Landscape of K-12 Computer Science Education in the U.S.: Perceptions, Access, and Barriers

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ABSTRACT

Through surveys of 1,673 students, 1,685 parents, 1,013 teachers, 9,693 principals, and 1,865 superintendents across the United States, this study explores perceptions, access, and barriers to computer science education at the K-12 level. We found most respondents were unable to distinguish computer literacy activities from computer science, with female, Black, or Hispanic respondents even less likely to do so. Perceptions of who does computer science were narrow and stereotypical (White, male, smart), but there was high value and demand for computer science across all populations, particularly among parents. Results indicate discrepancies in access to technology and computer science. Over 75% of principals reported their school did not offer computer science with programming/coding, but Hispanic students reported lower exposure to computers at home and in school and Black students and lower income students reported less access to computer science learning in school. Hispanic students and female students were also less likely to have learned computer science or have confidence to learn computer science compared to their counterparts. Finally, we explored barriers to access and identified a harsh disconnect: parent and student demand for computer science education was high while administrators' perceptions of this demand was low. Additionally, the most common barriers to offering computer science cited by principals and superintendents were the need to dedicate time to other courses and testing requirements and the lack of qualified teachers, with technology less common of a barrier.

CCS Concepts

K.3.2 [Computers and Education]: Computer and Information Science Education – computer science education.

Keywords

K-12; pre-university; pre-college; high school; middle school; teachers; principals; superintendents; parents; perceptions; knowledge; access; barriers; diversity; underrepresented minorities; Hispanic; Latino/a; Black; African American; income.

1. INTRODUCTION

Technical advancements and the expansion of professions in which computer science (CS) is relevant make it more important

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than ever for all students to have opportunities to learn CS. Research on underrepresented students in CS at the K-12 level is limited, as is research on key stakeholders in CS education including parents and administrators. We sought to understand the landscape and perceptions of CS for students and their influencers across the U.S. in order to inform outreach efforts and to advance CS education at the K-12 level.

This paper details the first year of a three-year study on the landscape of CS K-12 education in the U.S., surveying students, parents, teachers, principals, and superintendents. The goal of the study is to understand

- perceptions of CS,
- interest in and demand for CS,
- in- and out-of-school opportunities for CS,
- participation in CS, and
- barriers to providing and accessing CS opportunities.

2. RELEVANCE

The field of computer science has faced a major hurdle in expanding diversity in participation. At the high school level, Advanced Placement (AP) Computer Science A enrollment is low overall, but drastically lower for Blacks and Hispanics. For instance, among the 49 states with at least one student who took the computer science exam, 12 had no Black students participating in 2014 [1]. Of all the AP Computer Science A test takers in 2014, only 3.9% were Black and 8.8% were Hispanic, with dramatically lower pass rates for both Black (33.4%) and Hispanic (39.2%) when compared to the overall pass rate of 70.3% [1]. 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 with the recent release of diversity data by top technology companies (e.g., Google, Microsoft, Facebook, Apple, Ebay, Pinterest, Pandora, LinkedIn), the lack of diversity is sounding the alarm for action.

Perceptions, encouragement, and exposure play important roles in the lack of participation and interest [3]. Carter [4] found that students chose not to study CS not because of lack of ability, but because of an incorrect or incomplete perception of the field. Fifty percent of students opposed CS because of their perception that computer scientists spend their days working in front of a computer. Furthermore, Cheryan et al. [5] found that a sense of belonging led to a greater likelihood of indicating interest in computer science. Stereotypes of computer scientists being male, “nerdy,” and lacking social skills are pervasive. However, the authors found that students confronted with non-stereotypes about CS were more likely than students confronted with stereotypes to indicate an interest in majoring in CS.

Similarly, perceptions in one's own ability (i.e., self-confidence) have been found to be correlated with interest and participation.

