Is Computer Science for Me?: Understanding the Barriers of Enrollment and Engagement in Computer Science Courses in High Schools

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Abstract

This qualitative research study is part of a larger NSF-funded project entitled "Cogenerative Development of Culturally Relevant Pedagogical Guidelines for Computer Science and Computational Thinking in High Schools." During Year 1 of the project, qualitative semi-structured interviews were conducted with 26 high school students to better understand the challenges and barriers to enrollment in and/or engagement/success in Computer Science courses in high school. A grounded theory approach was used, given the exploratory nature of the study. Students were selected from three regional high schools and had to meet at least one of the criteria associated with underrepresented students in Computer Science: identifying as female; low socioeconomic status; and/or racial/ethnic minority (Black/African American; Hispanic/Latinx/Chicanx; Native American/Alaskan, and Native Hawaiian/Pacific Islander, or multi-racial). Common themes that emerged included the following: Challenges (Financial Factors, Role of Gender (i.e. identifying as female), and Race/Ethnicity Issues); Positive Influences (Role of Teacher, Role of Family); Other Interesting Insights (Wanting to be challenged in Computer Science Classes, Problems with the Marketing of Computer Science as a discipline). Social Identity Theory is used to better understand the experiences of high school students, especially what practices or beliefs keep underrepresented students of Computer Science from enrolling in Computer Science courses in the first place and/or persisting in the Computer Science field. Limitations of the current study are discussed as well as directions for future research and implications for a more culturally relevant pedagogical approach to teaching Computer Science and Computational Thinking in high schools. This project is funded by the National Science Foundation CS for All: Research and RPPs program, Award No. 2122367

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Is Computer Science for Me?: Understanding the Barriers of Enrollment and Engagement in Computer Science Courses in High Schools

This qualitative research study is part of a larger NSF-funded project entitled "Cogenerative Development of Culturally Relevant Pedagogical Guidelines for Computer Science and Computational Thinking in High Schools." The purpose of this research study is to better understand the challenges and barriers to enrollment in and/or engagement/success of underrepresented high school students in Computer Science (CS). Underrepresented students in Computer Science include females, students of color, and students from low-socioeconomic (SES) households. Underrepresented students of color in Computer Science are defined as those students who identify as any of the following: Black/African American, Hispanic/Latinx/Chicanx, Native American/Alaskan, and Native Hawaiian/Pacific Islander, or multi-racial. In an effort to bring in students' voices, we went directly to the source—students—to ask them about their experiences with Computer Science courses in high school. By interviewing these students and gaining an understanding from their perspective, we are addressing a gap in the research—namely, the fact that the research community has not made it a practice of asking *students* about what has kept them from enrolling in or engaging in Computer Science courses.

Background and Previous Research

Computer Science, as an academic discipline and career field, lacks diversity in a number of demographics, including race/ethnicity and gender identity. It has been noted by a number of researchers that the field of Computer Science would benefit greatly from the introduction of diverse viewpoints (Goode, Chapman, & Margolis, 2012; Hazzan, 2006). There is also a great demand for individuals with computing degrees (USBLS, 2020), yet computing remains a

largely white and Asian, male field (Zahedi et al., 2020). According to the U.S. Bureau of Labor Statistics, computer and information technology occupations are projected to grow 11 percent from 2019-2029. This lack of diversity in Computer Science is the result of two factors, namely a lack of interest in Computer Science among high school students (recruitment) and lack of persistence in Computer Science (retention). That is, students are not taking Computer Science courses (especially more advanced ones) in high school and even after being introduced to Computer Science courses, they are not continuing to take additional courses in high school and/or choose the discipline of Computer Science as a major post-graduation.

Data from a 2016 NY Times article shows that Computer Science and engineering graduates with bachelor's or advanced degrees are only 8% Hispanic and 6% Black (Bui & Miller); according to data from the Center for Education Statistics Science, Integrated Post-Secondary Education Data System, the share of Computer Science degrees awarded to women was only 18.7% in 2016 (NCSES). Similarly, there is growing evidence that students from lower socioeconomic backgrounds are also underrepresented in Computer Science (Fancsali et al., 2018).

