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Computer Science for All: Opportunities through a Diverse Teaching Workforce

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Abstract

Leaders in education and industry have long emphasized the need for high school graduates to improve knowledge and skills in STEM fields. Given the immense impact of technology on both the domestic U.S. job market and the global economy in the 21st century, computer science preparation will be critical for students to achieve a strong education and gain the skills needed to pursue careers in cutting-edge fields. Access to quality computer science, particularly for low-income, Latina/o students, hinges on the recruitment and preparation of a diverse teaching workforce. This paper examines the current STEM educational landscape for all students, particularly Latina/os, as well as the career and college readiness opportunities that exist in computer science. In addition, this paper explores the need to recruit well-prepared, culturally competent teachers if we are to meet the demands for STEM knowledge and skills for the coming century.

Introduction

Computer science and technological innovations have rapidly and drastically changed nearly every aspect of our lives, making it increasingly necessary to acquire new computer science skills and understandings for academic and professional success. Thus, K–12 schools, particularly public schools, can no longer ignore computer science as a core discipline in the 21st century. Even for students who are not pursuing computing or other STEM-related careers, computer science offers students opportunities to increase critical thinking and problem solving skills, improve math and science performance outcomes, and to become producers instead of solely consumers of ever-changing technologies.

Changing the perception of computer science as an abstract, isolated field is essential to attract more students—particularly women and minorities—to technology. Showing that the profession plays an important role in solving significant, real-world problems is crucial. Computer scientists will play pivotal roles in partnering with other professions to solve almost all of our most imminent global issues including climate change and energy dependencies, healthcare and disease eradication, artificial intelligence and robotics, and issues within the humanities and the arts. Solving these pressing problems requires people who can integrate computing knowledge with other discipline-specific knowledge as well as being effective team members in multi-disciplinary and cross-cultural approaches.

Before we can educate all students in computer science and prepare them for these careers, however, we must first recruit and train diverse teachers in computer science. When President Obama announced his White House Initiative "Computer Science for All," he noted that teachers are the "most critical ingredient to offering computer education in schools." [1]

Without diverse teachers armed with both high level computer science knowledge and cultural competencies, our schools will not be able to prepare our students for a 21st century global economy. Moreover, as affluent and predominately White schools steadily integrate computer science education into their curricula, schools serving low-income students of color must also keep up. Without the proper resources and diverse teaching workforce to match this integration, this chasm will further exacerbate achievement and opportunity gaps.

Background

Computer Science Career Opportunity
As society becomes more dependent on technology, a student's understanding of basic technology knowledge, such as the use of social media or word processing software, proves inadequate.[2] Skills acquired in computer science education,

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as opposed to basic technology literacy, can be applied to many areas within STEM fields, which are necessary for maintaining scientific and innovative stature in the global market. The Bureau of Labor Statistics (BLS) projects that by the year 2020, 4.2 million new jobs will exist in computing and information technology in the United States, making these fields among the fastest growing occupations. Further, these jobs pay 75 percent more than the national median annual salary.[3] Moreover, according to BLS, Latinos will account for three-quarters of the growth in the nation's labor force by that same year.[4] With national focuses on STEM and STEM education, we must also distinguish the importance of computer science and the increase in computing jobs—67 percent of all new jobs in STEM are in computing; yet, only 8 percent of STEM graduates major specifically in computer science.[5] Finally, the wide range of jobs requiring computing professionals varies—two-thirds of computing jobs are in sectors outside information technology. Computational skill continues to prove necessary for schools to prepare students, regardless of their ultimate field of study or career path. Ironically, as the role of technology in our society has increased, computer science education in our K–12 school systems has declined, or never started.