Smith, Pasero, and McKenna [6] used data from Trends in International Mathematics and Science Study (TIMSS) and found that in fourth and eighth grade, boys had higher confidence than girls in science and were more likely to like science than girls. Cheong, Pajares, and Oberman [7] found that while teachers rated both boys and girls equally competent, girls rated themselves lower than boys on computer self-efficacy and self-concept. Girls' lower participation and interest in STEM and CS may also be explained by their lower confidence. In one study, Hispanic girls gained increased interest in computer careers, mediated by self-reported computing skills and confidence [8].

External influences involve encouragement from adults (parents, teachers, and other family and adult leaders) as well as peers [3]. Parental encouragement of science and mathematics in middle and/or high school increases the likelihood of a young adult pursuing [9] and persisting in STEM careers [10]. Teachers, as well as parents and peers, also play key roles as influencers [8].

In order to address issues of lack of awareness and exposure to CS, as well as negative perceptions that may discourage students from pursuing CS, we embarked on a study to understand the landscape of CS access for students in the United States. We sought to investigate the potential and interrelated factors of perceptions, encouragement, and exposure behind the low numbers of minorities pursuing computer science.

3. DATA SOURCES

This study details results from year one of implementation, surveying 1,673 students, 1,685 parents, 1,013 teachers, 9,693 principals, and 1,865 superintendents in the United States, as shown in Table 1.

Telephone interviews were conducted for students, parents, and teachers currently living in all 50 states and the District of Columbia using a combination of two sample sources: the Gallup Panel and the Gallup Daily tracking survey. The Gallup Panel is a proprietary, 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 minimum quota of 50% cellphone respondents 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.

Students and parents were representative of the U.S. population, with targeted, detailed data on underrepresented populations (Blacks and Hispanics). Students were in grades 7-12 and parents had students in grades 7-12. Student and parent interviews were conducted in both English and Spanish. Student and parent samples are weighted to correct for unequal selection probability and nonresponse. Student and parent data are weighted to match national demographics of age, gender, education, race, ethnicity and region. Demographic weighting targets are based on the most recent Current Population Survey. Black and Hispanic student and parent populations were targeted for a minimum sample for comparisons with White students and parents. Other races were included in the survey but were not used for comparison by race due to small sample sizes.

Teachers were also a representative sample, including teachers of 1st-12th grade, with approximately 20.6% teaching or having taught computer science. Teacher samples are weighted to correct for unequal selection probability and nonresponse. The data are weighted to match national demographics of age, gender, education, race, ethnicity and geographic region.

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 from a panel including more than 20% of all U.S. K-12 superintendents. The principal and superintendent populations were comprehensive, but not representative, with principals from all 50 states and the District of Columbia, and superintendents from all states except Hawaii and the District of Columbia.

Table 1. Methodology overview for the five populations.

Target Population	Methodology
Students (nationally representative)	Mode: Phone Respondents: 1,673 <ul style="list-style-type: none"> 234 Black 262 Hispanic Response rates: <ul style="list-style-type: none"> Landline: 38% Cell: 36%
Parents (nationally representative)	Mode: Phone Respondents: 1,685 <ul style="list-style-type: none"> 208 Black 276 Hispanic Response rates: <ul style="list-style-type: none"> Landline: 29% Cell: 35%
Teachers (nationally representative)	Mode: Phone Respondents: 1,013 Response rates: <ul style="list-style-type: none"> Landline: 49% Cell: 47%
Principals	Mode: Online Respondents: 9,693 Response rate: 11%
Superintendents	Mode: Online Respondents: 1,865 Response rate: 14%

4. METHODS

The surveys for students, parents, teachers, and principals each lasted about 12 minutes, with 30-40 questions. Superintendents were surveyed as part of another regular online survey, with 10 closed-ended questions for this study. Table 1 shows the mode of surveys and respondents completing the surveys for the study.

After data were collected and demographic weighting applied, the data were coded and reviewed by response. Indices of related variables were created and analyzed using regression to understand trends across and within the surveyed populations.

