COMPUTER SCIENCE IN CALIFORNIA'S SCHOOLS:
An Analysis of Access, Enrollment, and Equity

KAPOR CENTER

#CSforCA

Date

June 17, 2019

Authors

Allison Scott, Ph.D.
Sonia Koshy, Ph.D.
Meghana Rao
Laura Hinton
Julie Flapan, Ed.D.
Alexis Martin, Ph.D.
Frieda McAlear, M.Res.

Acknowledgements

The authors would like to express deep appreciation for all members of the CSforCA coalition who have been working tirelessly to improve access and equity in CS in California. We would also like to express gratitude for the expertise provided by a host of collaborators, including: Dan Garcia, Joanna Goode, Solomon Russell, Bryan Twarek, Sam Berg, Roxana Hadad, Jane Margolis, Kamau Bobb, and Debra Richardson. We would also like to express appreciation to colleagues at the California Department of Education for providing the data for us to analyze and providing support in interpretation of findings, including Karl Scheff and Emily Oliva, and Barbara Murchison, and Nicole Vasgerdsian for the report layout. Finally, we would like to acknowledge the National Science Foundation and Program Officer Fay Payton Cobb for providing support for this project under grant #1748316, and Mitch Kapor and Freada Kapor Klein for generous support of this project.

#CSforCA

www.csforca.org

KAPOR CENTER

www.kaporcenter.org

COMPUTER SCIENCE IN CALIFORNIA'S SCHOOLS: An Analysis of Access, Enrollment, and Equity

EXECUTIVE SUMMARY

Advancements in technology are occurring rapidly across all industries and sectors, driving economic growth across the nation and the state of California, with continued exponential growth projected into the next decade. While California leads the nation in overall economic output (GDP), the size and productivity of its technology economy, its overall population size, and in the diversity of its population, California must invest in the development of a skilled and diverse technological workforce to maintain economic competitiveness, drive innovation, and ensure its residents are prepared to participate in the workforce of the future.

There are three significant challenges that California faces in developing a robust and diverse future workforce: (1) the lack of access to fundamental computing knowledge and literacy for students in grades K-12; (2) the lack of alignment between K-12 and post-secondary education and the needs of the technology workforce; and (3) the lack of racial and gender diversity in K-12 computer science (CS) education, among computing degree-earners, and within California's technology sector.

To examine the earliest stage in the computing pipeline (K-12 education), this report provides data on computer science access, enrollment, and equity across the state of California. Examining 4 years of data from the California Department of Education and the College Board, this report summarizes current and trend data on the availability of computer science courses, enrollment and participation in computer science courses, passage rates on AP CS exams, and equity gaps by race, gender, socioeconomic status, and geography. Key findings from this report include:

COMPUTER SCIENCE COURSE AVAILABILITY

While the number of high schools offering CS courses has grown steadily over the past 3 years, more than half of all high schools in California do not offer any CS courses, and low-income students, students of color, and rural students are least likely to have access.

- **39%** of high schools in California offer CS courses, while **61%** have no CS course offerings.
- AP CS A courses are taught in only **14%** of high schools, and **5%** offer AP CS Principles.
- The number of high schools offering CS courses has grown by **61%** since 2014, but equity gaps by race/ethnicity, SES, and geography remain large.
- Low-income schools are **4x less likely** to offer AP CS A courses than high-income schools.
- High-URM schools are nearly **2x less likely** to offer any computer science course and **3x less likely** to offer AP CS A than low-URM schools.
- **1 in 4** rural schools offer CS courses, compared with 39% of urban schools.

COMPUTER SCIENCE ENROLLMENT & PARTICIPATION

Student enrollment in introductory CS courses has nearly doubled across California in the past 3 years, and enrollment in AP CS has tripled. Yet, just a small fraction of the high school students in California take CS courses (3%), and there are significant disparities by race/ethnicity and gender in CS participation.

- Just **3%** of the **1.9** million high school students in California were enrolled in computer science, and only **1%** took an Advanced Placement CS course.
- Black, Latinx, and Native American/Alaskan Native students comprise **60%** of California's high school population but just **16%** of AP CS A test-takers (n=1,907).
- Just **1%** of AP CS test-takers in California are Black (n=479 students).
- The percentage of Latinx students taking AP CS has increased by 14 percentage points, but there has been no increase for Black students and both groups remain underrepresented by **2-3x** relative to their population.
- Female students comprise **50%** of California's high school population, but just **29%** of students taking introductory CS courses, and **27%** of students taking AP CS A.
- Just **36** Black girls and **453** Latinx girls took AP CS A.

COMPUTER SCIENCE COURSE SUCCESS

71% of students enrolling AP CS courses across California receive passing scores on the AP CS exams (one standardized indicator of performance), and significant gaps exist in passage rates by race/ethnicity.

- **7** in **10** students in California who take the AP CS A or AP CS Principles exam receive a passing score (3+).
- Just **4 in 10** Black and Latinx AP CS A test-takers pass the exam.
- Female students pass both AP CS exams at the **same rate** as their male peers, demonstrating no gender differences in CS performance.

As momentum for computer science education has increased in recent years at the national, state, and local levels, the number of schools offering CS courses and the number of students participating in CS courses has steadily increased across California. Yet, data indicate that far too few students in California attend high schools which offer introductory and AP CS courses, and even fewer students participate in computer science courses. Even more troubling, the large and persistent equity gaps in access, enrollment, and success in computer science courses negatively impact low-income students, underrepresented students of color, female students, and rural students.

The current state of computer science education in California and the future need for a skilled and diverse technologically-savvy workforce must be met with strategic and systemic reform in K-12 education to align with this new reality.

California must invest in the development of a skilled and diverse tech workforce to drive innovation, power the economy, and ensure Californians are prepared for the workforce of the future.

