Diversity Barriers in K–12 Computer Science Education: Structural and Social

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ABSTRACT

As computer science (CS) education expands at the K–12 level, we must be careful to ensure that CS neither exacerbates existing equity gaps in education nor hinders efforts to diversify the field of CS. In this paper, we discuss structural and social barriers that influence Blacks, Hispanics, and girls, based on surveys of 1,672 students, 1,677 parents, 1,008 teachers, 9,805 principals, and 2,307 superintendents in the United States. We find that despite higher interest in CS among Black and Hispanic students and parents, these students experience greater structural barriers in accessing computers and CS classes than White students. And while girls have the same access as boys, social barriers exist with girls reporting lower awareness of CS opportunities outside of classes, less encouragement from teachers and parents, and less exposure to CS role models in the media. It is critical for expanding CS opportunities to address the unique issues for each group.

CCS Concepts

Computer and Information Science Education – computer science education.

Keywords

Diversity; gender; girls; race; ethnicity; Black; African American; Latino/a; Hispanic; K–12; pre-university; students; parents; teachers; interest; access; exposure; perceptions; encouragement; pathways.

1. INTRODUCTION

The national CS for All initiative has created tremendous support for computer science (CS) education at the K–12 level. It is increasingly recognized that all students should have the opportunity to learn CS as it becomes more relevant in our technology-dependent and technology-enhanced society and world. For years, national, state, and local education initiatives have been emphasizing the importance of CS and begun widely implementing CS into every school and even every grade. With growing opportunities in K–12 CS education, we must understand its challenges to ensure these opportunities do not further gaps for underrepresented students nor hinder efforts to create a more diverse pipeline. However, since CS is not traditionally part of K–12 formal schooling, there are unanswered questions regarding how different populations would experience the expansion of

CS. Could these opportunities exacerbate rather than mitigate gaps in education? We sought to understand how students currently experience and view CS by demographic. Our paper focuses on race/ethnicity and gender, specifically Blacks, Hispanics, and girls and how the story unfolds for each in the current K–12 CS education landscape.

2. RELEVANCE

While Blacks and Hispanics make up 13.3% and 17.6% of the U.S. population [1], they are underrepresented in CS from high school to career. At the high school level, Advanced Placement (AP) Computer Science A participation is low overall, but drastically lower for Blacks and Hispanics. For instance, among the 49 states with at least one student who took the exam, nine had no Black students participating in 2015 [2]. Of all the AP Computer Science A test takers in the U.S. in 2015, only 3.9% were Black and 9.2% were Hispanic, with dramatically lower pass rates for both Black (36.8%) and Hispanic (39.3%) students when compared to the overall pass rate of 64.4% [2]. At the university level, only 11.4% of CS degrees were awarded to Blacks and 8.5% awarded to Hispanic students in 2012 [2]. And in industry, this lack of diversity is both reflected and exacerbated in top technology companies.

Additionally, gender gaps have been well documented, beginning as early as 5th grade for CS [4]. Girls made up only 21.9% of AP CS A test takers, with pass rates of 60.5% compared to the average 64.4% [2]. In universities, women comprise roughly 18% of CS degree earners, down from a peak of 37% in 1984 [5]. Similarly, the representation of women in industry is not near the 47.4% of women who make up the workforce [6].

The reasons behind disparities by race/ethnicity and by gender are complex. The 2015 National Assessment of Educational Progress data show that lower income students and Black students in 12th grade have less access to CS classes compared to their counterparts [7]. This structural barrier is one potential reason for the lower participation of Black students and, with the greatest portion of children under 18 living in poverty for the Black and Hispanic populations [8], is also a potential factor for Hispanic students. Technology access is also unequal, with poorer populations more likely to suffer from lower access [9]. And even with the recent pushes to incorporate technology into schools, many of these efforts are futile without proper training and use of the technologies [10].

