THE COMPUTER SCIENCE TEACHER LANDSCAPE:

RESULTS OF A NATIONWIDE TEACHER SURVEY

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SUMMARY

Background

The technology sector remains one of the fastest growing industries across the nation and continues to rapidly permeate all facets of society. The next generation of the computing workforce must be equipped with the skills to examine how current systems exacerbate inequities and to develop new, more equitable innovations. To enable this shift, computer science (CS) instruction needs to develop not only students' computing identities and computational thinking, but also critical thinking and ethical reasoning. Teachers are key to this transformation, yet little is known about the landscape of PreK-12 CS teachers and how equipped they are to provide equitable CS instruction. In order to examine the backgrounds of CS teachers and the support and resources needed to implement culturally-relevant computing pedagogical practices, the Kapor Center and the Computer Science Teachers Association surveyed nearly 3,700 PreK-12 CS teachers across the nation in summer 2020.

Key Findings

DEMOGRAPHICS OF CS TEACHERS

Despite the growing racial and ethnic diversity of the U.S. PreK-12 student body, the majority of CS teachers were white (75%) and women (64%), situated predominantly in high income, urban, and less racially diverse schools.

CREDENTIALS AND EXPERIENCES OF CS TEACHERS

Data revealed that CS teachers have a wide variety of post-secondary degrees and credentials, and took multiple pathways to enter CS classrooms. The majority of teachers did not hold a degree or credential in the Computer and Technical Sciences. Despite this, participation rates in ongoing CS professional development remained low.

30%

of teachers graduated with a Computer and Technical Sciences degree and 6% graduated with a minor in CS.

46%

of teachers held credentials in Computer and Technical Sciences, 49% held credentials in another area, and 5% held no credentials.

53%

had 11+ years of classroom experience, but considerably fewer teachers reported 11+ years of experience in CS classrooms (16%).

61%

reported participating in a professional learning community, and 28% of teachers reported participating in ongoing coaching.

CHALLENGES TO EQUITABLE CS CLASSROOMS

In their efforts to design and facilitate equity-focused CS education to meet the needs of all students, teachers reported several challenges to implementation, including insufficient resources, limited budgets, a lack of computing content knowledge, and a lack of student engagement.

35%
of teachers did not have the material, supplies, equipment, and space necessary to teach CS.

27%
felt limited by their own subject matter expertise, specifically in elementary schools and lower-income schools, and expressed the need for low-cost CS professional development and collaboration opportunities.

24%
reported that inequitable access to early computer science coupled with a lack of support often restricts and deters students historically excluded from pursuing the computing field.

39%
of teachers did not see the importance of covering computing's role in perpetuating biases related to racism, sexism, and other inequities in the classroom.

CURRENT STATE OF CULTURALLY-RELEVANT PEDAGOGY IN CS CLASSROOMS AND CHALLENGES TO IMPLEMENTATION

Data revealed that not all classroom curricula are effectively engaging students in a culturally-relevant manner nor do CS teachers feel equipped to lead culturally-relevant pedagogical practices.

65%
of teachers believed that existing CS curricular resources met the needs of a diverse student body.

55%
of teachers found themselves having to revise existing curricula to make it more engaging and relevant to students.

53%
of teachers felt existing curricula were culturally-relevant, and 57% felt equipped to utilize culturally-relevant pedagogical practices.

59%
of white teachers (compared to 67% of Black, Indigenous, Latinx, and Pacific Islander teachers) were confident utilizing material highlighting race, ethnicity, and culture.

Recommendations for Policy and Practice

1. **Develop Incentive Structures to Recruit, Retain, and Diversify the Pool of CS Teachers**

   There is a dire shortage of CS teachers nationally, especially those who are Black, Indigenous, Latinx, and Pacific Islander. By developing new approaches to incentivize teachers to join and stay in the CS educator pipeline, schools will more likely be able to tackle the current challenge of filling and diversifying these roles.

2. **Build Comprehensive Teacher Training, Certification, and Endorsement Programs Aligned to an Equity-Focused Computing Education Framework**

   Data showed high degrees of variability among CS teachers with respect to their experience with computing, confidence in enacting culturally-relevant pedagogy, and ability to adapt material to meet their classroom needs. Greater alignment between teacher training, credentialing, and licensure programs, and an equity-focused computing education framework can mitigate these gaps in knowledge to ensure more equitable classroom practices.

3. **Expand Access to Ongoing Teacher Professional Development**

   The low rate of participation in ongoing professional development and coaching opportunities is a concern for teachers staying up-to-date on promising practices in CS education. Districts must commit to investing in quality ongoing teacher development, including coaching and learning communities, particularly for early-career teachers, elementary school teachers, and those teaching marginalized students groups.

4. **Prioritize CS as a Core Course Across the PreK-12 Pipeline**

   In order to develop students' computational thinking abilities for the needs of the workforce of the future, CS must be offered earlier in students' educational experience, across all school profiles, and must be adopted as a foundational discipline, similar to other core academic content areas.

5. **Build a District-Wide Coalition to Champion an Equitable CS Implementation Plan**

   Developing an effective strategic plan to implement equitable CS programming within schools is more likely to be successful when school districts--including leadership, teachers, parents, and students--show a collective commitment and shared buy-in to prioritizing CS education.

Conclusion

The nation must make long-term investments in the CS teacher workforce to ensure the equitable development of the next generation of computing professionals and informed citizens. Current teachers continue to report insufficient support and limited resources to carry out culturally-relevant CS practices. However, through strategic investments in teacher recruitment efforts, teacher preparation, and sufficient pedagogical resources, schools can effectively prepare students to become part of a more socially just workforce of the future.

INTRODUCTION

In this period of economic uncertainty spurred by the global pandemic, the technology industry is projected to be one of the leading industries in job growth during 2021 with 180,000 new jobs. Technology has also strengthened its hold on shaping society, from reimagining modes of communication to influencing user behavior. However, while technology can be channeled for positive sociopolitical impact, we continue to grapple with more deleterious effects, such as the rapid spread of misinformation and extremism across social media, and the overuse of algorithms to target, surveil, and discriminate against Black, Latinx, and Indigenous communities.

The pervasiveness of human biases that power these technological innovations pose lasting threats to communities of color. And while policies can regulate and minimize the harms caused by existing technologies, creating the next generation of technologists will require preparing all students with computational skills, and ensuring students can understand and interrogate inequity to build a more inclusive tech economy. This shift will require a transformation of computer science instruction to not only equip students with the knowledge and skills to develop new technologies but to also expand students' critical thinking abilities, computing identities, and ethical reasoning skills to reflect upon their own biases and critique systems that exacerbate inequities in computing.

Teachers of computer science will play a key role in revolutionizing approaches to computing education, ensuring equitable computer science classrooms, and preparing the next generation of computing professionals and the future workforce. Yet, very little is known about the current landscape of computer science (CS) teachers across the nation, including their demographics, their preparation, and their ability to advance equitable and inclusive classroom practices for young people from all backgrounds. Thus, the Kapor Center and the Computer Science Teachers Association administered a nationwide survey to 3,693 PreK-12 computer science teachers in summer 2020, in order to examine their background and experiences and identify opportunities for improving pedagogical and curricular practices to create equitable student outcomes.[1] The survey was distributed widely in order to capture voices representing a variety of school profiles and teacher backgrounds that can inform a broad set of recommendations to build more equitable computer science classrooms. In the following sections, this report will examine the following questions:

1. **What are the demographic backgrounds of PreK-12 CS teachers, and what credentials and experiences do they bring to CS classrooms?**
2. **What challenges do PreK-12 CS teachers face in building equitable classrooms?**
3. **To what extent are effective culturally-relevant CS teaching practices currently implemented in PreK-12 CS classrooms, and what are the challenges faced by teachers?**
4. **What are the recommendations to support PreK-12 CS teachers in building equitable and inclusive classrooms?**

[1] See Appendix 2 for survey methodology.

What are the demographic backgrounds of CS teachers?[2]

The following sections, based on the nationwide survey data, describe the profiles of schools in which computer science is taught, the demographic and professional backgrounds of computer science teachers, and which computing courses are being taught.

SCHOOL CONTEXT

The majority of respondents taught in public schools (77%), with 27% serving grades PreK-5, 38% serving grades 6-8, and 56% serving grades 9-12 (Figures 1 and 2).[3] In alignment with data revealing gaps of computer science course access to schools serving lower income, rural, and racially diverse student bodies, survey respondents predominantly taught in higher income schools, urban areas, and schools with a low proportion of Black, Indigenous, Latinx, and Pacific Islander (B/I/L/PI) students (Figure 3).

