CS1 Students' Perspectives on the Computer Science Gender Gap: Achieving Equity Requires Awareness

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***Abstract*—There are numerous initiatives to improve diversity within the computer science field. However, women still disproportionately drop CS majors and earn less than one quarter of CS bachelor's degrees in the United States. The extent to which CS students—especially male students—are aware of this gender gap is an open question. This paper reports on a study to investigate that question. We analyzed 325 CS1 students' survey responses and found significant differences between women's and men's awareness of the CS gender gap. Men were significantly less aware of the gender gap than women, and men had significantly milder beliefs about whether women experienced adversity in CS and whether there should be targeted efforts to support women. Twenty students (10 women and 10 men) participated in follow-up interviews after the survey, where they discussed their experiences and perceptions of the computer science gender gap. Even among students who were aware of the gender gap, many had a superficial understanding of its cause, believing it to be due to women having less natural interest in CS. We argue that these findings are a call-to-action: university CS curricula need to include diversity, equity, and inclusion (DEI) training so that students have a more complete understanding of this complex issue, and so that these misconceptions do not continue to be perpetuated into the workplace.**

***Index Terms*—gender, women, introductory computer science, CS1**

I. Introduction

Enrollments in computer science programs are on the rise [1], [2], driven in part by a global demand for more computing professionals. Although the popularity of computing-related majors has increased, the diversity among graduates and working professionals in industry has remained largely stagnant in many western countries, such as the United States. For example, there is a large gender gap in the tech field; according to the U.S. Department of Labor, in 2018, only 25% of people in computing occupations were women [3]. This gap is also present earlier in the pipeline; in 2019, women comprised just 21% of the CS bachelor's degree graduates at doctoral-granting institutions in the U.S. and Canada [2]. Previous research on the gender gap has identified important factors in women's CS experiences, such as sense of belonging [4], and has recommended recruitment and retention initiatives for supporting women in computing majors [5].

Although there have been many initiatives to support women in CS and many studies that have helped researchers understand women's experiences, there has not been research on students' understanding of the gender gap issue itself. This study contributes to the discussion about the gender gap in CS by revealing the awareness and perspectives of CS1 students on the gender gap. We focused this investigation on CS1 students because previous research suggests that CS1 plays an important role in a woman's decision to remain in—or abandon—a CS major [6]. The awareness of a woman's classmates on the gender gap may play a substantial role in her experience in both CS1 and later in her career.

This paper addresses the following **research questions**:

- **RQ1:** To what extent are CS1 students aware of the gender gap in CS?
- **RQ2:** What are their perspectives on interventions to support gender diversity in CS?
- **RQ3:** How are women's and men's awareness and perspectives on the gender gap different?

We analyzed survey responses to questions about the gender gap and women's experiences in CS contexts. We also conducted follow-up interviews to gather open-ended responses to these questions on the gender gap. We categorized the interview participants' responses and summarized the different perspectives among this CS1 student population, using quotes from their interviews to ground the reasoning behind the perspectives. The results indicate that many of the CS1 students were unaware of the gender gap and had a shallow understanding of the gender disparities in computer science. The implications of this work point to a need for diversity, equity, and inclusion (DEI) training within CS curricula.

II. Related Work

Like other STEM fields, computer science has issues with underrepresentation of women and people of color [2]. The percentage of CS bachelor's degrees earned by women has decreased between 1990 and 2013 [7], and many studies

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have therefore focused on why this gender gap exists and understanding women's experiences in CS. A study of CS1 enrollments found that women were less likely to report their major as computer science than men; additionally, women that *had* declared CS majors were more likely to report a double major compared to men who had declared CS majors [8]. Several studies have also found that women had less confidence in their computing skills than men [9], despite performing just as well in their coursework as men [10]. Even women instructors in CS encounter disadvantages, as they tend to receive more negative student evaluations than men and may need to alter their behavior in order to reduce the impact of these negative evaluations [11].

Gender disparities in computer science have been identified in populations as young as fifth grade students [12] and among established female computer science academics [13]. Tsan et al. [12] investigated gender differences in fifth grade students' dyadic block-based coding sessions, comparing the quality of the students' code solutions by gender composition of the dyads. They found that the all-female dyads performed poorly compared to the other dyads that included at least one male student, indicating that the gender gap may be present as early as fifth grade. Falkner et al. [13] interviewed female academics and postgraduate students in computer science to identify their gendered perceptions on their development as computer scientists. Many participants mentioned that their families supported them or encouraged them to become a computer scientist because it is a 'good job' with long-term economic stability. Some participants, however, were discouraged by their family or society because other careers, like teaching or medicine, are deemed more suitable for women, and additional pressures are placed on women to focus on building a family. Among these women, many struggled with their identity as computer scientists, noting their incompatibilities with the stereotypical CS traits like desiring to work with people or being good communicators. Even among these established academics, many had imposter syndrome and felt that women had to be exceptional to succeed or feel a sense of belonging.

