Equitable Learning Environments in K-12 Computing: Teachers' Views on Barriers to Diversity

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The current efforts to expand computer science (CS) education in K-12 schools, such as the "CS for All" initiative, highlight the need for all students to get an opportunity to study computing. However, as recent research has shown, diversity in computing at the K-12 level remains problematic, and additional research is needed to look at how computer science learning environments can impact minority student interest and retention in CS. In this article, we report results from an in-depth qualitative study of high school computer science teachers' perspective on barriers to increasing diversity in their classes. Based on teachers' experiences, we provide practical recommendations on how to encourage equitable learning environments in K-12 computer science courses.

CCS Concepts: • **Social and professional topics** → **K-12 education**;

Additional Key Words and Phrases: Equity, teachers

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1 INTRODUCTION

In 2016, the White House publicly acknowledged the need to integrate computer science (CS) instruction across K-12 education in its CS for All initiative. The initiative vowed to expand computer science education in U.S. public schools to respond to a growing need for students to acquire the computing competencies needed to succeed in our digital economy. Given that computing is a crucial driver of innovation and productivity in today's technology-led society, it is imperative that all students have the opportunity to engage in computing ideas at the elementary and secondary level for them to consider pursuing an education in computing-related fields. However, there are wide disparities in minority students' access to computer science due to structural and social barriers, including technological skills and purpose of use, stereotypes, lack of role models, curriculum materials, or unconscious biases that discourage individuals from taking computer science classes

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[26, 55]. And while overall enrollment in CS courses has increased over time, the number of women and underrepresented minorities (i.e., African Americans, American Indians/Alaska Natives, and Latinos) who complete undergraduate degrees in CS is not growing [9, 48]. For instance, only 22% of students taking the AP CS exam in 2015 were female students, and 13% of students were minority students—mirroring the current makeup of technology firms in the United States [55]. In some states, like California, African-American students only comprised 1% of the 10,244 high school students taking the AP CS exam in 2016 [15, 32]. Consequently, scholars like Cooper, Grover, Guzdial, and Simon have stressed the need for computing education researchers to not only better understand the lack of diversity in computing but to also look into ways to render computing classes more equitable for a broad spectrum of students [16]. Equity, in that sense, is defined as the democratization of computer science for all students through the recognition of existing advantages and barriers [39]. But how can we ensure that all students have equal access to computer science courses, particularly in secondary education when students refine the direction of their career path? One step to address this issue is by looking at equity issues directly from teachers' perspectives. While the topic of equity in CS is often explored from a student-centered approach [25], the goal of the present article is to contribute to the existing literature aiming to understand computing culture from within the CS classroom [6, 36, 49]. If teachers are considered key agents of change through "engaging pedagogical techniques that make computer science exciting and meaningful for a diverse body of students" [38], then we need to better understand their perceptions of barriers to increasing diversity in their practices [56]. To do so, we interviewed current high school CS teachers in the United States and asked them to reflect on how issues of equity played out in their classrooms. Results from this study will help identify ways to support diversity and inclusion in computing through mechanisms to increase participation of underrepresented students in high school CS courses. The following sections provide an overview of the existing diversity issues that the field of computing has been facing.

1.1 Issues of Gender Diversity in CS

The lack of gender diversity has become problematic for the computing and technology workforce and can be traced back to the lack of female participation in computing in schools. Hayes [29] pointed out that "if this trend were to continue at the rate experienced from 1986 to 2006, there will be no women bachelor's degree graduates in computer science by 2032" (p. 27). Research has suggested that the culture of computing in general, how it is portrayed in popular culture, and even classroom climate can influence women's participation in CS classes [5, 58]. For example, Garvin-Doxas and Barker used ethnography to study behaviors in CS courses and found that men quickly adopt the dominant discourse and norms of the course, giving an appearance of belonging whereas women in the course generally did not [21]. The authors argued that without adopting the communication styles exhibited within the course, women remain outsiders and feel like they do not belong there. Additionally, stereotyping computer science as a male-dominated field where the work involves developing games could lead to women feeling that they do not belong in the computer science field. In another study, Master and colleagues found that putting stereotypical male and geeky objects such as video games posters in the classroom can decrease girls' interest in computer science as well [43]. Prior work on gender differences in introductory computer science courses (CS1) has also found that creating early negative experiences in a CS1 course can lead women to have lower self-efficacy [37]. These findings suggests that CS instructors should carefully create inclusive learning experiences for all students in CS. A recent report by Google examined computer science perceptions and learning opportunities among traditionally underrepresented groups, such as women, Black, and Hispanic students in the United States [25]. With regards to female students, the findings suggested that females are less likely