There is also a persistence issue for students who are pursuing Computer Science as a field of study. Villa (2018) found that even when students from underrepresented groups enroll in Computer Science, they often do not persist to graduation. Wanzer and colleagues (2020) explain that there are three factors that affect persistence in Computer Science, including personal attitudes, attitudes of others, and self-efficacy. Specifically, if students do not have positive attitudes toward and about Computer Science, they are less likely to persist. Additionally, the attitudes of significant others—family members, teachers, and peers—are important. If these significant others have positive attitudes toward Computer Science, there is a

positive effect on the students. Last, when students believe that have control over their performance in the courses/field, they are more likely to persist (Wanzer et al., 2020)

In response to the need for more culturally responsive pedagogy, researchers have investigated the effectiveness of professional development that addresses the issues of inequity in high school curricula. Che, Kraemer, and Sitaraman (2019) oversaw an NSF-funded project which included a week-long Computer Science professional development experience for high school teachers that sought to understand teachers' perspectives on inquiry and equity in the teaching of Computer Science courses. While the authors stress the importance of teaching through a culturally responsive approach, they found that the teachers' perspectives of inquiry and equity did not change after the week-long professional development; however, the teachers expressed greater confidence in using equitable practices in teaching (Che et al., 2019).

The goal of the current research study is to increase engagement and representation of students in Computer Science by including students and teachers in the process of creating a set of culturally relevant pedagogical guidelines that can be used to help all students realize that Computer Science may be a good fit for them, despite the current demographics in the field and stereotypes about Computer Scientists. The key research question guiding the current study is the following: What are key fundamental challenges faced by underrepresented students (female students, low SES students, students of color) in enrolling in and/or engaging with Computer Science courses in secondary schools?

While researchers have started to pay attention to increasing diversity in Computer Science (Stevenson, 2018; Fall et al., 2020; Rodriguez & Lehman, 2017) and to improving curriculum and content knowledge (Nager & Atkinson, 2016; Boda & McGee, 2021), the research community has not made a practice of asking students from groups underrepresented in

Computer Science, including female students, students from underrepresented racial/ethnic groups (DataUSA, 2020), and students from low socioeconomic backgrounds to help researchers understand the educational practices and pedagogies preventing them from enrolling in and/or engaging in Computer Science and pursuing computing professions. Students from low socioeconomic backgrounds were those individuals who lived in households that qualified for free/reduced school meals in their school district.

One of the major contributions to this gap in the research was integrating students and their voices in this research project. During the span of the three year grant period, high school students are involved across all three years. In the first year, a sample of high school students who met the criteria of under-represented groups in Computer Science (those identifying as female, racial/ethnic minorities (see above description), and those of low SES were interviewed to better understand why students from these underrepresented groups did not enroll in high school Computer Science courses in the first place and why they were not engaged in these Computer Science courses.

In year two of the grant, six of the 26 students who were interviewed in year one were selected to participate in the six workshops that were held to create a culturally relevant pedagogical Computer Science and Computational framework for teachers to incorporate in their high school classes. Year three includes a series of professional development workshops related to implementing the framework in their classes as well as focus group interviews with both the teachers and students from the classes where this framework has been implemented. Thus, students' voices are solicited during the entire three year process of creating this unique framework (note that this is not a replacement for existing curriculum; rather, it is a lens/framework to be scaffolded onto existing lessons plans to make lesson plans in both

Computer Science and non-Computer Science courses with Computational Thinking skills more culturally relevant.)

Methods

With the primary objective of addressing the research gap in the existing literature, namely that previous researchers have not asked students about the educational and pedagogical practices that have kept them from enrolling in and/or engaging in Computer Science courses in high school, we wanted to speak with students to gain their perspective on this important issue. Given that we were most interested in understanding their personal experiences and perspectives, qualitative methodology was the best approach to gain answers and a nuanced understanding of their perspectives regarding Computer Science courses in their high school experience.

The key research question guiding this research project is the following: What are key fundamental challenges faced by underrepresented students (female students, low SES students, students of color) in enrolling in and/or engaging with Computer Science courses in secondary schools? Semi-structured in-person interviews with a sample of students who were currently enrolled in high school were conducted. The questions from the interview protocol guide, discussed below, reflect this overarching research question.

Recruitment

Three high schools located near the researchers' university were selected based on their demographic profile, including number of students who identified as a racial/ethnic minority and number of students who qualified for free/reduced school meals. Thus, purposeful sampling was used in selecting the high schools to be partner schools for this research project. One school is located in a rural area, the second is in a suburban area, and the last is a school in an urban area.