One of the factors that influence a student's decision to pursue a computer science major is a sense of belonging, or identifying as a "computer science person." In a survey of AP CSP high school students, female students were less likely to see themselves as computer scientists than male students across racial/ethnic groups [14]. A study of sense of belonging throughout an introductory programming course found that women's sense of belonging decreased significantly more than men's and that feeling supported by the department and peers can positively affect this sense of belonging [4].

Some studies have focused further on the intersection of gender and race/ethnicity, specifically the experiences of Black women in computer science. Interviews with Black women in CS showed that they experienced discrimination, racism, sexism, and feelings of isolation [15]. These women must sometimes decide on which identity they should project (i.e., being Black or being a woman) in order to manage the expectations of others and help them be successful in CS [16].

Two approaches stand out in prior research on reducing the gender gap in computer science: support from role models and outreach programs. Finding role models that have been successful in their studies or their careers can help improve women's sense of belonging [17]. In a study comparing different kinds of role models, women's confidence in their success was improved by role models that did not embody computer science stereotypes, regardless of the role model's gender [18]. Support from parental figures may also have a positive impact on a woman's decision to pursue and complete a computer science major [9], [13], [15].

Outreach programs have shown great success in recruiting diverse students into CS, especially women [5]. Examples of these programs include professional workshops and conferences specifically targeted toward women, such as the Grace Hopper Celebration [19]. Programs such as InWic help provide women with information on careers in CS, connections with potential role models, and networking opportunities to help build connections with the larger CS community [20]. Research-focused workshops have also been successful, with women who attended these workshops reporting improved self-efficacy and interest in CS as well as stronger identities as computer science researchers [21], [22]. With these many initiatives designed to decrease the gender gap, building students' understanding of the gap as it exists today is a highly under-studied area. This work, which identifies CS1 students' awareness and perspectives on the gender gap, is an important first step toward building that understanding.

III. Data Collection

This study was conducted at the University of Florida in Fall 2019. Participants were recruited from a CS1 course with a total enrollment of 601 students.

A. Survey Participants

Participants completed a survey and received extra credit in their CS1 course as compensation. There were 331 participants: 229 men, 96 women, and six individuals who indicated they preferred not to disclose their gender.[1] Of this sample, 42.2% reported their race/ethnicity as White/Caucasian, 24.1% Asian/Pacific Islander, 15.7% Multiracial, 13.8% Hispanic/Latino, 3.3% Black/African American, and 0.9% Other. Participants were between the ages of 18 and 43, with an average age of 19.

B. Survey Questions

Students completed the survey during the last few weeks of the semester. The survey was constructed to gather students' attitudes towards various aspects of computer science and their experience in the course. There were six total questions on the gender gap: Q1 was a yes-or-no question and only students who answered "yes" to this question were shown Q2 and Q3. All students were shown the remaining questions (Q4, Q5, and

[1]Participants had the opportunity to identify their gender as 'Female', 'Male', 'Prefer to self describe' with a text field to enter their gender identity, or 'Prefer not to say'.

Q6). While Q1 was a yes-or-no question, the remaining gender gap questions were Likert items, which were introduced with the statement 'Indicate to what extent you agree or disagree with each statement.' The Likert items were on a 5-point scale from *Strongly Disagree* (1) to *Strongly Agree* (5).

C. Interview Participants

All survey participants were asked whether they were interested in participating in a 30-minute follow-up interview, in which they would be compensated with a $20 Visa gift card. An email was sent out to all interested participants to sign up for an interview slot (first come, first served), with 10 slots reserved for women and 10 slots reserved for men. All interview participants were between the ages of 18 and 20. For additional demographic information on the interview participants, see Table III.

D. Interview Protocol

All interviews were conducted between the last day of CS1 lectures and the last day of final exam week. The interviews were conducted by following a semi-structured interview protocol, which was synonymous with the survey questions but more open-ended. The interview protocol consisted of questions about their chosen major, their confidence in completing a degree in CS, course satisfaction, classroom climate, and their views on the gender gap. The protocol outlined the main questions, but also gave the interviewers the flexibility to follow up with participants about their responses and ask additional questions that were not explicitly included in the protocol. We estimated the interviews to take about 30 minutes. All of the female participants were interviewed by a female researcher, while all the male participants were interviewed by a male researcher.

