

California Department of Education

Executive Office

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# California State Board of EducationMarch 2019 AgendaItem #05

## Subject

Approval of the California Computer Science Strategic Implementation Plan.

## Type of Action

Action, Information

## Summary of the Issue(s)

California *Education Code* (*EC)* Section 53310(a) requires the State Superintendent of Public Instruction (SSPI) to convene a computer science strategic implementation advisory panel to develop recommendations for a computer science strategic implementation plan. *EC* Section 53311(a) requires that the panel submit its recommendations to the SSPI, the State Board of Education (SBE), and the Legislature on or before January 15, 2019. *EC* Section 53313 requires the SSPI to develop, and the SBE to consider adopting, a computer science strategic implementation plan on or before July 15, 2019.

Beginning in March 2018, the California Department of Education (CDE) convened the Computer Science Strategic Implementation Plan Panel (CSSIPP) for three public meetings. In July 2018, the CSSIPP completed the recommendations development process. The panel’s recommendations were presented to the SBE for information and to partially fulfill the requirements of *EC* Section 53311(a) in September 2018.

WestEd staff was contracted to draft an implementation plan based on the panel’s recommendations. CDE staff brought the draft plan to the Instructional Quality Commission (IQC) in September 2018. The IQC voted to post the plan for a 30-day public review period. At its January 2019 meeting, the IQC reviewed the public comments as well as staff recommendations and acted to update the draft plan and submit it to the SBE for approval.

## Recommendation

The CDE recommends that the SBE approve the California Computer Science Strategic Implementation Plan.

## Brief History of Key Issues

The development of the California Computer Science Strategic Implementation Plan was a multi-step process that involved educators, content experts, and other stakeholders. Throughout the development process, there were opportunities for public input at CSSIPP, IQC, and SBE meetings and during the public review period.

*EC* Section 53311 requires the CSSIPP to develop a set of recommendations for a computer science strategic implementation plan that addresses, at minimum, the following topics: broadening the pool of teachers to teach computer science; defining computer science education principles that meet the needs of pupils in kindergarten and grades one to twelve, inclusive; and ensuring that all pupils have access to quality computer science courses.

The CDE convened public meetings of the CSSIPP in Sacramento on the following dates: March 1–2, April 11–12, and June 25–26, 2018. The panel was comprised of teachers, administrators, faculty from institutions of higher education, and representatives from private industry. The CSSIPP also included a public school student, a representative from a parent organization, and representatives from the California Commission on Teacher Credentialing and the IQC. 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) and were selected based on their expertise in computer science education.

WestEd staff was contracted to draft an implementation plan based on the panel’s recommendations. CDE staff brought the draft plan to the IQC in September 2018. The IQC voted to post the plan for a 30-day public review period. Between October and November 2018 the draft plan was posted with a survey for public review. The public comments collected during this period are available at <https://www.cde.ca.gov/be/cc/cd/documents/cssippubcomments.docx>.

At the January meeting of the IQC, CDE, and WestEd staff presented the comments gathered through the public review process as well as staff recommendations based on feedback provided by the SBE at its September 2018 meeting. The staff recommendations are available at <https://www.cde.ca.gov/be/cc/cd/documents/cssipstaffrecommend.docx>. WestEd staff made updates to the draft plan based on the public comments, staff recommendations and IQC action. The updated plan is provided as Attachment 1.

More information regarding the California Computer Science Strategic Implementation Plan development process, including CSSIPP meeting agendas and a schedule of significant events, is available on the CDE Computer Science Strategic Implementation Plan web page at <https://www.cde.ca.gov/pd/ca/sc/cssip.asp>.

## Summary of Previous State Board of Education Discussion and Action

**September 2018:** The CDE presented to the SBE an information item including the recommendations of the CSSIPP and information regarding the plan development process.

## Fiscal Analysis (as appropriate)

The estimated cost of developing the California Computer Science Strategic Implementation Plan is $261,954. This estimate includes the costs for the contracted writers, travel for the CSSIPP members, production of materials for CSSIPP meetings, technology services, and CDE staff costs.

The CSSIPP made a number of recommendations that would require additional funding to implement. These expert recommendations are included in the document in Appendix A as a resource to those seeking to invest in computer science through legislation or philanthropy. However, the activities described in the body of the plan do not require new state funding.

## Attachment(s)

* Attachment 1: California Computer Science Strategic Implementation Plan
(37 Pages)

# Attachment 1: California Computer Science Strategic Implementation Plan

**California Computer Science Strategic Implementation Plan—DRAFT**

March 2019

## ACKNOWLEDGEMENTS

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## Introduction

Our society has witnessed profound changes in the ways we live and work due to advances in computing. California’s digital natives are growing 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 have cautioned that unless students are taught how computing works, they will remain merely passive consumers of these technologies. The integration of computer technology into every aspect of daily life necessitates a foundation in CS for a well-rounded general education. Today’s 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.

In the *Computer Science 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). Although CS as a discipline of study is well established at the post-secondary level, it is relatively new to the kindergarten through grade twelve (K–12) system. While the public is becoming more aware of CS and recognizing its value for all students, there is still some confusion over what the discipline constitutes. 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.