Figure 1. Types of Schools

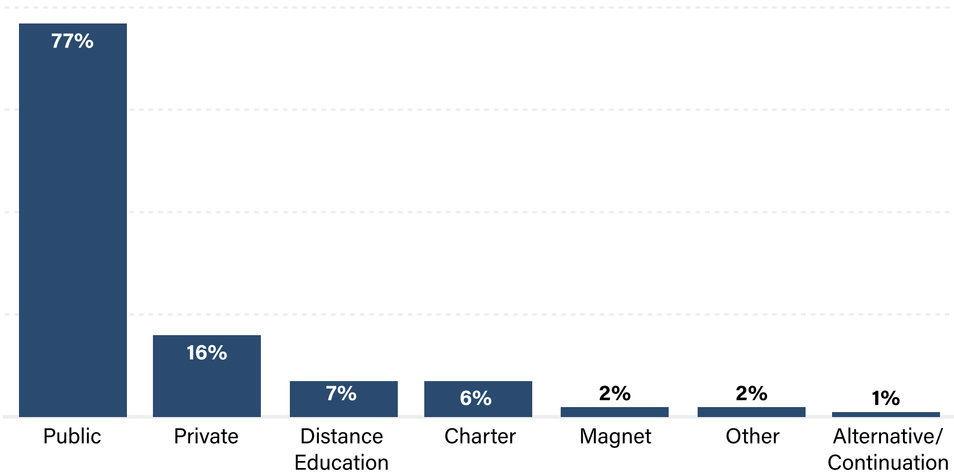
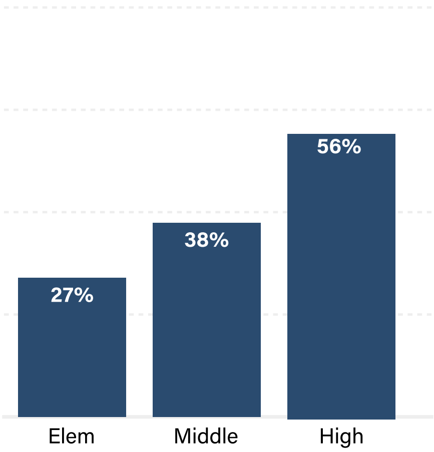
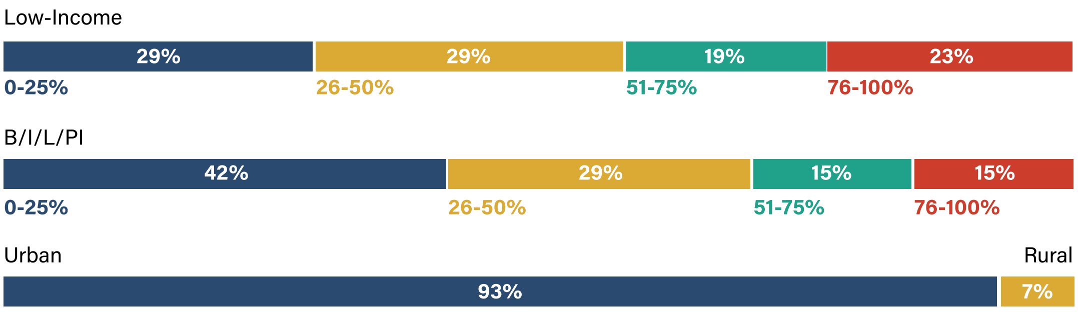


Figure 2. Grade Levels Taught



Note: Multiple options allowed, does not sum to 100%

Figure 3. Representation of Student Body Income, Race/Ethnicity, and School Location



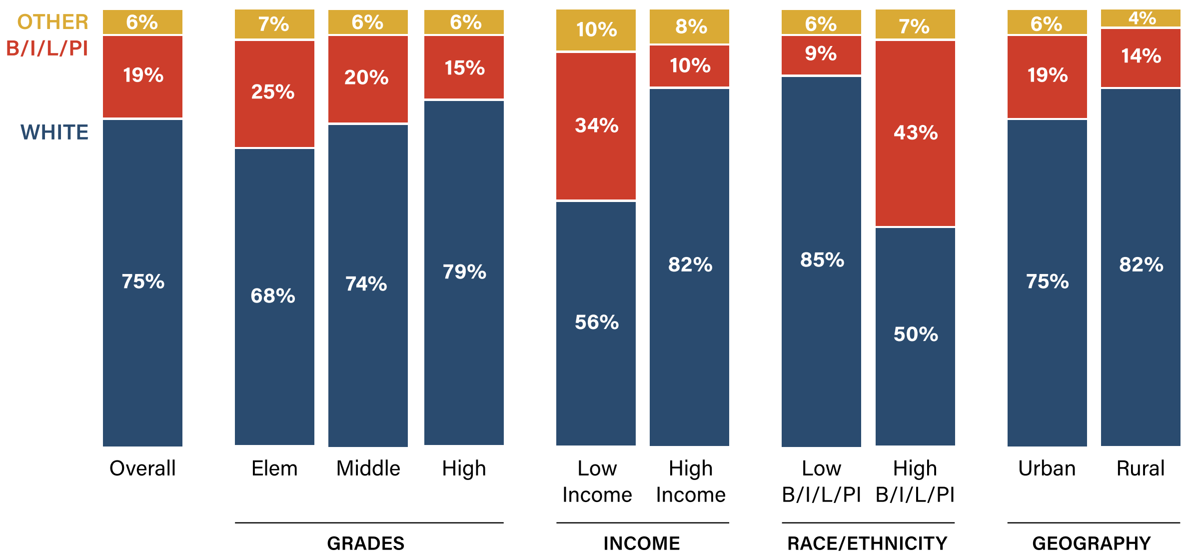
[2] Additional demographic information can be found in the accompanying interactive dashboard.

[3] Does not sum to 100%, as multiple options were allowed.

TEACHER DEMOGRAPHICS

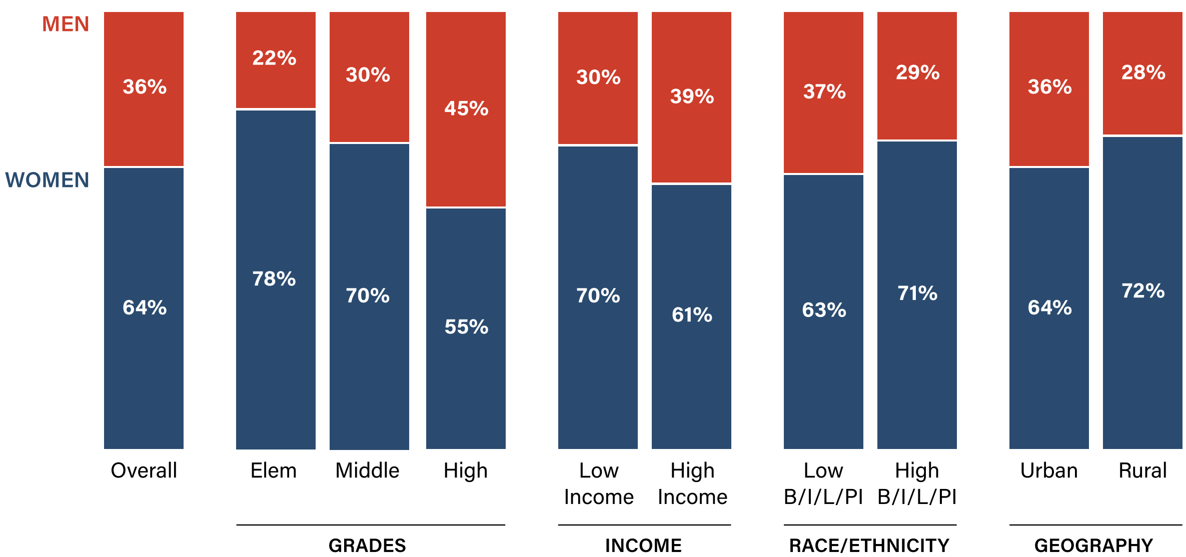
The racial demographics of computer science teachers in this survey reflected the general PreK-12 teacher population, with a majority (75%) being white across varying school contexts. Black, Indigenous, Latinx, and Pacific Islander teachers were represented at greater rates in elementary schools than in middle and high schools (25%, 20%, and 15%, respectively). Similarly, Black, Indigenous, Latinx, and Pacific Islander teachers were represented at higher rates at lower income, more racially-diverse, and urban schools, yet computer science teachers of color are still underrepresented relative to their proportion of the teaching workforce (Figure 4).

Figure 4. Representation of Teacher Race/Ethnicity, by School Profile



In terms of gender, although women are underrepresented in computing more broadly, the majority of computer science teachers were women (64%), in alignment with the general PreK-12 teacher population. While women were the majority across school contexts, gender gaps shrunk in particular school profiles. There was greater representation of men in higher income schools, urban areas, high schools, and schools serving a lower proportion of Black, Indigenous, Latinx, and Pacific Islander students (Figure 5).

