COMMENTARY

Optimizing for Equity in Computer Science Education

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Technology transforms nearly every aspect of our lives: the economy, the environment, health care, and our social lives. Today 92 percent of jobs across most industries require some form of digital skills, underscoring the importance of computer science (CS) for career and college preparation. But it's not just about jobs—it's about equipping students with critical thinking skills to examine the biased algorithms and the data sets they draw from, which could influence the way students think and make decisions about voting and social justice, as well as their own relationships and well-being.

Cultivating these critical skills with technology begins with K–12 education. While there is an urgency to meet this technological moment, it's essential that we build the systems necessary to sustain CS education that is equitable, accessible, and culturally relevant so that it will engage our most underrepresented students.

Despite an increased emphasis on technology and CS in the classroom, not enough attention is given to preparing teachers to teach these subjects, determining what students need to know and when, and importantly, to addressing the ethics and impacts of CS. The national Computer Science for All initiative is moving quickly to ensure access—and rightly so, given the current opportunity gaps in CS. As California considers bold statewide policy goals to keep up, it's important to recognize the challenges for schools to implement new policies in an existing unequal system of education.

As with many other K–12 initiatives, CS education opportunities are not fairly distributed, and they should be. Opportunities to learn CS fall along familiar persistent gaps that deny access for low-income, Black, Brown, and Indigenous students as well as for girls, youth from rural areas, and students with special needs. According to the Kapor Center, just 42 percent of high schools in California offer CS courses, and low-income and rural students are two times less likely to have access to this foundational learning. In our haste to right these wrongs with bold policy goals, I worry about exacerbating existing inequities. Critics argue that an incremental approach is too slow and the need is too great, but a wise investment in high-quality instruction and student engagement is our best hope for long-term change.

Five years ago, the governor, the legislature, and the State Board of Education approved California's Strategic Implementation Plan for Computer Science and CS standards, highlighting the importance of teaching CS and what it takes to build the necessary infrastructure. The state plan, developed by an appointed panel from the governor and the state superintendent of public instruction, set forth a blueprint to ensure that (a) all schools offer rigorous and relevant CS education equitably and sustainably throughout grades K–12 and (b) all teachers are adequately prepared to teach rigorous and relevant CS aligned with California's CS standards.

Building on California's progress to bring CS education to all students, State School Superintendent Tony Thurmond and Assemblymember Marc Berman introduced Assembly Bill (AB) 2097 this year, which would make CS a graduation requirement. The bill has since been scaled back to an earlier goal that all high schools just *offer* CS. While requiring CS for high school graduation remains a worthy long-term aspiration, California must work to ensure that all schools provide high-quality teaching and learning opportunities in CS as a precursor to a graduation requirement. If we increase access with more required CS courses but don't improve student interest and engagement by providing well-prepared teachers, certification pathways, a high-quality curriculum, and financial resources, policy "wins" like this could be a loss for students. Here, I offer seven key policy recommendations for state and local leaders to sustain high-quality, equitable CS education for all students.

Recommendations for State Policy and Local Actions

1 PROVIDE ONGOING, STANDARDS-ALIGNED PROFESSIONAL LEARNING FOR EDUCATORS

High-quality CS education hinges on preparing and retaining high-quality CS educators. Providing opportunities for current in-service teachers, school counselors, paraprofessionals, and school leaders is a hallmark of the Seasons of CS professional learning model replicated throughout the statewide system of support with funding provided by the California Educator Workforce Investment Grant. The grant—awarded to the University of California, Los Angeles (UCLA) and Computer Science for California (CSforCA), in partnership with the Sacramento County Office of Education and the Californians Dedicated to Education Foundation—has helped build the leadership capacity of nearly 1,000 educators across the state, but continued investment is needed to scale and sustain this program and provide ongoing support to teachers to keep up with the changing technology landscape.

2 REVISE THE CS STANDARDS FOR CALIFORNIA

California's CS standards were first introduced in legislation in 2014 and approved by the State Board of Education in 2019. During the intervening decade, CS has evolved. For instance, CS standards don't mention artificial intelligence because AI wasn't in the public consciousness at the time the standards were developed, as it is today. More emphasis needs to be placed on the ethics of technology, with a deeper understanding of the social, political, and economic consequences of biased algorithms and their impact on society. The national Computer Science Teachers Association is currently revising its CS standards, which could serve as a basis for California's own standards revision.

The state also never included a curriculum framework to help guide teachers with instructional content, but it's not too late to develop one. Furthermore, as the market for open-source curricular options increase, school leaders need principled guidance on vetting content providers and ensuring that accompanying professional learning is available with ongoing support for teachers.