While disparities by race/ethnicity are intertwined with income, gender gaps cannot be explained by the same factors. With statistically even distribution by gender across income and race/ethnicity, access may not explain the disparity in participation between boys and girls. Social barriers may be the stronger factors influencing girls. For instance, Cheryan et al. [11] found that a sense of belonging led to a greater likelihood to

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indicate interest in CS. The perceived stereotypes around CS include being male, nerdy, and lacking social skills, which contrasts with what girls may feel they identify with. However, if students were confronted with non-stereotypes about CS, they were more likely than students confronted with stereotypes to indicate an interest in majoring in CS. This social perception of who belongs in CS may also impact those who influence students, including adults and the media. Parental encouragement of science and mathematics in middle and/or high school increases the likelihood of a young adult pursuing [12] and persisting in STEM careers [13], yet parents are more likely to encourage boys than girls in STEM fields [14]. Teachers, as well as parents and peers, also play key roles as influencers [15]. Social perceptions, therefore, potentially influence girls' decisions early on, creating an early gender gap. Webb et al. found that middle school boys were more likely than girls to use computers and to have taken computer classes that promote using computers to solve problems [16].

Because the disparities between groups can be so complex, we conducted an extensive survey of the representative U.S. population. The purpose of this study was to better understand the existing context and barriers in order to inform efforts to broaden participation. Data analysis focused on Black and Hispanic students and girls to provide insights on current barriers to full inclusion in CS education efforts for these populations.

3. METHODS

3.1 Data Sources

This study details results from year two of a multiyear study, surveying 1,672 students, 1,677 parents, 1,008 teachers, 9,805 principals, and 2,307 superintendents in the U.S. These populations were selected to enable us to better understand the perspectives of students and those who influence their education.

Telephone surveys were conducted with students, parents, and teachers living in all 50 states and the District of Columbia using a combination of the Gallup Panel and the Gallup Daily tracking survey. The Gallup Panel is a probability-based panel of U.S. adults selected using random-digit-dial (RDD) and address-based sampling methods. The Gallup Panel is not an opt-in panel. The Gallup Daily tracking survey sample includes national adults with a quota of 50% cellphone and 50% landline respondents, with additional minimum quotas by time zone within region. Landline and cellphone numbers are selected using RDD methods. Landline respondents are chosen at random within each household based on which member had the most recent birthday. Eligible Gallup Daily tracking respondents who previously agreed to future contact were contacted to participate in this study. Student and parent samples included targeted, detailed data on the underrepresented (Blacks and Hispanics, including Spanish-speaking only). Students were from grades 7–12 (typically ages 12–18). Participating parents had one or more children in these grades. Teachers in the sample taught 1st–12th grade, with approximately 21% teaching or have taught CS.

Principal and superintendent samples were provided by established education sample providers. The sample sources are representative of all principals and superintendents currently in the U.S. The population for principals was sampled from a list of 99% of U.S. public schools and approximately 30% of U.S. private schools. The population for superintendents was selected from a panel including more than 20% of all U.S. K–12 superintendents.

Student and parent samples were weighted to correct for unequal selection probability and nonresponse. Student data were weighted to match national demographics of age, gender, race, ethnicity and region. Parent data were weighted to match national demographics of age, gender, education, race, ethnicity and region. Demographic weighting targets were based on the most recent Current Population Survey [17].

Teacher samples were weighted to correct for unequal selection probability and nonresponse. The data were weighted to match demographics of age, gender, education, race, ethnicity and region. Demographic weighting targets were based on the Gallup's tracking information.

Principal and superintendent samples were weighted to match national demographics of school ZIP code, school enrollment size, and census region. The margin of sampling error for each population is between ± 1.0 and ± 3.9 percentage points at the 95% confidence level [18].

The inclusion of K–12 students as well as influencers in their education (i.e., parents and educators at various levels) provides us with a wider lens to understand both the social and structural factors for students: stereotypes, self-perceptions, exposure, and encouragement. The oversampling of Black and Hispanic students and parents, along with representative samples of the U.S., allowed for comparisons among Black, Hispanic, and White populations. Other races or ethnicities were included in the representative sample, but their sample sizes were too small for comparisons. The representative samples also allowed us to analyze differences by gender and income for the students and parents.

3.2 Data Collection and Analysis

All five populations were surveyed on topics related to CS education. The surveys for students, parents, and teachers each lasted about 10 minutes, included 30–40 questions as part of a script and were conducted by telephone by Gallup. Principals and superintendents were emailed online surveys by Gallup. Principal surveys had approximately 30 questions. Superintendents were surveyed as part of another regular online survey, with 10 closed-ended questions for this study. Table 1 shows the methodology for the five populations.

