

**California Department of Education  
Report to the Legislature, Department of Finance,  
State Board of Education, and the Legislative Analyst's  
Office:**

**California Computer Science Strategic Implementation Plan**



**Prepared by the  
Educator Excellence and Equity Division  
Teaching and Learning Support Branch**

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### **California Department of Education**

#### **Report to the Legislature, Department of Finance, State Board of Education, and the Legislative Analyst’s Office**

#### **California Computer Science Strategic Implementation Plan**

### **Executive Summary**

This report is required by Chapter 19 added by Statutes of 2016, Chapter 693, Section 2, California *Education Code* sections 53310–53315. The attached report is the California State Board of Education-Approved Computer Science Strategic Implementation Plan (CSSIP).

The report includes a vision statement, mission statement, and computer science principles that were developed by the CSSIP panel. Also included is a description of the importance of computer science, California’s recently adopted computer science standards, and the origin and purpose of California’s CSSIP. The CSSIP is divided into three sections: Equity and Access, Supporting Educators to Teach Computer Science, and Expanding Computer Science Course Offerings.

If you have any questions regarding this report, please contact Emily Oliva, Education Programs Consultant, Educator Excellence and Equity Division, by phone at 916-319-0198 or by email at [STEM@cde.ca.gov](mailto:STEM@cde.ca.gov).

This report may be found on the California Department of Education Computer Science web page at <https://www.cde.ca.gov/pd/ca/cs/index.asp>. For a copy of this report, please contact the Teacher and Leader Policy Office by phone at 916-445-7331 or by email at [TLPO@cde.ca.gov](mailto:TLPO@cde.ca.gov).



# California Computer Science Strategic Implementation Plan



**JULY 2019**

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## Computer Science Web Page

Information and resources related to computer science education is available on the CDE Computer Science web page at <https://www.cde.ca.gov/pd/ca/cs/index.asp>.



## Vision, Mission, Principles

The California Computer Science Strategic Implementation Plan is guided by the Panel’s vision of kindergarten through grade twelve (K–12) computer science education, mission, and principles with the goal of supporting California’s commitment to equity.

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### Vision Statement

California’s vision is to ensure that all students develop foundational knowledge and skills in computer science to prepare them for college, careers, and civic engagement.

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### Mission Statement

All schools offer rigorous and relevant computer science education equitably and sustainably throughout grades K–12.

All teachers are adequately prepared to teach rigorous and relevant computer science aligned with the California K–12 Computer Science Standards (CA K–12 CS Standards).

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### Principles

These principles (P) apply to all K–12 California schools and the students they serve.

- P1. Every student and every teacher is capable of learning computer science. Access to and achievement in computer science should not be predicated on the basis of race, ethnicity, gender identity, socioeconomic status, language, religion, sexual orientation, cultural affiliation, learning differences, or special needs.
- P2. Every student in California should have equitable access to high-quality computer science curriculum and instruction aligned to the CA K–12 CS Standards.
- P3. Every student should have continuous opportunities and multiple entry points to engage in computer science education, including articulated pathways toward college, careers, and community engagement.
- P4. Computer science instruction should involve real-world, engaging, meaningful, and personally relevant activities for students that focus on problem-solving, critical thinking, and creativity while emphasizing the ethical impacts of computing.
- P5. Computer science should align with the CA K–12 CS Standards and be integrated, as appropriate, into other subject areas in grade bands kindergarten through grade two (K–2), grades three through five (3–5), grades six through

eight (6–8), and grade nine through twelve (9–12); computer science should be offered as standalone courses from introductory to more advanced in middle and high school.

- P6. All California schools should have the infrastructure to support computer science education (including hardware, software, and personnel).
- P7. Computer science content knowledge and relevant pedagogical practices should be included in all California teacher preparation programs, differentiated by multiple subject and single subject teaching credentials.
- P8. The state budget should allocate funding for teachers to participate in ongoing, high-quality, and differentiated professional learning and support to assist them in implementing and integrating computer science education in their classrooms.
- P9. California should engage stakeholders, including, but not limited to, members from K–12 education, higher education, industry, local communities, parent organizations, policy makers, and students to implement computer science statewide.

## The Importance of Computer Science

Our society is witnessing profound changes in the ways we live and work due to advances in computing. California’s digital natives are growing up using technology to communicate with family and friends, to partake in educational opportunities, and to express themselves creatively. Many advocates of computer science (CS) education caution that unless students are taught how computing works, they will remain merely passive consumers of these technologies. Students need to understand how their digital world works in the same way they study science to learn how the natural world works or study history to understand cultures and politics. The integration of computer technology into every aspect of daily life necessitates a foundation in CS for a well-rounded general education.

In the *Computer Science Standards for California Public Schools, Kindergarten Through Grade Twelve, 2018 (CA CS Standards)*, CS is defined as “the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society” (Tucker et al., 2006, page 1). CS is often misconstrued with other technological terminology such as computer literacy, educational technology, digital citizenship, and information technology. These areas focus more on the use of computing systems (e.g., learning to use word processing software). In contrast, CS calls upon students to understand why and how computing technologies work and then to build upon that conceptual –knowledge by creating computational artifacts.