Despite the drastic need for computing skills, only one in four schools teaches computer programming, with lower-income students and students of color having the least access.[6] Further, even when schools offer computer science education, evidence exists that it often lacks the core elements in its coursework—programming and coding. According to recent studies by the Computer Science Teacher Association (CSTA), computer science courses have decreased by 17 percent since 2005 and made up only 30,000 of the 3.2 million Advanced Placement (AP) tests taken in 2013.[7] Only 14 states have adopted computer science curriculum standards to any significant degree. Even more startling, 14 states do not include any computer science standards in their curriculum. In 29 states and the District of Columbia, computer science can count towards math or science requirements for high school graduation.[8] This number has risen from only nine states in 2013, primarily thanks to campaigns from non-profit organizations like Code.org; however, none of the 50 states require computer science courses as a condition of graduation. These statistics represent a significant burden within our education system influenced by nation and statewide focus on high-stakes testing in K–12 education.

Across the United States, much of K–12 education has become preoccupied with high-stakes test scores and curricula that can ensure success on such tests. School systems have "allowed [their] instructional effectiveness to be determined by students' scores on tests that were never built to be determiners of school success."[9] Because schools are frequently evaluated almost exclusively on the basis of students' scores on these tests, disciplines outside of the scope of these tests—history, computer science, art—have been relegated to elective courses with little importance or funding placed on them. The burden placed on schools to ensure students perform well on tests primarily stems from the No Child Left Behind Act (2001) and only recently has been scaled down through the Every Student Succeeds Act (2015). The remaining burden to perform well all but assures that computer science will not garner significant resources without wide-scale educational reforms.

Improving STEM Outcomes

Targeting all students, not just those who will pursue postsecondary education or careers in STEM or STEM-related fields, will better prepare our children to face the challenges of a science- and technology-driven society. Career readiness and job market needs, however, are not the sole reason we must educate all students in computer science. Gaining a deeper understanding of computer science can help students develop problem solving and critical thinking skills that can be transferred to and/or integrated with other disciplines. Moreover, STEM classrooms present greater challenges for disadvantaged students, frequently low-income and of color. A majority of Latino youth does not receive an adequate education in math and science, which limits their academic success overall in K–12 and these challenges are compounded in the more demanding postsecondary education. The initial step in helping students achieve success in STEM and closing the achievement gap increasingly depends on K–12 math and science proficiency.

Computer science offers another opportunity to improve outcomes across the STEM fields. In one study by Brigham Young University, middle school students studying Bootstrap, a code-based curriculum to teach algebraic concepts, saw significant increases in understanding as evidenced by better math test scores after a few months. Teachers used students' excitement around gaming and aimed it toward mathematics and more advanced computer programming. Beyond simply expanding students' interest in math, Bootstrap proves to be among the first curriculum to demonstrate real improvement in students' algebra.[10]

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Diversity and Access to Computer Science

Minorities and women experience underrepresentation in computing and information technology careers, which can limit academic and economic success. Latinos make up only 7 percent of the computing workforce and Latinas (Latino/Hispanic women) only 1 percent.[11] Recent reports from leaders in the technology industry, including Facebook, Google, and Apple, focused heavily on the lack of representation of women and people of color and many companies have committed to recruiting more of a diverse workforce. These companies have even committed to funding STEM education to better prepare underrepresented students for these careers.[12] Since 2000, the total number of bachelor's degrees and the number of STEM-related degrees rose for all racial and gender groups, except in computer science. According to the National Science Foundation (NSF), women received only 18 percent of bachelor's degrees in computer and information sciences, and Latinos accounted for only 8 percent of undergraduate degrees in 2013.[13] Success in computer science degree programs and related careers requires substantial pre-college education and skills development, particularly in mathematics and science. A lack of proper preparation and encouragement at the middle school and even elementary levels continues to result in a lack of interest in computer science programs further along in the education process. Women who enroll in Advanced Placement (AP) Computer Science in high school are ten times more likely to major in it in college, and Latino students are seven times more likely.[14] Despite these statistics, in 2014, only 20 percent of AP Computer Science test takers were women, even though women represented 57 percent of all AP test takers. Further, in 2013, only 3.7 percent of AP Computer Science test takers were black and 8.1 percent were Latino.[15]

Compounding the issue of lack of diversity is the fact that learners from low-income communities and underserved minority groups still are less likely to have access to computers and cable broadband—as opposed to cellular—and have fewer people in their social circles with the skills to support technology-based learning at home.[16] Due to the lack of access to technologies and technology education, too many young people will go through school without fully developing the skills that give them a fair shot in the digital age or the exposure to role models or mentors who can inspire a future in the technology fields.