to be made aware of CS learning opportunities than their male peers, which influences their interest in computing [25]. Google conducted another study to "identify the critical exposures and experiences that influence a woman's decision to pursue a Computer Science degree" (p.3) [23]. The results suggested that four key controllable factors related to encouragement and exposure influenced whether young women decided to pursue CS. These four factors were: social encouragement (positive reinforcement from family and peers), self-perception (own proficiency in Mathematics and problem-solving significantly), academic exposure (ability to participate in CS courses and activities), and career perception (perception of CS and its associated careers) [23]. In another study, Friend also found that female students open to computing careers had higher confidence in their computing skills, higher interest in computing, and also placed higher value in computing [19]. In addition, media accounts of computing also often characterize it as a male-dominated field, and popular culture often supports the stereotype of males as computer geniuses and females as end-users or "computer-phobes" [12, 45]. Given the malleable nature of these factors, these findings taken together suggest that it is important to make girls aware of and provide experience with CS learning opportunities and support their interest in problem solving in a supportive environment [23]. Additionally, it is important that family, friends, and educators encourage girls regardless of their technical expertise and also help them visualize themselves in the field by showing female role models and telling stories about the positive impact of computing [23].

1.2 Issues of Ethnic Diversity in CS

Similarly, and despite representing 29% of the population, African-Americans and Hispanics only make up 9% of the science and engineering workforce [41]. This low representation has been traced back to a lack of institutional encouragement, educational opportunities, and preparation, in addition to beliefs in skills needed to succeed in CS classes [38]. For instance, the Google 2014 study found that Black (58%) and Hispanic (50%) students were less likely to use computers at home than their White (68%) peers, which negatively influences their confidence in learning CS [23]. Moreover, research has identified other social and structural circumstances like misconceptions, stereotypes, absence of role models, unwelcoming environments, inequitable school resources, shortage of access to basic CS courses, and few opportunities for out-of-school CS activities as negative elements of diversity in CS classes for minorities. Margolis and colleagues further examined some of the structural and psychological barriers that limit access, recruitment, and retention of Black and Latino/a students in CS [38, 40]. One of the findings was that teachers have deficit belief systems about their Black and Latino/a students, such as "they don't know how to problem solve," "they don't have that curiosity," and so on. These deficit-based views lead to minority students not having access to learning environments like CS and are disproportionately put in low-track remedial programs [38].

2 METHODOLOGIES

The current demand to increase diversity in computing [14], along with the high risk of attrition of underrepresented students [59] and the current urge for CS initiatives in K-12 education [55] makes it imperative to better understand how educators, who are predominantly (83%) White perceive the barriers that underrepresented students face in computer science classrooms [47]. This study addressed this need by examining computer science teachers' views on issues of equity, barriers to diversity, and opportunities to retain a variety of students in high school computer science classes. Specifically, this study addressed the following research questions:

(1) What diversity issues do high school computer science teachers identify in their classroom?

(2) What are high school computer science teachers' views about existing barriers to increasing diversity in computer science classes?
(3) How do high school computer science teachers address diversity issues in their own classrooms?

2.1 Participants

Twenty-three high school computer science teachers participated in the study, including 13 males and 10 females. Majority of participants were Caucasian (N = 21). One teacher identified as Hispanic, and another one as Asian. This sample is representative of high school teacher demographics in the United States [47], and accurately represents the range of teachers that students typically interact with in grades 9–12. Appendix A includes demographic information about the school where teachers taught including school type (public vs. private), percentage of minority students (Blacks, Hispanic/Latino, Native American), percentage of female students, and percentage of students on free and reduced lunch in the school.

2.2 Interview

We used a semi-structured interview protocol to elicit teachers' views on barriers to diversity in computing and to discuss their experiences related to diversity in their classroom. We pilot-tested the interview protocol with two computer science teachers to examine the clarity of questions and modified it based on their feedback. The data from the two pilot teachers was not included in the data analysis.