POLICY RECOMMENDATIONS

The following recommendations are provided to policymakers, educators, tech industry leaders, and the philanthropic community to increase access and participation in computing education, and to ensure all Californians have access to the education and skills to prepare them for the workforce of the future:

1. Utilize the Computer Science Strategic Implementation Plan (CSSIP) as a Guidance Document for Expanding Access to Computer Science in California.
2. Increase Participation of Students from Underrepresented Backgrounds in CS Education, by Prioritizing Funding and Developing Initiatives for the Most Underserved Schools and Populations.
3. Establish Rigorous CS Teacher Preparation, Certification, and Professional Development for K-12 Teachers.
4. Ensure Access to Technology Infrastructure to Support CS Education, Prioritizing Districts and Local Education Agencies with the Highest Needs.
5. Implement K-12 CS Standards Within All CS Courses, and Integrated Across Subjects, by Providing Support for Local Education Agencies, Administrators, and Teachers.
6. Develop Assessment, Data Collection, and Accountability Mechanisms to Track the Implementation and Efficacy of CS Education and Track Equity Gaps.
7. Ensure CS is Prioritized as a High School Graduation and College Entry Requirement.
8. Implement Large-Scale Policies and Initiatives that Address Systemic Educational Inequity Affecting Student Outcomes across Subject Areas.

CONCLUSION

California urgently needs bold and comprehensive education reform to ensure Californians are prepared to participate in the rapidly evolving global technology economy. The inability to meet the growing demand for a skilled and diverse technology workforce threatens to have a detrimental impact on economic growth, competitiveness, innovation, and inequality, especially among communities of color. It will no longer be sufficient for computing knowledge and skills, degrees, and occupations to be limited to a select few—California must take a long-term, strategic approach to preparing its students and its future workforce, or risk being left behind.

California's technology sector leads all other states, contributing **$482 billion** to the state economy and employing **1.78** million people.

COMPUTING AND CALIFORNIA'S ECONOMY

Advancements in technology, from artificial intelligence and the Internet of things, to autonomous vehicles and biotechnology, are occurring rapidly across all industries and sectors of the economy, and driving economic growth in California, the United States, and across the globe (Baller et al., 2016; Schwab, 2016). Labor market trends and projections highlight the critical role that computing plays in the United States economy: Nearly ¼ of the country's economic output is produced by high-tech industries, currently employing 17 million workers; and computing-related occupations are the fastest-growing group, projected to produce nearly 1 million job openings over the next 10 years (Bureau of Labor Statistics [BLS], 2016, 2017).

California, the most populous state in the country, has the 5th largest economy in the world and 19% of its annual economic output is produced by the technology sector, totaling $482 billion. Seven of the ten top-grossing technology companies, including Apple, Google, and Intel, are headquartered in California, with a combined annual revenue of over $580 billion and employing more than 500,000 employees (Forbes, 2018). California leads the nation in the number of technology workers (1.78 million), the number of computing job gains between 2017 and 2018 (43,600), and the percentage of all venture capital invested in technology startups (50%; CompTIA, 2019; Florida, 2018). If California, and the United States more broadly, are to maintain economic competitiveness, we must invest in the development of a skilled and diverse technological workforce to drive innovation, power the economy, and ensure its citizens are prepared to participate in the workforce of the future. In addition, increasing computing knowledge and skills for all Californians is vital to ensuring individuals understand the ethical, social, political, and economic implications of advances in technology.

The state faces three significant challenges in developing its future workforce: (1) the lack of access to fundamental computing knowledge and literacy for students in grades K-12; (2) the lack of alignment between K-12 and post-secondary education and the needs of the technology workforce; and (3) the lack of racial and gender diversity in K-12 computer science (CS) education, among computing degree-earners, and within California's technology sector.

- **The lack of access to rigorous K-12 computer science education.** Only 39% of high schools in California offer CS courses, and just 3% of California's high school students took a CS course in 2017. While California has adopted K-12 CS standards, and a Computer Science Strategic Implementation Plan, there is limited infrastructure and funding to ensure access to CS courses for all students, to develop a pool of highly-qualified teachers, and to increase racial, gender, and socioeconomic equity in CS. Meanwhile, 25 other states have allocated funding for K-12 CS education, 17 states require high schools to offer CS, and 14 states have developed pre-service teacher preparation programs (California Department of Education, 2017, 2019; Code.org/CSTA, 2018).

- **The lack of alignment between K-12, post-secondary education, and workforce needs.** Computer science is not prioritized as a core high school graduation or college entry requirement (although CS can count as an elective, a 3rd year of science, or a 4th year of math under the UC/CSU college entry requirements governed by the University of California). Higher education institutions in California rank near the bottom in Bachelor's degree completion rates in CS (38th) and engineering (37th), producing less than 5,000 CS graduates per year. CS remains an impacted major across most University of California and California State University campuses, restricting the number and diversity of students who can major in computer science and restricting growth in the number of computer science graduates (Campaign for College Opportunity, 2016; Code.org/ CSTA, 2018; California State University, 2019; Computing Research Association, 2017, National Center for Education Statistics, 2012).
- **The lack of racial and gender diversity in computing education and California's technology sector.** People of color comprise the majority of California's population with diversity projected to increase significantly over the next 20 years. Yet the students taking computer science courses, completing computing degrees, and participating in the tech workforce are not representative of the state's population: Latinx, Black and Native American/Alaskan Native students make up 60% of California's student population, but comprise only 16% of students taking AP CS A and 20% of UC/CSU computing degree earners. Thirty-nine percent of California's workforce is Latinx, but just 5% of the Silicon Valley tech workforce is Latinx. Seventy percent of the Silicon Valley workforce is male, despite women making up 50% of California's population (College Board, 2018; Phillips, et al., Forthcoming, Rangarajan, 2018; U.S. Bureau of the Census, 2016).