A recent study by the Pew Research Center found that more than half of teachers in low-income communities said that their students' lack of access to online resources at home presented a major challenge to integrating technology into their teaching.[17] Moreover, these low-income communities are disproportionality Black and Latino, meaning that the digital divide—gap between demographics that have access to modern information and communications technology—further exacerbates educational opportunity gaps. According to a report by Google, Inc., Latino students are less likely than White or Black students to both use computers at school daily and have exposure to computers with broadband access at home. One in four Latino students does not have a computer at home that they can use to access the Internet, compared with only 2 percent of White students.[18] For students in households without broadband,[19] simply completing homework and applying for a scholarship or admission to postsecondary education creates a challenge. While low-income families adopt smartphones with Internet access at high rates, a phone is not sufficient for researching and typing a paper, let alone applying for jobs or colleges. Not only are students who lack broadband access at home struggling to stay ahead of the digital divide, their lack of access is holding our education system back as educators struggle to teach in classrooms with such uneven family resources.

While schools have less control over exposure to technology at home, ensuring that all students have access to computer technology at school is vital to providing the technological foundation for computer science learning. However, over 40 million students in K–12 public schools remain behind the learning curve of technology and its ever-changing implications. Today, 63 percent of schools do not have enough bandwidth to meet the current needs for digital learning.[20] Through efforts from the White House initiative, ConnectEd, FCC's E-rate modernization, and state's public-private partnerships, schools are closing the connectivity gap but low-income schools still remain behind. Access to computers and other technologies, however, simply does not do enough to close the digital divide. Low-income, students of color are less likely to have access to computer science learning opportunities in school as well as at home or in their neighborhoods. According to Professor Linda Darling Hammond, "today's students will need to use a variety of technologies in their future lives as workers and citizens, thus schools must play a role in closing the gaps in access to this knowledge represented by the current 'digital divide' in home and community access."[21] As affluent, mostly White schools integrate computer science into their

The alarming lack of diversity in the teacher workforce and its negative impact on student achievement is an issue that demands national attention and real solutions. Though Latino children are almost one in four students in our country's public schools, Latinos represent only 8 percent of the teacher workforce.[25]

curriculum, schools serving low-income and minority students must provide quality computer science education—with well-prepared, highly skilled, diverse teachers—so as not to exacerbate further opportunity and achievement gaps both in STEM and non-STEM related subjects.

High-Tech and Non-Profits

Because many high-tech corporations, including Google, Facebook, and others, see market advantages in supporting computer science education, many grants, funding, and research for these programs come from the technology industry. Creating coalitions with the tech industry can help serve computer science educators and advocates in various ways. They can provide funding and research, access to innovative, new technologies, and have influence over policymakers that the general public and educators may not have. These public-private partnerships, however, can cause further imbalances in educational opportunity and equity. As for-profits entities pour private equity into public education, educators may potentially lose autonomy in the classroom and discretion over curriculum. Moreover, these partnerships may become another move toward the privatization of education. The bottom line for these private corporations resides in gaining profits, which is in tension with the funding principles of equitable, democratic education.

Non-profit organizations like CODE.org, Girls Who Code, and Black Girls Code have made it their mission to provide computer coding education to all students, have developed curricula, and are attempting to "reach gender parity in computing fields."[22] By providing resources and technology education to girls in schools, libraries, and community centers, these organizations are attempting to mitigate the increasing racial and gender gaps in STEM careers. Though these organizations are showing encouraging results, K–12 schools must shoulder the responsibility for educating all students in computer science skills to ensure proper preparedness. Because of negative perceptions, stereotypes, and an unwelcoming technology culture, female students and underrepresented minorities are less likely to seek out afterschool computing clubs or summer computing camps. Formal computer science education pathways, particularly within public schools serving underrepresented minorities, are the best chance to broaden participation in computing. In order to properly integrate computer science into K–12 schooling, states must commit to recruiting, preparing, and retaining a diverse, culturally competent teaching workforce.