Each school was asked to send a list of 40 students who met the criterion for underrepresented groups in Computer Science and their contact information (school email addresses), for a total of 120 students; specifically, 20 of those students would have taken at least one Computer Science course; the other 20 would not have taken a Computer Science course in high school yet. After agreeing to participate in the study and submitting their informed consent (by the parents) and their assent (since most of the participants were minors), these students were prompted to complete the Interview Screening Survey, provided through an online link in an email from the Principal Investigator. (Note: at the time of this paper submission, interviews had not yet been conducted with students from the urban school due to factors out of the researchers' control—to be discussed in the Discussion section).

Informed Consent

Informed consent was obtained from each of the participants prior to beginning the interview. Since the recruitment process was in two stages, informed consent from the participants' parents and participant assent was obtained prior to completing the Interview Screening Survey. Participants for the semi-structured interviews were selected from the participants who completed the Interview Screening Survey; thus, informed consent and participant assent was already documented and recorded.

Interviews

Twenty-six semi-structured in-person one-on-one interviews were conducted by one of the co-PIs and an undergraduate research assistant. Interviews were conducted at the high school that the students were attending. Interviews were conducted during regular school hours and in a private location—such as conference rooms/empty offices so that the conversations could not be

overheard. Interviews lasted between 20 and 30 minutes on average. The interviews were audio-recorded and then transcribed at a later date. An interview protocol guide with questions was used to guide the interviews and make sure that similar questions were asked of all participants.

Interview Protocol Guide/Sample Interview Questions

Demographic questions relating to the participants' gender identity, racial/ethnic identification, parents' highest level of education, and household members, age, and grade level were asked on the Interview Screening Survey; thus, these questions were not repeated during the interviews. General questions related to the participants' connection to technology and their favorite classes in high school made up the first part of the interview protocol guide.

More specific questions related to classes (including the Computer Science course(s)) they have taken and their experiences in those classes were in the second part of the interview protocol. Participants were asked about their participation and sense of belonging in their Computer Science Courses and any challenges that they experienced in their Computer Science courses. The last set of questions pertained to post-high school plans and role of their family in terms of school, post-graduation plans, and career options. Specifically, participants were asked if they talked to their parents about their courses and their family members' views toward Computer Science courses and jobs related to Computer Science and Information Technology.

Compensation

Each participant was provided a $20 gift card as a token of appreciation for their time for participating in this study. In addition, their name was entered into a raffle for an opportunity to win an additional prize.

Benefit/Risk Analysis

The methods and protocol were reviewed and approved by the researchers' university Institutional Review Board. Participants were informed in advance of the potential benefits and risks associated with their participation in this study. Confidentiality was assured and all personally identifying information has been removed. The potential benefit for participants is the opportunity to share their voices and experiences with Computer Science, which will ultimately inform the development of the pedagogical framework aimed to increase the recruitment and retention of underrepresented students in Computer Science. The research team firmly believes that this benefit outweighs potential risks.

Sample

(See Table 1 in the final draft of the paper)

The target sample size was a total of 50 students from across the three high schools/partner schools; however, that number was not met due to a couple important factors. The total sample size was N=26. First, there was a low response rate in terms of the number of students/parents who completed the Interview Screening Survey which was the preliminary survey to be completed before students would then be invited to participate in the one-on-one interviews. In addition, ideally we were hoping to have an equal number of students who had taken a Computer Science course already and who had not taken a Computer Science course at the time of the interview; this was not the case. Second, interviews have not been conducted

with students from the urban school at the time of this paper submission. However, 20 interviews with students from the urban school are scheduled to be completed in the spring. Consequently, the additional data will be included in the "final" draft of this paper.

Demographics of the sample (N=26) include the following: 18 out of 26 participants (69%) identified as female, while 5 out of 26 (19%) identified as male. Three out of 26 identified as non-binary (11.5%). In terms of identifying as an underrepresented racial/ethnic minority in Computer Science, there were 10 out of 26 participants; 16 out of 26 (62%) did not identify as a racial/ethnic minority in Computer Science. Only eight out of the 26 (31%) came from a low SES household; 18 out of the 26 (69%) did not come from a low SES household. Last, a majority of the participants, 15 out of 26 (58%), had either completed a Computer Science course or were enrolled in one at the time of the interview, while 11 out of 26 (42%) had not yet taken a Computer Science course.