2.3 Procedure and Data Analysis

The interviews were conducted via video-conference, and teachers were asked questions about the challenges of teaching high school CS, among which were questions specific to issues of diversity in their classes. Based on principles of data saturation [42], we interviewed 23 high school CS teachers to address the research questions. The interviews were then transcribed and imported into the qualitative analysis software Dedoose for a detailed line-by-line analysis. The inductive analysis generated a list of initial codes, which were then merged and collapsed into related themes through an iterative process. The themes were then deductively grouped into categories representing teachers' views of diversity in computing classes, barriers to diversity, and factors fostering equity, to respond to the three research questions (see Appendix B). Inter-rater reliability was conducted using the themes that emerged from the raw data. One coder created a code-book in Excel with a list of themes and their corresponding definitions. One-third of the raw data was randomly selected and placed in a separate document, and two different coders performed the analysis using themes and descriptions from the code-book. Cohen's kappa was run to determine the agreement between the two raters and based on guidelines from Landis and Koch [33] suggested a substantial agreement, $k = 0.80$, $p < 0.05$. Finally, we performed negative and deviant case analysis—the discussion of elements in the data that do not support or are missing from the themes that were emerging from the data analysis—to help us revise and broaden the patterns found in our data. These cases or themes are identified during the data analysis phase to understand where and how data diverged from the rest and to protect the analysis against our own biases in what and how we interpreted and reported the data [7]. A negative or deviant case, typically, is one where a participant's experience differs from the main body of data. In other instances, negative or deviant cases are revealed as no participant makes mention of issues that are prevalent in the research literature. The negative or deviant cases in the present study reflect themes that emerged across participants rather than at the individual teacher level.

3 RESULTS

The rich qualitative interview data revealed a number of codes related to teachers' views of barriers to diversity in computing. The qualitative analysis generated an initial list of 11 codes (see Appendix B), which were collapsed into three overarching categories corresponding to the research questions: (i) issues of diversity in the computer science classroom, (ii) barriers to diversity in the computer science classroom, and (iii) factors fostering equity in the computer science classroom. In the next section, we discuss each of the overarching categories and corresponding themes.

3.1 Issues of Diversity in CS Classrooms

Overall, teachers expressed a number of realities related to equity in the computer science classroom, including several sub-themes related to gender, ethnicity, and economic status. Themes related to issues of equity in computer science classes are discussed below.

3.1.1 Gender. One of the main issues that emerged from the interviews was that teachers (N = 14) noticed issues of gender diversity in the computer science classroom. Specifically, teachers expressed that they had difficulties engaging female students in taking computer science classes due to generalizations associated with the field of computing. This is highlighted by one teacher's comment, who stated: *"I think CS has the double whammy of historical girls aren't engineers, girls aren't scientists' Plus, I think that the gaming industry has been dominated by White boys. I think that this dissuades girls from going in, you know, they're seen as, not the traditional, not girly, not cute, you can't be smarter than the boys. And this isn't just coming from school you know, social entertainment is there, I think they're getting double hit with generalizations."* Another critical issue for teachers was the isolation of female students taking computer science classes. Without a larger presence of female students as representative groups of students, teachers expressed female students' struggle to find peers in the computer science classroom: *"I think a lot of it is just socially and culturally, where the girls are at this particular age. One of the best things that you can do is, once you start to get a critical mass of girls, girls tend to travel in packs at this age. You know the joke where they all go to the bathroom together. That's true with them taking classes together too, so it's very, very, very hard to be the one girl in a class full of guys. I don't know, you're kind of invisible in that situation."* Another teacher commented about the similar invisibility of female students in his class. He stated, "I don't like the male/female ratio. I'm starting to get more diversity as far as Hispanic and African American kids though, so that's a plus. I just need to work on the female ratio." While this comment addressed gender issues, it also highlighted another diversity issue in computer science classroom: ethnicity.

3.1.2 Ethnicity. In addition to gender, another major concern for teachers (N = 13) was ethnic diversity in the computer science classroom. For instance, one teacher shared, "I do struggle to get female students and Hispanics into my classes." Similarly, another teacher highlighted the demographics in his classroom, stating: "We do have some Indian, some Asian, and some African American population, but not a lot. I have always had some Asian and some Indian population in my classes. I've had maybe one or two African Americans in my class. But still mainly, predominantly White Caucasian." Another issue in ethnic diversity that teachers brought up was the disparity between diversity in their computer science classroom in contrast to the general demographic of their school. This sentiment was underlined by one teacher who said that, "Our class is heavily White and Asian dominated. We have a stronger Hispanic demographic in our school that is not being represented in our CS courses." Another teacher talked about these issues in her class. She stated, *"I get a fair number of Hispanics, Mexicans for the most part here, I do get. But they have very good command of our language to be in my class. I've never had any who don't have*

a good command of English. I do not get African Americans, very few." While ethnicity was listed as a feature of the lack of diversity observed in some computer science classrooms, teachers also commented on socioeconomic status as a related factor.