Figure 5. Representation of Teacher Gender, by School Profile

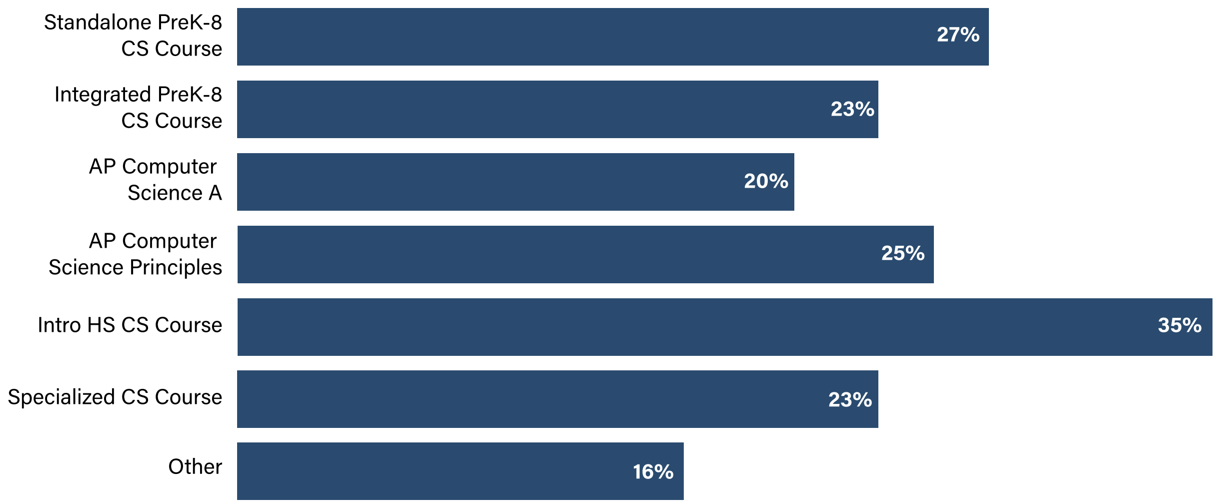


Note: Less than 1% of respondents identified as non-binary.

COMPUTER SCIENCE COURSES TAUGHT

Consistent with computer science being often taught as an integrated, specialized, or elective course, only 38% of computer science teachers had more than 75% of their teaching responsibility allocated to teaching computer science. Of the respondents, 27% taught a standalone PreK-8 course, 23% taught integrated PreK-8 courses, 20% taught Advanced Placement Computer Science A, 25% taught Advanced Placement Computer Science Principles, 35% taught an introductory[4] computer science course, and 23% taught a specialized[5] computer science course (Figure 6). Of the respondents teaching high school courses, 46% classified their course as Career Technical Education (CTE).

Figure 6. Courses Taught, by Type



Note: Multiple options allowed, does not sum to 100%

[4] Introductory courses include: Introduction to Computer Science, Computer Science 1, Exploring Computer Science, Computer Programming.

[5] Specialized courses include: Robotics, Game Design, Coding, Networking, Cybersecurity.

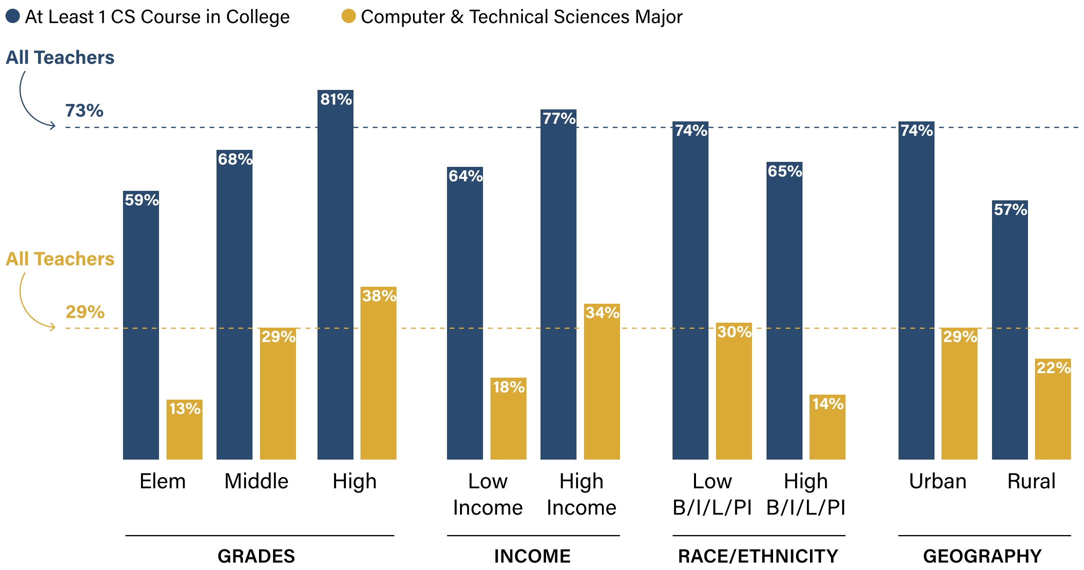
What credentials and experiences do teachers bring to CS classrooms?

Data revealed that computer science teachers have a wide variety of post-secondary degrees and credentials and took multiple paths to enter computer science classrooms. While earning a degree and a credential in computer science is not essential to a teacher's success in effectively teaching computer science, teachers with either a degree or a credential did report greater confidence in teaching computing content and concepts (79% vs. 65%, respectively). These data become critical when we see disparities in who is served by these teachers; students in elementary schools, schools that are racially-diverse, lower income, and in rural areas are more likely to have a teacher without a degree/credential in computer science and also reporting lower levels of confidence in teaching computing content.

EDUCATIONAL BACKGROUND

Almost three-quarters of teachers indicated that they took at least one computing course during their undergraduate education experience. Nearly 30% of teachers graduated with a Computer and Technical Sciences[6] degree and 6% graduated with a minor in computer science. Notably, high school teachers were more likely than those in elementary and middle schools to have had exposure to post-secondary computer science coursework, with 81% having taken at least one computer science course and 38% having majored in the Computer and Technical Sciences. Similarly, teachers who taught at higher income schools, urban areas, and schools with a low proportion of Black, Indigenous, Latinx, and Pacific Islander students were more likely to have post-secondary computer science exposure in comparison to their counterparts teaching in lower income schools, rural areas, and more racially-diverse schools (Figure 7).

Figure 7. Percent of Teachers with Exposure to CS During Undergraduate Training, by School Profile



[6] Computer and Technical Sciences degrees include: Computer Science, Information & Communications Technology; Information Technology, Engineering, Networking, Cybersecurity.

CREDENTIALING

Among computer science teachers, 95% held at least one teaching credential. Of those, 46% held a credential in Computer and Technical Sciences, 23% in Career Technical Education, and 1% in another STEM subject. Teachers in high schools and middle schools were most likely to hold a Computer and Technical Sciences credential, while teachers in elementary schools were most likely to hold a multiple-subject credential (Figure 8). Analyses showed teachers in lower income schools, rural areas, and schools with majority Black, Indigenous, Latinx, and Pacific Islander students were less likely to hold credentials in the Computer and Technical Sciences (Figure 9). These differences in teacher credentials, among other factors, could contribute to disparate instructional experiences for students in these schools.

Figure 8. Teacher Credentials, by Grades Taught

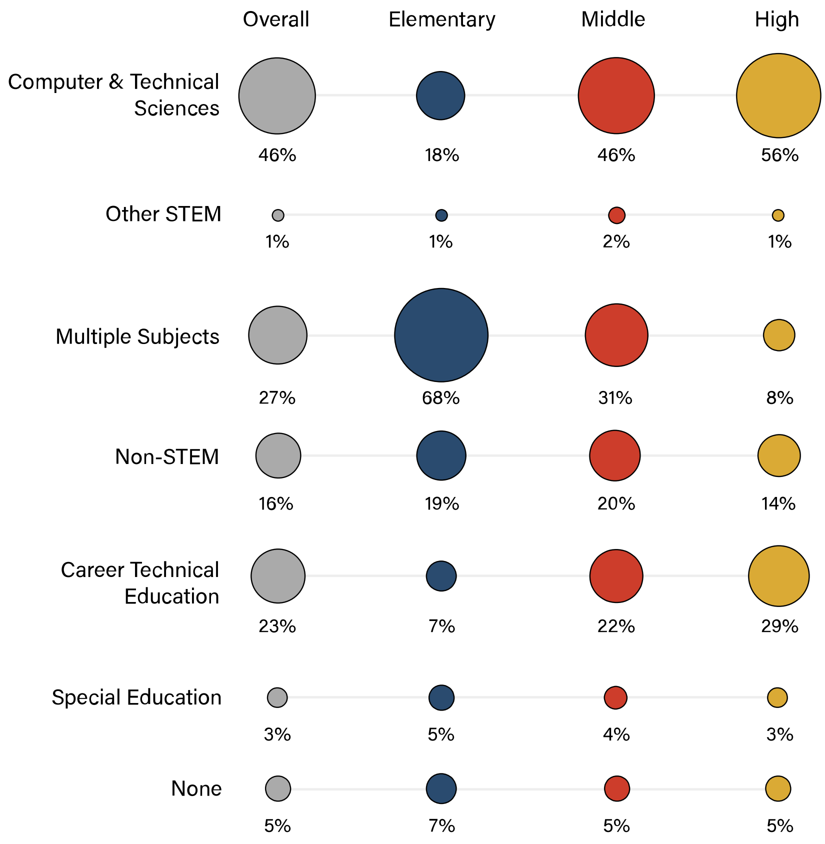
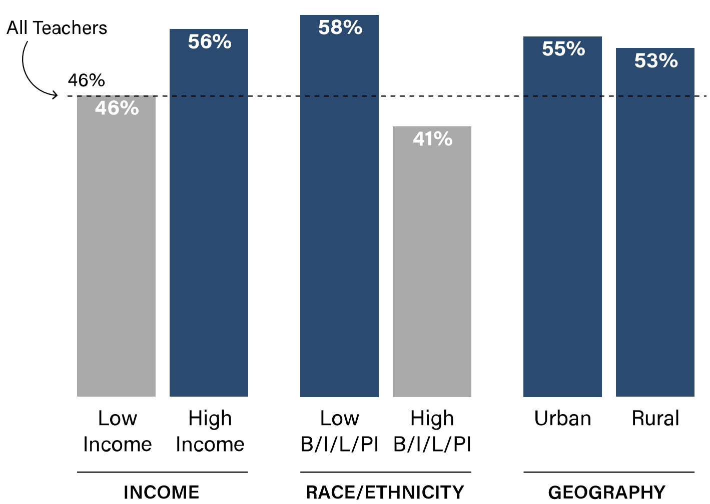