IV. Survey Results

There were significant gender differences in the survey responses to all six gender gap questions, indicating that women overall felt more strongly about gender gap issues and the need for women to be supported (see Table I). The distribution of survey responses for each question is also shown in Figure 1. In response to whether they had heard about the gender gap, 93% of the women answered "yes" compared to only 67% of the men. This comparison is statistically significant as determined through a likelihood ratio Chi-Square test, with a strong effect size of 0.563 according to Cohen's *d* [23]. All Likert-scale items were compared using Wilcoxon Rank Sum tests, and all effect sizes were calculated according to Lenhard and Lenhard [24]. Compared to men, women on average felt that it was more *important to address* and *make an effort to reduce* the gender gap (see Q2 and Q3 in Table I and Figure 1). Women also felt more strongly than men that the university should *do more to support women in CS* (see Q4). Similarly, compared to men, women felt to a lesser extent that *women in my computer science course are supported* (Q5). Lastly, women more strongly believed that *there are gender-specific problems that women in tech face* compared to men (Q6).

In addition to checking for gender differences among the gender gap questions, we also conducted a principal component analysis (PCA) to check whether (and to what extent) participants' responses to the questions were correlated (see Table II). Q2 and Q3 were strongly correlated with each other (0.9042), while Q2 and Q3 were moderately correlated with both Q4 and Q6 (> 0.6). Q5 was not correlated with any other questions.

V. Interview Analysis

As stated in section III-C, survey participants that indicated they were interested in participating in a follow-up interview were sent an email to sign up for an interview time slot. The women were sent a link to sign up for one of 10 interview times, and the men were sent a separate link to sign up for one of 10 interview times. The interview slots were filled on a first-come first-served basis until all 20 interviews were scheduled. On average, the interviews for women and men were 29 minutes long and 19 minutes long, respectively. The longest interview among the women was 51 minutes long, and the shortest interview was 14 minutes long. The longest interview of the men was 29 minutes long, and the shortest interview of the men was 16 minutes long. For the gender gap section of the interview, the women spent about nine minutes and the men spent about five minutes on average. All interviews were transcribed verbatim and their responses to the gender gap questions were categorized according to their overall perspective. Table III describes the interview participants' demographic breakdown and responses to the survey questions. Note that all interview participants answered

TABLE I
GENDER GAP SURVEY QUESTIONS. Q1 SHOWS THE COUNT OF YES AND NO RESPONSES. Q2-Q6 SHOWS THE AVERAGE LIKERT RESPONSE, WITH THE STANDARD DEVIATION IN PARENTHESIS. *ONLY THOSE STUDENTS WHO INDICATED THEY HEARD ABOUT THE GENDER GAP IN Q1 WERE SHOWN Q2 AND Q3, THEREFORE THEY HAVE AN *n* OF 89 WOMEN AND 153 MEN.

Question	**Women** (n=96)	**Men** (n=229)	p-**value**	**Effect size** (d)
Q1: Have you heard about the gender gap in computer science?	yes: 89, no: 7	yes: 153, no: 76	<0.0001	strong (0.563)
Q2: I feel that it is important to address the gender gap.*	4.38 (0.78)	3.63 (1.10)	<0.0001	strong (0.738)
Q3: I feel that there should be an effort to reduce the gender gap.*	4.38 (0.83)	3.58 (1.12)	<0.0001	strong (0.784)
Q4: I feel that the university should do more to support women who are interested in computer science.	4.18 (0.92)	3.57 (1.04)	<0.0001	strong (0.569)
Q5: I feel that women in my computer science course are supported.	3.75 (0.93)	4.00 (0.87)	0.0277	small (0.246)
Q6: I believe there are gender-specific problems that women in tech face.	4.26 (0.84)	3.45 (1.12)	<0.0001	strong (0.731)