Bold and systemic solutions are required to address these challenges and ensure all Californians have access to the education and skills to prepare them for the workforce of the future, and to ensure California's future workforce can meet the needs of its economy. These challenges in computing education and the workforce exist within the broader context of educational and social inequality and the deeply entrenched disparities in school funding and resources, teacher quality, technology, and extracurricular activities across California and the nation (Darling-Hammond, 2004; EdTrust-West, 2015; EdBuild, 2019; Edley & Kimner, 2018). While equity in computing education is critical, this goal must be viewed as part of a broader strategy for educational equity.

This report will specifically focus on the earliest stage of the computing pipeline, by summarizing the current landscape of access, enrollment, and equity in K-12 CS education across the state of California. The report will then conclude with strategic recommendations for policymakers, educators, tech industry leaders, and the philanthropic community to implement in order to improve access and equity in computer science education for all students in California.

California ranks **6th** in AP CS participation, **38th** in the production of CS degree earners, and its tech workforce does not reflect the racial and gender demographics of the state.

6 in 10 high schools in California do not offer any CS courses, and low-income students, students of color, and rural students are least likely to have access to computer science education.

COMPUTER SCIENCE COURSE AVAILABILITY

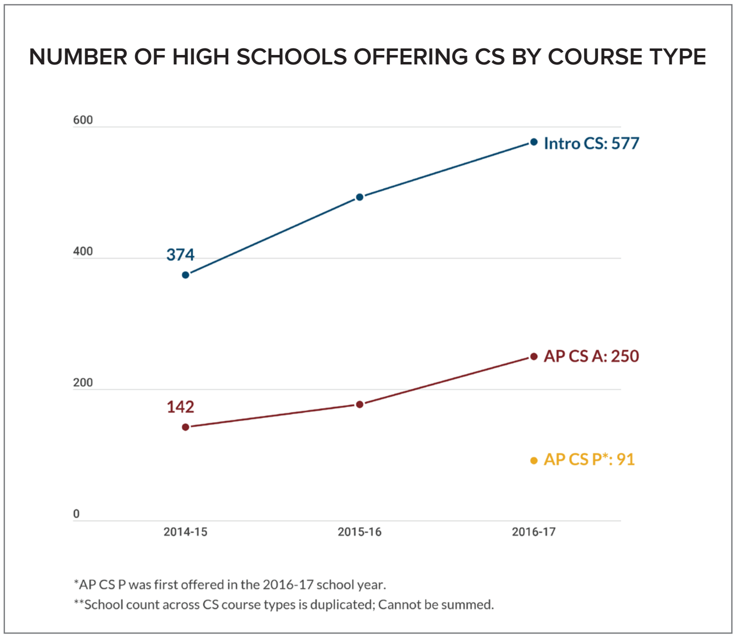
STATEWIDE DATA

Across the state of California, 712 high schools (39% of the public high schools in the state) offer at least one CS course, while 61% of California's high schools do not offer any CS courses. Far fewer high schools offer Advanced Placement CS courses, with 14% of California's high schools offering Advanced Placement (AP) CS A and 5% of high schools offering AP CS Principles (Figure 1).

PROMISING TRENDS

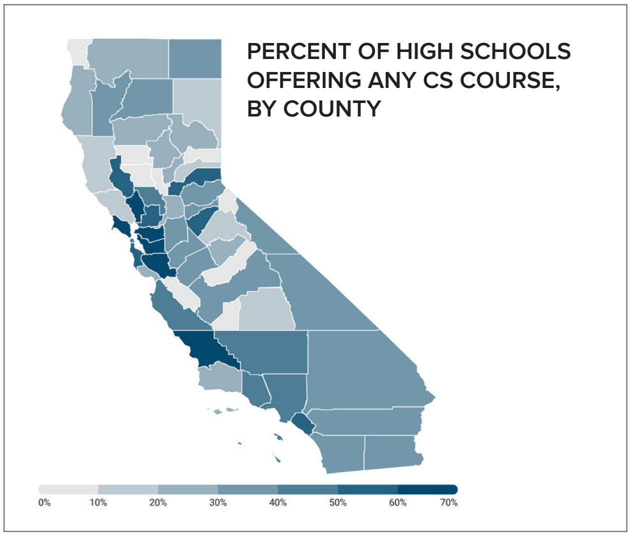
Trends in course availability indicate that there has been steady growth in the number of high schools offering CS courses from 2014-15 to 2016-17, with the number of schools offering at least one CS course increasing by 61%. The growth in CS course offerings can be seen across both introductory computing courses, and AP CS, including the new AP CS Principles course, which launched in 2016-17 (Figure 1). In 9 counties in California, more than half of the high schools in that county offer CS courses: Marin, Napa, Placer, Contra Costa, Alameda, Santa Clara, San Mateo, San Luis Obispo, and Orange County (Figure 2). The counties which have the largest percentage of high schools offering Advanced Placement courses are: Marin, Contra Costa, Alameda, Santa Clara, and Orange counties (Figure 3). Access to the new AP course, AP CS Principles, is available in relatively equal percentages across high-and low-income schools and high-and low-URM schools, demonstrating promise for increasing equity in access to AP CS Principles (Figure 4).

Figure 1.