Figure 9. Percent of Middle and High School Teachers Holding Computer & Technical Sciences Credential, by School Profile

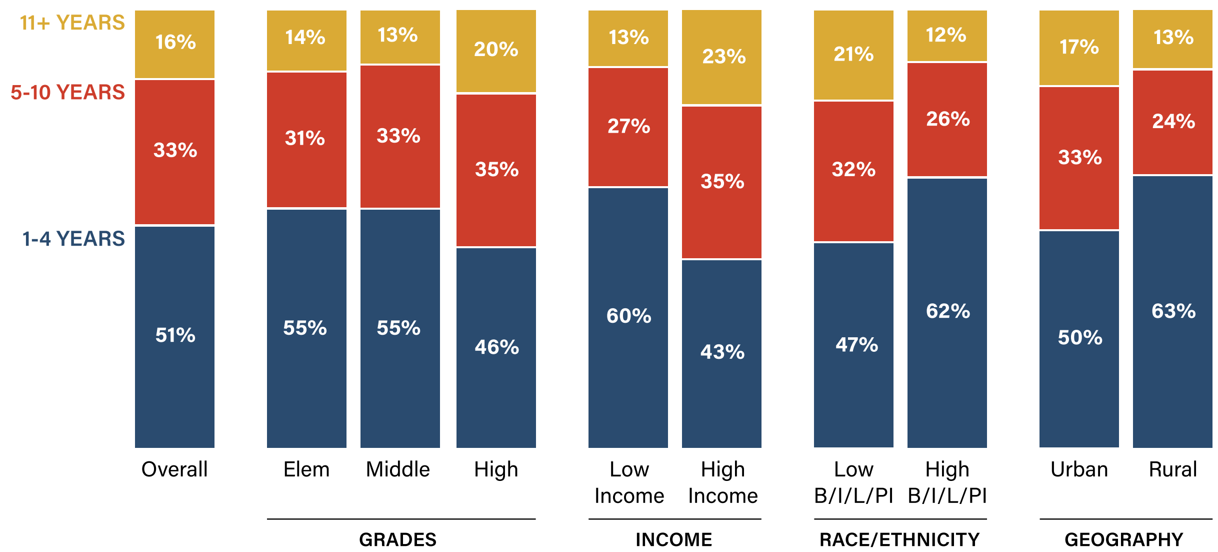


Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

CLASSROOM EXPERIENCE

Over half of respondents had 11 or more years of general classroom experience (53%), but considerably fewer teachers reported comparable experience specifically within computer science classrooms (16%). Fifty-one percent of teachers reported having one to four years of experience in computer science classrooms, 33% reported between five and ten years of experience, and the remaining 16% of teachers reported more than 11 years of experience. Data revealed that teachers with a longer tenure in computer science classrooms were serving high school populations, higher income schools, urban areas, and schools with a low proportion of Black, Indigenous, Latinx, and Pacific Islander students (Figure 10).

Figure 10. Teacher CS Classroom Experience, by School Profile



PROFESSIONAL DEVELOPMENT

Despite the importance of ongoing professional development and learning communities, low participation rates among teachers persisted across school profiles. Less than two-thirds of teachers (61%) reported participating in a professional learning community and less than one-third of teachers (28%) reported participating in ongoing coaching. Yet, data illustrated teachers' current challenges in the classroom might be mitigated with the support they are not currently receiving.

What challenges do PreK-12 CS teachers face in building equitable classrooms?

In their efforts to design and facilitate equity-focused computer science to meet the needs of all students, teachers reported facing several challenges to implementation, including insufficient resources and limited budget, a lack of computing content knowledge, and a lack of student engagement (Figure 11). To address these challenges, a collective commitment from school and district administration is essential to drive solutions. Yet, we continue to see that this is not the case across schools, with 30% of teachers reporting a lack of administration and staff buy-in for CS implementation.

School leadership and administration have key roles to play in garnering support towards a strategic vision, including ensuring buy-in from stakeholders in decision-making, allocating adequate resources for successful school-wide implementation, and engaging community partners who can offer additional resources towards the initiative. When staff across the district are committed to prioritizing computer science for their students, only then will effective actions be taken to develop computer science programming within schools, including allocating budget and time for teacher professional development, investing in resources for classrooms, and messaging the importance of computing pathways to students and families.

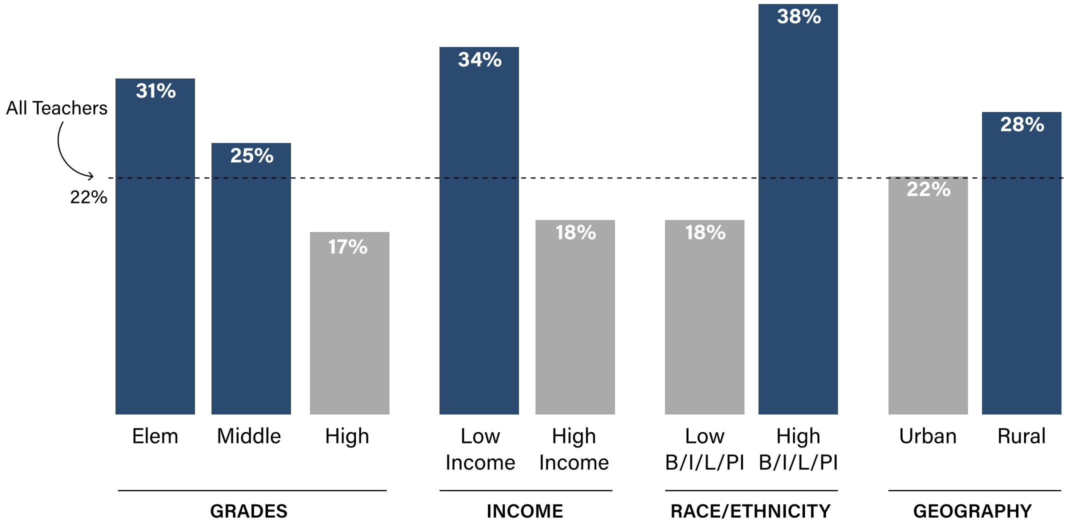
Figure 11. Major Challenges to CS Education

ACCESS TO RESOURCES

When asked if they had the material, supplies, equipment, and space necessary to implement computer science teaching, only 65% of teachers reported sufficient resources. Nearly a quarter of teachers indicated specific challenges to teaching equitable computer science that included a lack of hardware and software (as reported by 22%) and a lack of curricular resources (as reported by 20%).

Almost two times more teachers in lower income (in comparison to higher income) and elementary schools (in comparison to middle/high schools) were likely to be affected by insufficient hardware/software (Figure 12). Teachers serving at schools with a more racially diverse student body were disproportionately affected by resource inaccessibility, reporting major challenges in accessing hardware/software resources at a rate over twice as high as those serving at less racially diverse schools. Not only were Black, Indigenous, Latinx, and Pacific Islander students facing these challenges within the classroom setting, but in qualitative responses, 30% of teachers serving more racially diverse schools described their students facing barriers brought on by the lack of technology in their homes. As shared by one teacher, "None of my students have access to internet or personal computing devices at home. School is the only place they interact with computers in any capacity." This resource gap in marginalized communities becomes even more concerning during the COVID-19 pandemic, with students becoming more reliant on hardware and software access as a result of the shift to virtual instruction.