3 EXPAND PRE-SERVICE TEACHER EDUCATION PROGRAMS IN SCHOOLS OF EDUCATION

In addition to continued funding for professional development initiatives for current in-service teachers, a longer term investment needs to be made to institutions of higher education to integrate CS into their pre-service teacher preparation programs. Several schools of education, within both University of California (UC) and California State University (CSU) campuses, are using federal funding to share best practices with one another and replicate the strongest elements of these programs by integrating computational thinking and digital literacies across disciplines. Programs like UCLA STEM+C3 and others offer the CS Supplementary Authorization to add to existing single-subject credentials. Funding from the Commission on Teacher Credentialing (CTC) is available to support teachers to get the Supplementary Authorization, but the per-teacher amount is inadequate, and the reimbursement process is difficult to navigate.

4 FIX TEACHER CREDENTIALING IN CS

California's teacher authorizations are confusing for school leaders trying to determine who is appropriately credentialed to teach CS. There is no single-subject CS credential and therefore no exam to test for content knowledge. Instead, CS can be taught by teachers with a single-subject credential in mathematics, business, or Industrial and Technology Education (ITE) or with other credentials plus a CS Supplementary Authorization. To add to the confusion, when the course is part of a career technical education (CTE) pathway, only a CTE teacher can teach it. To develop a more coherent system for teacher authorizations, a bill passed last year (AB 1251) to convene a workgroup to make recommendations on fixing teacher credentialing in CS. That workgroup is still yet to be formed by CTC, despite legislation requiring recommendations by July 1, 2024.

5 INCENTIVIZE STUDENTS BY OFFERING A CULTURALLY RESPONSIVE CURRICULUM THAT COUNTS TOWARDS GRADUATION AND COLLEGE ELIGIBILITY

Recent data make clear that students are already struggling to graduate with their minimum A–G requirements for eligibility to UC and CSU schools, with only about half of California's 429,000 graduates completing these requirements. Depending on how local school districts offer CS, it can count for a third- or fourth-year math course, a third- or fourth-year science course, a general elective, or one of various CTE pathways. Ensuring that CS "counts" towards graduation and college eligibility is an important incentive for students to make space in their schedules and take advantage of increased access to these course offerings.

Some non-STEM-focused students may have limited space in their schedules while other students, such as emerging bilingual learners, may have competing requirements. In *Four Practical Challenges for High School Computer Science*, Bruno et al. documented that adding CS requirements reduces students' abilities to take other classes that may better meet their personal interests and career goals. Attracting and retaining underrepresented students hinges on ensuring that they see themselves reflected in the subject matter. Aligning courses with student interests and culturally responsive learning experiences can help engage youth in solving problems that are relevant to them and their communities. All students should have the opportunity to learn CS, but any state policies and local implementation should support students' voices and choice in their selection of a high school schedule that appeals to their interests.

6 GATHER COMPREHENSIVE DATA ON INDICATORS OF CS PROGRAM QUALITY AND ACCESS

As California scales up CS education, there is more to learn about the course-taking patterns of students and the characteristics of the teachers who instruct them. CSforCA draws from California Department of Education data to analyze course-taking patterns by race and gender (see the CSforCA Data Tool), but the most recent data available are from 2019. By collecting data on course-taking patterns, teacher credentials, and the development of evidence-based equity pathways, the state can gain insights into what works and how to drive impact for all students. California is well-represented in Expanding Computing Education Pathways, a national network of states funded by the National Science Foundation to share best practices, research, and data to make analogous comparisons among states. Without updated data, California's contributions and the benefits of developing shared metrics remain unrealized.

7 COMMIT TO SUSTAINED FUNDING TO SUPPORT STATE AND LOCAL IMPLEMENTATION

Implementing CS and making it accessible to all students require significant investment in school infrastructure. Although California has made meaningful investments in professional learning with programs like the Educator Workforce Investment Grant and the Mathematics, Science, and Computer Science partnership grant, educators need more systemic and long-term support. For example, more funding is needed to hire additional full-time teachers and pay them competitively. Other states, such as Massachusetts, are undergoing research studies to determine what is necessary to ensure equitable access to CS, including the numbers of teachers needed and what it will cost the state to prepare and pay them. A more informed assessment of these costs will help California ensure that we are responsive to local needs. For example, small schools—especially in rural districts—have a particularly difficult time sourcing CS teachers, so the costs may be greater and more flexibility may be required. Schools and districts that lack funding and the necessary personnel might exercise flexibility with online coursework, potentially reinforcing existing inequalities for students in rural areas.

Conclusion

To enable all students to participate fully in our technological world and be critical consumers and creators of it, we should offer them the opportunity to learn the foundational knowledge and the broader principles of CS. With larger state investments in curricula, professional learning, teacher preparation, and other critical building blocks, we can build a shared understanding of CS and increase equity and access for underrepresented groups, such as women and Black, Brown, Indigenous, and rural students.

These building blocks are necessary to define what a comprehensive CS education looks like in the classroom and how to implement these bold policies with equity, at scale, and sustainably. Ambitious efforts to broaden participation in computing can't be a quick fix. Instead, optimizing for equity includes applying what we know about our current education system and imagining what it could be when all students have access to optimal high-quality teaching and learning opportunities in CS education.

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