3.1.3 Socioeconomic Background. While majority of the teachers reported issues of gender and ethnic diversity in their computer science classroom, some (N = 5) also addressed socioeconomic background as a contributing factor to such lack of diversity. In some cases, teachers related ethnicity directly with socioeconomic status, like this teacher, who explained, *"When I first started, there was no African American or minorities, not like we wanted to, and I foresee that a lot of these kids they come from socioeconomic that the AP class. They would not, they just wouldn't take them [the courses]."* It was also mentioned that a lower socioeconomic status was one of the compounding factors making it difficult for students to both integrate and succeed in computer science classes. For example, one teacher stated that students from lower socioeconomic statuses struggled more with technical knowledge, which made it difficult for them to thrive in the class: *"My poorer kids don't have a lot of touch time [experience with computers]. They may function off a cell phone, but they don't tend to have even computers at home. I got a boy last year who, I mean literally the first two weeks of the school year we're just getting him to be able to double and right click on things."* Another teacher communicated that in some cases, socioeconomic status was reflected in parents' knowledge about computer science options in the school, and that this had direct repercussions on enrollments. This teacher stated that administrators and other computer science teachers in the school wondered about demographics in computer science classes and their lack of diversity. She explained, *"We were finding that what was happening at middle school parents' night was that fatal demographic of White boy parents were showing up, and that was excluding a lot of people who were working two jobs or had socioeconomic situations that prevented them from getting the word."* Teachers in our study also talked about general misconceptions about computer science that students from a lower socioeconomic background might hold, which often times reduced diversity and created a socioeconomic gap in student representation in computer science classrooms. Speaking about his class, one of the teachers stated, "Our lower socioeconomic class students don't generally take it, because they're not sure what programming is and they feel like it's for the elite." Together, gender, ethnicity, and socioeconomic status form a triad of elements that represent current diversity issues in computer science classrooms. Teachers uncovered what they viewed as barriers to diversity for these groups.

3.2 Barriers to Diversity in CS Classrooms

While the issues of diversity above were related to realities observed by teachers in their classrooms, these educators also identified two main barriers to increasing diversity in their classrooms: self-identity and isolation. These points are discussed here in relation to gender, ethnicity, and socioeconomic status alike.

3.2.1 Self-Identity. The barriers to diversity in computer science classrooms in relation to female students, minority students, and students from lower socioeconomic status could be due to their lack of self-identity in computing activities. Teachers in our study (N = 11) expressed that the lack of identification with computing roles was a challenge; specifically, they observed several issues coming into play for underrepresented groups when feeling like they could contribute to the computing field. This issue is summarized by this teacher's statement: *"The different ethnicity or lower socioeconomic class aren't born with an iPad in their hands so they haven't really had the experience with it and they see. I think they're afraid to take it [the class]."* Some teachers (N = 6) highlighted how self-identity was a particularly difficult barrier to overcome for female students. One teacher said, *"Girls at this level, they don't self-identify as being good problem solvers. And you'll*

hear them say 'Oh, I got lucky' or 'I had a really good teacher' or 'You're a really good teacher, that's why I'm doing well.' And it's like well, 'No I'm not that good, you're really good at what you're doing." Similarly, another teacher expressed that female students are affected by gender stereotypes associated with computing. She shared how, *"They have seen or think that computing is, I don't know, they think it's for boys and it's male dominated by the gamers or they think it's the guys that sit and play on their computers all the time."* She believed that these stereotypes are perpetuated through middle and high school and as a result, female students do not identify with computer science; hence, they don't enroll in computer science classes. Likewise, another teacher expressed that, *"Women tend to think that especially at the high school level that it's for those geeky kinds of kids, it's not cool to do it, it's that kind of thing, 'Oh I don't wanna seem that smart [or] I wanna stand in the light crowd and all that stuff.'"* While teachers highlighted self-identity as a barrier to diversity in computer science classrooms, participants reflected an underlying issue related to isolation between groups in computer science classes.

3.2.2 Isolation. One of the main barriers to diversity that teachers observed in computer science classrooms was the problem of isolation, or the feeling of not belonging to a group. Teachers in our study (N = 8) talked about the isolation and the lack of belongingness that students from different gender, ethnicities, or socio-economic backgrounds experienced in their classes. One teacher explained how it could often be difficult for these groups to feel welcomed, because a more dominant group in the class had already dictated the classroom atmosphere. He shared, *"You come into a class of twenty kids and five of them are these boys who have been programming since they were ten. And they spout all the buzzwords and it intimidates everybody else in the class."* For him, this intimidation can create an unfavorable response from other students who might not be as familiar with computing, and this has consequences not only in the existing classroom, but for the larger population of students and the school community. Another teacher expressed that, *"Some of them [underrepresented students] won't even take our web design class, because they think it's too challenging or too riveting, I mean it's weird how mindsets block the medium makes it, the misconception that it's a bunch of nerdy White guys."* Similar stereotypes about what it takes to be successful in a computing class are also present for female students as highlighted by the following comment: *"For a lot of girls, they hear a guy talking about playing World of Warcraft online at night and that sounds, to a kid that doesn't know much about computer science, like that kid who's online all the time really knows what they're doing. When the fact is that has nothing to do with whether or not they can program at all."* Another teacher expressed a similar view: *"I think one of the major issues, too, in computer science and it's very hard to manage this as a classroom teacher, boys at this age have a lot of false bravado about everything. They're amazing drivers, they're amazing at sports, you know, anything a boy that's 15–16 year old does, they tend to brag a lot, they're very vocal, they're obnoxious, they're overbearing. And so they will talk about their skills with computers and I think girls really internalize that."* The issues raised above are not only examples of girls and minority students being intimidated but also reflect a broader computing culture where underrepresented students lack a sense of belongingness. As discussed previously, the stereotypical view of computer science as a male dominated discipline is a serious impediment to broadening participation. Teachers in our study discussed how they try to address these diversity issues and presented some ideas they implemented to increase diversity in their classes.