Figure 12. Percent of Teachers Challenged by Limited Hardware/Software, by School Profile

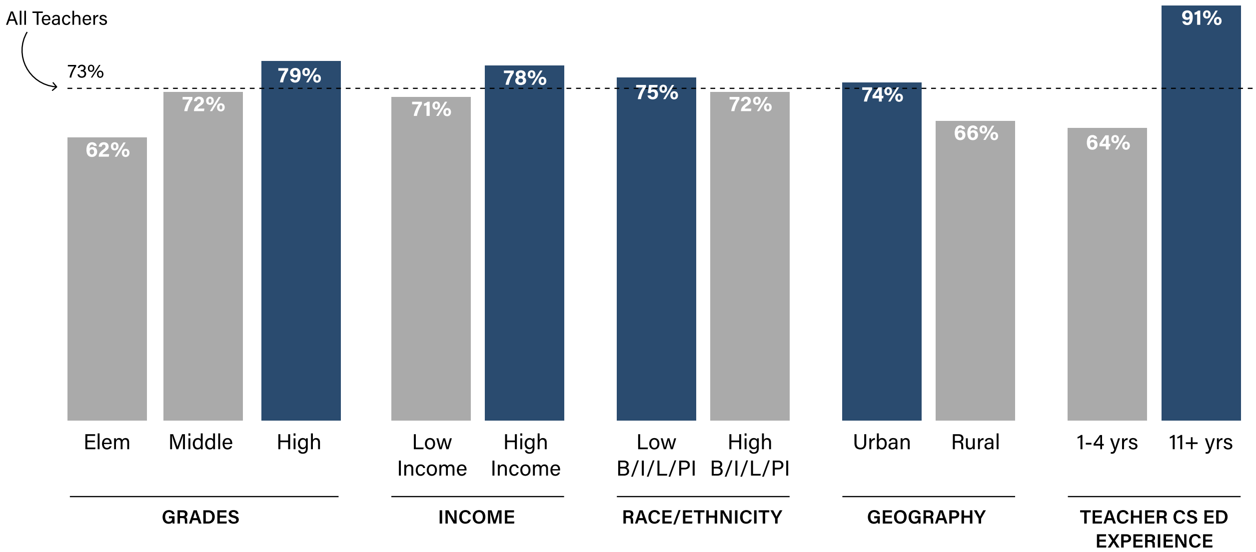


Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

TEACHERS' KNOWLEDGE OF CS CONTENT

Over one-quarter of teachers felt limited by their own subject matter expertise, specifically in elementary schools and lower income schools, and expressed the need for low-cost computer science professional development and collaboration opportunities. Additional analyses revealed that while 91% of veteran teachers reported confidence in their computer science content mastery, only 64% of teachers early in their computer science classroom careers reported the same (Figure 13). Of respondents, 30% cited the need for more opportunities to learn programming languages. As one teacher described, "I need more training on specific computer languages. I have not had the time to thoroughly learn some that I am required to teach."

Figure 13. Percent of Teachers Confident in CS Content, by School Profile and CS Teaching Experience



Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

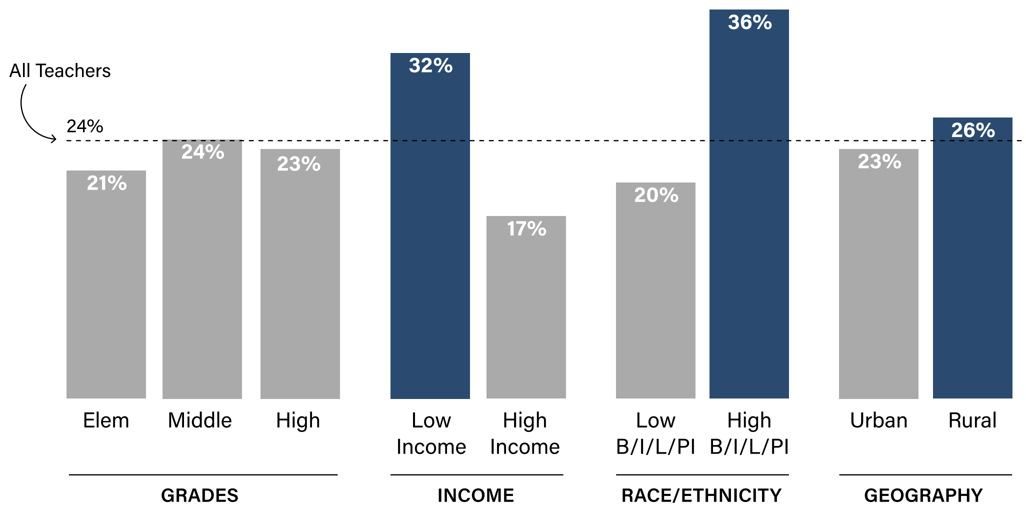
TEACHERS' PERCEPTIONS OF STUDENT BARRIERS

Broadening participation in computing will require challenging and transforming preconceived notions of who belongs in computer science and providing support to students to develop a passion to pursue computing pathways. Inequitable access to early computing exposure coupled with lack of support to pursue computing often restrict and deter students historically excluded from the field.

Students' Prior Exposure to Computer Science

Across schools, 24% of teachers reported that students' lack of exposure to computer science content was a major challenge to classroom instruction. Middle school and high school teachers were more likely to identify students' lack of content knowledge as a major challenge in comparison to elementary school teachers. Furthermore, almost twice as many teachers in lower income schools and schools with greater proportions of Black, Indigenous, Latinx, and Pacific Islander students identified the lack of content knowledge to be a challenge in comparison to their respective counterparts (Figure 14). As described by one teacher, "There [are] a lack of schools providing computer science courses at the younger grades. More minorities must be given access and opportunity equally to CS exposure." If teachers are expected to play a role in broadening participation in computing, these data illustrate the need to not only provide universal access to computer science from early grades, but to also support teachers in developing ways to differentiate learning experiences in their classrooms for those with less exposure to computer science.

Figure 14. Percent of Teachers Challenged by Lack of Student CS Knowledge, by School Profile

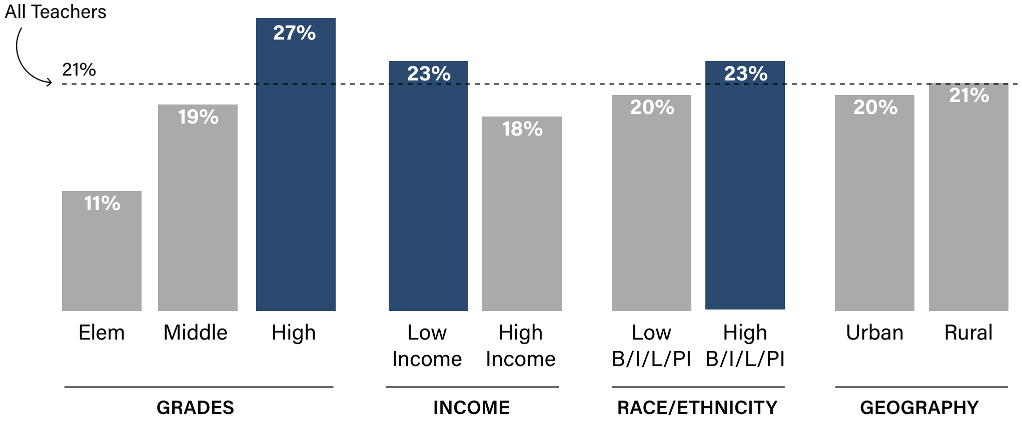


Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

Engaging Students to Pursue Computer Science

Concerns about student interest levels in computer science were also reported by teachers, with 21% of respondents identifying it as a challenge. The proportion of teachers who identified lack of student interest as a major challenge incrementally increased with grade level and at lower income schools. Differences, while smaller, also existed in the rates of teachers who reported lack of student interest as a major challenge in schools with greater proportions of Black, Indigenous, Latinx, and Pacific Islander students and rural areas (Figure 15). Additional data revealed only 57% of teachers believed they would be able to influence students who showed low interest in computing.

Figure 15. Percent of Teachers Challenged by Lack of Student CS Interest, by School Profile



Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

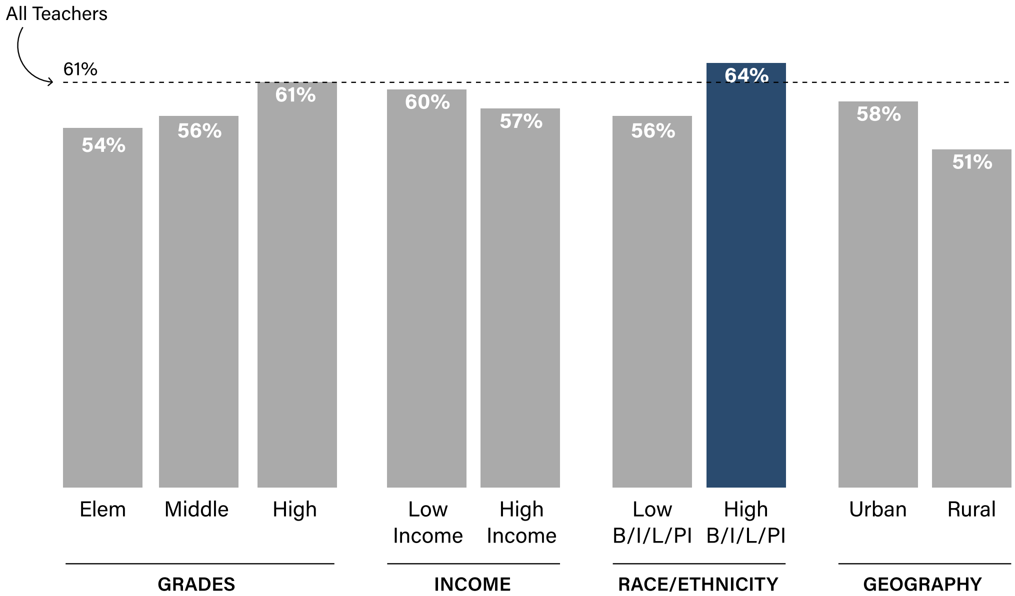
When teachers were asked an open-ended question about what they felt were key barriers to computing participation among Black, Indigenous, Latinx, and Pacific Islander students, 14% of teachers identified students' sense of belonging in computer science as a challenge. Teachers, for example, described students as "not feeling invited/included" and "not seeing themselves in the field." Nine percent of teachers believed students' confidence in their ability to do the work in class were factors in reduced participation rates, sharing, for instance, "they don't think they can do it" and "they feel intimidated." These findings demonstrate the need to ensure teachers are equipped to coach, encourage, and motivate students to increase engagement.