Despite growing recognition of the importance of CS education, the majority of high schools in California do not offer any CS courses. Even some of the largest districts in the state do not offer CS courses. These limited opportunities for CS education lead to issues of access and equity for students. In schools that offer CS, student participation in these courses too often does not reflect the demographic makeup of California. The state offers no single-subject credential in CS, requiring educators to meet other unrelated requirements to teach CS. Improving CS education throughout all of California is vital for preparing our children for tomorrow’s challenges.

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 United States Bureau of Labor Statistics’ (US 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(US BLS, 2018a). 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 $105,380 (US BLS, 2018a). Computing jobs exist inside and outside the tech sector. The emerging field of e-agriculture employs 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). Computing jobs exist across the state and in every industry sector and can provide students with important social mobility opportunities.

However, employment in computing occupations does not reflect California’s demographic makeup. The BLS estimates that in 2017 only 26 percent of people employed in computer and mathematical occupations were women, nine percent were Black or African American, and seven percent were Hispanic or Latinx (US BLS, 2018c). Only 2.3 percent of all employed persons with a disability were employed in computer and mathematical occupations (US 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.

Today, there is greater access to K–12 CS education in California today due to the numerous initiatives spurred by various stakeholders in education, industry, and the nonprofit sector. For example, the *Exploring Computer Science* (*ECS*) course, developed by researchers at the University of California (UC) Los Angeles and the University of Oregon, has reached more than 14,000 high school students across 43 schools in Los Angeles since its launch in 2008 (ECS, 2018). As another example, the new Advanced Placement (*AP) Computer Science Principles* (AP CSP) course, launched in 2016–17, has more than doubled the number of students taking AP CS courses each year.

AP CSP is specifically designed to reach a larger student population. The College Board approved ten different curriculum providers―including many familiar to California such as Code.org and The Beauty and Joy of Computing―to provide professional development on the course (College Board, 2018). As a result, California saw 21,446 public school students take an AP CS exam in 2018―a 31 percent increase over 2017 and a 109 percent increase over 2016. However, more needs to be done to reach the over six million public school students enrolled at over 10,000 schools across the state.

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, page seven). This implementation plan presents four overarching strategies to guide stakeholders in implementing CS education across the state:

(i) expanding CS course offerings, (ii) improving access to CS education for all students, (iii) supporting educators to teach CS, and (iv) making systemic improvements in CS education. It is hoped that this implementation plan will 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.

“[As] computer science education is becoming increasingly accepted in our schools... K–12 educators may find it useful to also focus on Papert’s reasons: Teach students computer programming to help them learn everything else.”

Sheena Vaidyanathan, CS Integration Specialist, Los Altos School District, Los Altos, California

## California’s Commitment To Computer Science

On September 30, 2014, Governor Brown signed Assembly Bill 1539 into law, which added Section 60605.4 to the California *Education Code (EC)* 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.

The *CA CS Standards* are based on the revised international Computer Science Teachers Association (CSTA) standards, which were released in July 2017 and align with the national K–12 CS Framework[[1]](#footnote-1) released in November 2016. The California Computer Science Standards Advisory Committee (CS SAC) retained the core concept and sub-concept areas and the CS practices from the CSTA standards, and they added, removed, and modified the CSTA standards to fit California’s educational context. The CS SAC also drafted introductory material and appendices to introduce and explain the standards to educators, identify areas of alignment between the CS standards and other content standards, and provide recommendations for implementation. Additional detail on the standards development process is available on the Computer Science Education CDE web page at <https://www.cde.ca.gov/be/st/ss/computerscicontentstds.asp>.

As with all California content standards, 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. As of this writing, there are no plans to develop a CS curriculum framework or a state summative CS exam to accompany the standards. However, local educational agencies (LEAs) will have the freedom to determine their own curriculum and implementation needs. They can choose to develop their own curricula as well as select curricula and professional learning opportunities from many existing vendors in addition to the College Board approved providers of the two AP CS courses.

Early into the CS content standards development process, the CDE, SBE, and Legislature began the process of developing the California Computer Science Strategic Implementation Plan (CSSIP) per *EC* sections 53310–53315. Per the requirements of *EC* Section 53310 (b), the Governor, the SBE President, the Senate Committee on Rules, the Speaker of the Assembly, and the State Superintendent of Public Instruction appointed 23 members to the CSSIP Panel (Panel) to develop recommendations to inform this implementation plan. Panel members were selected based on their expertise in computer science education, experience in standards-based interdisciplinary instruction and differentiated instruction for a diverse student population, other areas of expertise and leadership, and their previous committee experience.

The CDE convened public meetings of the Panel in Sacramento between March and June of 2018. During these meetings, the Panel participated in small and whole group discussions to develop recommendations consistent with the requirements in *EC* Section 53311. CDE held additional meetings with the Panel co-chairs in July 2018 to finalize the panel’s recommendations. The recommendations described in this report are included for each level in California’s educational system to consider when designing or expanding their CS programs and should not be viewed as requirements or mandates. The recommendations include timeframes for implementation, which are incorporated in this document. The Panel recognized that districts across the state vary in their readiness to implement CS education and that schools face many other priorities that may compete with CS education efforts. As such, the timeframes are offered with the understanding that LEAs may require more or less time to implement the recommended strategies. The Panel was also tasked with defining CS education principles that meet the needs of pupils in K–12. Additionally, the Panel created mission and vision statements to guide CS education in California. The work of the Panel informed this strategic implementation plan.