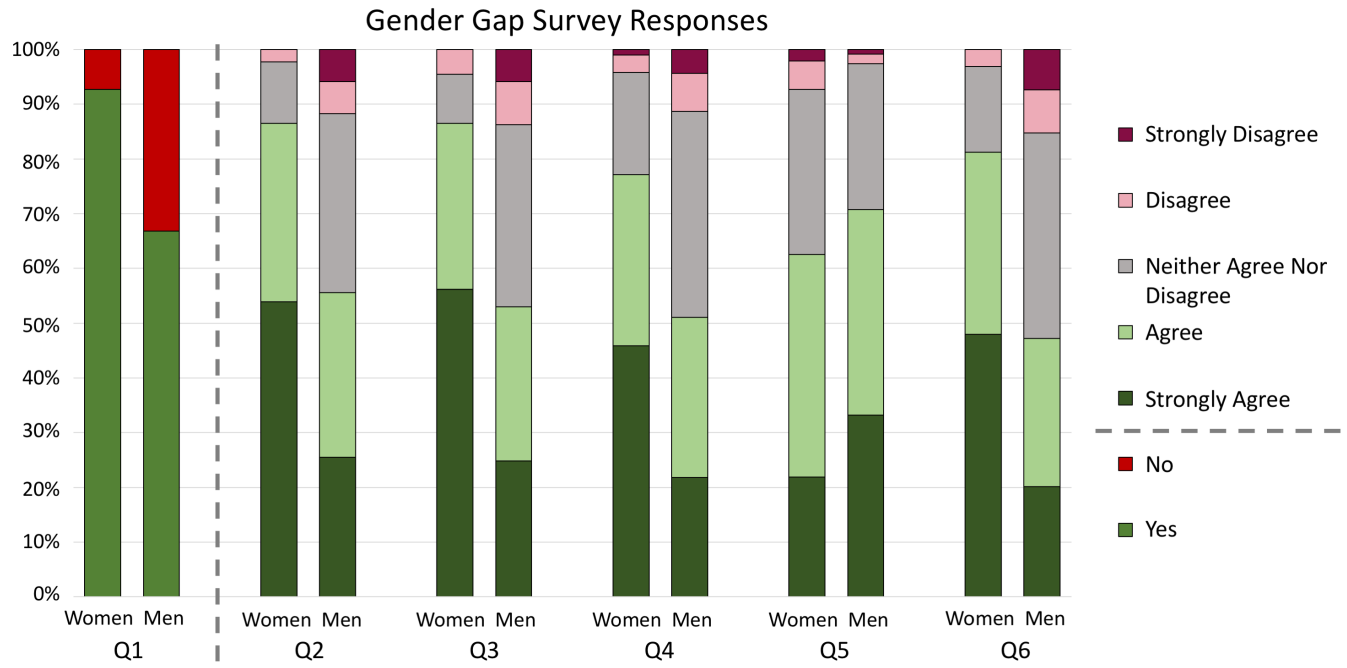

Fig. 1. Responses to the gender gap survey questions: Q1) Have you heard about the gender gap in computer science? Q2) I feel that it is important to address the gender gap. Q3) I feel that there should be an effort to reduce the gender gap. Q4) I feel that the university should do more to support women who are interested in computer science. Q5) I feel that women in my computer science course are supported. Q6) I believe there are gender-specific problems that women in tech face.

TABLE II
PCA CORRELATION MATRIX OF SURVEY RESPONSES. THE SHADED AREA INCLUDES ALL PARTICIPANTS WHO IDENTIFIED AS "MALE" OR "FEMALE" (n=325). THE UNSHADED AREA INCLUDES ONLY THOSE PARTICIPANTS WHO ANSWERED 'YES' TO Q1 (n=242).

	Q2	Q3	Q4	Q5	Q6
Q2	1.0000	0.9042	0.6450	-0.0465	0.6284
Q3	0.9042	1.0000	0.6962	0.0006	0.6410
Q4	0.6450	0.6962	1.0000	-0.0124	0.6394
Q5	-0.0465	0.0006	-0.0124	1.0000	0.0056
Q6	0.6284	0.6410	0.6394	0.0056	1.0000

'Yes' to Q1, indicating that they had heard about the gender gap in computer science.

To initialize the categorization process of the 20 interviews, we utilized the interviewee's survey responses to two questions. Specifically, we looked at their response to whether they felt there should be an *effort to reduce the gender gap* (Q3) and if they believed there were *gender-specific problems that women in tech face* (Q6). Interviews were categorized into buckets based on whether they (1) agreed or strongly agreed, (2) neither agreed nor disagreed, or (3) disagreed or strongly disagreed on Q3 and Q6, creating six possible buckets. These two questions were chosen among the six because they were more broadly focused on the gender gap issue as a whole, as opposed to the questions that were focused on women's experiences at the local university (Q4) and course level (Q5). We used responses to Q3 instead of Q2 because while they were strongly correlated (0.9042), Q3 garnered slightly more variation in responses. The interview responses covered five of the six potential buckets: the majority (11) were in Bucket 1 (agreeing or strongly agreeing to both questions); three were in Bucket 2 (agreeing or strongly agreeing to Q3 and responding neutrally to Q6); two were in Bucket 3 (responding neutrally to both questions); three were in Bucket 4 (disagreeing to Q3 and agreeing to Q6); and one was in Bucket 5 (disagreeing to both questions).

While the initial categorization into buckets helped us identify common patterns among the interview responses, they did not dictate the final categorization of perspectives. Two researchers collaboratively read the interview transcripts to summarize each interview participant's beliefs on the gender gap issue. After summarizing all interviewees' perspectives, interview participants were grouped according to their common perspectives. We prioritized what was said in their interview over their survey responses, if there were discrepancies. We identified these perspectives by noting the repeating themes present in the responses, and we created labels that best characterized the perspective of all participants in each category. Although we started with initial categories based on the survey responses, we used the interview data to construct high-level codes for each participant, following a grounded theory process [25].