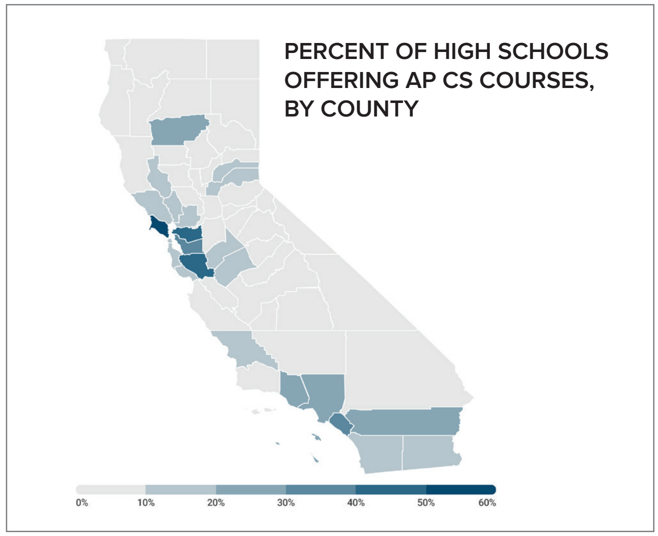
Source: CDE (2017)

Figure 2.



Source: CDE (2017)

Figure 3.

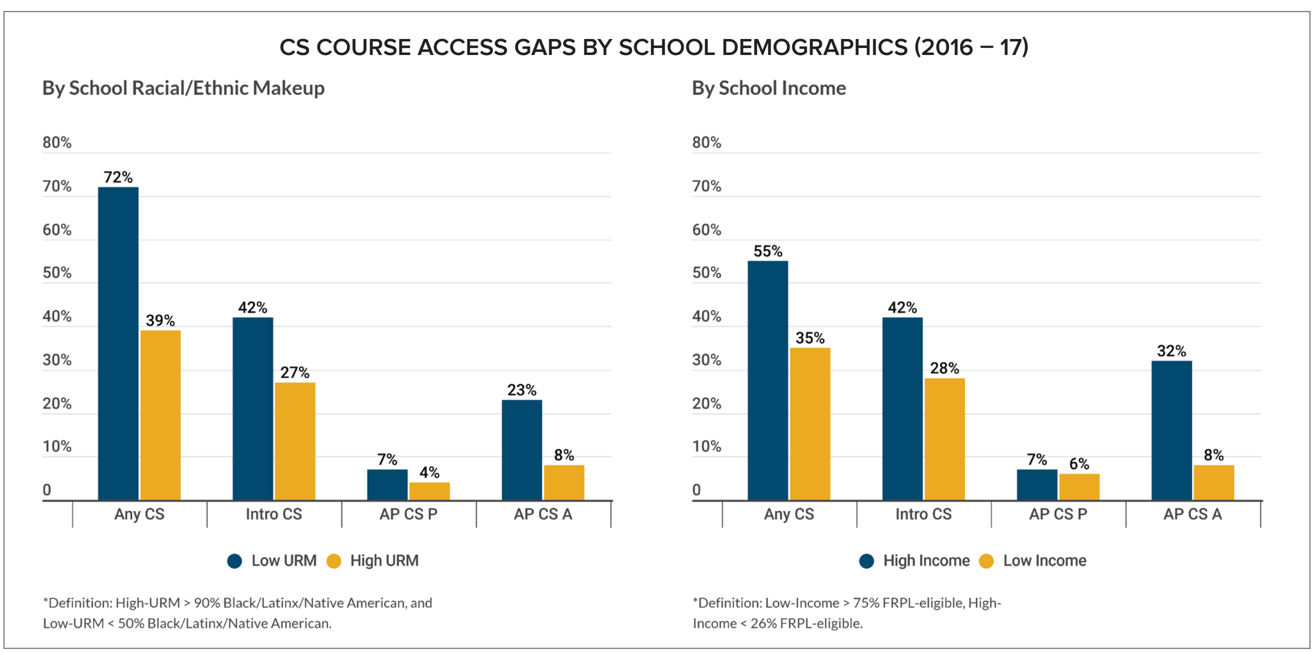


Source: CDE (2017)

EQUITY GAPS

Despite growth in the number of California high schools offering CS courses, when CS access is analyzed by geographic region and school demographics, significant equity gaps persist. The high schools which offer CS courses are concentrated in the San Francisco Bay Area and Los Angeles regions, with fewer CS courses available in Northern California and the Central Valley. In 24 counties across California, fewer than one-quarter of high schools in that county offer CS courses (Figure 2). In the majority of California counties, less than 10% of their high schools offer AP CS courses (Figure 3). Rural high schools in California are less likely to offer CS courses than urban high schools (24% vs. 39%) and rural high schools are seven times less likely to offer AP CS A than urban schools (2% vs. 14%). Race/ethnicity and socioeconomic status are significantly related to access to CS courses in California high schools, and low-income students and students of color are less likely to attend schools that offer CS courses. Just 39% of high-URM schools (schools attended by predominantly Black, Latinx, and/or Native American/Alaskan Native students) offer CS courses, compared to 72% of low-URM schools (schools attended predominantly by white and/or Asian students). Disparities are consistent across introductory CS courses, AP CS A, and AP CS Principles, with just 8% of high-URM schools offering AP CS A (versus 23% of low-URM schools; Figure 4). Similar trends are present by school socioeconomic demographics: CS courses are more likely to be offered in high-income schools (55%) than low-income schools (35%; Figure 4).