Computer Science Teacher Preparation and Retention

Currently, teacher preparation programs within the United States lag behind other countries in recruiting high-achieving students and maintaining rigorous standards for admission and completion. Across the teaching profession spectrum from early childhood programs through doctoral programs, policymakers, educators, and community members demand better teacher preparation for teachers to increase student achievement and education quality across school systems, colleges and universities. Within these conversations, including computer science and technology classes for all teachers is necessary for our technology-driven education and economic systems. By requiring technology classes, especially for all K–12 teachers, preparation programs can encourage students to become computer science educators and give them the skills necessary for certifications.

Students who have interest in becoming computer science teachers lack the support and clarity for entering and completing teacher preparation programs and acquiring certifications. Within teacher preparation programs, many states do not have a clear definition or understanding of the field of computer science and exhibit a tendency to confuse it with other subject areas such as educational technology or even the use of computers to support learning in other subject areas.[23] Without explicit programs for training computer science educators, interested students can get lost in the confusion and move on to other computing fields, where they can often make more money.

According to a CSTA report, current computer science teachers indicated that the on-going battle for adequate resources, the lack of acceptance and understanding of computer science as a scientific discipline distinct from technology training, and increasing budget cuts in these times of fiscal restraint deterred many interested and qualified teachers from teaching computer science.[24] Little motivation exists for those with the requisite skills to pursue a career teaching high school computer science. In most cases, teachers' salaries are much lower and the working conditions more challenging when compared to other career fields, making it impossible for education to attract individuals with the appropriate skills. Even for those who consider a second career in computer science education or for whom salary issues may not be a primary factor, the lack of consistent and readily available information concerning certification requirements make it almost impossible to determine how one should go about preparing for such a career change.

Diversity in Teaching Profession

The alarming lack of diversity in the teaching workforce and its negative impact on student achievement creates an issue

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that demands national attention and real solutions. Though Latino children are almost one in four students in our country's public schools, Latinos represent only 8 percent of the teacher workforce.[25] Shortages of teachers of color can be linked to limited recruiting by universities and the lack of proper funding to Hispanic Serving Institutions (HSIs), and other minority serving institutions. Currently, HSIs award approximately 90 percent of all teacher education degrees earned by Latinos.[26] Moreover, though research and policies have focused on substantially increasing the numbers of teachers of color, high levels of attrition offset these successes. While the lack of proportional diversity exists in several professions, because teaching increasingly focuses on leading a largely black and Latino student population to succeed academically and socially in a predominantly White society, race matters so much more.

Research clearly shows the impact of teacher diversity on student outcomes. According to a report from the Center for American Progress, when Black students had teachers of color,[27] fewer were placed in special-education classes, suspended, or expelled and more were placed in gifted and talented programs and graduated from high school. Teachers of color are also known to be personally committed to the success of children of color.[28] They affect a wide range of student academic outcomes serving as powerful role models for all students, and proving that teaching can be a viable career for people of color. In addition, teachers of color are more likely to work and remain in high-poverty, hard-to-staff, urban schools and districts than their White counterparts.[29]

Diversifying the race, ethnicity, and gender of the teaching field will impact the nation's schools by shaping perspectives, curriculum, and school culture in a transformational way that raises expectations for student learning and improves school climate. The Shanker Institute reports that, "minority students derive academic benefits from having access to demographically similar teachers," on a variety of outcomes, including increased test scores, graduation rates, college matriculation rates, school attendance, and enrollment in academically demanding classes.[30] Racially diverse teachers also provide culturally relevant perspectives for all students, not just students of color, which is just as important in fostering a better understanding and appreciation for diversity.