Data Analysis

All of the interviews which were audio recorded were transcribed by an undergraduate research assistant during the spring and summer of 2021. Coding of the data was aided with the use of MAXQDA software. MAXQDA software is an efficient data-handling tool for textual data such as transcribed interviews. The software allowed us to explore documents such as transcriptions and memos, create categories and coding texts, manage, and organize the data in a way that saved a lot of time. The software was used to generate themes that illustrated patterns throughout the interview data.

A grounded theory approach was used to best understand the barriers and challenges that keep underrepresented students from enrolling in and persisting in Computer Science courses in

high school. This approach was deemed to be an appropriate choice, given the exploratory nature of this study, with a particular emphasis on the research question guiding this study:

What are key fundamental challenges faced by underrepresented students (female students, low SES students, students of color) in enrolling in and/or engaging with Computer Science courses in secondary schools? Thus, the resulting theory is "grounded" in actual data. In our case, we started with 10-15 interviews with students from each of the high schools and let the theory "emerge" from the data.

Research memos, including theoretical, case, and conceptual memos, were used during the data analysis stage in order to supplement the data analysis enabled by the use of the MAXQDA software. The theoretical memos were used as documentation of the researchers' thinking processes and helped the researchers theorize from the data. Case-based memos were also utilized to reflect on what was learned from the interview, including the interviewer's reactions to the interview. These memos were noted immediately at the conclusion of the interviews to enhance recall ability. Also known as inductive coding, thematic coding was used in this study. We initially identified about 30 codes and looked for overlap and redundant codes, reducing those codes down to 15. Then, the codes were collapsed even further, resulting in approximately 5-7 themes/codes. Last, conceptual memos, notes, and reflections about the initial codes that were being developed were used while working with the coding process associated with MAXQDA. Inter-rater reliability was established during this process since both the co-PI and the undergraduate research assistant were involved in the coding process.

Theoretical Framework/ Social identity Theory

Social Identity Theory aims to specify and predict the circumstances under which individuals think of themselves as individuals or as group members; this theory also considers the consequences of personal and social identities for individual perceptions and group behavior. Social Identity Theory helps us to understand (at least partially) why underrepresented students in Computer Science do not enroll in Computer Science courses (and as a result do not pursue Computer Science as a field of study/major in college) at the rate that others do. Specifically, females and racial/ethnic minorities (in Computer Science) do not "see" themselves as fitting the "mold" of a Computer Scientist; therefore, they do not feel it is a good fit for them, and pursue other interests.

McChesney et al. (2022) explain that most women's career preferences do not match the characteristics of the STEM environment with indications that the potentially misleading stereotypes of Computer Science could disadvantage women. McChesney et al. (2022) explain that women also tend to be better represented in STEM fields that emphasize social activity such as medical services or the social sciences, and less represented in STEM fields that emphasize working with inanimate tools and technologies such as computer science or engineering. This demonstrates that women could be deterred from CS careers due to stereotypes about the field, such that if a woman perceives Computer Science to be stereotypically masculine in nature, she could be dissuaded from entering the Computer Science field regardless of their career interests. Furthermore, McChesney et al. (2022) found that women who majored in Computer Science during college and considered dropping their major was because they experienced some form of gender bias in the classroom. These findings coincide with what we have from our own results from the student interviews, that minorities, namely women, in this case are turned away from the Computer Science fields due to the marketing of the discipline. Other research has focused

on exploring the issue of why minorities are underrepresented in the field of Computer Science. Lopez et al. (2022) explored this issue with Black and Hispanic female computing students. Cheryan et al. (2015) argue that cultural stereotypes keep girls from pursuing Computer Science and Engineering, and discuss ways to break this pattern.

Results

A number of challenges were noted by the participants in this study. These are perceived barriers to going into Computer Science in the first place and persisting in the field/discipline—through additional Computer Science courses and/or continuing to take Computer Science courses/major if going on to college. While participants did not directly state that they were personally experiences such challenges, during the course of the interview, it was evident that these factors were barriers that kept them from either taking Computer Science courses in the first place or pursuing an academic interest in the field of Computer Science. Noted challenges included financial factors, identifying as female, and the role of race/ethnicity.