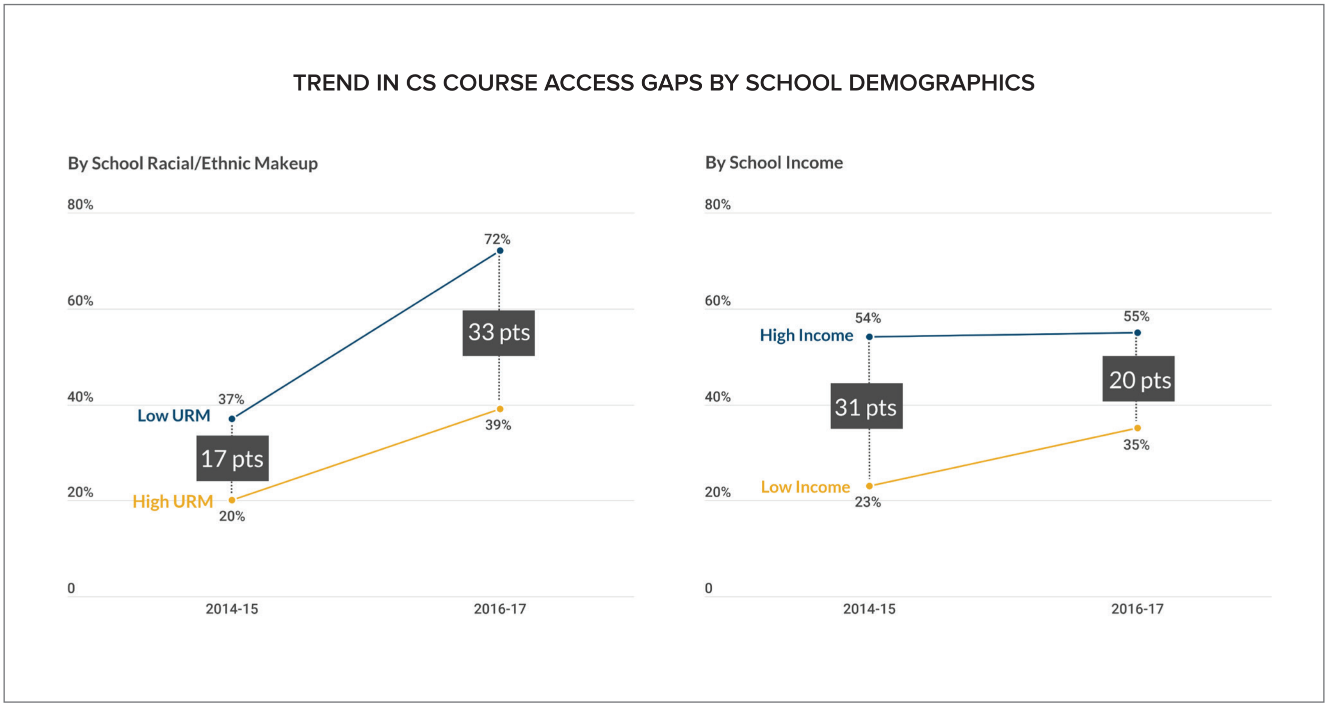
Figure 4.



Source: CDE (2017)

Between 2013 and 2017, gaps in the percentage of schools offering CS courses between high-URM and low-URM schools have increased by 16 percentage points (Figure 5). Gaps between the percentage of high-income schools and low-income schools offering CS courses have decreased by 11 percentage points (Figure 5). Overall, equity gaps in course availability by school racial and socioeconomic demographics remain large—CS is offered at rates 33 percentage points higher in low-URM schools than high-URM schools, and at rates 20 percentage points higher in high-income schools than low-income schools.

Figure 5.



Source: CDE (2017)

Equity gaps in course availability by school racial and socioeconomic demographics have remained large over the past four years.

Just **3%** of California's 1.9 million high school students took a computer science course in 2017, and only **1%** took an Advanced Placement course. Of the students enrolled in AP CS A, just **27%** were female, and just **16%** were Black, Latinx or Native American.

COMPUTER SCIENCE ENROLLMENT & PARTICIPATION

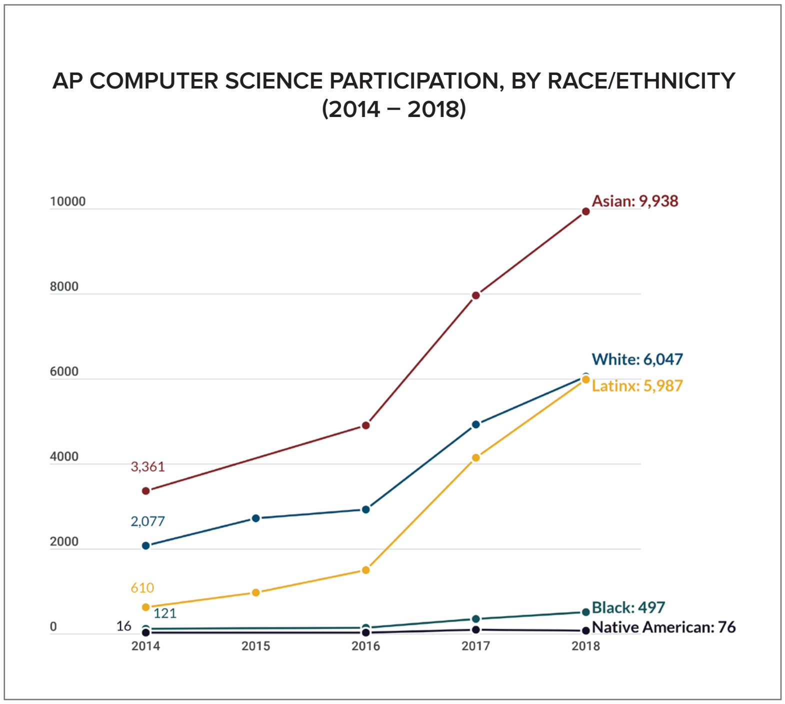
STATEWIDE DATA

While CS courses are available in 39% of California's high schools, just 3% of California's roughly 1.9 million high school students in California were enrolled in a CS course in 2017. Despite being a significant predictor of persistence into computing majors in post-secondary education, just 1% of all California high school students took an AP CS exam in 2018. In comparison to other states, California ranks sixth in AP CS test-takers (in proportion to its population), with 39 students taking AP CS for every 10,000 students in the state. Maryland and New Jersey have AP test-taking rates that are much higher than California: 63 and 50 students per 10,000 K-12 students, respectively. Overall, AP CS participation in California has grown by 30% from 2017 to 2018, yet it is growing at a faster rate in states like Michigan (74%), Arizona (50%), Arkansas (45%), Wisconsin (45%), and Florida (44%).