Their recommendations identified specific entities responsible for the strategies they proposed. In this plan, responsible entities are condensed into four groups: schools and districts (LEAs); county offices of education (COEs); institutions of higher education in the UC, the California State University (CSU), and the California Community College systems (IHEs); and state level entities including the CDE, the California Commission on Teacher Credentialing (CTC), the Legislature, and the SBE (State). A detailed list of the Panel recommendations and additional information about the Panel are available on the CDE CSSIP web page at <https://www.cde.ca.gov/pd/ca/sc/cssip.asp>.

## Vision, Mission, And Principles

When the Panel met in 2018, they decided it was important to communicate the larger goals of K–12 CS education in California. This strategic implementation plan is guided by their vision of CS education, mission for stakeholders involved in implementing CS education, and set of principles supporting California’s commitment to equity in CS education.

### 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.*

### 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 California’s K–12 computer science.*

### Principles

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

1. 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.
2. Every student in California should have equitable access to high-quality computer science curriculum and instruction aligned to California’s K–12 computer science standards.
3. 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.
4. 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.
5. Computer science should align with California’s K–12 Computer Science Standards and be integrated, as appropriate, into other subject areas in grade bands kindergarten through grade two (K–2), grade three through five (3–5), grade 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.
6. All California schools should have the infrastructure to support computer science education (including hardware, software, and personnel).
7. 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.
8. The state budget should allocate funding for teachers to participate in on-going, high-quality, and differentiated professional learning and support to assist them in implementing and integrating computer science education in their classrooms.
9. 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.

## Expanding Computer Science Course Offerings

### **Current State Of Kindergarten Through Grade Twelve Computer Science Course Offerings**

While CS education opportunities exist in California, measuring their availability is challenging for a variety of reasons. For example, at the elementary and middle school levels, CS is often integrated into existing curricula and information about the prevalence or quality of these offerings is not tracked. LEAs report student course enrollment and completion through course codes as part of California’s Longitudinal Pupil Achievement Data System (CALPADS). However, these course codes are
self-reported, making it possible to miscode a course (e.g., keyboarding) as containing CS content. Miscoded course information can lead to false assumptions about the spread of CS education in California and either exaggerate or attenuate issues of access and equity.

At the secondary level, relatively few high schools offer CS courses. A recent analysis by the Kapor Center for Social Impact (Kapor Center) found only 43 percent of public high schools in California offered any CS courses in 2016–17 (Kapor Center, in preparation). Table 1 shows the number and percent of California high schools that did offer AP CS and other common CS courses in 2016–17.

Overall, only two percent of public high school students enrolled in any computing course, and only one percent enrolled in an AP CS course. 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, 2016).

**Table 1.** Number of California High Schools Offering CS Courses (2016–17)

| Course Name | Course Code | Number of Schools | % of Schools |
| --- | --- | --- | --- |
| Exploring Computer Science | 4634 | 284 | 12% |
| Computer Science | 2453 | 298 | 12% |
| AP Computer Science Principles | 2472 | 71 | 3% |
| AP Computer Science A | 2470 | 235 | 10% |
| Robotic Technologies | 4647 | 323 | 13% |

**Source:** Kapor Center/ACCESS. (2018). Computer Science in California’s Schools
Fact Sheet: Course Availability and Enrollment (Draft version April 11, 2018); **Note:** AP Computer Science Principles was in its pilot year in 2016–17.

The College Board provides the most reliable data source of current CS education opportunities through its yearly reports of AP CS A and AP CSP exams. California is one of the top ten states with the highest per capita AP CS A participation (Kapor Center, 2016). Yet, compared to other disciplines, the number of California students who take AP CS exams is relatively low. In 2018, 9,783 California public school students took the AP CS A exam and 11,663 California public school students took the AP CS Principles exam. 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, US and World History, and English Language and Composition.

**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.

AP exam reports are not without their limitations. First, AP courses only reflect a limited number of high school course offerings. Second, as AP courses target college-bound students, exam reports may not accurately capture information of students who enroll in CS courses but do not complete the corresponding AP exams. Third, students can sit for an AP exam without enrolling in the related course that year or without taking the AP course at a high school. As indicated in Table 2, the number of California students enrolled in the AP CS Principles and AP CS A courses in the 2016–17 academic year differed from the number of students who took the related AP exams.

**Table 2.** Number of California Students in AP CS Courses and Exams (2016–17)

| Course Name | Course Code | Total Course Enrollment | Total AP Exam Test Takers |
| --- | --- | --- | --- |
| AP Computer Science Principles | 2472 | 3,146 | 7,636 |
| AP Computer Science A | 2470 | 10,821 | 8,679 |

**Sources:** Kapor Center/ACCESS (2018). Computer Science in California’s Schools Fact Sheet: Course Availability and Enrollment (Draft version April 11, 2018); College Board’s AP Program Participation and Performance Data 2017.

### Strategies For Expanding Kindergarten Through Grade Twelve Computer Science Offerings

Expanding CS course offerings will require alignment across the kindergarten through grade eight (K-8), grade eight through twelve, 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 Next Generation Science Standards include **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.