Table 1. Methodology overview for the five populations.

Population	Mode	Sample Size
Students	Phone	1,672
		<ul style="list-style-type: none"> • 228 Black completes • 310 Hispanic completes
Parents	Phone	1,677
		<ul style="list-style-type: none"> • 197 Black completes • 264 Hispanic completes
Teachers	Phone	1,008
Principals	Web	9,805
Superintendents	Web	2,307

Surveys for all five groups covered topics on perceptions of CS, interest in and desire for CS, in- and out-of-school opportunities for CS, participation in CS, and obstacles to providing and accessing CS opportunities. Survey items were closed-ended, with agreement for yes/no questions and Likert scales for agreement with statements (1–3 Likert for students and parents

and 1-5 Likert for teachers, principals, and superintendents). Surveys were not completely the same from the first year to second year, as new questions were introduced based on findings from the first year. Many questions were retained so that trends could be tracked over the entire research study.

After data were collected, a rigorous quality assurance process was used to clean the data. The data were then coded and reviewed by response. Indices of related variables were created and analyzed using regression to understand trends across and within the surveyed populations. When analyzing differences by race or gender, income was controlled. The indices created from survey questions were exposure to technology, knowledge of CS, perceptions of CS careers, foundational skills for CS, opportunity to learn CS, value of CS in schools, and institutional support for CS.

4. RESULTS

We found that structural barriers in access and exposure to CS and technology were varied for Blacks, Hispanics, and Whites, while social barriers of perceptions and encouragement were not seen to be differentiating factors by race/ethnicity. On the other hand, social barriers seemed to be stronger for girls, while structural barriers did not differ significantly by gender.

4.1 Interest in CS

Overall, we found that interest differed by demographic (Figure 1). By race/ethnicity, the differences are actually in opposition with current representation in the CS field. Black and Hispanic students are more likely than White students to say they are very interested in learning CS—31% of Black and 35% of Hispanic students said this compared to just 21% of White students. On the other hand, boys are more than twice as likely as girls to say that they are very interested in learning CS—34% of boys versus 16% of girls. And we also see that nearly twice as many girls as boys say that they are not at all interested, with 24% of girls versus 13% of boys saying this. Thus, with interest proposed to often stem from a triggered situation involving a positive affect [19], social factors influencing affect appear not to be negatively influential for Black and Hispanic students but may be so for girls.

Interest is important because our Pearson's correlation analyses indicate that it is linked to other factors (see Table 2). Encouragement from both teachers ($r = 0.313$, $n = 1663$, $p < 0.001$) and parents ($r = 0.360$, $n = 1668$, $p < 0.001$) is found to be correlated to interest. It is therefore important to be wary of whom influencers are and are not encouraging. Confidence in learning CS is also related to interest ($r = 0.397$, $n = 1668$, $p < 0.001$) as is indication of likelihood to have a job needing CS ($r = 0.360$, $n = 1667$, $p < 0.001$).

Figure 1. Interest in learning CS by demographic—gender and race/ethnicity.

Table 2. Significant correlations with interest, using Pearson correlation.

	Interest		
	r	n	p
Teacher encouragement	0.397	1668	< 0.001
Parent encouragement	0.313	1663	< 0.001
Confidence	0.360	1668	< 0.001
Likelihood to have job with CS	0.360	1667	< 0.001

A well-developed interest, of course, may determine who will persist in the field [19]. With surprising findings on the inconsistency between interest and Black and Hispanic representation in CS, we next take a look at other factors that may be at play for Black and Hispanic students.

4.2 Race/Ethnicity

Despite the greater interest among Black and Hispanic students, we found that there are structural barriers that may hinder pathways towards CS for these students. In particular, we found discrepancies in access to computers and to CS classes in school—two important pieces for learning CS. Without access to computers at home or use of computers in school, lack of CS classes in school would result in few other opportunities for learning CS.

Figure 2. Exposure to technology, by race/ethnicity.

We found that both Black and Hispanic students are less likely than White students to use a computer at home everyday (30% of Black and 26% of Hispanic compared to 45% of White students; see Figure 2). On the other hand, when asked about mobile use—cell phones or tablets—there was no significant difference by race/ethnicity as nearly all (90%) used these devices at least some days, with 70% of students using them everyday. However, less computer use corresponded with lower confidence in CS (see Table 3).