VI. INTERVIEWEE PERSPECTIVES

While many of the survey respondents were not aware of the gender gap (83/325 answered "No" on Q1), all of the interview participants were aware to some extent of the

TABLE III
INTERVIEW PARTICIPANTS' DEMOGRAPHICS AND SURVEY RESPONSES

Pseudonym	Gender	Race	Q2	Q3	Q4	Q5	Q6
Claudia	Woman	Hispanic/Latino	Strongly Agree	Strongly Agree	Strongly Agree	Neither Agr Dsg	Agree
Emily	Woman	White/Caucasian	Strongly Agree	Strongly Agree	Strongly Agree	Neither Agr Dsg	Strongly Agree
Hanna	Woman	White/Caucasian	Agree	Neither Agr Dsg	Neither Agr Dsg	Strongly Agree	Neither Agr Dsg
Madison	Woman	White/Caucasian	Strongly Agree	Strongly Agree	Agree	Agree	Strongly Agree
Riya	Woman	Asian/Pacific Islander	Strongly Agree	Strongly Agree	Strongly Agree	Agree	Strongly Agree
Ashley	Woman	White/Caucasian	Strongly Agree	Agree	Strongly Agree	Agree	Strongly Agree
Vivian	Woman	Asian/Pacific Islander	Strongly Agree	Agree	Neither Agr Dsg	Neither Agr Dsg	Strongly Agree
Dolores	Woman	Asian/Pacific Islander, Hispanic/Latino	Strongly Agree	Agree	Agree	Agree	Agree
Fatima	Woman	White/Caucasian, Other: Middle Eastern	Neither Agr Dsg	Agree	Agree	Neither Agr Dsg	Agree
Cam	Woman	Asian/Pacific Islander	Neither Agr Dsg	Disagree	Agree	Disagree	Agree
Miguel	Man	White/Caucasian, Hispanic/Latino	Neither Agr Dsg	Disagree	Disagree	Agree	Agree
Pranav	Man	Asian/Pacific Islander	Agree	Agree	Agree	Neither Agr Dsg	Agree
Matthew	Man	White/Caucasian	Neither Agr Dsg	Neither Agr Dsg	Disagree	Agree	Neither Agr Dsg
Kai	Man	Asian/Pacific Islander	Strongly Agree	Strongly Agree	Strongly Agree	Neither Agr Dsg	Strongly Agree
Jacob	Man	White/Caucasian	Agree	Agree	Agree	Strongly Agree	Neither Agr Dsg
Joshua	Man	White/Caucasian	Agree	Agree	Neither Agr Dsg	Neither Agr Dsg	Neither Agr Dsg
Christopher	Man	White/Caucasian	Disagree	Disagree	Disagree	Agree	Disagree
Lucas	Man	White/Caucasian, Hispanic/Latino	Neither Agr Dsg	Disagree	Strongly Agree	Agree	Agree
Jorge	Man	Hispanic/Latino	Agree	Agree	Agree	Neither Agr Dsg	Agree
Luis	Man	White/Caucasian, Hispanic/Latino	Strongly Agree	Strongly Agree	Neither Agr Dsg	Strongly Agree	Neither Agr Dsg

gender gap, based on their 'Yes' response to Q1 on the survey. Due to the self-selection and first-come first-served nature of participating in the interviews, the interview participants were not necessarily a balanced representation of the remaining survey participants; however, they had a variety of different perspectives on the gender gap. The perspectives listed below include the main beliefs of the interview participants. The perspectives are not mutually exclusive and some participants held multiple perspectives. All quotations below are verbatim accounts from the participant's transcribed interview session, and each interview participant was given a pseudonym (see Table III). While all participants in this study were enrolled in a co-ed CS1 class, the university newly offered an all-women CS1 class during the same semester, and some participants discussed their thoughts about it during the interview.

A. Let's do everything we can to fix it!

Eight participants held this perspective, five women (Emily, Madison, Riya, Ashley, and Fatima) and three men (Pranav, Kai, and Jorge). They believed in proactive efforts to reduce the gender gap and suggested initiatives for collegiate women-women mentorship, K-12 exposure, and women-centered clubs/organizations. Ashley stated that "the big thing is encouragement in school, telling [women/girls] they can do well in these classes" and "experience with [CS] early on can really boost your confidence in thinking that it's not a scary subject." Kai recognized some misconceptions of CS might inhibit women and suggested a "social movement" to show that "it's not just sitting in front of the computer all day":

> "It's obviously a lot of collaboration, a lot of discussion. There's a lot more to it. So if people understood that, they would know that it's more of a social major, not just sit-in-your-room-and-type-all-day kind of major. So it would take perhaps a learning campaign [...] that shows this is what comp sci is, [...] this is why you should be interested, and maybe more people would be interested."