Preparing Teachers in Cultural Competency

A diverse teaching workforce is not enough to bridge the cultural and linguistic gaps that a growing number of educators struggle with to better serve students in response to dramatic demographic changes that have created culturally diverse schools. Moreover, this cultural gap between students and their teachers often factors into students' academic performance and contributes to achievement and opportunity gaps among different student groups. To close this cultural gap, teachers must be trained and well-versed in cultural competencies—the skills and awareness related to issues such as culture, language, race, and ethnicity. Professor Gloria Ladson-Billings states that cultural competence is present in classrooms where the teacher "understands culture and its role in education… takes responsibility for learning about students' culture and community… uses student culture as a basis for learning… [and] promotes a flexible use of students' local and global culture."[31] Students of color, and Latinos in particular, experience vast cultural and linguistic gaps between their home and school lives. Teachers must be well-prepared to help students mitigate the challenges in bridging these gaps. Referred to as "equity pedagogy," teachers need to be prepared to employ methods and materials that support the academic achievement of students from diverse groups. However, building equity pedagogy is not necessarily as simple as enrolling in a single "diversity" or "multicultural education" course. Rather, teachers must examine how culture shapes all aspects of teaching and learning—including considerations of curriculum, assessment, learning materials, instructional strategies, classroom management, school conditions, community circumstances, and even one's understanding of the subject matter itself.

Culturally responsive teaching is a pedagogical strategy constructed to engage culturally and linguistically diverse youth. Unlike deficit thinking which faults students' personhood, communities, backgrounds, and families therefore assuming "the solutions for improvement or reform are beyond the teachers" and school systems, culturally responsive teaching views these factors as assets on which learning can occur. Culturally responsive educators develop and openly demonstrate their own cultural competency about students' identities, use this knowledge as the foundation on which to build lessons, develop meaningful and sustainable relationships with students predicated on the notion that they will succeed, and maintain a heightened sensitivity to the school's sociopolitical context as a place that can emancipate or oppress.[32] Building on this framework, culturally responsive computing seeks to both diminish the separation between the worlds of culture and STEM and to ensure technology responds not only to identity issues, but also satisfies pedagogical demands of the curriculum.[33]

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Existing Policy and Initiatives

STEM Education Act of 2015
This bill, signed into law in October 2015, strengthens efforts at the federal level to ensure that computer science skills are included among STEM subjects. The STEM Education Act expands the definition of STEM to specifically include computer science to encourage students to study these subjects and train more teachers in the field. Further, the Act directs the NSF to continue to award competitive, merit-reviewed grants to support informal STEM education—work that takes place outside of the classroom at places like museums, science centers and afterschool programs.

The Act also amends the NSF Noyce Master Teaching Fellowship program to allow teachers in pursuit of master's degrees to participate in the program, which will allow more teachers the opportunity to compete for the grants, and requires that computer science be officially added as a subject for the scholarship program. The Act also mandates federal financial support for developmental activities, including research and development that improves understanding of learning and engagement in informal environments, as well as engagement for elementary and secondary school students, teachers, and the public.

Every Student Succeeds Act (ESSA)
When the President signed the Every Student Succeeds Act into law on December 10, 2015, it replaced the thirteen-year-old "No Child Left Behind" legislation as the nation's major K–12 education law. The Act massively broadens state-level access to federal funding that can be utilized to support STEM education activities both in and outside the classroom. The Act contains more than a dozen significant STEM provisions that support professional development in STEM subjects and the establishment of a STEM Master Teacher Corps. Notably, computer science was included with other core subjects, such as writing, science, and mathematics, in ESSA's definition of a "well-rounded education."

Title II of ESSA also pertains to teacher quality programs and state grants for teacher preparation programs. The new bill includes provisions that would allow states to set up new degree-granting academies for teachers outside of traditional higher education systems and encourages the creation of residency programs, in which teacher recruits are paired with veterans for a year of in-classroom training in addition to their coursework. In theory, these provisions could attract more teachers, but critics worry that public money will support teacher preparation programs that are not held accountable. Worse, lower standards for teacher education programs that prepare teachers for high-poverty schools.