3.3 Fostering Diversity in CS Classrooms

Identifying the barriers to diversity in the computer science classroom is a first step, and there are a number of things that computer science teachers, along with their school community, have done to increase diversity. During the interviews, teachers in our study addressed methods they

Fig. 1. Image of a CS classroom.

have used to foster diversity and retain students in computer science classes, including creating welcoming environments for students to identify with the computer science community and recruiting to actively decrease their sense of isolation. This section presents efforts that teachers identified during the interviews.

3.3.1 Creating Inclusive Classrooms. A number of teachers (N = 13) brought up the need to create an inclusive environment in the computer science classroom to increase diversity. Participants stated that such welcoming environments provided students with opportunities to develop a sense of identity aligned with the computing community. One teacher related efforts in his school and expressed that: *"We're very sensitive to the demographic spread. We're trying to diversify as much as possible to combat those daunting national figures as far as student minorities and underrepresented populations. And we've made a lot of headway in the last few years, but there's still work to be done."* Another teacher reported examples of such changes that he had tried to bring about in his classroom to address gender disparity and make female students feel welcome. He explained how, *"I've done everything they've told me to do about making the classroom neutral, I don't pair them up with boys anymore, all the girls are in a group together. I've tried to do everything I can so it's not a typical boys class."* Modifying current classroom atmosphere is one way teachers tried to address diversity issues and make students able to self-identify with peers in the computing community. For example, one of the teachers used physical artifacts in the classroom that were not stereotypically male, and instead had posters that showcased women engaged in computing (see Figure 1).

Another way mentioned by participants was to show students examples of individuals from these underrepresented groups who are already part of the computing industry. During the

interviews, one of the teachers described a school-wide effort to increase diversity through self-identity: *"One way we have tried to forego that is we host two events every year called 'Speaker Day' where we bring in six folks from industry, government, and education to try to turn kids onto the different opportunities there are instead of education. And we've always gotten someone who is somehow or another affiliated with computers. And we always try to make sure we've got a least one of the six representatives, we're looking for a youthful speaker. We're looking for at least one or two Hispanic or African American speakers. And obviously female students, we're lucky if we can get two or three out of the six to be female. So that's another way we're trying to overcome those perceptions. And it works! You know, never in a million years did I think it would matter what gender, what skin color the person teaching you or talking to you is! But I have heard otherwise, so we're gonna keep knocking away at that too."* Participants' experiences with creating more equitable environments in computer science classes reflected the need to also foster students' sense of belongingness in the computer science community through active recruitment of students from underrepresented groups.

3.3.2 Increasing a Sense of Belonging. Teachers in our study (N = 10) talked about their experiences recruiting students from a variety of backgrounds. For example, one teacher's method was the following: *"I say spread the news. Talk to your friends, tell them to take ECS [Exploring Computer Science] So word of mouth and trying to put up posters that have girls. NCWIT (National Center for Women in Technology) is a good one. I get stuff from them that show hip, cool girls doing CS things, or minorities saying 'This is your future."'* Teachers borrowed different techniques to connect with different groups and invite them to take their courses. Another teacher did the following to make female students invited to take her class: *"I went out and recruited to get a lot more girls in the class, because computer science is typically underrepresented in terms of female students and also just to, say hey, this is a good class, this is useful. So I was able to really boost enrollment over the several years that I taught because of that. And I had a much better gender ratio than is typical of computer science."* Alternatively, one teacher decided to change her recruitment methods: *"I've switched a couple years ago and I've started recruiting through the English classes and I managed to build up my program, despite the fact that some of my intro classes have just been kind of a wasteland the last couple years. And I don't ever say the word 'math' in there."* During the interviews, participants acknowledged that increasing diversity in the computer science classroom was essential to developing students' self-identity and sense of belonging to the computer science community. They also identified barriers to such diversity, as well as existing strategies to remove them and foster heterogeneity in computer science classrooms. Next, we discuss these findings and draw implications from teachers' views about barriers to diversity in computing, before proposing a set of recommendations for K-12 teachers.