Conversely, some of the participants talked more about the positive influences that have led to them either taking Computer Science courses in the first place or pursuing Computer Science as a field of study in the future. Positive influences noted by participants included inspirational teachers and the role of family members.

Additional themes that emerged from the data include participants talking at great length about wanting to be challenged more in Computer Science courses and offering strong critiques of the way that Computer Science is marketed as a discipline—which offers at least a partial explanation as to what keeps students from pursuing Computer Science courses in the first place but also what keeps them from persisting in the field of Computer Science. Each of these themes

is discussed in greater detail. Note that CS-Yes or CS-No represents whether or not the student has taken a Computer Science course. The preceding letter is used in place of the participant's name to protect confidentiality.

Challenges

Financial Factors

Computer Science can be an expensive discipline. Students are aware of this cost and some even discussed how they are impacted by the "costs" associated with Computer Science courses. One student (I, CS-Yes) expressed concern about not only the gender composition of upcoming Computer Science courses, but also the associated financial costs.

I'm sure next year is gonna be mostly guys for my Computer Science classes, and that's- I feel like that's how it is in a lot of like camps and things like that. Like I don't ever take Computer Science camps 'cause it's like 'Eugh, I'm gonna be the only girl. It's gonna be awkward.' That sort of thing.

[So you wouldn't do any camps because of that reason?]

Pretty much, and also money, but. . .

Another participant (A, CS-Yes) discussed the limitations of doing Computer Science-related school work at home, noting:

If I want to work on something at home, it's a little more difficult because, you know, the equipment is here at school, and I was thinking of maybe getting not a school issued computer to be able to download more like, applications, like there's real basic where it has python, C++, and all that in there, but I am not able to do that with a school issued computer.

[So, do you have plans to get your own computer?]

Yeah, I mean I was trying, but it's a lot of money.

Gender/Identifying as Female

Students who identified as female were well aware of being a minority in their Computer Science classes. While some noted that it did not really bother them; others spoke about not wanting to be seen as representative of their gender. Some talked about wanting to "show others that girls can be successful at Computer Science despite their underrepresentation in the discipline." A few powerful quotes are noted:

I'm the only girl in my Computer Science class. . . it doesn't really bother me all that much, but and I only knew a few kids in the class, but um I don't think there was anything really about the demographics that really um negatively impacted me. . . sometimes somebody might say something like, "Oh, you know how, what is it, what's it like to be like the only girl in the class?". . . it doesn't feel great to always be called out, like, I just want to be seen as a Computer Science student or an engineer I don't want to be seen as a female Computer Science student or a female engineer. (*Q, CS-Yes*)

When asked if they felt intimidated by the fact that they are one of the few girls in their Computer Science class, despite having a female teacher, one participant (A, CS-Yes) responded in the following way:

I do. I think it's both. I am basically ahead in that class, and I know some kids that aren't, and it makes me feel better, because I thought that if I was a girl, I couldn't do it, but here I am. . . I try to encourage others to do it because of the aspect of being the only girl with a lot of guys

everywhere, and it's tiring, and also people of color, and I don't know, I just want more involvement for everybody.

Race/Ethnicity

As noted in the above quote, students are aware that Computer Science is a field that is not very diverse in terms of race/ethnicity. However, for the majority of students who met the criterion for identifying as a racial/ethnic minority in Computer Science, they did not discuss their identity as a racial/ethnic minority as a barrier to their engagement in or interest in Computer Science courses/the Computer Science discipline. However, it is worth noting that some of the participants spoke candidly about not only the lack of racial/ethnic diversity in their schools, but also some of the racial issues that they were aware of in their schools. Some of these issues, as expressed by the participants are noted below:

It's [challenges at school] definitely harder than it looks. Like I'm not even like visibly um someone of color, but I still got a lot of comments, just like little things like, "Are you adopted?" Or "Oh, what country are you really from?" And I was like okay, just like it's the student influence. . . teachers just kind of turn a blind eye. I think it's not their fault; they don't really know what to do, but I feel like that should be something that should be changed. (S, CS-No)

Another student expressed a similar concern about race issues in their school:

I mean, I'm not going to lie, this school is mostly White. Since I've been here, there's maybe a handful of people of color here, but there's not really a lot. It's gotten better, but it's just. . . I remember in English class we were talking about controversial topics, and this one girl brought up how people would comment on her because she looks different, and I was like, I can relate because you know, you're just different, the handful of people here. (A, CS-Yes)