CS prepares students for the future and also fosters skills that support their education, furthering their development and motivation as learners. The importance of CS is recognized at a national level, with the Every Student Succeeds Act including CS as part of a “well-rounded education” (2015).

The United States Bureau of Labor Statistics (U.S. BLS) estimates that in 2017 only 26 percent of people employed in computer and mathematical occupations were women, 9 percent were Black or African American, and 7 percent were Hispanic or Latinx (U.S. BLS, 2018c). Only 2.3 percent of all employed persons with a disability were employed in computer and mathematical occupations (U.S. BLS, 2018b). Large inequities in computing workforce participation reinforce long-standing injustices in society, including wage gaps. A highly inequitable computing workforce can lead to bias in the way tools are designed and function.

California's economy and workforce needs also depend on ensuring more students have access to CS education. Computer and mathematical occupations are among the fastest-growing and most lucrative sectors in the modern economy, particularly in California. The U.S. BLS Occupational Outlook Handbook projects that computer and information technology occupations will grow 13 percent between 2016 and 2026, faster than the average growth for all occupations (U.S. BLS, 2018a).

Computing jobs exist inside and outside the technology sector. The emerging field of e-agriculture utilizes computing technology such as wireless sensors, smartphones, and GPS in order to optimize farm productivity (Food and Agricultural Organization of the United Nations, 2018). Modern visual effects in television and film depend on computing power (Kleinman, 2016). Computing has become central to the automobile industry, the practice of medicine, and finance (Motavalli, 2010; Al-Jumeily et al., 2016). In 2017, California had the highest employment in computer and mathematical occupations of all 50 states, with nearly 600,000 jobs earning an annual mean wage of \$105,830 (U.S. BLS, 2018d). Computing jobs exist across the state, in every industry sector, and provide students with important social mobility opportunities. However, employment in computing occupations does not reflect California's demographic makeup.

California is committed to supporting equity of access to CS education "by ensuring that all student groups are visible in accountability and improvement efforts and setting goals for closing gaps" (Superintendent's Advisory Task Force on Accountability and Continuous Improvement, 2016). This is further emphasized by the Guiding Policy Principle of the California Workforce Pathways Joint Advisory Committee (CWPJAC) to "promote equity and access by eliminating institutional barriers and achievement gaps for all students to realize their educational and career aspirations" (CWPJAC, 2019). Consequently, the CSSIP is meant to catalyze efforts to transform K–12 CS education so that all of California's students will be better prepared to contribute to our digital world.

## California’s Kindergarten through Grade Twelve Computer Science Standards

On September 30, 2014, Governor Brown signed Assembly Bill 1539 into law, adding Section 60605.4 to the California *Education Code (EC)* and directing the Instructional Quality Commission (IQC) to consider developing and recommending to the State Board of Education (SBE) CS content standards on or before July 31, 2019, pursuant to recommendations developed by a group of CS experts. The IQC approved and recommended the draft *CA CS Standards* to the SBE on July 2018. The SBE approved the IQC recommendations and adopted the *CA CS Standards* in September 2018.

The *CA CS Standards* are based on CS core concepts and core practices from the revised international Computer Science Teachers Association standards, which align to the national K–12 Computer Science Framework.<sup>1</sup> The *CA CS Standards* are model standards that define the knowledge, concepts, and skills that students should acquire in each grade band and encourage school districts to provide opportunities for CS education for all students. CS core concepts and practices in the standards are vertically aligned, coherent across grades, and designed in developmentally appropriate grade spans K–2, 3–5, 6–8, and 9–12. The standards are designed to be accessible to each and every student in California and to inform teachers, curriculum developers, and educational leaders to ensure all students receive quality CS instruction. Consequently, educators are encouraged to design CS learning experiences according to their local capacity and context to meet the needs of their students.

The *CA CS Standards* include much more than coding, including the core concepts of computing systems, networks and the internet, data and analysis, algorithms and programming, and impacts of computing. In addition, the *CA CS Standards* develop computational thinking, which is “the human ability to formulate problems so that their solutions can be represented as computational steps or algorithms to be executed by a computer” (*CA CS Standards*, 2018). The *California Mathematics Standards* include Standards for Mathematical Practices, and the *California Next Generation Science Standards (CA NGSS)* include Science and Engineering Practices, which are both part of instruction and learning and behaviors educators seek to develop in students. Similarly, the *CA CS Standards* have core practices, which focus on how students interact with CS and the ways in which they apply conceptual knowledge.