Furthermore, Hispanic students are significantly less likely than Black or White students to say that they know an adult who works with computers or technology (49% of Hispanic students versus 68% of White and 65% of Black students). Therefore, we see that Hispanic students not only have less exposure to the computer technology itself, they are also less likely to know influencers who work in the field.

Table 3. Percent of students who are very confident they could learn CS if they wanted to, by frequency of computer use at school.

	Every school day (n = 647)	Most school days (n = 441)	Some school days (n = 534)	Never (n = 49)	
Percent very confident			63%	57%	53%
				55%	

Students who report having access to classes with CS are more likely to say they are interested in learning CS, particularly when CS is taught as part of other classes—see Table 4. When we looked at access to CS classes in school, both in dedicated CS classes and other classes with CS, we found that Black students are less likely than White or Hispanic students to have access (Figure 3). After controlling for income and parents' education, Black students are no longer significantly less likely than Hispanic students to report having CS classes.

Table 4. Interest in learning CS, by access to classes with CS.

		Very interested	Somewhat interested	Not at all interested
Are there classes where ONLY CS is taught in your school?	Yes	59%	55%	58%
	No	35%	38%	32%
Is CS taught as part of OTHER classes at your school?	Yes	57%	51%	44%
	No	40%	42%	49%

Interestingly, when we look at where students are learning CS, we find that the majority (80%) of students who have learned CS learned it in a class at school, regardless of demographic. However, when looking at some other modes, particularly via afterschool and other outside-of-school programs, we see more stratification by race/ethnicity. Specifically, 34% of Black and 41% of Hispanic students versus 18% of White students who have learned CS learned it in a group or club at school, and 38% of Black and 21% of Hispanic students versus

Figure 3. Access to classes with CS, by race/ethnicity.

Figure 4. Of the students who have learned CS, the modes through which they've learned, by race/ethnicity.

17% of White students have learned it in a group or program outside school (Figure 4). It is important to note that Black and Hispanic students who have learned CS are still twice as likely to have learned it in a class at school as through these out-of-school means. We see that Black and Hispanic students are more likely than White students to participate in the out-of-school programs.

Finally, we note that beyond interest, we observed other surprising data points that contrast with racial/ethnic representation in CS. These other social data points are particularly surprising for the Black students. We found that Black students were more likely than White students to report that they have been told by a teacher or parent that they would be good at CS, to see people like themselves engaged in CS in the media, and to be confident in learning CS. Black and Hispanic students were more likely than White students to report a parent has told them they would be good at CS (40% of Black and 41% of Hispanic students compared to 35% of White students); this corroborates other data that show that Black and Hispanic parents are more likely than White parents to want their child to learn CS (91% of Black and Hispanic parents versus 85% of White parents) and to believe their child will learn CS (35% of Black and 53% of Hispanic versus 24% of White parents).

In contrast to Black students, we do see lower confidence in learning CS among Hispanic students (51% of Hispanic students versus 68% of Black and 56% of White students are very confident). Therefore, the factors that may be contributing to underrepresentation are not straightforward.

While Black and Hispanic students have less access to computers at home and in school, they and their parents report more interest in learning CS. Hispanic students do not have less access to CS classes, but they are less likely to know an adult working in technology and less likely to be confident in learning CS. And Black students do not report less encouragement, less often seeing people in the media like themselves engaged in CS, or less confidence. Yet, both of these groups are underrepresented among AP CS participants, CS bachelor's degree earners, and the CS workforce.

4.3 Gender

Finally, we take a look at the barriers potentially contributing to girls' underrepresentation. Not surprisingly, we do not see any discrepancies in terms of access to computers or CS learning opportunities. However, in terms of awareness of opportunities and encouragement, we see significant differences by gender.

Outside of classes, girls are less aware of CS opportunities than boys. Specifically, as shown in Figure 5, girls are less aware of

Figure 5. Awareness of CS learning opportunities outside of school classes, by gender.

groups or clubs at their school involving CS (39% of girls versus 48% of boys), opportunities in the community to learn CS (51% of girls versus 58% of boys), and online CS learning opportunities (62% of girls versus 69% of boys). Therefore, besides the mandatory participation in classes, girls are less likely to be aware of optional learning opportunities when it comes to CS.