5. RESULTS

5.1 Knowledge and Perceptions of Computer Science

Knowledge of computer science can influence perceptions; perceptions can influence who receives encouragement. Results on knowledge of computer science indicate that most respondents do not have a clear understanding of what computer science is and is not, and responses were varied. The most common misunderstanding was that CS includes creation of documents and presentations (77.6% of students, 64.3% of parents, 74.8% of teachers, and 63.4% of principals agreed) as well as searching the Internet (56.9% of students, 49.3% of parents, 63.8% of teachers, and 53.6% of principals agreed). In particular, female students, parents, and teachers are less likely than their male counterparts to correctly identify CS (see Figure 1).

Figure 1. Computer science knowledge, by gender. Responses to the survey question gauging computer science knowledge, with respondents indicating whether these activities were part of computer science or not. Bars indicate the percentage of each population agreeing that the activity is part of computer science.

We also saw that Black and Hispanic students and parents were less likely to understand computer science than their White counterparts (see Figure 2). These misunderstandings could potentially contribute to underrepresentation of these groups in the field of computer science.

Encouragingly, a large majority of the respondents agreed that CS was important and had wide-impact and applicability. For instance, 82-94% of teachers, parents, and students agreed that people who do computer science work on fun and exciting projects, and 93% of students and parents agreed that people who do computer science make things that help improve people's lives. Furthermore, 81-96% of all five populations agreed that computer science can be used in many different types of jobs. Furthermore, most students (68%) and parents (79%) agreed that computer scientists have good-paying jobs.

Figure 2. Computer science knowledge, by race. Responses to the survey question gauging computer science knowledge, with respondents indicating whether these activities were part of computer science or not. Bars indicate the percentage of each population agreeing that the activity is part of computer science.

Figure 3. Responses to “Do you think offering opportunities to learn computer science is more important, just as important or less important to a student's future success than ... ?”

In particular, we see that a majority of parents, teachers, principals, and superintendents felt that computer science was just as important as or more important than required core classes, like math, science, history, and English (see Figure 3).

On the other hand, when considering perceptions of those who do do computer science, there is a clear distinction of those who do and do not. Almost half (48.5%) of students agreed that computer scientists need to be very smart. Teachers (62.3%) and principals (56.0%) agreed that students good at math and science would be more successful in computer science. However, only 42.2% of students rated themselves as skilled in math and 39.3% rated themselves as skilled in science. Only 54.2% of students stated that they were very confident they could learn computer science.

Gender biases were also prevalent. 73.7% of students, 64.1% of parents, and 63.4% of teachers think that boys are more interested

Figure 4. Student responses to items on interest and success in computer science, by gender and race.

Figure 5. Percentage student agreement with “People who do computer science need to be very smart,” by gender and race.

in CS than girls. And, 43.9% of students, 37.1% of parents, and 35.7% of teachers believe that boys would be more successful than girls in CS. These findings imply that many students may not be getting the encouragement to do computer science and many may not have the confidence to pursue learning computer science.

By demographic, we see that White and Black students are more likely than Hispanic students to say boys are more interested in learning CS. White students are the least likely to say girls are more likely to be successful in learning CS and the most likely to say you need to be very smart to do CS (see Figures 4-5). In other words, interestingly, White students are most likely to hold a stereotypical view of those in computer science, with respect to gender and mindset.

Not surprisingly, both students and parents perceive those who do computer science in the media as mostly white, male, and “wearing glasses.” Considering this popular perception, Black and Hispanic students are less likely to have a sense of belonging

Figure 6. Student access to computer technology, by race.

in CS and, consequently, an interest in the field [5]. Further, with students’ low ratings of their own skills in math and science, teachers and principals may be less likely to encourage these students to pursue CS. We saw that Hispanic students were less likely than White or Black students to rate themselves as skilled in science (28% of Hispanics, compared with 40% of Whites and 50% of Blacks). Perhaps the stereotypes of who does computer science is self-perpetuating, making the issue of diversity a deeply imbedded challenge. These findings point to the need to better shape CS learning environments and social influencers to be inclusive of all backgrounds.