Some participants with this perspective noted that women might experience feelings of discomfort in CS because it is seemingly a toxic, male-dominated field. They mentioned that classrooms might be more welcoming if there was a more-balanced gender composition and if there were more female teaching staff. Pranav believed we could "make the classes a little more approachable" by "having an environment that's like not so toxic and dominated by men." Fatima felt that an all-women's CS1 class would be beneficial:

> "It's easier to approach them about problems and you're all kind of girls so you all have the same experience. Girls struggling together. Or hopefully not struggling if it's a good class. But if you're all going through the same class, you can kind of like bond over more versus when it's mixed kind of."

B. That's just how things are.

Seven participants held this perspective, three men (Matthew, Lucas, and Jorge) and four women (Claudia, Hanna, Vivian, and Cam). They believed that the gender inequities in computing are largely the result of natural interest. Many of them mentioned that women tend to pursue medical or soft science careers. Claudia explained that she knows "so many girls studying psychology and not many are engineers." She mentioned that "it would be nice to have more women" and

that "we could totally do it," clarifying that "it's not about that, it's just a lot of people aren't interested in it." Lastly, these participants mentioned a promotion of K-12 STEM exposure to get more women and girls interested in computer science.

Four of these participants specifically mentioned the pressures of studying STEM, societal influences, and/or early exposure as contributors to the gender gap. Jorge noted that "STEM is a high stress major" and that it might be a factor in the widening of the gender gap because "some people just aren't up to it." Matthew expressed that "guys play a lot of video games" so they might be "more interested in technology" because they "get that introduction to do it, which makes them curious to try it out." Vivian believed that the gap is "probably just like the effects of back then because I don't think they let women do that back then," and that now women are deterred when they see there are "not as many [women]." Lucas also felt that "it's just interest in terms of personal and also in general societal interest" and that "there's more pressure for men to go into something like STEM and less for women."

Cam and Hanna believed that we should not interfere with people's interest. Cam said she likes "to let things be as they be." Similarly, Hanna felt we should not "force people to do something that they don't want to do." When asked what we could do to get more women involved, she said we could "just make [them] more aware [of the field], but everyone is just going to choose whatever they want anyways."

C. It's just not realistic.

This perspective revolves around participants' thoughts about the all-women CS1 class. Seven women (Claudia, Emily, Madison, Riya, Vivian, Dolores, and Cam) and one man (Christopher) felt that offering an all-women's class is an unrealistic and possibly counterproductive effort. They noted that an all-women's CS1 class could be a comforting experience for women who feel intimidated, but that it is an unrealistic safety net. Emily said, "it gives the females a false sense of how few of us there are" and "that's not what it's going to be like in the real world." On the same note, Madison said it was "more beneficial for me to be in a normal classroom" because "in the real world, you're going to be collaborating with men at some point." Riya also had hesitations about the all-women class, saying "it's a comforting experience, but it's kind of fake." Cam was a bit more positive about the all-women class, saying it was a "pretty nice opportunity," but she felt that "it's more isolating" and she preferred "to learn in more open, diverse environments." Christopher thought that the class might help women "feel like they are in a community," but that it was "babying them through the major" and "when they get in the workforce it's going to be mostly men they are working with."

Some women also felt that the all-women's class would put them at a disadvantage because they would be limiting the diversity of shared knowledge/ideas by eliminating men and the 'male mindset' from the classroom environment. Dolores mentioned that "they're looking for females to get a different mindset" and that she enrolled in the co-ed CS1 class as opposed to the all-women class because "how [else would I] get the other mindset that men have and be exposed to it?" Similarly, Vivian also worried that being "in a primarily female class," she "would lose out on getting [...] a different mindset."

D. I'm just not too sure about it.

This perspective had a total of three participants, two men (Joshua and Luis) and one woman (Dolores). Their interview responses revealed they do not have strong opinions on the gender inequities in CS because they are not well-informed about it. These participants believed that women should simply pursue CS since it would be notably beneficial for the advancement of the field. Additionally, they mentioned that encouraging young girls to learn about gaming and other computing topics could plateau the steepening gender divide.

Dolores knew about the gender gap, but admitted that she was "not too sure on [...] what it has caused and if it's caused anything negative for women or for men," although she figured "it probably does for women." Joshua shared his understanding of the origin of the gender gap in CS:

> "Well during our childhood, the focus on computers and video games was more directed toward the boys, and so it appears it may have just played a bigger role in the lives of boys our age more often."

Luis stated:

> "Yeah, I'm not entirely sure. I know there is a section that is devoted just for women so I guess if that fares well, they could make the big push on that and make it more widely available instead of just one section."