PROMISING TRENDS

Trends in course enrollment demonstrate a steady increase in the number of students in California participating in CS courses over the last several years. Since 2014, enrollment in introductory CS courses has more than doubled since 2014, and enrollment in AP CS has nearly tripled, due in part to the launch of a new AP CS Principles course in 2016-17 (Figure 6). Growth in AP participation since 2014 has occurred across all racial groups, with the fastest growth occurring among Latinx, White, and Asian students, but slower growth among Black students (Figure 6). In AP CS Principles, the percentage of girls enrolled is higher than in either introductory CS courses or AP CS A (Figure 8). While Latinx students are still underrepresented in AP CS Principles, they participate in AP CS Principles at higher percentages than AP CS A (32% vs. 15%; Figure 7), and have increased in percentage of AP CS enrollment by 14 percentage points since 2014.

Figure 6.

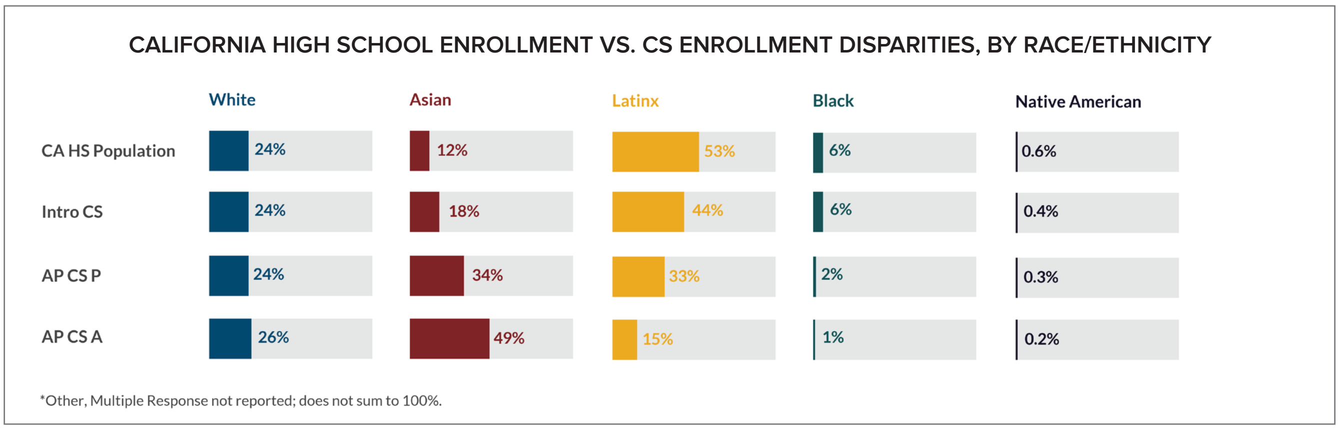


Source: College Board (2014-2018)

EQUITY GAPS

While more students in California are taking CS courses than ever before, significant racial and gender disparities exist in CS enrollment. Black, Latinx, and Native American/Alaskan Native students represent almost 60% of California's high school population, and 50% of students enrolled in introductory CS courses, but just 16% of students enrolled in AP CS A. Latinx students are underrepresented in introductory CS courses (44%), AP CS A (15%), and AP CS Principles (32%) relative to their representation in the California high school student population (53%). Black students are underrepresented in AP CS A (1%) and AP CS P (2%) relative to their overall high school population (6%). The starkest disparities exist in AP CS A participation: 75% of students taking AP CS A are White or Asian, while just 15% were Latinx, 1% were Black, and less than 1% were Native American. Asian students are more likely to take AP CS A (versus AP CS Principles), while Latinx students are more likely to take AP CS Principles than AP CS A (Figure 7). Between 2014 and 2018, the percentage of AP CS participants who are Latinx has increased, but Latinx students are still underrepresented relative to their population by 2x. Black students have remained underrepresented relative to their population by 3x for the past 4 years, with no gains and slower growth than other racial groups. Asian students remain significantly overrepresented (Figures 6 and 7).

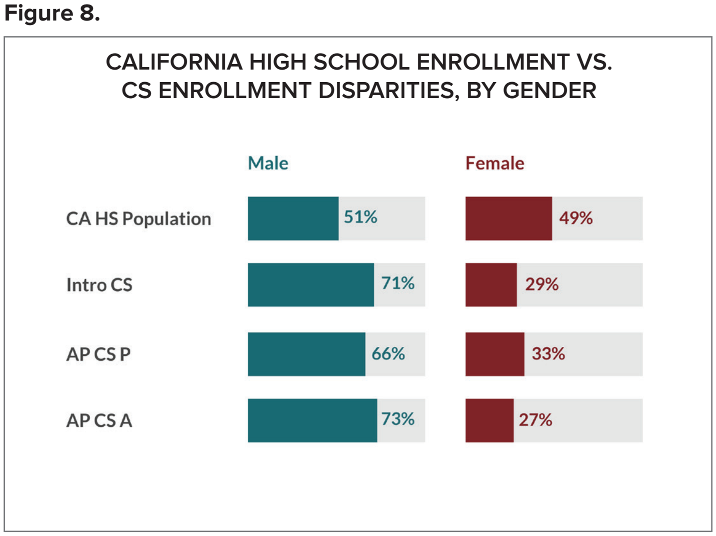
Figure 7.