Teacher Perceptions of Inequity in Computer Science

Evidence continues to grow that inequities are embedded in our technological systems. However, a divide exists in how teachers view whether those issues related to these systems should be discussed in their classrooms. Survey responses highlighted disagreement among teachers about the importance of covering computing's role in perpetuating biases related to racism, sexism, and other inequities in the classroom. Moreover, teachers' own perceptions of barriers to participation among Black, Indigenous, Latinx, and Pacific Islander students demonstrate a crucial need for teachers to examine their own mindsets, perceptions, and practices that uphold systems of oppression.

Only 61% of teachers across school profiles believed topics of inequity should be covered in their computer science class. A greater number of teachers were reticent to discuss topics of inequity in elementary schools, higher income schools, rural areas, and schools with a small proportion of Black, Indigenous, Latinx, and Pacific Islander students (Figure 16).

Figure 16. Percent of Teachers Who Think Inequities Should be Discussed in CS Classes, by School Profile



Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

Qualitative responses from teachers also showed that 8% of teachers perceived a lack of family support as an issue to participation among Black, Indigenous, Latinx, and Pacific Islander students. These responses primarily reflected a deficit model with responses such as, "[there is a] lack of support at home due to broken families, incarcerations, negligence, irresponsible lifestyles," "intellectual disabilities," "poor support systems in the family," and "these groups have no barriers other than the ones they bring from their culture."

These responses suggest a crucial need for professional development to provide teachers with space to authentically explore the role that they play in perpetuating the various systems of inequity within schools, build competencies to interrogate power and privilege in society alongside their students, and develop culturally-relevant pedagogical practices. Discussions about the role of race, culture, nationality, ethnicity, institutional and structural racism, white supremacy, and privilege are essential to the development of critical consciousness. It is imperative for teachers to develop these skills in order to then facilitate meaningful conversations among students. It is imperative for teachers to develop these skills in order to then facilitate meaningful conversations with students.

To what extent are effective culturally-relevant CS teaching practices currently reflected in PreK-12 CS classrooms, and what are the challenges faced by teachers?

There is growing evidence that integrating rigorous, culturally-relevant content is essential for the development of computational competencies and computing identities in students. Moreover, current events have continued to illustrate the need to develop students' critical consciousness to challenge the systems and structures that perpetuate inequities within computing fields. When students are presented with pedagogical practices that (1) connect computing to students' lived experiences, (2) create opportunities to critically analyze community-based problems that can be solved using computing, and (3) value student voice and choice in the classroom, there is evidence that greater engagement and learning take place, especially for students who have been traditionally underrepresented or marginalized.

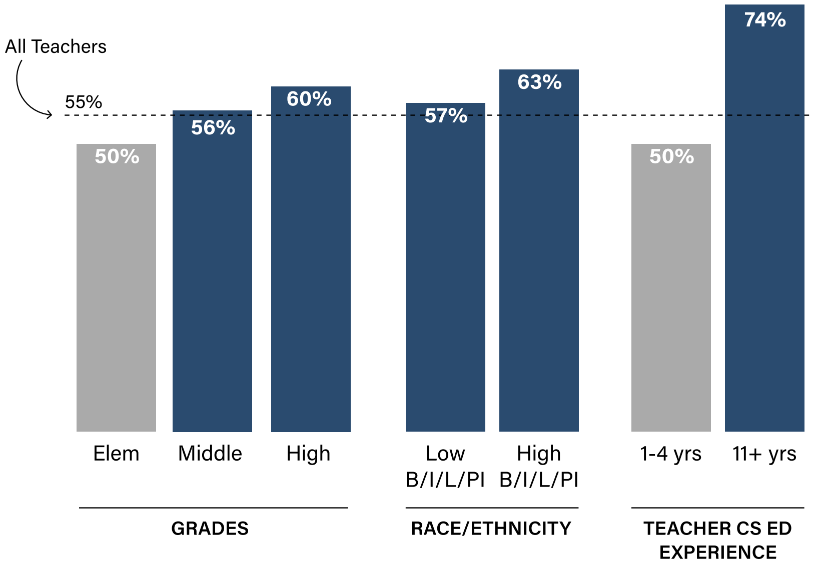
An approach used in computing classrooms to center these practices is project-based learning, which enables students to learn computational thinking. Yet, data revealed that not all classroom curricula are effectively engaging students in this manner nor do computer science teachers feel equipped to lead culturally-relevant pedagogical practices.

TEACHERS' PERCEPTION OF EXISTING CURRICULA

In computer science classrooms, 65% of teachers believed that existing curricular resources met the needs of a diverse student body, with little perceived difference across teachers in varying grade levels, student body composition, income levels, and geography. When data were then analyzed to assess curricular alignment with culturally-relevant pedagogical practices, teachers reported misalignment to varying degrees. While 71% of teachers perceived current curricula unpack the role of computing in society and 76% believed current curricula include project-based learning experiences, only slightly more than half (53%) felt that current computer science content is culturally-relevant and aligned to student interests.

Given this gap between student interests and computing content, 55% of teachers found themselves having to revise existing curricula to make it more engaging and relevant. A greater proportion of teachers in high school settings, in schools with a high percentage of Black, Indigenous, Latinx, and Pacific Islander students, and those with greater computer science classroom experience were likely to revise curricula in comparison to their counterparts serving younger students, in schools with a low percentage of Black, Indigenous, Latinx, and Pacific Islander students, and earlier in their computer science teaching careers (Figure 17).

Figure 17. Percent of Teachers Revising Curricula to Engage Students, by School Profile



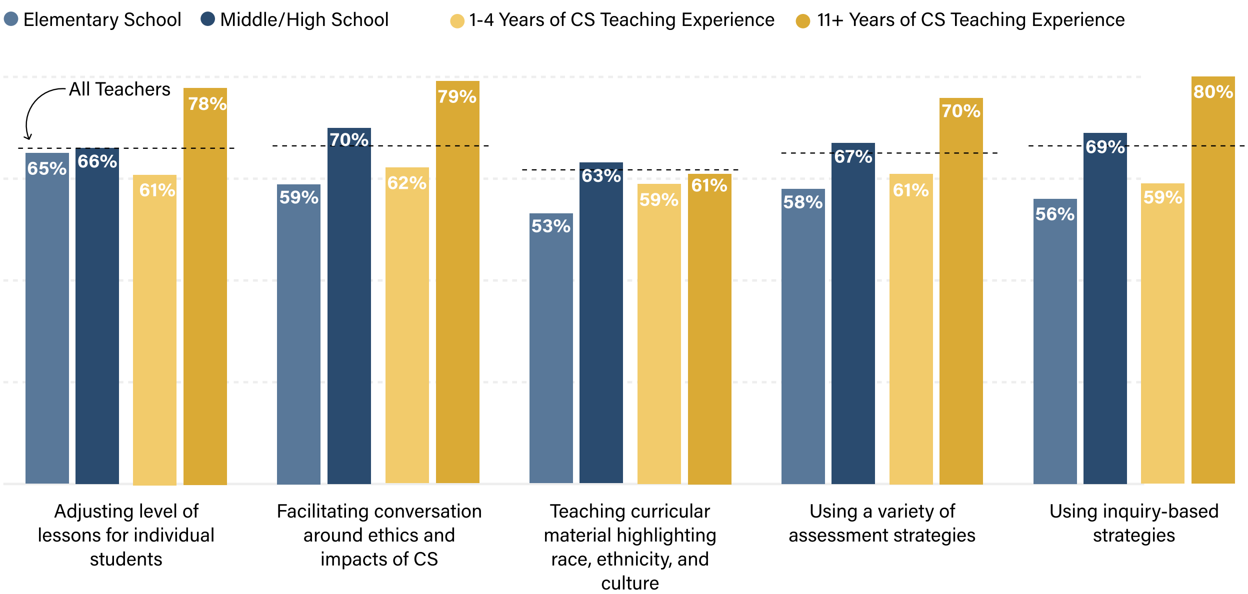
Note: Blue represents any teacher sub-category percentage that falls above the overall percentage.