One student answered directly about how they felt being an underrepresented student in Computer Science, as a racial/ethnic minority. The student also spoke passionately about the importance of being presented with opportunities such as taking STEM courses and more advanced courses. The participant (Y, CS-Yes) noted the following:

I would never say I feel disincluded. Obviously the whole thing about it not being diverse, but, um, you know, just being a person of color in an area like this, you get used to it. . . I think a lot of people who are underrepresented--you know, some fault lies in how society is and the certain pressures and stereotypes that people put on certain endeavors but especially with the people in my school, the opportunity is sitting right there. So, if I can do it, then anyone can do it. [This] is really what I'm trying to say because when you're presented with opportunities but you don't have the willpower to take them then all you can blame is yourself so I really would say when it comes to groups like myself being underrepresented in STEM, especially in areas like this where it is available, you just have to open your mind and get out there and learn things. . . Go out and learn and if it's not for you, then it's not for you but you're never gonna know unless you try.

Positive Influences

The idea behind the inclusion of these themes is to learn about "what has worked"—that is, what are some factors that encouraged students to pursue Computer Science courses/career in the first place (recruitment) AND what has kept the students engaged in the Computer Science high school courses (persistence). Whether or not this is "enough" to encourage them to pursue Computer Science or IT as a major in college/post HS graduation is unknown, but it is a good indicator. Only future follow-studies would provide answers to those questions.

Teacher Influence

For the participants who had already taken at least one Computer Science course and especially those who had taken more than one Computer Science course, a number of them spoke highly of their teachers and noted the positive influence these teachers had on their view toward not only Computer Science courses, but the field of Computer Science generally. The following quotes demonstrate the positive role some of the teachers played:

[Teacher] was awesome. [They] definitely explained things in a very coherent way. You can understand it even if you knew nothing about computers before that, so it was definitely a really nice introduction and it definitely kept me interested and from there on out I've had [teacher] . . . the way that they teach, it's really, it's engaging and they make sure that you understand the concepts. (Y, CS-Yes)

[Teacher], [they are] really nice, and [they] really help. Like if you don't understand something, [they will] really like sit with you and help you work through it. (D, CS-Yes)

I really liked [teacher]; I think [teacher's] still my favorite teacher. They were really nice, and they were always there to help you out with your code. They explained it in a really nice way, in a way that you could fully understand it. (A, CS-Yes)

Super helpful. . . [they are] just very calm and. . . I very much enjoy [them] as a teacher. Um, [they don't] give you the answer, which I like. [They] sort of lead you in the direction of the answer, um, because I hate it when they're just like 'oh well it's this!' when I just have like a simple question. (I, CS-Yes)

Family Influence

It is argued that family is the primary agent of socialization and related to this, one's family can be quite influential when it comes to schooling/education/career paths. This was the case

with the students in this study. A number of questions on the Interview Protocol Guide asked about the role of family in selecting courses, career plans, etc. The students noted the important role that their family/parents played in terms of course selection and especially in thinking about careers in the Computer Science/IT field. It was also interesting to note that even when parents were employed in the field, if the students did not have an interest, the parents did not "push" them into that field/discipline. The following quotes are examples of the role that family members played in the students' selection of courses and future post high school graduation plans:

Yeah, I've talked with my parents a lot, especially my dad. They said engineering --that's like a good career to go into 'cause it's growing a lot, stuff like that--Computer Science. [So they're supportive of you going off to college and pursuing something with engineering or Computer Science?] Yeah. (C, CS-Yes)

Yeah, I do like Computer Science. Also as I said, it's a lot of guys and I just want to be like one of the girls in it to change it. Also my mom is really pushing me because none of my family members have really finished college. (A, CS-Yes)

In freshman year when I was going through my course selections my mom pointed out that I should just. . . try Programming I because it's a field that's, you know, actively needing more people, so she recommended me that, and I accepted it and I got into it. (T, CS-Yes)

While the aforementioned examples are from students who decided to try Computer Science (many of whom had a positive experience), still others were turned away from taking Computer Science courses in the first place. For some, family played a role in this decision, as in the following examples. When I asked V, CS-No (father was formerly employed as a

programmer) if they intended on taking a Computer Science course before they graduated, they explained why they did have an interest in Computer Science:

I think I was always just kind of turned away from it because I grew up seeing, what like I perceived as his career and it was always just like, "No, that seems boring. I don't want to do that," but I know that like realistically moving forward, now that I'm like growing up, I realized that going into STEM field especially in like 2022 I'm going to need some kind of uh foundation at least in Computer Science, so I'm definitely not opposed to it or not as opposed to it as I was based off of the perceptions that I had in the field growing up.