As a field, CS crosses multiple disciplines. In order to accurately reflect the field, the standards are interdisciplinary in nature to ensure that every student learns CS core concepts in relevant contexts. The *CA CS Standards* are consistent with other SBE-adopted curriculum standards with an emphasis on problem-solving,

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<sup>1</sup> A national consensus document that outlines a progression of concepts and practices by grade span in CS that all students could learn in elementary and secondary school. (<https://k12cs.org/>)

communication, critical thinking, creativity, and collaboration and an integral part of college and career readiness for all students

## California's Computer Science Strategic Implementation Plan: Origin and Purpose

CS is an essential component of a broad and comprehensive education, containing necessary foundational concepts and corresponding practices that ensure opportunities for success in our increasingly competitive, globally connected economy. Digital technologies are largely responsible for the global connectivity of the economy. While the impact of CS on multiple areas of the human endeavor continues to increase rapidly, CS education has not kept pace with this increased influence on society.

Concurrent with the creation of the *CA CS Standards*, Computer Science Strategic Implementation Plan (CSSIP) development began per *EC* sections 53310–53315. *EC* Section 53310(a) requires the State Superintendent of Public Instruction (SSPI) to convene a CSSIP Panel (Panel) to develop recommendations for a CSSIP. *EC* Section 53313 requires the SSPI to develop, and the SBE to consider adopting, a CSSIP on or before July 15, 2019.

The development of the CSSIP was a multi-step process that involved 23 Panel members comprised of teachers; administrators; faculty from institutions of higher education (IHEs); a public school student; and representatives from private industry, a parent organization, the California Commission on Teacher Credentialing (CTC), and the IQC. Members were selected based on their expertise in CS education, experience in standards-based interdisciplinary and differentiated instruction for a diverse student population, other areas of expertise and leadership, and their previous committee experience. Members were appointed by the Governor, the SBE President, the Senate Committee on Rules, the Speaker of the Assembly, and the SSPI as required by *EC* Section 53310(b).

The CDE convened public meetings of the Panel in Sacramento from March through June 2018. Throughout the development process, there were opportunities for public input at Panel, IQC, and SBE meetings and during the public review period.

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### How to Use This Document

California's education system is founded on the belief that most education decisions should be made by local educational agencies (LEAs) and their communities of stakeholders. Each of California's diverse LEAs experiences its own local context, many competing priorities, and different challenges to effective CS implementation. The ability for agencies to resource CS education, including the ability to recruit and provide professional learning for educators, procure and maintain technology, and dedicate time to expanding course offerings, is fundamentally dependent on local contexts, and,

therefore, is a matter best addressed by the stakeholders most familiar with those contexts.

This document represents the best thinking of the Panel of CS education experts to support California and its LEAs to improve CS education on behalf of our students. **None of the activities described in this plan are required.** However, LEAs are encouraged to use the information and guidance in this plan to develop their own CS education plans designed to meet their own local needs.

The plan includes activities and recommendations organized into three sections: Equity and Access, Supporting Educators to Teach CS, and Expanding CS Course Offerings. Each section provides the following:

- A brief overview of the topic, its current status, and why it is important,
- A description of state activities, both those that the state plans to implement right away and those that should be considered pending funding, and
- Expert suggestions and guidance for schools, districts, county offices of education (COEs), community and business partners, and other entities to consider as they work to improve CS education for the students in their local schools and communities.

## Equity and Access

### Overview

CS education for all ensures each and every student develops foundational conceptual knowledge and proficiency in CS practices to provide the skills to responsibly and productively participate in a world in which digital technologies are broadly integrated. More than availability of CS classes, equity requires leaders and educators to carefully consider inclusive practices regarding how classes are taught, student recruitment and retention, instructional practices that guarantee universal access, and high expectations for all students. CS is not designed to be offered merely to a select few or as an elective for interested students.

Access to CS courses is highly variable across the state. This is particularly evident at the secondary level where it is easier to track CS offerings. Access to computing courses also varies by ethnicity and income. An analysis of CDE data by the Kapor Center found that:

- High schools with the highest percentages of underrepresented students of color are two times less likely to offer any CS course and three times less likely to offer Advanced

Placement Computer Science A (AP CS A) than schools with the lowest percentages of underrepresented students of color.

- High schools with the highest percentage of low-income students are four times less likely to offer AP CS A courses than high-income schools (8 percent versus 32 percent).
- Rural schools are seven times less likely to offer AP CS A than urban schools (2 percent versus 14 percent; Kapur Center, 2019).

The Kapur Center and the Alliance for California Computing Education for Students and Schools (ACCESS) recently compiled data on secondary CS course enrollment in both AP and non-AP CS courses (see Table 1). Few students are enrolled in secondary CS courses in California, and students studying CS are disproportionately male.