5.2 Access to Technology and Computer Science

We now look at students’ exposure to technology and computer science, as it may be influenced by students’, parents’, and educators’ perceptions of the field. With regards to exposure to technology, Hispanic students are least likely to have exposure to computers at home and at school compared to Black and White students. Only 75% of Hispanic students report having access to a computer at home, compared to 85% of Black students and 98% of White students. At school, only 31% of Hispanic students report using a computer everyday, compared to 45% of Black students and 42% of White students. See Figure 6.

In terms of CS opportunities, over 75% of principals say their school offers no CS programming/coding classes. Black students, regardless of income, are less likely than White or Hispanic students to report opportunities to learn computer science at school, including dedicated CS classes, CS as part of other classes, and groups or clubs (see Figure 7). Hispanic students are also less likely than White students to report having dedicated computer science classes, but after accounting for household income, this effect diminishes. However, by income, lower income students are less likely to report access to CS learning opportunities.

Figure 7. Student access to computer science learning in school, by race and income (% agree).

Figure 8. Student confidence (% very confident) and experience (% agree) in learning computer science, by race and income.

Of those students who had learned computer science, the most common means were in a class at school (73.1%) and on their own (55.8%). As shown in Figure 8, Hispanic students are the least likely to say they have ever learned computer science (44% compared to 60% Blacks and 55% Whites) and are the least likely

to say they are very confident they could learn computer science if they wanted to (45% compared to 60% Blacks and 56% Whites). By gender, girls are less likely than boys to have learned CS or have confidence to learn CS (50% vs. 57% boys; see Figure 8).

For participation, teachers and principals indicated that students in CS classes are usually high-ability, white, and male. This confirms our findings on perceptions and stereotypes of those who do computer science, and implies the need to provide broader examples of those who do CS and encourage broader populations to participate.

5.3 Barriers to Access

To understand potential reasons for low access and exposure, we investigated barriers to offering CS. Surprisingly, we saw contrasting results between parent and student demand for CS and administrator perceptions' of parent and student demand. Demand, particularly from parents, was surprisingly high, with 90% agreeing that offering CS is a good use of their school's resources and 91% indicating that they would like their child to learn CS. 67% of parents and 56% of teachers even indicated that CS should be required, and 96% of students reported adults in their family would be supportive of their learning CS.

On the other hand, principals and superintendents did not believe there was high demand from parents. Over 50% of principals indicated demand from parents was low (with only 7% indicating demand was high) and 43.8% indicated demand from students was moderate, while 51.4% of superintendents indicated demand from parents was low (with only 6% indicating demand was high) and 49.1% indicated student demand as moderate. 30% of principals and 50% of superintendents indicated that low demand from parents and students was a barrier to offering CS. Furthermore, less than 30% of educators reported that CS is a top priority at their school or district. Interestingly, only 27.2% of teachers versus 82.9% of superintendents believed that computer

Figure 9. Barrier to offering computer science in their school or district (% agree).

science would be offered at their school in the next three years. And, many principals (41.5%) and superintendents (47.8%) did not indicate that students should be required to take a computer science course.

We also found the most common responses about barriers to offering CS were the need for qualified CS teachers and teaching support, cited by half of principals and superintendents (see Figure 9). Across teachers (82.8%), principals (79.3%), and superintendents (81.1%), there was strong agreement that teaching CS requires extensive training while 59.6% of teachers, 44.3% of principals, and 73.6% of superintendents indicated that they would need to hire a new teacher or could not identify a teacher already at the school to teach CS.

As schools prioritize and direct resources towards preparing for tests, testing requirements were cited as a barrier to offering CS by half of principals and superintendents. Testing was cited as the *main* barrier by 32.4% of principals and 23.6% of superintendents. Principals whose schools did offer CS most commonly (15.8%) cited “too many other courses students need to take” as the biggest barrier they had to overcome in order to offer CS.