### Strategies For Expanding At The Kindergarten Through Grade Eight Level

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 who 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. An increasing number of teachers in California already offer K–8 students CS opportunities. Their initiatives should be leveraged to support other teachers in incorporating CS into their classrooms. A first step in expanding CS course offerings would be identifying these opportunities, sharing this work across the state, and aligning these efforts with the state standards adopted by the SBE.

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 computer science 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 kindergarten through grade two, grade three through five, and grade six through eight (K–2, 3–5, and 6–8) to help educators identify ways in which computer science fits into existing coursework.

### Strategies For Expanding At The High School Level

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 should work in the next five years to expand their course offerings to offer **a-g** approved CS course sequences in all high schools. These sequences would 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 should consider developing flexible programming that would allow them 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 category **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 can search the University of California’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 (<https://hs-articulation.ucop.edu/agcmp/login#/>).

The Board of Admissions and Relations with Schools could allow greater flexibility in designating CS courses in other areas besides **g** as well. For example, a course focused on the history, ethics, and social implications of computing could be allowed to fulfill requirements in category **a** (history/social science). This would incentivize more students to participate in CS coursework.

### Strategies For Expanding Course Offerings

Expanding CS course offerings may be challenging for many districts in the absence of new funding, particularly when there are teacher shortages and districts are unable to have full-time CS teachers on staff. The Local Control Funding Formula (LCFF), enacted in 2013, 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 with low income, English learners (ELs), and foster youth; this is called supplemental and concentration funding. This funding is specifically designed for schools to implement increased and improved services for their unduplicated students[[2]](#footnote-2). Many districts already implementing CS have been using their LCFF funding for this purpose.

The UC Course Integration (UCCI) 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, which also allowing them to fulfill **a-g** subject requirements for admission into the UC and CSU systems.

**Summary of Recommended Strategies for Kindergarten Through Grade Twelve Computer Science Course Offerings**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Identify current K–8 CS instruction and align it to the *CA CS Standards* | Within 4 years | LEAsCOEs |
| Develop pathways to expose K–8 students to CS across all grade bands (K–2, 3–5, and 6–8) | Within 4 years | LEAsCOEs |
| All high schools develop course sequences and/or alternative methods (tests, portfolios etc.) to ensure CS proficiency | Within 6 years | LEAs |
| Offer **a-g** approved CS courses in additional areas | Within 5 years | LEAsCOEs |
| Develop articulation agreements and/or dual-enrollment course options | Within 4 years | LEAsIHEs |
| Participate in free UCCI workshops to develop CS courses that are integrated into core academic subjects | 2–5 years | LEAs |

## Improving Access To Computer Science Education For All Students

### Current State Of Computer Science Education Access

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. Schools in California’s urban areas are much more likely to offer CS courses; very few schools in rural counties do. For example, over 75 percent of public high schools in Santa Clara, Ventura, and Orange counties offer CS, compared to less than 25 percent of public high schools in Humboldt, El Dorado, and Tulare counties (Kapor Center, in preparation).

Access to computing courses also varies by ethnicity and income. The Level Playing Field Institutefound that:

* High schools with the highest percentages of underrepresented students of color were half as likely to offer any CS course and 12 times less likely to offer AP CS compared to schools with the lowest percentages of underrepresented students of color.
* High schools with the highest percentages of low-income students were less than half as likely to offer any CS course and 11 times less likely to offer AP CS as schools with the lowest percentages of low-income students (Martin et al., 2015).

As can be seen in Figure 2, students taking either AP CS exam are disproportionately male, unlike students taking AP Calculus AB, AP Biology, or AP English Language and Composition. Students taking AP CS A do not reflect the ethnic makeup of California public schools while the demographics of students taking AP CS Principles come closer to mirroring those of California.

**Figure 2.** Percent of California 2018 AP Exams Taken by Course, Gender, and Ethnicity



In addition to the College Board data, the Kapor 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 3). Similar to the AP CS exam data, few students are enrolled in secondary CS courses in California and students studying CS are disproportionately male.

**Table 3.** Number of California High Schools Offering CS Courses (2016–17)

| Course Name | Course Code | Total Enrollment | % of Total HS Enrollment | % Male Enrollment | % Female Enrollment |
| --- | --- | --- | --- | --- | --- |
| Exploring Computer Science | 4634 | 18,741 | 1.0% | 69% | 31% |
| Computer Science | 2453 | 15,350 | 0.8% | 64% | 36% |
| AP CSP | 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:** Kapor Center/ACCESS (2018). Computer Science in California’s Schools Fact Sheet: Course Availability and Enrollment (Draft version April 11, 2018).

Inequities in CS opportunities also exist for English learners and students with disabilities. There are approximately 1.3 million English learners in California public schools, or 20 percent of the student population(California Department of Education, 2018). In California, approximately 700,000 students (or 11 percent) have a disability. These student populations face unique barriers to CS education. English learners 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).

### Strategies For Improving Access To Computer Science Education For All Students

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. The strategies described below were recommended by the Panel; additional strategies for reaching specific student groups—young students and beginners, students with disabilities, females, and underrepresented minorities—are described in Chapter two of the K–12 Computer Science Framework (K–12 Computer Science Framework, 2016).