The framework for K–12 education policy starts with the federal government through ESSA, but this is only a framework as most decision-making on policy is vested in the state and local level. For example, while the U.S. Department of Education distributes billions of dollars in education aid across the United States, it cannot tell states specifically what courses to teach or how to teach them. Additionally, the current divisive political orientation at the state level focuses on the local control of schools and the rejection of federal influence on curriculum and teaching methods.

White House Computer Science for All Initiative
On January 30, 2016, President Obama announced his Computer Science for All Initiative that recognizes that computing is a "new basic" skill necessary for economic opportunity and social mobility and hopes to build on the effort of a growing movement led by parents, teachers, states, districts, and the private sector to expand computer science education. This Initiative will provide $4 billion in funding for states, and $100 million directly for districts to increase access to K–12 computer. The funding will allow more states and districts to offer hands-on computer science courses across all of their public high schools, get students involved early by creating high-quality computer science learning opportunities in elementary and middle schools, and ensure all students have the chance to participate, including girls and underrepresented minorities. In addition, with more than $135 million in investments by the NSF and the Corporation for National and Community Service (CNCS), the Initiative seeks to properly support and train teachers—the "most critical ingredient to offering computer education in schools."[34] This initiative, among others, shows President Obama's investment in computer science education and the critical need to prepare our students in emerging technologies but further policies are necessary for nationwide integration.

Problems with Existing Policy

Many reasons exist why computer science education has not been more adequately implemented into our education system. Given today's dependence on technology, few educators and policymakers argue against computer science education. However, creating policies and properly implementing this coursework engenders many questions such as: Where do we get the resources? How do we properly prepare teachers? How do we stay up-to-date with rapidly advancing technologies? The high ambiguity in the implementation of

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computer science education makes policy difficult to implement in practice.

Though several national and international organizations have created technology content standards, most U.S. states do not have well-defined computer science standards. Without these standards, computer science curricula frequently lack the necessary components—primarily learning to code—and instead focus on more basic aspects like computer graphics and creating template-based websites. In a Google study, only 53 percent of the computer science opportunities offered in schools included computer programming.[35] So even the students who have access to computer science often lack the essential elements to learn relevant skills. Computer science is not considered a "core" subject and its funding is frequently limited if not non-existent. Despite rollbacks in testing in ESSA, schools often cannot devote time and resources to teaching classes that are not evaluated by standardized testing measures and evaluation. Finally, despite a technology-driven economy and its continued inaccessibility in most schools, computer science is not considered a high-need subject, meaning there are few incentives to become a computer science teacher and few meaningful incentives for schools to engage in the cumbersome processes to change their graduation requirements.

Many teacher preparation programs do not include technology or computer science requirements, and the pathways for those that do want to become computer science teachers have no clearly designation. Both of the major federal education policies, ESSA and the Higher Education Act (HEA),[36] have specific provisions and regulations regarding teacher preparation and quality, but neither specifically mentions computer science in these contexts. Beyond federal policy, only a few states have pathways for teacher certification and preparation in computer science. When the New York City Department of Education unveiled a 10-year plan to make computer science education available in all public schools, Mayor Bill de Blasio cited training teachers as a particular challenge because "there is no state teacher certification in computer science, and no pipeline of computer science teachers coming out of college."[37] Moreover, states frequently have requirements that their own preparation programs cannot meet. In Florida, for example, computer science teacher candidates have to take a K–8 Computer Science methods course that is not offered in any teacher preparation program in the state.[38] Lastly, because computer science curricula are undefined and lacks standards, it is difficult for teachers to be fully prepared to teach and moreover, many of the current teachers often lack sufficient preparation to teach advanced and AP classes.