4 DISCUSSION

Teachers in our study called attention to a number of barriers to diversity that they observed in their high school computer science classes. They reported issues of diversity related to gender, ethnicity, and socioeconomic status. They also stated that self-identity and isolation were the main obstacles to encouraging equity in CS classes and discussed possible ways to address these hindrances through recruiting and retaining students in CS classes. Among the obstacles they identified, students' self-identity and connection with CS interests played a significant role in their decision to pursue CS. The results also revealed that while teachers saw gender and ethnicity as important aspects of diversity in CS, they also thought that, to some extent, socioeconomic background played a role in student access to CS activities. Overall, the study revealed that

teachers' views about diversity their classrooms were symptomatic of the larger U.S. culture around computing.

In fact, our analysis of the data uncovered some fallacies in teachers' views of diversity issues in the CS classroom that displayed underlying stereotypes as fixed characteristics of students' identities. Indeed, negative case analysis allowed us to revise and broaden the patterns found in our data analysis by looking at what was missing from teachers' discourses. In this case, we found that teachers tended to associate issues of diversity with students rather than with their own teaching practices. For instance, while teachers acknowledged the importance of stereotypes in CS, they did not question these stereotypes. Instead, some teachers attributed the lack of diversity in CS to student mindsets or misconceptions about CS. This implies that teachers saw students having erroneous views of CS, but they did not problematize where these erroneous views came from, how they were perpetuated, or whose interests they served. In addition, teachers did not cite actual examples of instances with students or from student testimonies. This revealed the possibility that teachers might not actually be talking to their marginalized students about their experiences and might project their own stereotypes onto what they believe are issues that these students face. As such, teachers' solutions to increase diversity and access to CS were focused on structural changes such as creating a more inclusive classroom environment rather than finding remedies to addressing these erroneous views of CS from a more critical standpoint. Thus, locating CS misconceptions as a student mindset issue instead of institutional or individual practices may itself be a barrier to increasing diversity in CS [46]. Our results also highlighted that sometimes teachers had views that focused on what minority students might lack—such as language skills or access to technology—instead of the richness of experiences and knowledge they bring to the class. For instance, one teacher implied that Latino/a students did not necessarily have good language skills to be in CS class. We see these deficit views not as actively perpetuated by teachers, but as a part of the larger structural barriers that remain for minority students to access K-12 computer science. For example, prior work has found that minority students, such as second language learners do face institutional mechanisms that limit their access to certain curricula [31]. Even the geographical location of the school and students' institutional identities association with that informs pedagogical practices and curricula those students have access to [8]. Buenda and Ares found that notions associated with a geographical area as being "culturally, cognitively, and morally deficit" leads to students in those schools having "low-status knowledge and academic programs." More importantly, the notion of intersectionality, that is, the ways the youth navigate multiple identities and position themselves across race, class, or gender [3] was absent from teachers' comments, and therefore in our own categorization of the results section as well. For instance, teachers in our study did not mention how students navigate the intersection of different elements of their identities or how they experienced them in the CS classroom (i.e., being a Black female in a CS class has different implications than being a White female or a Black male). Instead, Brah and Phoenix argued that, because the intersection of social class with gender and race is subjective, structural, and embedded in our everyday practices, looking at these intersections can create a more complex and dynamic understanding than focusing on one of these aspects alone [4]. As such, focusing on how race, gender, and class intersect can lead to different questions about self-representation and potential for different groups of students [54] while challenging the logic of how some of the observed disparities are produced and remedied [28]. Considering such intersectionality when addressing the composition and functioning of CS classrooms could help create more equitable CS environments by looking at how computing and computer science education can integrate students' complex identities instead of focusing on the perceived limitations of their singled-out identity—a concept called intracategorical complexity by McCall [44], which calls to go beyond narrow forms of identity to address forms of inequity within disciplinary systems [18].

Altogether, these results have important implications for creating equitable learning environments in secondary computer science classrooms; and can inform how to support computer science teachers to help them address the existing lack of diversity in their current classrooms. For example, tackling stereotypes about what it takes to be successful in computer science could increase underrepresented students' interest and volition to take CS courses. Cheryan, Plaut, Handron, and Hudson [10] found that when a CS classroom did not have stereotypical objects (e.g., video games, Star Trek poster, etc.) but instead displayed neutral objects (e.g., nature poster, phone book) girls' interest in CS increased to match their male peers' interest. Similarly, our findings also suggested that isolation was another barrier to diversity in their computing courses. To counter this lack of belonging and foster a sense of inclusion for all students in CS, multi-pronged strategies are needed, including creating engaging curricula, developing culturally inclusive pedagogies, including collaborative exercises, providing role models, clarifying pathways to CS careers, and connecting students with support networks [22]. Our findings therefore have important implications for computer science education policy and institutional as well as teacher practices around computing.