Accordingly, boys are more likely than girls to have learned CS (59% of boys versus 50% of girls). When looking at students who have learned CS, again, there is no difference by gender for the most commonly reported way of learning CS—through a class in school. However, boys are more likely than girls to have learned CS in other opportunities outside of a class (Figure 6). Again, this confirms that when the opportunity is not necessarily part of a regular or required component, girls are less likely to participate. This also means that boys are spending more of their own free time learning CS, possibly contributing to preparatory privilege as they become more experienced and knowledgeable than other students [10].

We also found that encouragement is greater for boys than for girls. While we do not know which comes first—interest and participation or encouragement—they are intertwined. 44% of those who have been told by a teacher they would be good at CS say they are very interested in learning CS, compared to just 12% of those who have not been encouraged by a teacher. Similarly, 43% of those who have been told by a parent they would be good at CS say that they are very interested in learning CS, compared to 17% of those who have not been encouraged by a parent. As mentioned earlier, this encouragement is also significantly correlated with interest in learning CS. Boys are more likely than girls to report that they have been told by a teacher or parent that

Figure 6. Of the students who have learned CS, the modes through which they've learned, by gender.

Figure 7. Encouragement from adult influencers as well as media, by gender.

they would be good at CS. 39% and 46% of boys say that they've been encouraged by a teacher or parent, respectively, compared to just 26% and 27% of girls (see Figure 7).

When looking at media encouragement, we found that girls are less likely than boys to see people practicing CS in the media (Table 5). Additionally, of the students who do see people practicing CS in the media, girls are half as likely as boys to often see someone like themselves (11% versus 21%) and nearly twice as likely as boys to never see someone like themselves (31% versus 18%). Thus, not only are girls less likely to see examples of people practicing CS in the media, when they do see them, girls are less likely to identify with them.

Table 5. Exposure to CS in the media, by gender.

How often do you see or read about people doing computer science in each of the following places?		Boys	Girls
In TV shows	Often	25%	21%
	Sometimes	55%	61%
	Never	20%	19%
In movies	Often	28%	23%
	Sometimes	59%	61%
	Never	13%	16%
Online through social media, articles or videos	Often	39%	26%
	Sometimes	43%	55%
	Never	17%	18%
[If often or sometimes see people doing CS] Thinking about all of the people you see or read about doing computer science in TV shows, in movies or online, how often do you see people like you doing computer science?	Often	21%	11%
	Sometimes	61%	57%
	Never	18%	31%

With gender, we saw that girls have lower confidence in their ability to learn CS, report less interest in learning CS, and are less likely to have learned CS compared to boys. Furthermore, we found that students who are more interested in learning CS are also more likely to believe they will have a job using CS, with boys more likely to believe so. For girls, access may not be the challenge; instead, the belief that girls are less likely to be interested in CS [20] may result in them receiving less encouragement from parents and teachers, which in turn, exacerbates girls' belief that they do not belong in CS.

5. SIGNIFICANCE

With our survey and analysis of various barriers for Blacks, Hispanics, and girls in CS education, we find it more important than ever for educators and researchers to address the barriers that play out distinctly for the different groups as CS education expands in the K–12 space. It's important to incorporate supportive elements for all students and to be aware of any biases that may discourage groups of students. Our research implies that educators, researchers, and even parents and role models should ensure images of CS and those who practice CS are diverse and representative of the students, and that they should be thoughtful with regard to whose interest in CS they encourage and support. Actions and words can potentially influence the expressed interest and pursuit of CS among students. Our study confirms much of the research on gender [e.g., 11-16,21-24] and it fills a gap by comprehensively comparing racial/ethnic groups. For instance, while large surveys have explored demographic differences in access to technology [9,10,25] and CS classes [7,24], our paper contributes a comprehensive survey of racial/ethnic differences in interest among parents and students, confidence, encouragement, and where students learn CS. Future research should further explore differences in CS learning and perceptions by race/ethnicity as well as how to effectively provide all students with equitable opportunities to learn and enjoy CS.

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