Source: CDE (2018), College Board (2018)

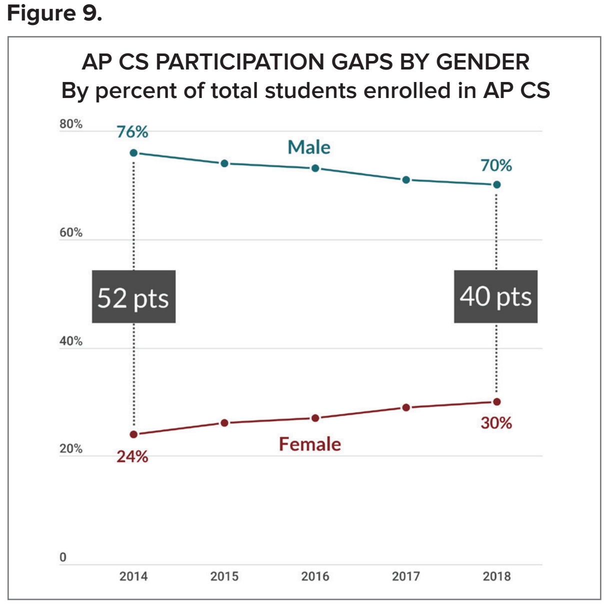
While female students comprise 50% of California's high school population, CS enrollment is skewed heavily by gender. Seventy-one percent of students who take introductory CS and 73% of students taking AP CS A in California are male (Figure 8). When examining AP CS A participation by race and gender, just 36 Black girls and 453 Latinx girls took AP CS A. White girls comprise just 21% of all white students in AP CS A, while Asian girls make up 30% of all Asian students taking AP CS A. Since 2014, the gender gap in AP CS participation has slowly decreased, from 52 percentage points in 2014 to 40 percentage points in 2018, yet female students remain underrepresented by more than 2x compared with male students (Figure 9).

Figure 8.



Source: CDE (2018), College Board (2018)

Figure 9.



Source: College Board (2014-18)

7 in 10 students in California who take the AP CS A or AP CS Principles exam receive a passing score, while Black and Latinx students pass AP CS exams at far lower rates than their peers.

COMPUTER SCIENCE COURSE SUCCESS

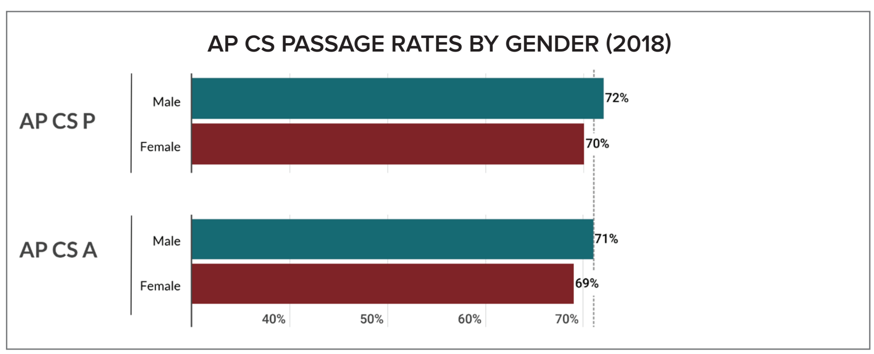
STATEWIDE DATA

When students do enroll in CS courses, it is also critically important to examine students' success in the course and whether they have acquired requisite computing knowledge and skills. Advanced Placement CS passage rates provide one indicator of course performance, and across the state of California, 71% of students who take the AP CS exams earn a passing score of 3 or above. In comparison to other states, California ranks 13th in AP CS passage rates (among states with more than 1,000 test-takers, including Wisconsin (82%) and Michigan (81%; College Board, 2018). The AP CS passage rates in California have remained relatively stable over the past four years.

PROMISING TRENDS

Across the state of California, while enrollment in AP CS has increased, passage rates have also increased slightly (from 69% in 2014 to 71% in 2018). Passage rates for all racial and gender sub-groups are slightly higher on the AP CS Principles exam than the AP CS A exam (Figure 10). Importantly, there are no disparities in passage rates by gender on the AP CS A or AP CS Principles exam, demonstrating that when girls participate in AP CS, they pass the test at the same rates as their male peers (Figure 10).

Figure 10.

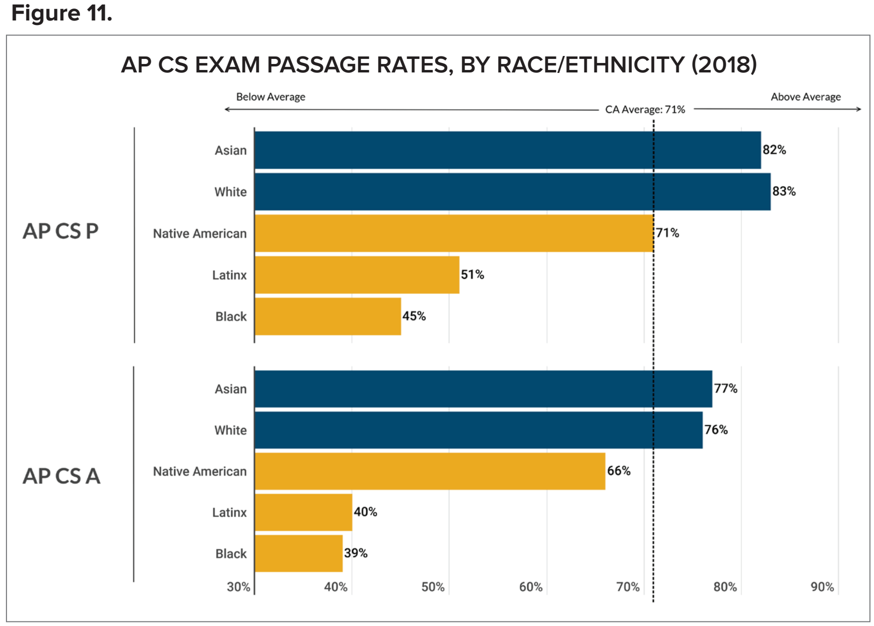


Source: College Board (2018)

EQUITY GAPS

Despite increasing rates of enrollment in CS courses, equity gaps in AP CS passage rates between underrepresented students of color and White and Asian students are as wide as 38 percentage points. While more than three-quarters of White and Asian students who take the AP CS A exam receive passing scores, just 40% of Latinx and 39% of Black students pass the exam, and similar disparities exist in AP CS Principles passage rates between Black and Latinx students and their peers (Figure 11).