4.1 Implications for CS Education

This study revealed various facets of equity issues in CS classrooms through the lens of teachers. First and foremost, results emerging from this work highlighted the need to openly discuss issues of diversity and inclusion with K-12 teachers. The teachers pointed out mechanisms that are key to fostering diversity in their own classes. But more importantly, the results suggest that there needs to be considerable work done at the nexus of research, practice, and policy to expand CS education for all students. First, there is a greater need to understand the underlying rationale for existing inequalities in CS. Sax [53] suggested that "efforts to recruit more women into computer science ought to be sensitive to the fact that women and men differ slightly in their reasons for selecting (or not selecting) computer science as a field of study" (p. 6). Thus, computer science education researchers need to further examine how students' physical, environmental or socio-emotional factors impact their decisions to choose or not choose CS pathways in high school and beyond. Second, creating inclusive CS classroom starts with debunking myths and misconceptions about CS and computing culture. Teachers can focus on these points through inclusive pedagogy that will transfer beyond the classroom walls to attract new students [3]. Computer science education researchers need to work closely with teachers to develop culturally appropriate curriculum and pedagogical approaches. Third, expanding CS diversity needs to become a school-wide priority. Administrators and school counselors can work with CS teachers to better understand how to promote CS career paths to all students, regardless of their background. Fourth, a clear link between CS classes and the labor market needs to be established. Industry representatives can be involved in helping students see the benefits of CS for their professional future, and can also serve as role models for students. Fifth, educational policies need to further align with the need to diversify CS. Exposing students to CS or computational thinking activities in earlier grades could help remove stereotypes about who can be successful in computing fields. This will help teachers recruit a diverse pool of students and reduce attrition rates in later grades. Finally, students need to see the connection with CS in and out of the CS classroom. Local and national organizations focusing on expanding CS outside of school should collaborate with schools to increase access to their CS activities to all students. Programs promoting computer science should be made accessible in low-resource settings where computer access is limited, or in rural areas where tech companies are not present. While these organizations play an essential role in increasing CS awareness and participation, inclusion efforts need to principally happen in K-12 schools to provide access to all students. Altogether, encouraging dialogue, collaboration, and partnerships between these

different educational agents will ultimately benefit students' personal, academic, and professional development.

4.2 Implications for Teachers and Teacher Training

Teachers in particular play an essential role in advocating for diversity in computer science classrooms [24, 38]. As reflected by the current study, there are many ways that diversity issues can be brought up to encourage teachers to design equitable learning environments through specific activities or pedagogical practices. For instance, Denner, Martinez, Thiry, and Adams [17] described how an after-school computer science program run by peer high school students increased Latino elementary school students' access, value, and exposure to role models in CS. Such peer relationships help students rely on what Shah et al. [34] called material and non-material CS resources. The access to these resources (i.e., access to content, access to quality instruction, access to identities as computer scientists, access to peer relationships) can guide subsequent pedagogical practices that foster equitable learning environments, such as emphasizing multiple solutions, customizing teaching for individual students, exposing students to diverse sets of computer scientists, or strategically partnering students for pair programming [34]. These are important instructional choices, as pair programming, for instance, has been shown to sometimes reinforce inequitable relationships between students if groups are not made in a deliberate fashion [20, 35]. One important aspect of implementing these practices, however, is for teachers to be informed about diversity issues and the design of equitable learning environments, which can be embedded through teacher training, both during initial teacher education for pre-service teachers, and during professional development for in-service teachers. Our findings showed that CS teachers are not necessarily aware of best practices for improving the diversity climate of their classroom. Given that teachers are predominantly White, middle class, and monolingual means that they bring their own assumptions about diverse learners and fall back on how they themselves learned to meet needs of diverse learners [1] This means that teachers need support and resources to work with diverse students, including developing a "repertoire of strategies for teaching diverse youth and fostering equity in CS classrooms" [1]. Additionally, it is important to make teachers aware of the broader societal and structural issues of inequity as well as developing a reflective stance on how their own biases may influence their instruction [1]. For inservice teachers, professional development activities and workshops could concentrate on issues of diversity in their own learning environments [3]. An essential practice is to actively address issues of diversity through reflective practices on racism, prejudice, expectations, lack of understanding of differences (e.g., reflecting about one's own beliefs and assumptions) [13, 30, 52, 61]. Our findings highlighted the need to make teachers aware of practices that would increase diversity in their classroom environment. Within teacher education programs, diversity should be a focal point of the program's conceptual framework and implementation (e.g., going beyond mission statements to implementing a diversity focus in teacher preparation); emphasized through curriculum or courses (e.g., specific courses on equitable teaching practices); or infused in field experiences (e.g., teaching placements in demographically diverse schools) [57]. Nieto (2000) recommended three ways for schools of education to put equity front and center in their teacher education [50]. Specifically, she suggested to "(a) take a stand on social justice and diversity, (b) make social justice ubiquitous in teacher education, and (c) promote teaching as a life-long journey of transformation." (p. 182–183). Nieto further argued that to make diversity a prominent place in teacher education curricula, we should focus on social justice issues and require future teachers to critically examine why and how schools are unjust for some students. Altogether, addressing issues of diversity in high school computer science classrooms and exploring teachers' views about the barriers they perceive for underrepresented students will not only encourage more students to enroll in and remain in CS classes, but it will also shed light