**Table 1.** Number of California Students in CS Courses (2016–17)

Course Name	Course Code	Total Enrollment	% of Total HS Enrollment	% Male Enrollment	% Female Enrollment
Exploring Computer Science (ECS)	4634	18,741	1.0%	69%	31%
CS	2453	15,350	0.8%	64%	36%
AP CS Principles (AP CS P)	2472	3,146	0.2%	70%	30%
AP CS A	2470	10,821	0.5%	72%	29%
Robotic Technologies	4647	13,197	0.7%	71%	29%

**Source:** CDE Enrollment Data (2016–17).

Inequities in CS opportunities also exist for English learners (ELs) and students with disabilities. There are approximately 1.3 million ELs in California public schools, or 20 percent of the student population (CDE, 2018). In California, approximately 700,000 students (or 11 percent) have a disability. These student populations face unique barriers to CS education. ELs may have fewer opportunities to enroll in CS courses because they also need to fulfill English language development requirements. Many programming tools designed to support K–12 CS education may not be accessible to students who are blind or students with mobility-related disabilities (University of Washington Alliance for Access to Computing Careers, 2019).

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## Implementation Strategies

Access to CS education for all students can be improved when families, community members, teachers, and counselors are equipped to engage in advocacy, implement equity strategies, and create expanded learning opportunities.

### State-Level Strategies

Educational equity is a cornerstone of California’s education system, and there are teachers and counselors already attending to these issues across the state. At the state level, exemplary teachers and counselors committed to improving access and equity in CS will be highlighted by the CDE through web pages and presentations so they can share their practices and success with other educators.

Provided with funding, the CDE could ensure adequate staff are available to support implementation activities and to provide technical assistance to LEAs. California could appoint a state-level CS supervisor at the CDE to spearhead CS education initiatives. In addition, the state-level CS supervisor would lead the launch of a multi-faceted campaign that communicates the *CA CS Standards* and the CSSIP. The campaign would emphasize the future of work, labor demand, and career opportunities requiring CS.

Pending funding, professional development events and workshops to build awareness of the *CA CS Standards* could also be developed by the CDE. These presentations would discuss how CS aligns with other content standards and with requirements for graduation and university admission. To support these workshops, CS foundation toolkits that describe the standards and how they can be integrated into the work schools are already doing could be developed for each grade band (i.e., K–2, 3–5, 6–8, 9–12). Furthermore, the state could assist districts in their implementation efforts by developing criteria to evaluate CS instructional materials.

### Local Strategies

Students and families, community members, teachers, administrators, schools, LEAs, IHEs, and industry may also engage in implementation strategies.

A variety of environmental factors contribute to students pursuing CS, such as early exposure, social support, and a sense of belonging. Districts and schools may consider implementing practices focused on equity, cultural responsiveness, and the elimination of bias by teachers and counselors in the school environment, which may attract and retain more students in CS courses. Additional methods for reaching specific student groups—young students and beginners, students with disabilities, females, and underrepresented minorities—are described in Chapter Two of the national K–12 Computer Science Framework (K–12 Computer Science Framework, 2016).

LEAs and COEs could engage in the creation of professional learning materials and evidence-based professional learning to inform teachers and counselors of best practices that encourage and support diverse students and female students to pursue CS opportunities. Training materials for teachers that introduce varied pedagogical techniques and include project-based activities with strong CS content, collaborative learning, inquiry-based pedagogy, and culturally responsive teaching could provide supports for educators to reach all students. In addition, training materials for counselors may provide an awareness of the *CA CS Standards*, describe the various pathways students can follow to pursue CS, and highlight common barriers that prevent students from enrolling in CS courses.

Access to CS learning can also be improved through activities that augment the classroom experience. These enriching activities need not be restricted to the regular school day. LEAs and COEs may consider partnering with community organizations to provide students with expanded learning and mentoring opportunities.

Engaging with activities outside of school helps students make connections between CS and their daily lives. Social supports, including peers, mentors, and positive role models, are important factors in the recruitment and retention of women into CS. In collaboration with community partners, opportunities could be created for students, especially underrepresented students, to participate in expanded learning, scholarships, internships, and mentorships related to CS.

Families and communities are fundamental to a student's educational success. Their support is important to ensure more students have access to CS. Girls frequently lack awareness of CS and the opportunities within the field, which is partly why female enrollment in CS is low (Cheryan et al., 2013). Families and community members could encourage students to explore CS, assist them in their course work, and provide them with learning opportunities outside of school. They could also advocate for more CS courses if there is a need at their local school.

Community organizations and nonprofits could partner with LEAs to develop outreach toolkits to help families improve awareness of and access to CS education. Toolkits could contain information about the field of CS, strategies for supporting students, and tips for advocating for CS opportunities. To ensure toolkits reach a broad audience, materials could be translated into multiple languages and differentiated for families of underrepresented students and community organizations that serve them (e.g., after school clubs). Toolkits could also be used to organize events focused on family engagement around CS.

Sufficient information technology (IT) infrastructure is essential for schools to have consistent access to the tools needed for CS education. An initial step a district could take for ensuring consistency in IT across the district is to define minimum specifications for networking, hardware, and software. With these specifications defined, the district could then identify hardware and software needs for CS education, which may include identifying areas where bandwidth or Wi-Fi may need to be upgraded. Personnel are

also crucial to maintain and update the infrastructure. Districts could define minimum criteria for the number and qualifications of IT personnel to ensure adequate maintenance support. Multi-tiered support plans could also be created that include dedicated staff to address advanced IT issues that may arise at schools.