**Improving Access Through Family And Community Support**

Families and communities are fundamental to a student’s educational success. Their support is needed 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 can encourage students to explore CS, assist them in their course work, and provide them with learning opportunities outside of school. Their voices can also influence local schools to offer more CS courses. Community organizations and non-profits could partner with state or LEAs to develop outreach toolkits to help families improve awareness of and access to CS education for their students. This toolkit should contain information about the field of CS, strategies for supporting students, and tips for advocating for CS opportunities. To ensure the toolkit reaches a broad audience, materials should 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.

**Improving Access Through Teacher And Counselor Support**

A variety of environmental factors contribute to students pursuing CS such as early exposure, social support, and a sense of belonging. In the school environment, teachers and counselors can attract and retain more students in CS courses by implementing practices focused on equity, cultural responsiveness, and the elimination of bias. Educational equity is a cornerstone of California’s education system, and there are teachers and counselors already attending to these issues across the state. Exemplary teachers and counselors committed to improving access and equity in CS should be highlighted so they can share their strategies with other educators.

Professional learning materials and evidence-based professional development should also be created to inform teachers and counselors of best practices in encouraging diverse students and female students to pursue CS opportunities. Training materials for teachers should introduce varied pedagogical techniques and include project-based activities with strong CS content, collaborative learning, inquiry-based pedagogy, and culturally responsive teaching. Training materials for counselors should 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. Publishing these materials on the CDE website can help in disseminating best practices to teachers and counselors across the state.

**Improving Access Through Expanded Learning Opportunities**

Access to CS learning can also be improved through activities that augment the classroom experience.For example, community partners can visit schools to mentor students or provide information about computing careers. These enriching activities need not be restricted to the regular school day. Engaging with activities outside of school can help students make connections between CS and their daily lives. Social supports, including peers, mentors, and positive role are an important factor in the recruitment and retention of women into CS. In collaboration with community partners, opportunities should be created for students, especially underrepresented students, to participate in expanded learning, scholarships, internships and mentorships related to CS. The roles and responsibilities of these school-community partnerships should be clearly defined in district technology plans.

**Summary of Recommended Strategies for Improving Access to Computer Science Education for All**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Partner with community organizations and non-profits to plan outreach advocacy events focused on creating awareness of CS, especially for groups traditionally underrepresented in CS courses | Within 3 years | LEAsState |
| Develop a web page to house materials that represent best practices in CS education with an emphasis on recruiting and serving historically underrepresented groups, including females in CS education | Within 3 years | State |
| Develop training materials and professional development for counselors and teachers that prioritizes equity, engages diverse learners, utilizes project-based activities, and introduces varied pedagogical techniques | Within 3 years | LEAsCOEs |
| Partner with community organizations to provide students with expanded learning and mentoring opportunities | Within 3 years | LEAsCOEs |

## Supporting Educators To Teach Computer Science

### Current State Of Kindergarten Through Grade Twelve Computer Science Educators

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. 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[[3]](#footnote-3). Secondary teachers with single-subject credentials in Math, 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 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 a Supplementary Authorization in CS after completing a college major in CS,
20 semester units in CS, or ten upper division semester units in CS or graduate level coursework:

* An **Introductory Supplementary Authorization** authorizes the holder to teach CS content in grade nine and below; teachers must complete coursework in computational thinking; computing practice and programming; computer and communication devices; and impacts of computing; their coursework may also include a CS teaching methods/pedagogy course.
* **Specific Supplementary Authorizations** authorize the holder to teach core academic CS courses for all grades; teachers must complete coursework in computer programming; data structures and algorithms; digital devices, systems, and networks; software design; and impacts of computing; their coursework may also include a CS teaching methods/pedagogy course.

For more detail on the required coursework for both authorizations, see the California Commission on Teacher Credentialing (CTC) Coded Correspondence 16-05[[4]](#footnote-4) (CTC, 2016).

A bachelor’s degree in CS also qualifies a credentialed teacher to get the Supplementary Authorization in CS. Degrees in Educational Technology or Information Technology 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.

In the 2016–17 academic year, approximately 2,273 teachers in California taught core academic CS courses[[5]](#footnote-5). This number has grown steadily over the past few years from 1,609 teachers in 2014–15 and 1,996 teachers in 2015–16. Most teachers leading core academic CS courses are credentialed in subjects other than mathematics, business, or ITE (see Figure 3). Aside from these other credentialed teachers, teachers credentialed in mathematics comprise the largest number of core academic CS course educators.

**Figure 3.** Number of Teachers of Core Academic CS Courses by Credential

(2014–2017)

**Source:** CDE; **Note:** A teacher credentialed in math, business, or ITE might also hold other credentials.; **Note:** Core academic CS courses reported are 2451, 2453, 2458, 2465, 2470, 2471, 2472, 4619, 4634

These trends generally hold when looking at the number of teachers by CS courses taught in California that are also taught across the country (i.e., AP, International Baccalaureate® [IB], and *ECS* courses) compared to other CS courses (see Figure 4). One noticeable difference is a lower number of other credentialed teachers teaching AP, IB, or *ECS* courses.

**Figure 4.** Number of Teachers of Core Academic CS Courses by Course Group
(2016–17)



**Source:** CDE; **Note:** A teacher credentialed in math, business, or ITE might also hold other credentials; **Note:** AP, IB, ECS courses are coded as 2465, 2470, 2471, 2472, and 4634. Other courses are 2451, 2453, 2458, and 4619.