Qualitative responses showed that teachers modified lesson plans primarily to make material more aligned to student interests and adapted curricula to meet the students who have had more or less exposure to the learning content. To align curriculum to student interests, one teacher described changes as follows, "Some of the lessons use old sayings or phrases or refer to older music or celebrities that my students don't know or understand." Another teacher noted, "Creating coding projects that are relevant to current events and the culture of the area...I have used local attractions in my town and state, as well as popular singers and their songs." Teachers also differentiated their lessons for students' varying previous experiences by, for example, "utilizing different learning platforms to engage students of varying skill levels," or adjusting the degree of challenge, as stated by one teacher, "I create three versions (levels) the students can choose from, and students are required to explain in writing how it works and challenges/ opportunities they experienced."

TEACHERS' CONFIDENCE IN CULTURALLY-RELEVANT PEDAGOGICAL PRACTICES

In addition to improving curricular alignment to culturally-relevant pedagogy, teachers also reported a need to gain confidence in culturally-relevant pedagogical practices. Fewer than two-thirds of teachers indicated they felt confident enacting specific practices tied to culturally-relevant pedagogy. While 77% of teachers acknowledged the importance of incorporating diverse cultures and experiences to the success of their students and 72% felt confident teaching students from diverse backgrounds, only 57% of teachers felt equipped to utilize culturally-relevant pedagogical practices to support student learning in their classrooms. Further analyses by school and teacher profiles identified a lower proportion of teachers in elementary schools and those early in their computer science teaching careers were confident enacting these practices as compared to those teaching older students and those with greater tenure in computing classrooms (Figure 18).

Figure 18. Percent of Teachers Confident in Culturally-Relevant Pedagogical Practices, by Grade Level and CS Classroom Experience



There were also differences in confidence using computer science curricular material highlighting race, ethnicity, and culture by the demographics of teachers. Concerningly, despite making up the majority of the computer science teacher workforce, only 59% of white teachers (compared to 67% of Black, Indigenous, Latinx, and Pacific Islander teachers) were confident utilizing material highlighting race, ethnicity, and culture. In qualitative responses, one teacher shared, "As a white person, I struggle with connecting CS to diverse cultures. I allow for personalization and encourage kids with the 'you be you' mentality, but I still struggle with knowing how they may learn or connect differently." Another shared, "I don't know what underrepresented kids might see as more relevant. I also struggle with getting them to be motivated about computer science, so I would add some things that might motivate them more (I just don't know what that is, yet)." As summarized by another teacher, "There is a lack of teachers who are prepared to teach students of color both academically and non-academically." Teachers' lack of confidence in this area can negatively impact utilizing material highlighting diversity, which is a disservice to students' academic progress. Not only will students have a narrower perception of who belongs in the field of computing, but it will also inhibit their ability to critically analyze bias in technology.

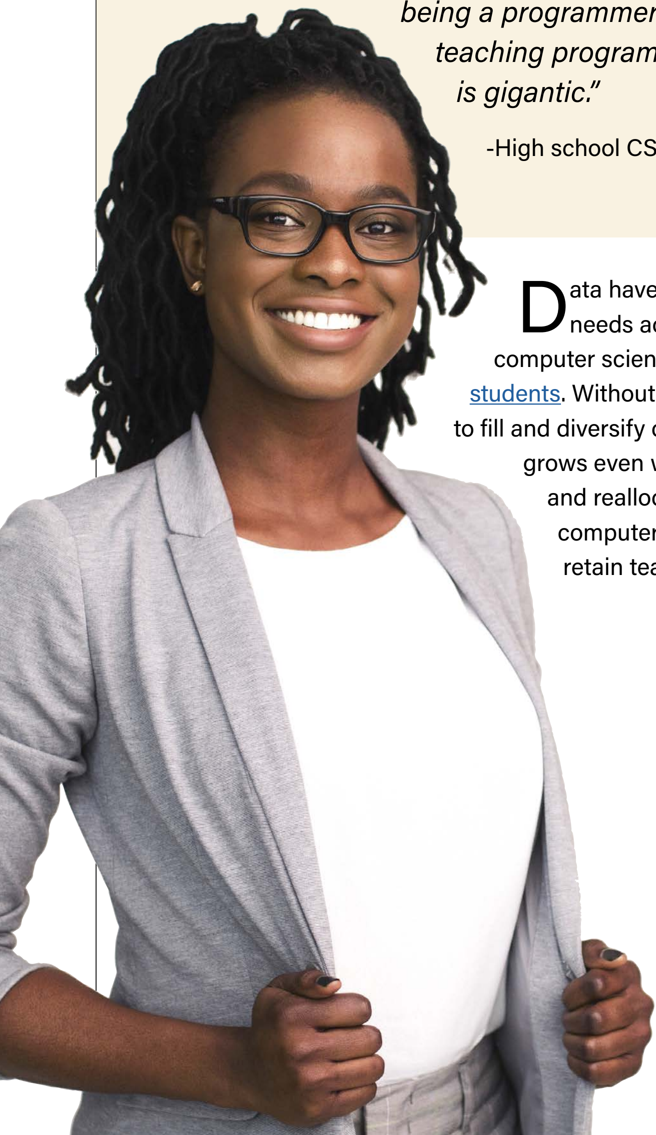
What are the recommendations for policy and practice to support PreK-12 CS teachers build equitable and inclusive classrooms?

This report demonstrates that a lack of access to resources, limited participation in professional development opportunities, and gaps in confidence to adapt computer science content and facilitate effective pedagogical practices to engage students are challenges to the deployment of equitable computer science education. These foundational disparities in computing education must be addressed, and are particularly urgent given the ways in which the COVID-19 pandemic is exacerbating resource gaps for already underserved schools and communities.

If the nation is to have a a well-informed citizenry and workforce trained for the jobs of the future, wherein students from every background can participate equitably in computing education, it is crucial to support all computer science teachers in having the necessary equipment, curricula, and training needed to enact equity-centered pedagogies. Therefore, the Kapor Center and the Computer Science Teachers Association put forth the following key recommendations:

RECOMMENDATION #1:

Develop Incentive Structures to Recruit, Retain, and Diversify the Pool of Computer Science Teachers



"The disparity in pay between being a programmer and teaching programming is gigantic."

-High school CS teacher

"Recruit, invest in, and empower educators of color who teach computer science. Pay them well so they don't leave to work in industry. Make computer science a hard to staff position just like Special Education and Math."

-Elementary CS teacher

Data have revealed the shortage in the computer science teacher pipeline to meet the needs across schools, particularly for those serving marginalized communities. Moreover, computer science teachers are predominantly white, despite the growing diversity of PreK-12 students. Without an incentive structure, particularly at lower income, racially diverse, and rural areas, to fill and diversify computer science positions, the gap for equitable access to computing education grows even wider. The development of incentive structures such as student loan forgiveness and reallocation of funding towards teaching roles that are difficult to fill, such as those in computer science, may ease the struggles that some schools currently face to recruit and retain teachers in computing education.

RECOMMENDATION #2:

Build Comprehensive Teacher Training, Certification, and Endorsement Programs Aligned to an Equity-Focused Computing Education Framework

"CS teaching needs to be recognized as a real subject with teacher prep programs just as they have for other subjects."

-High school CS teacher

"I am lucky to have a foundation in computer science. What has always been missing is colleagues, for much of my career I felt very alone, advocating year after year for changes that would address the underrepresented populations with no success. The idea that I solve the problem because I am a woman is not true or nearly enough."

-High school CS teacher

Despite the success of engaging underrepresented students in computer science with more culturally-relevant material, data showed that teachers lacked the confidence in both knowledge of computer science content and approaches to culturally-relevant computing to facilitate meaningful classroom experiences. State institutions should implement clear computer science teacher certification and endorsement pathways aligned to all five *CSTA Standards for CS Teachers*. The development of new computer science teacher preparation programs is critical to building a sustainable pipeline of PreK-12 educators who can support rigorous and inclusive instruction across a variety of computer science programs, including both standalone courses and integrated computer science, particularly at the elementary school level. Teacher preparation programs must be comprehensive and develop knowledge and skills in computer science content, pedagogy, and inclusive teaching practices. Developing an effective framework for teacher training models that strengthen their competencies in computing content knowledge and culturally-relevant student engagement strategies will be integral to building equitable computer education experiences for all students.[7]

RECOMMENDATION #3:

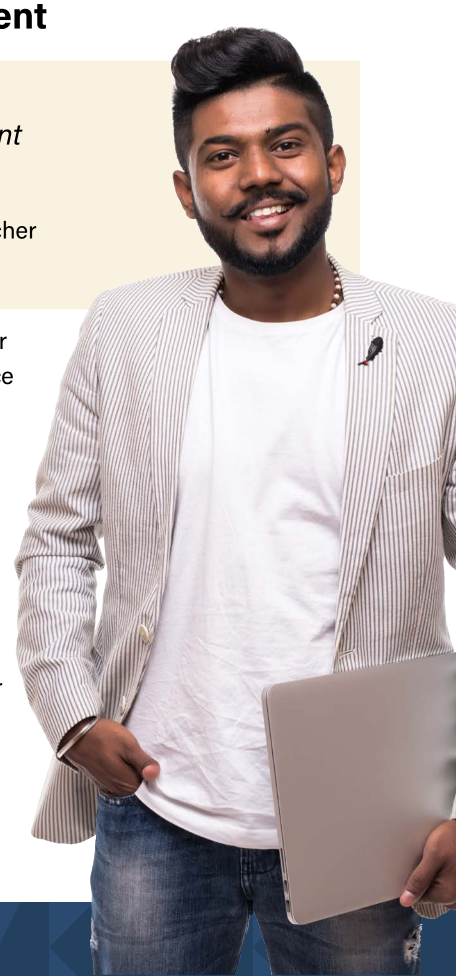
Expand Access to Ongoing Teacher Professional Development

"I would greatly appreciate more professional development opportunities. Hands-on, tried and true, classroom tested strategies, implementation, and content are invaluable."