Standards implementation initiatives benefit from being educator-driven and educator-focused, leveraging interest among teachers to pilot materials and disseminate information to colleagues. In the *CA CS Standards Appendix*, district leadership is encouraged to develop a shared vision and common language around CS education that builds coherence, inspires stakeholders, and promotes sustainable change. This vision could be reflected in school board policies and resolutions and in the Local Control and Accountability Plans. Such measures could support districts to track and reflect on the progress of implementation activities.

## Supporting Educators to Teach Computer Science

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### Overview

Ensuring there is a sufficient number of prepared teachers for CS courses for the over six million public school students in California is a daunting task. It is important that the content and pedagogical knowledge of our educators grow to create an educational environment where students thrive. Furthermore, clear CS credentialing pathways and professional learning opportunities for educators, including administrators, teachers, and counselors, are essential to successful implementation of CS within the educational system.

The *CA CS Standards* suggest implementing stand-alone courses at the high school level, but the state does not currently have a single-subject credential in CS. Those who wish to teach CS must first obtain a single-subject credential in another area.<sup>2</sup> Secondary teachers with single-subject credentials in Mathematics, Business, or Industrial and Technology Education (ITE) are currently authorized to teach CS courses that are coded as a core academic course. When a CS course is coded as Career Technical Education (CTE), then those with a Designated Subject CTE Teaching Credential in Information and Communication Technology are authorized to teach the course.

Teachers who hold a single-subject credential in another subject area are eligible to receive an Introductory or Specific Supplementary Authorization in CS after completing a college major in CS, 20 semester units in CS, or 10 upper division semester units in CS or graduate-level coursework. For more detail on the required coursework for both

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<sup>2</sup> In most cases, teachers of AP CS P have received district authorization to teach the course, provided the teacher has completed professional development and received a certificate.

authorizations, see the CTC Coded Correspondence 16-05<sup>3</sup> (CTC, 2016a). Degrees in Educational Technology or IT do not automatically meet requirements for supplementary authorizations in CS. Applicants must submit official transcripts to verify that the complete coursework covers all required content.

California does not have pre-service CS teacher preparation programs; however, content on computational thinking and CS have been added to some preparation programs in other disciplines, such as math and science. Some universities have created programs for in-service teachers to satisfy the course requirements for the Supplementary Authorization in CS. As of this writing, these institutions are offering coursework that may be used to apply for the Supplementary Authorization:

- University of California (UC), Irvine offers a certificate program consisting of four hybrid (face-to-face and online) courses (15 graduate-level quarter units) supplemented by a Professional Learning Community (UC Irvine, 2019).
- UC Riverside offers five online courses (19 quarter units) (UC Riverside Extension, 2019).
- California State University (CSU), Stanislaus also provides a list of suggested courses that can be used to meet the requirements for the supplementary authorization (CSU Stanislaus, 2016).

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## Implementation Strategies

### State-Level Strategies

The CDE will collaborate with various educational entities, including COEs, educator professional associations, and stakeholder organizations, to curate and promote via web pages and presentations existing and new CS standards-aligned resources. The CDE will also continue to work with the CTC to ensure that pre-service teachers and administrators have access to programs that provide the pedagogical and content knowledge needed to successfully support student attainment of the CS standards and will maintain ongoing communication with the higher education community in the development of professional learning resources for educators.

To grow K–12 CS education in California, the state will need to increase the number of teachers qualified to teach CS. Supporting more educators to teach CS would involve a multi-pronged approach that attends to credentialing; new teacher recruitment; professional learning for teachers, administrators, and counselors regarding the *CA CS Standards*; and institutional and financial support.

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<sup>3</sup> Teachers with a Supplementary Authorization in Computer Concepts and Applications awarded prior to April 2016 are also authorized to teach CS.

Current authorization pathways for CS teaching in California require all CS teachers to first receive authorization to teach some other subject. California could consider developing a single-subject CS credential through legislation. If such legislation passes, the CTC would then engage in its standard processes for developing a credential, including convening a panel of experts to identify standards for the CS exam and creating a California Subject Examination for Teachers or considering the adoption of the CS PRAXIS® exam from the Educational Testing Service (ETS) (ETS, 2019).

The CTC could reevaluate subject matter requirements for CS to determine if existing credentials or supplementary authorizations could also authorize teachers to teach CS. For example, the ITE single-subject credential already authorizes holders to teach CS. However, the credential is quite broad and could benefit from the addition of a distinct strand for CS. Since the *CA CS Standards* recommend that CS be integrated into multiple subject classrooms, all teacher preparation programs for multiple-subject and single-subject credentials could include CS content and pedagogy.

The state could also support teachers to pursue the CS authorization by making it easier to identify institutions where they can complete coursework required for existing authorizations.