California has not yet created pre-service CS teacher preparation programs; although, 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:

* UC, Irvine: 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: five online courses (19 quarter units) (UC, Riverside Extension, 2019).
* CSU, Stanislaus also provides a list of suggested courses that can be used to meet the requirements for the supplementary authorization (CSU, Stanislaus, 2016).

Currently, no additional credential or authorization is required for a teacher to integrate computational thinking and/or CS content into a non-CS course. However, schools and teachers would be well served to participate in professional leaning activities to better understand ways of integrating CS into existing courses and to create local communities of practice (CoPs). A large number of organizations provide free lesson plans, online resources, and other material for K–12 CS education.

In addition, single-subject credentialed teachers authorized to teach CS (i.e., Math, Business, or ITE) do not necessarily have subject matter requirements that cover basic CS content. Furthermore, they are not trained in pedagogical knowledge relevant to CS, which is different from their core subject. The supplementary authorizations in CS, on the other hand, requires courses that cover CS content knowledge. Yet, there are few opportunities for credentialed teachers to enroll in such programs and will not necessarily have taught in a CS classroom.

### Strategies For Supporting Educators To Teach Computer Science

K–12 CS education cannot grow in California without increasing the number of teachers qualified to teach CS. Supporting more educators to teach CS will require a multi-pronged approach that attends to credentialing, recruitment of new teachers, teacher training, teacher communities, administrator and counselor training, awareness of the *CA CS Standards* and institutional and financial support.

**Strategies For Credentialing**

A first step to supporting teachers in pursuing CS authorization is to make it easier to identify institutions where they can complete coursework required for existing authorization. For example, CTC could host a public portal that IHEs populate with their coursework that fulfills the supplementary authorization. As another strategy, 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. Also, CTC could update the Teaching Performance Expectations (TPEs) for teacher and specialist credentials to include foundational understanding of the CS standards and related pedagogy. While related TPEs already exist (e.g., TPEs 3.6, 3.7, and 3.8), they focus more on technology and digital literacy and not on CS. Updating the TPEs could ensure that more multiple-subject and single-subject teachers are prepared to include CS content and pedagogy in their teaching.

Due to the current authorization pathways for CS teaching in California, all teachers of computer science must first receive authorization to teach some other subject. Passing legislation to develop a CS single-subject credential could encourage more aspiring teachers to pursue CS teaching. To support this strategy, CTC could develop a California Subject Examination for Teachers (CSET) or consider adopting the forthcoming CS PRAXIS® exam from the Educational Testing Service (ETS) (ETS, 2019).

**Strategies For Recruitment**

Relying on in-service teachers to fill current and future courses will be insufficient to meet California’s needs for more CS teachers. By providing funding to incentivize partnerships between CS and education departments at IHEs, programs for CS teacher preparation can be developed. Some college students, including CS majors, might not consider teaching as a viable career path when lured by the high-paying salaries of the technology industry. So, the value of CS teaching should be highlighted in these preparation programs. For example, professors could recognize the work of K–12 CS teachers alongside other CS professionals when they aim to recruit students into teaching.

Some of California’s current CS teachers are career changers who previously spent many years working in industry. Programs could be created to provide a bridge for more industry professionals to enter into CS teaching. As another alternative, individuals in industry can be encouraged to pursue a Business and Industry Partnership Teacher Authorization (BIPT) allowing them to teach for a year and then apply for a CTE credential.

**Strategies for Teacher Professional Learning**

Many teachers who will help CS spread across California will be new tothe 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. While some of these programs already exist, many more opportunities are needed.

Funding should be provided to incentivize IHEs to offer credit-bearing courses or teacher preparation programs that satisfy the CS supplementary authorization and future CS teaching credentials. These opportunities should help teachers learn how to teach concepts and practices aligned to the *CA CS Standards* and differentiated for grade and skill levels. The UC Office of the President should also be funded to expand the California Subject Matter Projects with the addition of a new project focused on CS. As the standards recommend that CS be integrated into multiple subject classrooms, all teacher preparation programs for multiple-subject and single-subject credentials should include CS content and pedagogy.

Industry can also support educator training by hosting experiences that provide teachers with a deeper understanding of the computing discipline. These partnerships can also help industry build awareness of the CS teacher shortage and how that interacts with their need for computing talent. Through educator-industry exchanges, industry might become more invested stakeholders in developing their future workforce and continue to contribute to efforts to build sustainable teacher capacity.

Instructional leaders will also need to be prepared to offer equity-minded professional learning opportunities. IHEs will need to work with CTC to establish course articulation agreements with CTC-approved teacher preparation programs.

Training opportunities should be engaging, providing teachers with excitement-generating, hands-on experiences so they can see examples of activities they may want to do with students. Funding should be provided for the creation of materials to support teachers when they return to their classrooms. It is also 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.

**Strategies For Teacher Communities**

Providing teachers with training in CS pedagogy and content is just one step in the path to supporting educators. Once in the classroom, 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 CSe 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 CoPs, especially at the elementary level. In smaller districts, COEs can encourage CoPs that invite teachers from multiple schools.

**Strategies For Administrator and Counselor Professional Learning**

Administrators and counselors will play a vital role in the spread 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 should be offered to boost knowledge of what CS is and to provide strategies they can use to support CS education. 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.