on ways to attend to these issues in earlier grades. By modeling equitable learning environments in high school computing, middle and elementary schools could adapt their instruction to reflect inclusive teaching and encourage all students to pursue their education in computer science.

5 CONCLUSION

As the CS for All initiative, among others, builds on momentum in many states to provide resources and opportunities to create CS courses for students in K-12 education, understanding computer science teachers' views on barriers to diversity in computer science classroom is key in identifying how teachers and administrators can support students during throughout their K-12 experience and learn how to recruit and retain students in computer science. Increasing underrepresented groups' participation in computing is essential to improve technological innovations, enrich students' futures, reduce social inequalities, and ensure a competitive workforce [2]. Computer science is increasingly becoming an essential subject for students in the 21st Century [27, 60]; and in the coming years, significantly more computing-related jobs are expected to be available than U.S. graduates with computing degrees. The role of computer science education in K-12 education is, therefore, key in increasing diversity computing and providing opportunities for all students to take part in computing occupations [11, 51].

APPENDIX

APPENDIX A: TEACHER DEMOGRAPHIC INFORMATION

Teacher	Gender	CS teaching	School	Minority Stu	Female Stu	Free/Reduced
Adam	Male	12	Public	12.41	49.76	23.25
Benny	Male	10	Private	N/A	N/A	N/A
Martha	Female	15	Public	14.43	49.98	11.70
Cynthia	Female	13	Public	16.37	49.88	10.81
Chris	Male	6	Private	N/A	N/A	N/A
Anne	Female	30	Public	42.43	49.82	60.98
Jolina	Female	15	Public	20.01	47.67	0
Malika	Female	10	Public	24.50	50.37	12.08
Delmar	Male	8	Private	N/A	N/A	N/A
Tama	Female	11	Private	N/A	N/A	N/A
Tiera	Female	10	Public	13.81	49.28	15.93
Wanda	Female	9	Private	N/A	N/A	N/A
Eugene	Male	9	Public	24.23	48.00	23.32
Fermin	Male	3	Public	4.11	47.95	20.00
Gregorio	Male	7	Public	2.35	51.76	19.60
Hal	Male	1	Public	41.24	41.53	46.10
Patricia	Female	10	Public	33.81	49.48	17.55
Ismael	Male	1	Public	26.48	49.18	50.20
Jeremiah	Male	1	Public	73.72	44.45	52.84
Amanda	Female	14	Public	13.49	47.51	16.55
Kenneth	Male	1	Public	17.46	50.08	53.14
Lucien	Male	1	Public	11.23	50.28	22.84
Max	Male	1	Public	46.73	48.27	57.12
Irene	Female	2	Private	N/A	N/A	N/A

APPENDIX B

Research focus	Issues of diversity	Barriers to diversity	Factors fostering diversity
Themes	Gender, ethnicity and socioeconomic background	Self-identity and Isolation	Creating inclusive environments and Increasing sense of belongingness
Codes (n = number of instances)	Gender (n = 20) (Gender differences is an issue of diversity in CS) Ethnicity (n = 20) (Minority status is an issue of diversity in CS) SES (n = 8) (Socioeconomic background is an issue of diversity in CS)	CS as male-dominated (n = 52) (Female identify with CS differently than male students) Parents role (n = 2) (Having parents with no CS background can be a barrier to taking CS classes for low SES-students) Role models (n = 2) (Lack of role model for minority students can be a barrier to taking CS classes) Demographics (n = 24) (School demographics contribute to disparities in CS enrollment) Other (n = 2) (Other obstacles to CS)	Recruitment (n = 48) (Ideas related to teacher and school efforts to create inclusive CS environments and increase sense of belongingness) Attracting students (n = 3) (Ideas related to to attracting students to take CS classes) Retention (n = 3) (Ideas shared about retaining existing diverse students in CS)

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