Other participants had a similar experience and explanation. Note that the role of the parents in the following cases was to *not* push their children into the field of Computer Science:

We have conversations at dinner; I talk with friends on the phone about it; we talk about our classes. They're really supportive. They make sure I'm doing something practical. I want to do something practical, but also something I enjoy. I'd say they push me too, to take the harder stuff and I'm glad I do. . . I mean he—my dad [father has master's degree in Data Analytics] has brought it up a couple times, but he kinda got that wasn't my thing. I wasn't really interested in that so he kind of stopped pushing me in that aspect (J, CS-No).

I know my dad he was very supportive of my brother taking IT considering like the growth in technology and how well you can do when you have a computer-related job. Uh, so was my mom, she was very supportive of him, um they never- I guess they never really viewed me as one to be involved in computers since I never really showed an interest. (K, CS-No)

Interesting Insights

Other themes that emerged from the data/interviews that were not necessarily anticipated, but are noteworthy, especially because these are related to both the recruitment and retention of students in Computer Science courses and in careers related to Computer Science and IT include wanting to be challenged more in Computer Science courses and issues with the marketing of Computer Science as a Discipline.

Wanting to be Challenged more in Computer Science

For students who had taken more than one Computer Science course, they expressed a desire for being challenged more in their courses. These students reported being bored in the class and wanted to not only learn about more applications of Computer Science, but also wanted more opportunities to explore career fields related to Computer Science and IT. Sample quotations include the following:

I wish there was more opportunities for us to explore possible career fields like cyber security, digital forensics, um game development. Not just, you know, learning how to code in a language, or you know, applying it to very basic things like calculating a grade. You know that's all great for learning how to do it.. . . More applications. . . I've found if I didn't have stuff to do in the class like I found like I just kind of would sometimes do like personal projects , you know? (Q, CS-Yes)

I kinda just don't like doing the same thing over and over again. I like more like exploring options. . . I just kinda, don't say it. (F,CS-Yes)

Marketing of Computer Science as a Discipline

A few sub-themes emerged related to this more general one. First, the stereotype of Computer Science and IT being a field for only white men and Asian Americans still exists and

students are aware of this stereotype. The idea is that this stereotype is still prevalent today. Even though there are many programs/clubs/organizations to combat this stereotype (think "Women in STEM"), the stereotype exists nonetheless and has a negative impact. Another theme has to do with the marketing/advertisement of these courses in schools. The idea here is that if schools made a concerted effort to promote Computer Science courses and an even more concerted effort to encourage underrepresented students in Computer Science to take these courses, then we would see more underrepresented students in Computer Science enroll in these courses and pursue careers in the Computer Science/IT field. Students seemed to have a keen awareness of the need for schools to work on not only recruiting more students in the field of Computer Science, but to make the field seem more appealing—in order to increase the enrollment in the often low-enrolled Computer Science high school classes. The following suggestions/critiques express their concerns:

I think just one thing is that the school might need to make Computer Science a bit more intriguing, because I don't think enough people do programming classes in school, but they don't really have like a motive to try it. So I think they need to somehow make it more interesting to the common eye so they can start doing more, so people start joining programming class to at least try it. (T, CS-Yes)

I think a big thing that would help connect with just like anybody even if it's not underrepresented people in the field is just like try to show that there are more inventive or creative ways to reach out with Computer Science. Like I'm sure that there are, I don't know what they are personally, but if they're out there, the way that those classes are taught or the outcomes--make them appeal more to people. . . if you could get more kids who generally steer

towards English or like animation or stuff like that and show them the opportunities and give them like actual class time to do that (V, CS-No)