**Summary of Recommended Strategies for Supporting Educators to Teach Computer Science**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Recruit more teachers from colleges and from industry by working with IHEs and promoting the BIPT | 2–4 years | IHEsState |
| Develop more professional learning opportunities aligned to the CS standards that lead towards credit for authorization to teach CS | 2–5 years | LEAsCOEsIHEs |
| Support teachers in organizing CoPs to continue to develop their understanding of how to teach CS | 2–4 years | LEAsCOEs |

## Making Systemic Improvements In Computer Science Education

The previous sections of this document describe strategies for expanding CS course offerings, improving access to CS for all students, and supporting educators to teach CS. However, implementing CS across the state will require attention to issues that span across these levels of the education system. This section provides strategies related to information technology (IT) infrastructure, accountability and evaluation of initiatives, funding and institutional support, and dissemination.

### Strategies For Building Information Technology Infrastructure

Sufficient IT infrastructure is required for schools to have consistent access to the tools needed for CS education. In 2016, the Public Policy Institute of California reported 90 percent of schools would need **significant technological upgrades** within the next three years. Technological needs included network infrastructure, bandwidth, and devices. Large schools are more likely to face challenges related to maintaining a high-density wireless network, which would allow many students and classrooms to connect simultaneously, while rural schools are more likely to face bandwidth challenges. IT staffing is also a major challenge. Most schools lack onsite staff for maintaining the network and devices; increasing staffing to recommend levels is the largest expense category for technological upgrades (Gao and Murphy, 2016).

Defining standards for networking, hardware, and software is a first step to ensuring consistency in IT across a district. Another step is to identify hardware and software needs for CS education, including identifying areas where bandwidth or Wi-Fi may need to be upgraded. Simply installing IT infrastructure will not suffice to support CS education; personnel are also needed to maintain and update the infrastructure. Standards should be defined for the number and qualifications of IT personnel to ensure each district has adequate maintenance support. Multi-tiered support plans should also be created that include dedicated staff to address advanced IT issues that may arise at schools.

### Strategies For Accountability And Evaluation

In order to determine how well the strategies presented in this document are meeting the state’s goal of implementing CS education for all students, accountability systems are needed to track and evaluate progress. California could appoint a state-level computer science supervisor to spearhead CS education initiatives. Fourteen states already have such a position (Code Advocacy Coalition, 2018).

At the local level, CS education can be added as a college and career readiness indicator on Local Control and Accountability Plans (LCAPs) under Priority 7: Course Access. Districts can create four year implementation and evaluation plans to help all students achieve the K–12 *CA CS Standards*. Plans should be educator-driven and educator-focused, leveraging interest among teachers to pilot materials and disseminate information to colleagues. The state could assist districts in their implementation efforts by developing criteria to evaluate CS instructional materials.

Data gathered from these accountability and evaluation activities will provide useful information on the effectiveness of implementation initiatives. Also, stakeholders will likely identify areas of improvement from their experiences. As the new *CA CS Standards* shape California’s CS education in the coming years, they can serve as a vehicle for transmitting these improvements.

### Strategies For Funding And Institutional Support

Implementation plans will not go far without sustained, dedicated funding and staff at the state and local levels to support CS education efforts. Provided with funding, CDE could ensure adequate staff are available to support implementation activities and to provide technical assistance to LEAs. The California County Superintendents Educational Services Association’s Curriculum and Instruction Steering Committee (CISC) subcommittee could support stakeholders in addressing the needs of teachers and to provide a network for professional learning activities. LEAs could have sufficient resources to support the professional learning of teachers and school leaders.

Financial support could also help teachers overcome some of the barriers they face when completing coursework towards authorization to teach CS. For example, a grant program could be established to support teachers in completing course work for the CS supplementary authorization, with additional incentive for teachers who work in low-income and underserved school districts and rural and urban school districts. Also, a loan forgiveness program could be established to incentivize clear credentialed teachers to teach CS in these schools.

### Strategies For Dissemination

The state alone cannot implement CS education across California; support from students and families, community members, teachers, administrators, schools, LEAs, IHEs, and industry will be required. To garner buy-in for CS education, funding should be designated to launch a multi-faceted campaign that communicates *CA CS Standards* and CSSIP. The campaign should emphasize the future of work, labor demand, and career opportunities requiring CS.

Awareness roll-out presentations and workshops about the *CA CS Standards* should also be developed. These presentations should 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 should be developed for each grade band (i.e., K–2, 3–5, 6–8, 9–12).

Lastly, stakeholders should be recognized for the tremendous efforts they contribute to improving CS education for students across California. The state should identify model teachers, schools, and districts that successfully implement the CS standards during the early implementation stages. By sharing their experiences and best practices with the larger education community, other stakeholders may find motivation to continue with and innovate implementation efforts in their own regions.

**Summary of Recommended Strategies for Making Systematic Improvements in Computer Science Education**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Identify standards for IT infrastructure and dedicated personnel to support CS programs | Within 3 years | LEAsCOEs |
| Design accountability systems to evaluate the progress of implementation efforts | Within 2 years | State |
| Include support for CS education in district LCAPs under Priority 7: Course Access | Within 2 years | LEAsCOEs |
| Provide evaluation criteria to adopt CS instructional materials and develop an online CISC for CS | Within 2 years | State |
| Recognize successful early adopters as a model for other teachers, schools, and LEAs | Within 3 years | State |

## 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:

* 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 are lifelong learners, informed citizens with a conceptual knowledge of how computing technology works, and productive contributors to society as a whole;
* 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 materials and strategies to use in supporting students in pursuing CS opportunities;
* 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.