E. Let's not get carried away.

Four men (Christopher, Miguel, Jacob, and Lucas) held this perspective. They agreed that there are gender imbalances and sexism within the field, but they expressed some objections to initiatives that might improve the issue. Students with this perspective think people should be free to pursue what they are passionate about, yet interventions specifically targeting women to increase women's enrollment is an area of contention for these men. However, they acknowledge that there can be an intimidation factor that makes women in CS feel uncomfortable, and they are aware that societal stigma and bias can be deterrents.

Although his survey response indicated he disagreed that there should be an effort to reduce the gender gap, during the interview when asked about whether it is important to address the gender gap, Christopher expressed

> "...obviously women shouldn't not be allowed to learn a field that they are interested in. They could help innovate."

Miguel described CS as "a bit of a boys' club" and believed that although "there's tons of capable women, [...] it is definitely not a field that is [...] open to them." When asked what we could do to address the gender gap he replied that it's "hard because any explicit efforts I think to do it might just do

the opposite." He also mentioned "quotas or anything are [not] the answer because [quotas] foster this idea that women can't do it without some sort of outside resource helping them."

When asked whether it was important to address the gender gap, Jacob and Lucas had similar hesitations. Jacob stated that "promoting more women-based stuff [...] gets into the territory of why are we just promoting women-based stuff, it should be everybody included." He proceeded saying, "you don't have men society of computer science, you just have computer science, and if you start making women— I always have this thing where it's just like we don't have a white society of computer engineering because we're the dominant ethnic group but I guess making people aware of the issue more could help." Later in Jacob's interview, he expressed his dismay with the all-women class offering saying "I don't necessarily think that's fair if you don't give men their own course." Lucas similarly stated:

> "I think it is important to make everyone feel comfortable and make them feel like if they want to pursue a career, they should. And that goes for all genders and all careers. I don't know how you would approach something like that without making other people feel like they're being discriminated against. It's like a balance thing."

VII. Discussion

The survey and interview responses on the gender gap revealed a major concern with CS1 students' understanding of the issue. While the majority of students were aware of the gender gap, a large portion of the men (1/3) indicated they had not heard about it. Of the 2/3 of men that had heard about the gender gap, only about half of them felt there should be efforts to reduce the gap. Similarly, while 80% of the women believed there were gender-specific problems that women in tech face, only about half of the men agreed. From the interviews, we uncovered different perspectives behind these beliefs, including misconceptions about the issue and hesitations toward taking action to close the gap.

Across each of the survey items about the gender gap, supporting women in CS, and recognizing women's adversity in CS (Q2-Q4, Q6), 10-15% of the men explicitly disagreed or strongly disagreed, indicating they do not believe that we should take actions to support women and work toward gender equity in CS. One man who participated in the interview, Christopher, reported on the survey that he disagreed with all the aforementioned survey items. During the interview his reservations about women in CS were clear through his comment that "obviously women shouldn't not be allowed to learn a field that they are interested in." While the meaning reduces to "women should be allowed...," the use of a double negative and therefore indirect way of saying it, suggests his discomfort on the matter. Similarly, Jacob—who actually agreed on the survey that we should take action (Q2-Q4)—expressed concerns about initiatives for women that were alarmingly reminiscent of an *All Lives Matter* (lack of) understanding, stating "why are we just promoting women-based stuff, it should be everybody included." Lucas also felt that initiatives for women could make "people feel like they're being discriminated against." Miguel, who disagreed with combating the gender gap issue (Q3, Q4), revealed his bias about women when he mentioned that his instructor had a "lack of ability in teaching" and that "a lot of [men's] suspicions towards women not just being as capable as men were probably confirmed by that." His suggestion was that instructors should "just do better."

These misconceptions on the issue were not exclusive to men; some women, for example, opted against an all-women CS1 offering because they did not want to miss the opportunity to gain the "male mindset." Vitores and Gil-Juárez [26] identify this phenomenon, in which boys' and men's relationship with technology is viewed as 'normal', while women and girls have been seen as having an abnormal relationship with technology and have been pushed to "conform to a 'male' standard." These biases have clearly impacted the women in this study. One way to combat this bias, that men and boys have the "normal" relationship with technology and that women and girls are just "not interested," is to make counterexamples visible. Hanna mentioned that "a lot of women innovators kind of get overseen," but that initiatives like Girls Who Code and the Grace Hopper Celebration "try to invigorate the female sphere within CS." Cam also mentioned the idea of "showcasing more females in computer science" and "just normalizing seeing female computer scientists." On the same note, Vitores and Gil-Juárez [26] argue that "recovering women's contributions to the field" as well as "making non-western realities visible" directly challenge the notion that women are inherently not interested in CS and instead allow us to consider the historical, social, and cultural influences on women's experiences in computing.