I would just say like making it clear that everyone has- like has the opportunity to have a place in that field. 'Cause again, I really feel like I fell into like the concept of, 'You're not a math kid.' Like therefore you're not good at it, therefore you don't pursue it. . . so I think if it's marketed like "Computer Science is a class for everybody," 'cause I don't think-- like it seems to be like marketed to a very small group of students, like if this is your thing then you take a Computer Science class, if not you take the Microsoft word class and hope for the best. And so it's like, there are so many Computer Science classes that I know we offer and if it was marketed as like, "Hey, these classes are available to all of you guys. . . it's not like there's a requirement for certain courses on the entry level that you have to have taken in order to take these Computer Science classes." (N, CS-No)

Discussion

Limitations of the Current Study

While our research findings are an important contribution to the literature, the current study is not without limitations. Limitations of this study include small sample size, a sample that is lacking racial/ethnic diversity, and an unequal balance in terms of gender identity. These limitations The intended sample size was 50 high school students, with approximately 16-17 students/participants from each high school. However, given the low response rate with completion of the Interview Screening Survey, the yield of students interested in participating in the semi-structured interviews was lower than expected. In addition, we had no students from an urban school. While we established an agreement early on with an urban school, there were some

external factors out of our control, including a change in administration, that resulted in the school being unable to fulfill their original intended commitments. Fortunately, another urban school was selected and agreed to participate; however, given the school's late entry into this partnership, the interviews have not yet been conducted due to unanticipated delays. Nonetheless, we have plans to complete approximately twenty interviews with students from this school to a.) have a larger sample size and b.) have a more diverse sample. It is worth noting that the urban school is the school that yields the highest number of students who meet our study inclusion criteria, especially in terms of students coming from low SES households and those identifying as racial/ethnic minorities in Computer Science. These interviews are scheduled to take place in the spring and thus, the "final" draft of this paper will include these data.

Another limitation is that we relied on volunteer participants; thus, we cannot be sure that these students are representative of the general population of underrepresented students in Computer Science. Despite these aforementioned limitations, this research is a potentially fruitful starting point for future research on the barriers of underrepresented students in Computer Science.

Directions for Future Research

Drawing on the limitations of the current study, future research should strive to improve upon some of these limitations. Specifically, larger samples are needed in order to be able to make generalizations about the barriers that are keeping underrepresented students from enrolling in and engaging in Computer Science courses. Furthermore, future research studies should strive to have a sample that is more diverse. For example, in terms of the socioeconomic status of participants, there is a need for more data on students from low SES families/households. There is also a need for a more equal number of participants identifying as

males, as this sample had more female participants. Future studies should also seek to investigate the feasibility of the social identity framework in understanding the barriers that keep underrepresented students in Computer Science from enrolling in Computer Science courses and pursuing the field of Computer Science in the near future. It would also be interesting for future research to find out why a minority of underrepresented individuals in the field of Computer Science (those from low-SES families/households, those who identify as female, and racial/ethnic minorities in CS) persevere and do well. Last, future studies should further investigate the role of professional development aimed at addressing the inequities in Computer Science and the introduction of culturally relevant pedagogical frameworks that are used to address the recruitment and retention issues of underrepresented students in Computer Science.

Conclusions

As noted previously, this study is part of a larger NSF CS For All research project. As such, the focus in the current study was bringing in the students' voice to fill a gap in the research—namely, the fact that previous research on underrepresented students in Computer Science has not asked students about what has kept them from taking an interest in Computer Science courses and furthermore, thinking about a future career in Computer Science. This study contributes to the research in that we interviewed students to talk about their experience as an underrepresented students in Computer Science and asked about why they have or have not taken Computer Science course as well as their experiences in those courses. While the perceived challenges of the students were financial costs associated with Computer Science and the issues of females being outnumbered by males in their Computer Science courses, there were also positive factors that were perceived to be reasons why underrepresented students persisted in the Computer Science courses. These positive factors included having an influential Computer

Science teacher and influence from family members. The other themes that emerged—issues associated with the marketing of Computer Science and the quality of the Computer Science curriculum are also important and worthy of future research.

Social Identity Theory helps us to better understand why students do not take Computer Science classes in the first place and this relates to the marketing of the discipline. If existing stereotypes dominate our culture about what Computer Science is and what a Computer Scientist looks like, it makes sense that underrepresented individuals such as those identifying as female and underrepresented racial/ethnic groups in Computer Science do not choose these classes and ultimately CS or IT careers. Breaking these stereotypes through improved, more diverse marketing and changing the face of computer scientists, as well as improved curriculum are all steps to breaking down the perceived barriers that keep underrepresented students out of Computer Science.

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