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 A

The Panel made recommendations that would require additional funding to implement. These recommendations are included here as a resource to those seeking to invest in computer science through legislation or philanthropy.

**Summary of Recommended Strategies for Supporting Educators to Teach Computer Science**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Pass legislation to authorize CTC to develop a single subject credential in CS | Within 3 years | State |
| Provide administrators and counselors with training to learn more about CS and ways they can support CS education | 2-5 years | LEAsCOEs |
| Develop a CSET for computer science | 2-5 years | State |
| Expand the California Subject Matter Projects to include CS | 2-5 years | State |
| Develop credit-bearing courses professional learning opportunities that satisfy the CS supplementary authorization and future CS teaching credentials | 2-5 years | IHEsState |

**Summary of Recommended Strategies for Making Systematic Improvements in Computer Science Education**

| Strategy | Timeframe | Responsible Entity |
| --- | --- | --- |
| Provide sustained, dedicated funding and staff at the state level and local level to support CS education efforts | 1-2 years | State |
| Provide financial support to help teachers complete coursework towards CS authorization and to work in low-income and underserved school districts and rural and urban school districts | 2-3 years | State |
| Build awareness of CS standards and the implementation plan through roll-out workshops and CS foundation toolkits | Within 2 years | State |

## Appendix B

*This supplementary page contains long descriptions for the figures/graphics used on SBE Item 05 Attachment 1 titled, California Computer Science Strategic Implementation Plan – Draft, dated March 2019*

**Long description for Figure 1 on Page 13**

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 (85,882). Students took 69,366 exams in US history; 43, 607 exams in calculus AB; 35,943 in world history; 34,994 in biology; 30, 063 in statistics; 19,643 in chemistry; 17,748 in physics 1, 17,155 in Economics: macro, 11, 663 in CSP; 9,783 in CS A, and 9,088 in economics: micro.

**Long description for Figure 2 on Page 18**

Percent of California 2018 AP Exams Taken by Course, Gender and Ethnicity

* The percentage of African American students that take the AP CS A exam is 1%; American Indian or Alaska Native 0%; Asian 49%; Hispanic or Latinx 15%, Pacific Islander 0%, White 26%, two or more races 6%; male 73% and female 27%.
* The percentage of African American students that take the AP CS Principles exam is 2%; American Indian or Alaska Native 0%; Asian 33%; Hispanic or Latinx 32%, Pacific Islander 0%, White 24%, two or more races 5%; male 67% and female 33%.
* The percentage of African American students that take the AP Calculus AB exam is 2%; American Indian or Alaska Native 0%; Asian 33%; Hispanic or Latinx 32%, Pacific Islander 0%, White 26%, two or more races 5%; male 50% and female 50%.
* The percentage of African American students that take the AP Biology exam is 2%; American Indian or Alaska Native 0%; Asian 33%; Hispanic or Latinx 32%, Pacific Islander 0%, White 24%, two or more races 6%; male 39% and female 61%.
* The percentage of African American students that take the AP English Language and Composition exam is 3%; American Indian or Alaska Native 0%; Asian 21%; Hispanic or Latinx 42%, Pacific Islander 0%, White 26%, two or more races 5%; male 38% and female 62%.

**Long description for Figure 3 on Page 23**

Number of Teachers of Core Academic CS Courses by Credential (2014-2017)

* In 2014-15, teachers assigned to CS courses held the following credentials: 560 math; 473 business; 227 ITE; 729 other.
* In 2015-16, teachers assigned to CS courses held the following credentials: 724 math; 476 business; 250 ITE; 898 other.
* In 2016-17, teachers assigned to CS courses held the following credentials: 918 math; 568 business; 328 ITE; 953 other.

**Long description for Figure 4 on Page 24**

Number of Teachers of Core Academic CS Courses by Course Group (2016-2017)

* In 2016-17, the number of teachers that taught AP, IB and *ECS* that held a math credential was 331; 231 held a business credential, 156 held an ITE credential and 216 held other credentials only.
* In 2016-17, the number of teachers that taught other CS courses that held a math credential was 462; 337 held a business credential, 172 held an ITE credential and 737 held other credentials only.

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1. A national consensus document that outlines a progression of concepts and practices by grade span in computer science that all students could learn in elementary and secondary school. (<https://k12cs.org/>) [↑](#footnote-ref-1)
2. “Unduplicated” students are those who are: (1) English learners, (2) eligible for free or reduced-price meals, or (3) foster youth. Each student is counted only once even if multiple criteria are met. [↑](#footnote-ref-2)
3. In most cases, teachers of AP CS Principles have received district authorization to teach the course, provided the teacher has completed professional development and received a certificate. [↑](#footnote-ref-3)
4. Teachers with a Supplementary Authorization in Computer Concepts and Applications awarded prior to April 2016 are also authorized to teach CS. [↑](#footnote-ref-4)
5. This figure includes teachers who taught a computer science course coded as one of the following: 2451, 2453, 2458, 2465, 2470, 2471, 2472, 4619, 4634. [↑](#footnote-ref-5)