-Middle school CS teacher

"Support us with professional development that does not cost."

-Middle/High school CS teacher



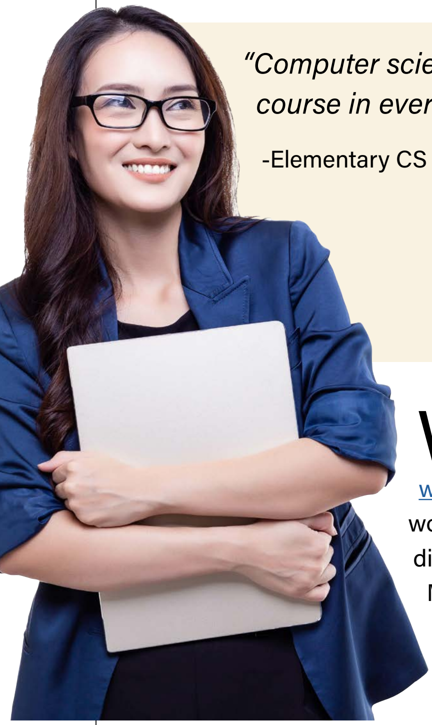
Research has shown the benefits of continuous learning, yet many research conferences and teacher preparation programs remain cost prohibitive to teachers. Because the majority of computer science teachers are still relatively new to teaching computer science, expanding access to free/low-cost training will ensure teachers stay updated on educational research and further develop their teaching practices.[8] Moreover, as schools struggle with the shift to virtual learning environments, budget cuts, and even greater competing demands on teachers' schedules, districts must also commit to investing in ongoing, job-embedded teacher development, including coaching and allocating scheduled time for professional learning communities. Further, because most computer science teachers are the only teacher of the subject at their respective schools, common collaboration structures such as departments often do not exist, creating a greater need for collaborative learning outside of the school in regional communities. These supports and learning structures are particularly crucial for early-career teachers, elementary school teachers, and those teaching in historically marginalized communities.

[7] A framework for culturally-responsive computer science education is currently under development at the Kapor Center via the Equitable Computer Science Curriculum Initiative.

[8] The CSTA Standards for CS Teachers can be utilized for goal-setting teacher development and to delineate what is required of teachers to effectively enable students to meet learning standards.

RECOMMENDATION #4:

Prioritize CS as a Core Course Across the PreK-12 Pipeline



"Computer science needs to be a required course in every school at every age."

-Elementary CS teacher

"The subject must be treated as another "core" subject. Students pick up on how courses are considered merely "elective" or not as important as core subjects like Mathematics and English, despite the fact that computer science requires serious effort in both of those areas."

-Middle/High school CS teacher

With school performance metrics reliant upon standardized testing in mathematics, reading, science, and writing competencies, computer science remains deprioritized in many schools. Yet, the workforce of the future will be driven by computing across all sectors. In order to fill roles in this future workforce, computer science must be offered across all schools and must be adopted as a foundational discipline, similar to other core academic content areas, for high school graduation and college entry. Moreover, if students are expected to develop mastery in computing content, course delivery must take place at younger grades in order to expose students to content in a developmentally-appropriate manner. Lastly, state-level computer science standards development must be prioritized in order to give content consistency across schools.

RECOMMENDATION #5:

Build a District-Wide Coalition to Champion an Equitable Computer Science Implementation Plan

"Administration should push the subject as a needed skill for our students. Opportunities for our students to shine in the field should not lie on the teacher alone. Administrators should know the importance of CS in education and be willing to throw money and time at making sure it happens in their schools."

-High school CS teacher

"My biggest challenge is a lack of support from administration in the district."

-Middle school CS teacher

District-wide buy-in is essential to championing an equitable computer science implementation plan. Building a coalition of stakeholders from across the school district, including school leadership, teachers, parents, and students will ensure collective decision-making, adequate resources for successful school-wide implementation, the development of community partnerships, and participation. When districts show a collective commitment in prioritizing computer science for their students, only then will effective actions be taken to develop computer science programming within schools, such as allocating budget and time for teacher professional development, investing in resources for classrooms, and messaging the importance of computing pathways to students and families.

Conclusion

The systemic exclusion of Black, Indigenous, Latinx, and Pacific Islander communities from the technology sector not only exacerbates wealth inequality, but also limits the voice of these communities in important decision making regarding why technology is created and how it is used. **Computer science education must be redesigned to bring culturally-relevant practices into the forefront, to build a computing pipeline that reflects the communities it serves, and to ensure a more equitable creation of technological products that impact more people in meaningful ways.**

While student mastery over computing content is important, computer science courses must concurrently build students' capacities to engage with varying social and cultural perspectives, allow students to think critically about the implications of technology through voices that have historically been marginalized, and empower students to build more ethical and inclusive innovations.

For successful implementation of this new vision of computing education, schools will need a well-prepared and thoroughly-supported computer science teacher workforce. However, this study demonstrates the ways in which computer science teachers still perceive a lack of support, insufficient preparation, and limited resources to effectively engage students to develop this critical lens. Through strategic, long-term investments in the computer science teacher workforce with a goal of increasing teacher recruitment, enhancing teacher preparation in culturally-relevant practices, and providing necessary classroom resources, the nation will be better prepared to develop a workforce of the future that can reimagine and reshape the technology sector to be more socially just.

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Appendix 1: Definitions

Computing and Computer Science: Computing is a broad term defined by the Association for Computing Machinery as "any goal-oriented activity requiring, benefiting from, or creating computers... including five sub-disciplines of computer science, computer engineering, information systems, information technology and software engineering." Computer science is defined by the Association for Computing Machinery as the "study of computers and algorithmic processes, including their principles, their hardware and software designs, their implementation, and their impact on society." The terms computing and computer science are used interchangeably throughout this report.

Culturally-Relevant Pedagogy: A model for teaching that focuses on: (1) student learning and academic success, (2) assisting students in developing positive social and cultural identities, and (3) supporting students' abilities to recognize and critique societal inequities.

Low B/I/L/PI and High B/I/L/PI Schools: While the term "underrepresented minority" or "URM" has often been used to reference the collective low participation rate among Black, Latinx, and Indigenous people within STEM, this report has shifted to naming the specific groups explicitly to recognize their unique experiences, challenges, and needs within computer science education. With space restrictions in charts, the first letter of each racial/ethnic category was used to identify the reference groups. Schools with the lowest (less than 25%) and highest (more than 75%) proportion of Black, Indigenous, Latinx, and Pacific Islander students were categorized under "low" and "high," respectively. These racial/ethnic groups are underrepresented in computing education, degree completion, and the tech workforce, relative to their percentage of the U.S. population.

Low-Income and High-Income Schools: The socioeconomic demographics of schools are determined by the percentage of the school's student population who qualify for Free/Reduced-Priced Lunch (FRPL; through federally-determined poverty guidelines) from the National School Lunch Program. "High-income" was defined as 0-25% FRPL and "low-income" was defined as 76-100% FRPL, consistent with the National Center for Education Statistics.

Urban/Rural Schools: Counties with less than 50% of the population living in rural areas are classified as urban; counties with greater than 50% living in rural areas are classified as rural (Census, 2010).

Appendix 2: Survey Methodology

An online survey was distributed May through July 2020. The Computer Science Teachers Association and the Kapor Center recruited PreK-12 computer science teachers nationwide through multiple channels including member & partner emails, blog posts, targeted social media, and newsletters. Teachers from all 50 states participated, with the first 3,000 participants given an incentive choice of either a $10 Amazon.com gift card or a $10 CSTA conference discount.

The 63-item teacher survey contained seven sections: Teacher Demographics; School Demographics; Satisfaction with Computer Science Teaching; Instructional Practice; Satisfaction with Curriculum; Perceptions of Incorporating Culturally-Relevant Pedagogy; and Professional Development.

Quantitative reporting was based on frequency analyses. Analyses on 5-point scaled items were based on the percentage of teachers who reported a 4 or 5. Scaled items to identify challenges to teaching used a 3-point scale (Minimal, Intermediate, or Major Challenge), and reporting was based on the percentage of teachers who reported a "Major Challenge." Qualitative analyses were conducted using MAXQDA software, by coding and sorting open-ended responses into numerical categories to produce frequency reports based on themes.

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