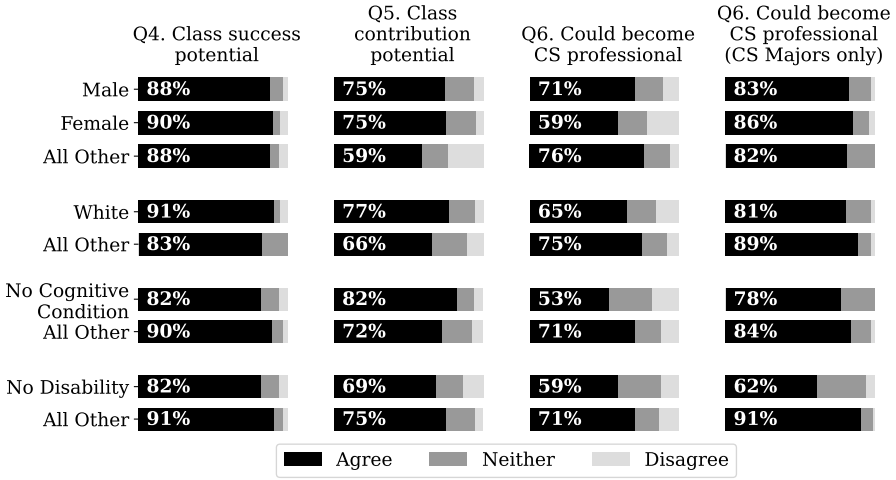

Figure 2: Student confidence of potential for success in a computer science course, expectation of making a significant impact in the course, and belief that they "have what it takes" to become a computer science professional.

Non-binary, transgender, and unlisted gendered students also showed a decline in their confidence between the classroom and the workplace, but the trend is only evident for non-majors. Compared to female students, these respondents showed a sharper decline in their confidence to make important contributions in class. While they agreed in their ability to generally do well in class (88%), many fewer agreed that they could make important contributions in the learning process (59%). This trend holds for non-white students as well. They are more confident in their potential to succeed in the class (83%) and in the workplace (75%) than in their classroom contributions (66%).

3.2 Finding 2: Peer Interactions

Students reported feeling that the computer science department faculty demonstrate respect for differences (90% agreement), and that they feel comfortable interacting with computer science professionals (84% agreement). However, they feel less comfortable interacting with computer science majors (76% agreement). As shown in Figure 3, underrepresented groups have a greater difference in their perception between faculty/professionals and their peers. For example, while 88% of individuals identifying as non-binary, transgender, or unlisted for gender feel comfortable interacting with CS professionals, only 46% feel comfortable interacting with their peers in class. Similarly, students identifying themselves as female, non-white, or disabled showed less comfort interacting with other computer science students than professionals.

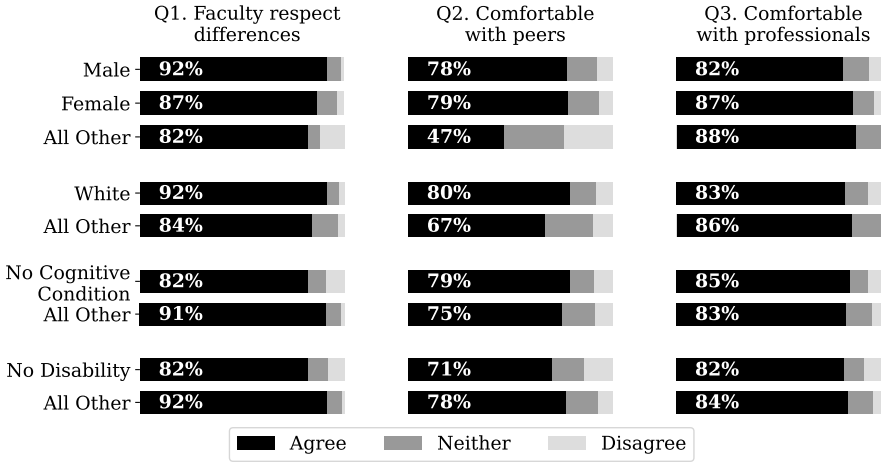

Figure 3: Student comfort with instructors, peers, and professionals.

Further evidence of this comes from the comments in the free-response questions. Question 7 asked students to describe what makes them feel included or excluded, and student responses often gave examples of either positive or negative experiences with faculty or peers in other classes. For example, one student's answer included "EVERYTIME I take a comp sci class there is some guy trying to hit on me." Another remarked that "Teachers not assuming students already know high-level stuff makes me feel included."