For example, the CTC could host a public portal that IHEs populate with their coursework that fulfills the supplementary authorization. In addition, some college students, including CS majors, might not consider teaching as a viable career path when high-paying salaries of the technology industry are more attractive. To counteract this, the value and social impact of CS teaching could be highlighted in these preparation programs. Furthermore, dependent upon funding, the state could incentivize partnerships between CS and education departments at IHEs to develop programs for CS teacher preparation.

In the short term, the state could consider offering incentives for IHEs to offer credit-bearing courses or teacher preparation programs that satisfy the CS supplementary authorization and future CS teaching credentials to help teachers learn how to teach concepts and practices aligned to the *CA CS Standards* and differentiated for grade and skill levels. IHEs could work with CTC to establish course articulation agreements with CTC-approved teacher preparation programs.

Contingent upon the availability of state funds, a grant program could be established to support teachers to complete course work for the CS supplementary authorization, with additional incentives for teachers who work in low-income and underserved school districts and rural and urban school districts. Additionally, the state could consider establishing a loan forgiveness program to incentivize clear credentialed teachers to teach CS in these schools. As another option for overcoming barriers to CS authorization, the state and IHEs can encourage individuals in industry to pursue a

Business and Industry Partnership Teacher Authorization allowing them to teach for a year and then apply for a CTE credential.

To support professional learning, the state could expand the California Subject Matter Projects (CSMPs) with the addition of a new project focused on CS to provide a network of professional learning opportunities across the state. The California County Superintendents Educational Services Association's Curriculum and Instruction Steering Committee subcommittee is already working to support stakeholders in addressing the needs of teachers and working to provide a network for professional learning activities. The state could resource the creation of materials to support teachers when they return to their classrooms inspired and ready to engage their students in these types of activities.

### **Local Strategies**

Many teachers who will help CS spread across California will be new to the discipline and will need to learn how to teach its concepts and practices. For teachers already experienced in CS, the dynamic nature of the subject will require them to update their teaching knowledge as new tools and curricula emerge. Professional learning opportunities can offer these teachers the training they need to implement CS confidently and effectively.

In addition to seeking philanthropic funds to boost CS programs, LEAs may consider existing resources to support the professional learning of teachers and school leaders, such as general funds; Title II, Part A funds; and Title IV, Part A funds. It is important that all teachers have access to these learning opportunities regardless of their locale. This can be accomplished by offering both face-to-face and online course offerings and making teaching materials available at central locations or through online collections.

Training opportunities provided by IHEs, COEs, and LEAs should be engaging, providing teachers with exciting, hands-on experiences so they can see examples of activities they may want to do with students. A number of organizations provide free lesson plans, online resources, and other material for K–12 CS education.

Educational leaders and teachers would be well-served to participate in professional learning activities to better understand ways of integrating CS into existing courses and to create local communities of practice (CPs). Teachers will benefit from opportunities to continue developing their understanding of how to teach CS and their identities as teachers of CS. This is particularly important as many CS teachers are often the only, or one of the few, people in their schools teaching the subject and can feel isolated in their roles. CS teachers and teachers interested in integrating CS into other courses should have opportunities to connect with professional colleagues with whom they can share experiences. For example, teachers could be given regular collaboration time to develop and participate in CPs, especially at the elementary level. In smaller districts, COEs can encourage CPs that invite teachers from multiple schools.

Administrators and counselors play a vital role in the expansion of K–12 CS education. Administrators make decisions related to course offerings and teacher assignments and they support teachers in their schools. Counselors inform students of CS educational opportunities and possible career paths. Ongoing professional learning for site and central office administrators and counselors could be offered by IHEs, COEs, LEAs, and other providers to boost knowledge of what CS is and to provide strategies they can use to support CS education. While keeping equity a focus throughout professional learning opportunities, key topics to include in these trainings are: the importance of CS, career and workforce demand, effective CS instruction, teacher certification requirements for CS, equitable implementation practices, and opportunities for CS coursework to fulfill college admissions requirements and/or earn college credit.

## Expanding Computer Science Course Offerings

### Overview

Challenges to measuring the availability of CS education in California are currently being addressed through a collaboration with the CDE and CTC to review course codes and clarify course descriptions. However, current research efforts have provided key takeaways regarding the status of CS offerings.

At the secondary level, relatively few high schools offer CS courses. Table 2 shows the number and percent of California high schools that did offer AP CS and other common CS courses in 2016–17. Overall, only three percent of public high school students enrolled in any computing course and only one percent enrolled in an AP CS course (Kapor Center, 2019). As noted by the Kapor Center:

From preschool through high school, underrepresented students of color disproportionately lack access to high-quality schools and teachers to develop fundamental knowledge, peers and role models to develop interest in computing, and CS courses to prepare for college. By the end of high school, just 16% of students who participate in AP CS A are Black, Latinx, or Native American/Alaskan Native, affecting participation in computing in higher education.