Some participants recognized that stereotypes about computer science may be preventing women and girls from pursuing it. Kai indicated that many people think of computer science as "sitting in front of the computer all day," but that "there's a lot more to it." He suggested having a campaign to show people the many apsects of computer science to mitigate this misconception and drive more interest from diverse groups. Similarly, in Falkner et al.'s study of academic women in CS, 80% of the participants mentioned the need to disseminate what computer science is to the broader public. They also felt the image of the CS discipline should be broadened to accurately portray the many opportunities within the field and to improve identity and sense of belonging among those in the field that do not fall under the stereotypical definition of computer science.

A few of the women talked about their adverse experiences as a woman in computing. Riya was particularly astute on the issue of women and girls' low self-efficacy in CS, mentioning several times that men are much more confident and sometimes "arrogant" about their CS skills. She also mentioned that she felt women had to work a lot harder for the same recognition and that men had a "minimum threshold" because the field is

male-dominated. Many of the academic women interviewed by Falkner et al. had similar sentiments that women had to have "flawless excellence" to succeed [13]. Riya suggested that "we should just humble the males." Later in the interview, Riya recounted her experience in high school competing in the engineering category of the science fair. As she progressed through the regional and state competitions, she noticed that the judges were "more weary" of her and other female competitors and she felt she had to "prove [her]self more." She saw the judges ask the boys "general questions," in contrast to how they were "scrutinizing [her] poster and asking very specific things." Hanna also noted being treated differently; when she told others she was a CS major, they replied "that's so weird" and "especially because you're a girl in computer science you're going to get a job way easier." While Hanna said that these types of comments did not offend her, they are prime examples of the types of microaggressions that many women face when pursuing a tech career. Another participant, Cam, described an "awful" working environment she endured in high school while she was the only girl working in an IT department. One coworker "would often make a lot of very sexist remarks and comments on [her] while [she] was working." She mentioned that she grew up as a minority in her community and "would often get made fun of," and using coping mechanisms from that experience, in response to the toxic workplace, she "kind of adapted to it" and "would laugh it off [...] but sometimes it would get very overwhelming."

To holistically combat the gender disparities in computer science, we need to not only have recruitment and retention initiatives, but also educational initiatives in which university students come to understand the issue more completely. These results point to both a lack of awareness and a shallow understanding of the gender gap issue for many students. To truly prepare our students for the field and potentially prepare future advocates for DEI in general, we need to include these topics in our computing curricula—the same way ethics is included in many computing curricula [27] and has recently been emphasized for data science [28] and AI education [29]. Curricula without topics of DEI will be doing a disservice to both students and society, as many students will continue into their career and perpetuate the same misconceptions and biases into the field.

A. Limitations

The results described here may be limited to this study's context. Specifically, the survey and interview data were collected from participants at a large public research university in the southeastern United States. Further research is needed to determine the generalizability of these findings to other contexts, such as smaller institutions or liberal arts schools. Additionally, this study only reports on the perspectives of students who identified as 'female' or 'male' because no other gender identity was specified. Future work should investigate people's experiences within CS that have other gender identities. Similarly, the racial demographics of this population was majority White/Caucasian and Asian/Pacific Islander; thus, this work is not representative of diverse racial/ethnic identities. The survey results may contain a selection bias since the students chose whether they wanted to participate and were not selected at random. The interview participants were selected using a first-come first-served method and therefore they are not necessarily representative of the rest of the student population in terms of demographics as well as perspectives. Future work should involve participants from a broader range of backgrounds, and intersectional identities should be considered in light of the findings.

B. Positionality

All the authors of this paper belong to underrepresented groups in computing and have strong interests in discovering pedagogical ways to combat the gender gap in computing. The two researchers directly involved in the qualitative and quantitative analyses were women: a White woman and a Black woman. We provide this personal information, acknowledging that our background and beliefs comprise the lens with which we view the data and may influence the results from the qualitative analysis.

VIII. Conclusion

This study examined the gender gap issue in a novel way, by asking university students *explicitly* about their perceptions of the gender gap. Over 300 CS1 students (96 women and 229 men) completed the survey, which included six questions related to the gender gap in CS. Additionally, 20 students (10 women and 10 men) participated in a follow-up interview. We found that compared to men, women were significantly more aware of the gender gap and felt significantly stronger that efforts should be made to reduce the gender gap. At the local level, the women felt less strongly that women in their CS course were supported, and they felt the university should do more to support them. From the 20 interviews, we identified a range of perspectives on the issue; some students felt we should do everything in our power to address the issue, while others felt the gender gap was just a natural occurrence that did not need any intervention. From the survey responses and interviews, it is clear that many students have a surface-level understanding of the gender gap issue. Some interview participants also expressed discomfort at the idea of opportunities specifically for women within CS because they did not think that those were *fair*; these students would benefit from understanding the idea of *equity* over *equality*. This paper is a call-to-action for educators and curriculum developers to include DEI training in undergraduate computer science programs.

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