Figure 4 shows the results of tagging student free-response replies to this question, where they expressed either feelings of inclusion or exclusion with regards to peers, instructors, STEM or the general field of computer science,

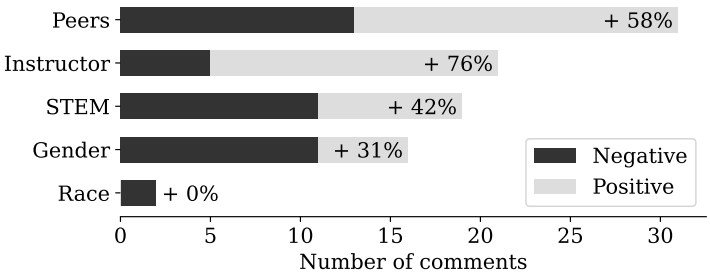

Figure 4: Number of tags across student responses to Question 7 relating to factors affecting feelings of inclusion. The number of negative comments is shown in dark gray, while positive responses are in light gray with the percentage of positive comments indicated.

gender, and race. Of responses about faculty, 76% were positive ("makes me feel included") while only 58% of responses about peers were positive. In fact, peers were paired more often with negative experiences than for any other topic, including race, gender, instructors, and STEM or field difficulty.

3.3 Finding 3: Craving Connection

Our survey included several free response questions asking about what things our department does that promote feelings of inclusion, and also for recommendations for changes or enhancements. We received positive feedback regarding our courses and environment, with one student noting that "[t]he Duke building is an awesome way to meet, hang out, and learn in. It's nice having a building with lots of fun activities like word problems, chess, sticker, places to draw, and more." Student responses also reflected the fact that they desire more structured opportunities to connect with their peers, both inside and outside of class. For example, students listed both clubs and events both as things that our department is doing well, and also as recommendations for doing more.

Perhaps most surprisingly, several students asked for more group work to be incorporated within courses. Traditionally, our students have not enjoyed working in groups, and when given the choice to pair-program, most decline. Other suggestions for improvement were to consistently have in-class student introductions and to facilitate creation of study groups. The latter is a type of peer connection historically initiated completely by students outside of class; however, these results indicate that those connections are no longer happening organically, and are still desired by many students.

4 Conclusions and Future Work

While the preceding discussion of findings centered on some of the surprising results from this study, we also noticed expected trends. Students have provided very positive, yet informal, feedback on our department's efforts to be more inclusive, and these were affirmed in our survey results. Students indicated that there are several things our department is doing well, which we can recommend to other departments trying to create a culture of inclusion:

- Train faculty on best practices for inclusive teaching, such as determining and using appropriate pronouns for students and using a diverse set of examples and images.
- Facilitate student organizations and events around computing.
- Create fun and inviting common areas. Our common area includes puzzles, games, food, stickers, and art, all of which facilitate community building and interaction.
- Experiment with alternative grading and classroom management strategies that give choices to the students.

We were encouraged by positive student feedback on these points; however, we are also interested in identifying areas needing improvement. When we began this work, our fundamental aim was to increase our students' feelings of inclusion in our computer science classes by creating curricular materials that are culturally relevant or showcase diversity in the field. The results of this study suggest more focus may be needed outside of our classrooms. Most students feel confident that they can do well in a classroom setting, but less so in a professional one. They have positive interactions with faculty, but often feel less accepted by their peers. The students' responses suggest that we need to spend more time thinking about what happens outside our classroom walls: in internship experiences, study groups, and social gatherings.

This finding presents a difficult and unfamiliar challenge for faculty, as interactions beyond our classrooms are further outside of our sphere of influence (and, often, comfort zone). Students are asking for more structured connections with their peers, such as with more group work assignments, while also acknowledging that these interactions are more likely to be negative. Students show the need to be able to see themselves as potential professionals, although encouraging internship or other "real world" experiences may backfire, since students may be faced with existing inequities in the industry. Further, we observed what appears to be diminished confidence and agency in establishing and strengthening peer relationships. Many students requested faculty facilitation of connecting with peers, which students previously were able to create for themselves. This does not appear to be specific to the computer science

department or people of underrepresented groups. Rather, it seems to reflect a general decline in students' interpersonal skills.

Combined, these factors show that a larger undertaking is needed beyond improved curricular approaches and materials. We need to contemplate how to teach our students the non-computing skills they need to be successful in their computing careers: to treat each other with respect, to be resilient in handling disrespectful interactions, and to confidently create relationships with one another. Attraction and retention of a diverse undergraduate computer science student population is one key to repairing the leaky pipeline to our profession. We plan to build on our successes, while simultaneously focusing on areas of weakness, in order to make our departmental climate one in which students from any background or identity can find success and belonging.

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