This has profound implications for the future computing workforce; students who participate in AP CS are eight times more likely to major in computing (Kapor Center, 2019).

**Table 2.** Number of California High Schools Offering CS Courses (2016–17)

Course Name	Course Code	Number of Schools	% of HSs
ECS	4634	284	15%

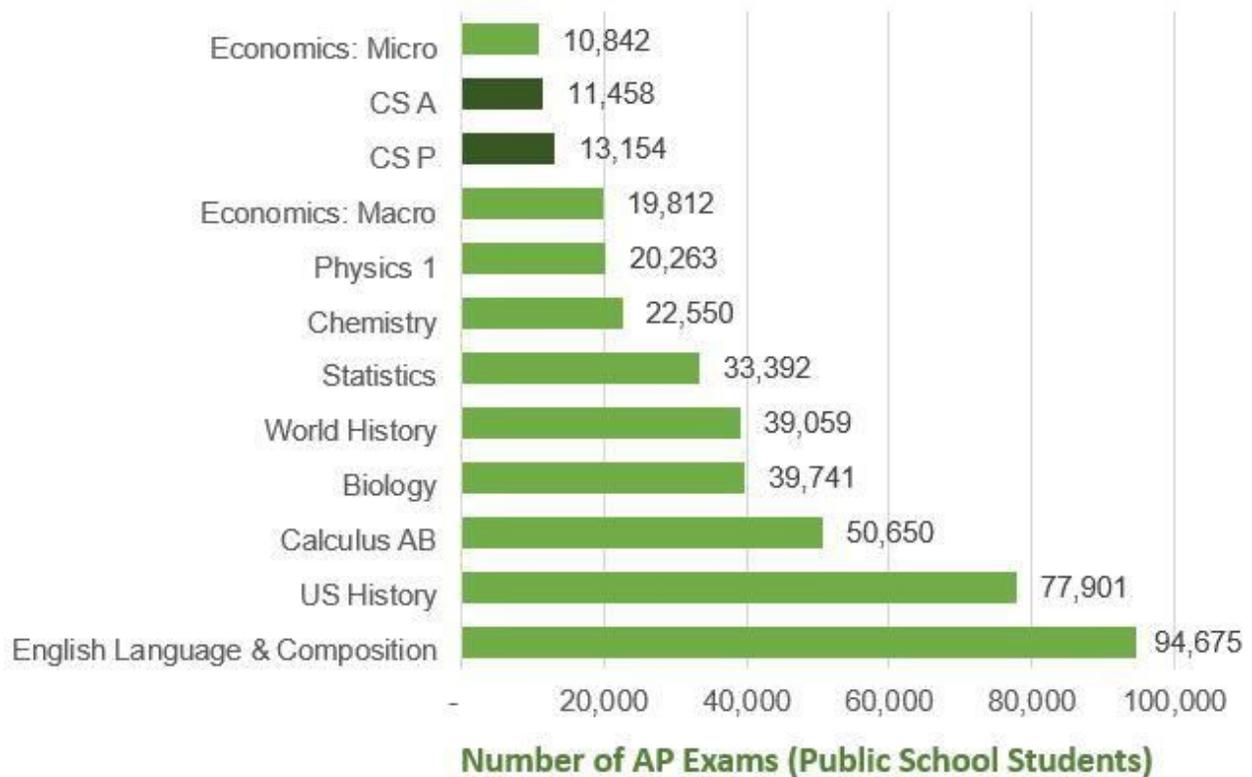
CS	2453	298	16%
AP CS P	2472	71	4%
AP CS A	2470	250	14%
Robotic Technologies	4647	323	13%

**Source:** CDE Enrollment Data (2016–17). Including all active traditional high schools serving grades 9–12, including K–12, but excluding schools with codes: COMM, COMMDAY, CON, JUV, OPP, SPEC, SPECAN, and YTH. Count of schools is duplicated.

**Note:** AP CS P was in its pilot year in 2016–17.

California is one of the top 10 states with the highest per capita AP CS (A and P) participation (Kapor Center, 2019). Yet, compared to other disciplines, the number of California students who take AP CS exams is relatively low. In 2018, 11,458 California public school students took the AP CS A exam and 13,154 California public school students took the AP CS P exam (College Board, 2018). As can be seen in Figure 1, these numbers are on par with the number of students who took the AP Economics exams and far less than the number of students who took exams for other science, technology, engineering, and mathematics areas; U.S. and World History; and English Language and Composition. AP exam data has its limitations as an indicator of CS offerings in California, but it is clear that fewer students are taking the AP CS A and CS P exams compared to other AP exams. This means that few students have been able to capitalize on the benefits afforded by AP exams.