Recommendations

Define Computer Science

Though included among core subjects, states must create a set of computer science standards that inculcate excellence and clearly define skills and knowledge that students should acquire during their K–12 education. Curricular standards act as both aspirational and operational and serve to define the skills and knowledge of the discipline to be acquired by every student. Though many organizations including CSTA and ISTE have created computer science curriculum standards, states must create a set of well-defined K–12 standards that inspire and define computer science and can be adopted by all schools to ensure that students are receiving quality computer science education. Further, these standards must not be developed solely for secondary schools. Students should start receiving computer science training at a young age in order to build on their skills throughout their K–12 education, much like in mathematics.

In addition, states and local districts must update laws and regulations to allow students to count computer science courses toward their graduation requirements. Currently, only 29 states allow students to count computer science courses toward high school graduation.[39] Many computer science courses are counted toward elective credits for students' graduation requirements; however, these credits should instead count toward core graduation credits preferably in computer science or technology, but also in mathematics or science. Currently little incentive exists for students to take or for schools to offer computer science, because it is not considered a "core" subject. Further, schools are unable to introduce new courses or invest in current ones with their limited resources, because computer science is not a requirement.

Finally, computer science should be designated as a high-need subject, much like math and English as a second language. Though 67 percent of parents believe students should be required to learn computer science and the demand is highest among parents of low-income students,[40] low-income schools do not have the resources or teachers to provide this education. By designating computer science as a high-need subject, school districts and educator training programs can use funds specifically allocated for these subjects. Moreover, many scholarships, grants, and loan forgiveness programs, including AmeriCorps grants for Teach for America members and the TEACH grant, specifically target teachers teaching high-need

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subjects. In addition, alternative teacher preparation programs, that often recruit more diverse teachers,[41] require teachers to teach high-need subjects.[42]

Recruit and Prepare a Diverse Teaching Workforce

Teacher preparation programs and school districts must be purposeful and intentional about recruiting teachers from diverse backgrounds. Other industries, including the tech industry, actively recruit to ensure diverse, high-achieving candidates are considered and granted employment within their companies. Federal policies should provide incentives and funding for the states to address the high school computer science shortage by investing in teacher recruitment, preparation, and retention. By creating scholarships, grants, and student loan forgiveness programs as incentives, students from low-income backgrounds can study computer science and continue into teaching instead of choosing higher paying private sector jobs. Scholarships and grants that target students of color and women can generate further incentives for studying computer science. By ensuring science classrooms in universities welcome and support students of color and women and by changing perceptions of the computer science field, we can recruit and retain students within computer science and computer science education.

The computer science teacher shortage can also be addressed by exposing more pre-service teachers to computer science during their required coursework. Pre-service education technology courses could easily integrate computer science content. Students preparing to be mathematics, science, or broader technology teachers could easily become computer science teachers in many states if they were exposed to relatively minimal computer science coursework within teacher preparation programs. Further, by designating computer science as a high-need field, existing incentives for teacher endorsements in mathematics can be replicated for computer science teacher endorsements. Currently, teachers with Federal Perkins Loans—needs-based loans through the U.S. Department of Education—teaching high-need subjects, typically math, science, and ESL, can begin to cancel loans after just one full year of teaching and receive full loan forgiveness after five years of teaching in a low-income school.[43] The STEM K to Career Act [44] amends HEA to require the U.S. Department of Education to forgive student loan obligations of borrowers employed as full-time teachers of STEM in low-income elementary or secondary schools, but this bill is still in in legislative committee consideration. By forgiving these loans, students from low-income backgrounds—disproportionally students of color—have the opportunity to go into teaching without worrying about finding a higher income to pay unreasonable amounts of loans.