Surprisingly, technology was not as common a barrier. Only 10% of administrators indicated access to Internet was a barrier and 20-33% mentioned software, equipment, and budget for technology as barriers.

An interesting opportunity arising from this need to dedicate resources to other required courses was that most teachers (66.6%), principals (70.0%), and superintendents (66.0%) indicated that it was a good idea to incorporate CS into other subjects.

6. SIGNIFICANCE

Overall, despite the positive image of CS careers and work, we still see a need for broader education on what CS is and is not among all populations, including educators. And, despite the high value and demand for CS from parents, the education infrastructure does not equitably provide all students with the desired exposure, possibly with insufficient encouragement and access for underrepresented populations. This may be due to the perceptions across populations that CS is only for certain types of people, as well as a lack of awareness of parent demands and lack of support for CS teacher training and flexibility in the curriculum. These indicate:

- A need to broaden perceptions of who does computer science as well as a need for greater awareness of biases;
- Educators should talk to parents and students, who should speak up about their demands;
- Computer science training resources that is inclusive of all students need to be made accessible, available, and known;
- Policymakers and administrators should consider strategies to be more supportive of computer science offerings, such as
 - more flexible curriculum and class schedules,
 - modifying requirements for standardized testing,
 - allowing computer science courses to count towards graduation and college admission requirements,
 - offering a variety of paths to learn computer science in and out of school, as well as through various means using computers, mobile devices, and without technology

Future research should further explore the possible connections between perceptions and its influence on those who may encourage and provide exposure to computer science students, as well as its influence on the students themselves to confirm our hypotheses as well as past studies (e.g., [4-5]). Research on equitable pedagogy in computer science can also help inform teaching and enlighten us on methods to lessen biases and discrepancies in exposure in order to create opportunities for all to advance with computer science.

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8. REFERENCES

- [1] College Board. (2014). AP Program Participation and Performance Data 2014. Retrieved from <http://research.collegeboard.org/programs/ap/data/participation/ap-2014>.
- [2] National Center for Education Statistics (NCES). (2012). Bachelor's degrees conferred by postsecondary institutions, by race/ethnicity and field of study: 2010-11 and 2011-12. Retrieved from http://nces.ed.gov/programs/digest/d13/tables/dt13_322.30.asp.
- [3] Wang, J., Hong, H., Ravitz, J., & Ivory, M. (2015). Gender Differences in Factors Influencing Pursuit of Computer Science and Related Fields. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 117-122). ACM.
- [4] Carter, L. (2006, March). Why students with an apparent aptitude for computer science don't choose to major in computer science. In *ACM SIGCSE Bulletin* (Vol. 38, No. 1, pp. 27-31). ACM.
- [5] Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, 69(1-2), 58-71.
- [6] Smith, T.J., Pasero, S. L., & McKenna, C. M. (2014). Gender effects on student attitude toward science. *Bulletin of Science, Technology & Society*, 34(1-2), 7-12.
- [7] Cheong, Y.F., Pajares, F. & Oberman, P.S. (2004). Motivation and academic help-seeking in high school computer science. *Computer Science Education*, 14(1), 3-19.
- [8] Denner, J., Werner, L., Martinez, J., & Bean, S. (2012). Computing goals, values, and expectations: Results from an after-school program for girls. *Journal of Women and Minorities in Science and Engineering*, 18(3), 199-213.
- [9] Fan, X. & Chen, M. (2001). Parental Involvement and Students' Academic Achievement: A Meta-Analysis. Retrieved from <http://rd.springer.com/article/10.1023/A:1009048817385>
- [10] Dabney, K. P., Chakraverty, D., & Tai, R. H. (2013). The association of family influence and initial interest in science. *Science Education*, 97(3), 395-409.