**Figure 1.** Number of AP exams in CS and other subject areas taken by public school students in 2018.



**Source:** College Board’s AP Program Participation and Performance Data 2018.

### Local Strategies

Expanding CS course offerings calls for alignment across the K–8, 8–12, and post-secondary levels so that students are prepared and motivated to pursue CS opportunities at each stage of their education. Opportunities for CS education exist in all subjects, especially mathematics, science, and engineering. As an example, the CA NGSS includes using mathematics and computational thinking as a core practice. The Appendix to the CA CS Standards contains a detailed breakdown of the relationships between CS practices and standards and those of other content areas.

Introducing students to CS at the K–8 level will prepare them to become computational thinkers who understand why and how computing technologies work and use that knowledge to create computational artifacts. A foundation in CS at the elementary and middle school levels will also prepare students for future CS course work in high school.

With many competing initiatives, including the need to address student success in English language arts and mathematics, adding a CS course to students' daily schedules may be a daunting task. In response to this concern, the *CA CS Standards* describe how CS instruction can be integrated into multiple subject classrooms or taught as a discrete, independent course. The standards also include interdisciplinary connection examples in grade bands K–2, 3–5, and 6–8 to help educators identify ways in which CS fits into existing coursework. COEs and LEAs may consider identifying current K–8 CS instruction that is aligned to the *CA CS Standards* to model best practices and support teachers in incorporating CS into their classrooms.

At the high school level, CS courses can offer students a deeper understanding of the discipline, motivation to pursue future CS studies, and exposure to related careers. Schools and districts could work to expand their course offerings to offer A–G approved CS course sequences in all high schools. These sequences could begin with an introductory-level course and end in an AP or other college-level course. For students who enter high school with advanced CS skills, schools could consider developing flexible programming that would allow students to demonstrate their knowledge of CS concepts and practices through tests and portfolios, thus allowing them to more fluidly move through the course sequences based on their proficiency levels.

The CSU and UC systems currently accept some CS courses to fulfill freshman minimum admission requirements in categories C (mathematics), D (laboratory science), or G (college preparatory elective). For CS courses to meet requirements for categories C and D, they must align with core competencies in mathematics and science, respectively (UC, 2018a; UC, 2018b).

Students and parents/guardians can search the UC's A-G approved course list to determine if a high school's CS course satisfies any of the minimum admission requirements. School administrators can submit CS courses for approval through the UC's A-G course management portal.<sup>4</sup>

The UC Course Integration Program offers free institutes in which high school and college educators gather to work in collaborative teams to create courses that integrate core academic courses with Career Technical Education (CTE) content. Developing and submitting integrated courses would allow more students to pursue CS in CTE pathways and fulfill a-g subject requirements for admission into the UC and CSU systems.

The Local Control Funding Formula (LCFF) allows for LEA flexibility in the use of funding, but this often means that districts must make difficult decisions between implementing new standards and programs and maintaining existing programs and staffing needs. LCFF includes targeted funding especially for schools serving students eligible for free or reduced-price meals, ELs, and foster youth, known as supplemental

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<sup>4</sup> The UC A-G course management portal is available at <https://hs-articulation.ucop.edu/agcmp/login/>.

and concentration funding. This funding is specifically designed for schools to implement increased and improved services for these student populations. Many districts already implementing CS have been using their LCFF funding for this purpose.

## Conclusion

This implementation plan, in conjunction with the *CA CS Standards*, represents an important initial step in California's efforts to expand CS education to all students. Embarking on the strategies recommended in this plan can lead to a future where:

- More individuals are recruited into CS teaching, multiple pathways exist allowing educators to teach CS, and educators have access to resources and peers that support effective CS teaching at all stages of their careers;
- K–8 students are prepared for secondary level CS coursework, CS course offerings are expanded so that all high schools offer at least one CS course, and students have access to CS in both college and career pathways;
- Students traditionally underrepresented in CS education have greater access to CS opportunities, and stakeholders (i.e., counselors, teachers, administrators, families, and community partners) are better equipped with strategies and materials to use in supporting students in pursuing CS opportunities; and
- Students are lifelong learners, informed citizens with a conceptual knowledge of how computing technology works, and productive contributors to society as a whole.

Much work remains to be done to guarantee our vision that all students develop foundational knowledge and skills in CS to prepare them for college, careers, and civic engagement. Successful implementation of equitable K–12 CS education in California will require the collaboration and creative effort of multiple stakeholders across all levels of the education system. This plan should be viewed as the beginning, not the end, of the state's efforts to achieve equitable, K–12 CS education for all students.

## Appendix

This supplementary page contains a long description for the figure/graphic used on the California Computer Science Strategic Implementation Plan dated May 2019.

### **Long description for Figure 1 on Page 18**

Number of AP Exams in CS and other subject areas taken by public school students in 2018.

- The largest number of AP exams taken in public schools in 2018 was in English Language and Composition (94,675). Students took 77,901 exams in U.S. History; 50,650 exams in Calculus AB; 39,741 in Biology; 39,059 in World History; 33,392 in Statistics; 22,550 in Chemistry; 20,263 in Physics; 19,812 in Economics: Macro; 13,154 in CS P; 11,458 in CS A; and 10,842 in Economics: Micro.

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