Finally, states should create competitive programs for educator training programs to encourage pre-service teachers to take computer science courses, integrate computer science content in education technology courses, or create specific methods courses to prepare computer science teachers. Furthermore, by targeting HSIs, and other minority serving institutions, states can ensure that schools of education are recruiting diverse cohorts and properly preparing them for computer science teaching. The shortage of Latino teachers correlates with the lack of funding for teacher education for the nation's HSIs serving the largest concentrations of Latino higher education students. By increasing funds to HSIs, their educator training programs can prepare larger numbers of Latino teachers for both computer science and other subjects. Though federal policies have limitations, Congress has introduced legislation to include computer science in teacher training programs. The Computer Science in STEM Act of 2015,[45] an attempt to amend current legislation, includes provisions that increase access to computer science teacher training programs and improves the teacher certification or licensure requirements and processes. While this bill awaits consideration in legislative committee, the public should consider that, if passed, it would help states create pathways for computer science educators.

Create Clear Pathways for Computer Science Teachers

By creating clear, navigable, and rewarding professional paths tied to content knowledge for computer science teachers, we can build and retain them. By first developing state certifications, more pre-service students can be better prepared to become teachers. As certification requirements become developed, existing teachers should be grandfathered into any new classifications. After clarifying the certification process, states should also incentivize partnership opportunities between local school districts and schools of education to create direct pathways for teachers into high-need school districts. In addition, computer science professionals should be encouraged to become teachers through expedited certification processes, ensuring that a transition to the classroom be as seamless as possible.

Career pathways represent critical strategies for recruiting and retaining quality teachers, not just within the computer science field. By first creating a clear pathway into the computer science teaching field and by ensuring that teachers have career ladders to lead and grow professionally, students and young professionals

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interested in computer science can go into teaching instead of being enticed into high tech private sector jobs. Moreover, states must invest in computer science teachers by providing competitive wages that compensate for highly skilled, culturally competent training.

Train Teachers in Cultural Competency

Teacher preparation programs must include training teachers in cultural competency no matter the content-subject matter. Because schools are becoming more and more culturally and linguistically diverse, teachers must be culturally aware and sensitive to the needs of each individual student. Given the excessive lack of representation in the technology sector and access to computing technologies, computer science education must be particularly designed to bridge access and opportunity gaps by incorporating real-world, culturally relevant curricula. Teachers should learn to design programs and curricula that take into account the Latino perspective on education issues, resources, and support systems in the communities. Teachers should be trained in culturally responsive teaching and culturally responsive computing. Programs like COMPUGIRLS, a free technology program designed for minority girls at Arizona State University, exemplify the extraordinary need and success in intersecting computer science with culturally responsive teaching. COMPUGIRLS aims to increase the number of women entering computer science fields by offering adolescent girls from under-resourced school districts a series of culturally relevant computer science courses. Supported by a grant from the NSF, COMPUGIRLS provides fun summer and after-school classes through which participants learn the latest technologies in digital media, games, and virtual worlds and become a voice for social justice and change in the world.[46] By supporting programs like these and using them as examples for increased culturally responsive computer science, we can train teachers to best support all students, primarily those from disadvantaged backgrounds.

Conclusion

Enhanced teacher preparation can both strengthen our national economy in the long-term and close opportunity gaps in STEM classrooms: 1) define computer science; 2) recruit and prepare diverse computer science teachers; 3) create clear pathways for computer science teachers, and 4) train teachers in cultural competencies, particularly STEM teachers. In adopting these principles, the U.S. can begin preparing and retaining a diverse teaching workforce who can solidify the critical understandings within computer science that will better equip students for 21st century life and careers. This report and recommendations herein prompt discussion and research for further changes. More recommendations surrounding computer science and technology education will arise as the landscape of computer science education remains opportune in this early part of the 21st century.

Endnotes

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45 HR 2057: This bill amends the America COMPETES Reauthorization Act of 2010 to include computer science in that Act's definition of "STEM" as the academic and professional disciplines of science, technology, engineering, and mathematics, which was included in the STEM Education Act passed in 2015. Moreover, the bill includes 1) programs to increase disadvantaged students' access to computer science courses, 2) computer science teacher training programs, 3) improved teacher certification or licensure requirements and processes, which were left out of legislation that has passed. This bill is currently in committee. The bill was introduced by Representative Tony Cárdenas, who is himself a Latino Congressman with a STEM background.

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