Figure 11.



Source: College Board (2018)

California must implement a comprehensive statewide strategy to provide access to computing for all of California's students, close racial, gender, and socioeconomic equity gaps, and prepare all Californians for the future technology-driven economy.

SUMMARY

In recent years, the recognition of the importance of CS education has significantly increased, prompting efforts and initiatives at the national, state, district, and school level to broaden participation in computing, including: the "CS for All" initiative launched by President Obama, the CS10K initiative from the National Science Foundation, the creation of Exploring Computer Science and AP CS Principles courses, and district/city-wide CS initiatives in Oakland, San Francisco, Los Angeles, Chicago, and New York City among others.

In California, these efforts have translated into a steady increase in the number of schools offering CS courses and the number of students participating in CS courses. Yet, the most current data indicate that far too few students in California attend high schools that offer any CS courses (39%) and only 3% of California's high schools students participate in CS courses. These percentages are even smaller in Advanced Placement CS courses, where just 14% of high schools offer AP CS A, and just 1% of high school students enrolled in AP CS A or P. Large equity gaps remain in access and enrollment to CS education, by race, gender, and socioeconomic status. Low-income schools and schools serving primarily students of color are significantly less likely to offer CS courses, and these equity gaps have remained (and in some cases, grown larger) since 2013. Similarly, even as CS course enrollment has increased across California, girls and Black, Latinx, and Native American students are still much less likely to take CS and are vastly underrepresented relative to their population in CS courses. There are also large gaps in success in CS, with only about half of Black and Latinx students passing the AP CS exams, compared to over 70% of their White and Asian peers.

Despite California's need to develop computational thinking skills, technological literacy, and programming skills among its populace to ensure a diverse and robust future workforce, California continues to fall short of a crucial component of workforce development by failing to provide rigorous CS education to all students. There has been promising progress over the past several years in pushing for statewide computer science implementation. Assembly Bill AB 2329 (Bonilla) and Assembly Bill AB 1539 (Hagman), have led to the development and adoption of K-12 CS content standards and a strategic implementation plan for statewide CS education. The University of California has approved CS as a third-year science under the UC/A-G entrance requirements (UCOP, 2019). Additionally, a host of legislative bills have been proposed for the 2019 legislative session aiming to develop CS teacher training pathways, appoint a CS coordinator to implement CS across California, and Governor Newsom's budget proposal includes several funding priorities for computer science education. But there is much more work to do. California must implement a comprehensive, statewide CS policy strategy to provide access to computing for all of California's students, close racial, gender, geographic, and socioeconomic gaps in computing participation, and prepare Californians for the future technology-driven economy.

POLICY RECOMMENDATIONS

The following eight items are priority policy recommendations for policymakers, educators, tech industry leaders, and philanthropy across the state of California:

1. **Utilize the Computer Science Strategic Implementation Plan (CSSIP) as a Guidance Document for Expanding Access to Computer Science in California.** The strategic plan, which was drafted by a 23-member panel of appointees and adopted by the State Board of Education in 2019, includes recommendations to ensure all high schools offer at least one CS course; Increase the participation of students traditionally underrepresented in CS; ensure districts have technology infrastructure including broadband connectivity, hardware, and software; and provide training, certification pathways, and incentives for CS teachers. The CSSIP provides guidance to drive meaningful legislation and action at the local education agency level to expand access to CS in California.

2. **Increase Participation of Students from Underrepresented Backgrounds in CS Education, Especially Black, Latinx, Native American, Rural, Low-Income, and Female Students.** Prioritize implementation funding for low-income districts and districts serving primarily students of color; Establish a grant and loan forgiveness program to prepare and attract CS teachers to teach in low-income and underserved school districts/Local Education Agencies; Increase awareness about CS and its importance and applicability to all fields, through outreach, media, events, and collaborations with non-profits; Raise profile through awards or incentives for schools, districts and Local Education Agencies closing equity gaps in CS.

3. **Establish Rigorous CS Teacher Preparation, Certification, and Professional Development for K-12 Teachers.** Provide incentives for schools of education to develop secondary CS pre-service teacher programs and integrate CS standards into existing elementary teacher preparation programs; Expand teacher credentials for CS to include both science teachers and a single-subject CS credential. Provide funding for ongoing professional development and to develop communities of practice.

4. **Ensure Access to Technology Infrastructure to Support CS Education.** Assess the current status of key technology components across all districts (including hardware, software, broadband connectivity, and IT staffing support); Provide funding for districts and Local Education Agencies with the highest needs, including low-income and rural districts.

5. **Implement K-12 CS Standards Within All CS Courses.** Ensure Local Education Agencies have necessary support to implement K-12 CS standards by providing implementation funding to Local Education Agencies, funding for teacher professional development, creating a new Curriculum and Instruction Steering Committee (CISC) sub-committee specific to CS, and aligning standards to assessment and accountability mechanisms.

6. **Develop Assessment, Data Collection, and Accountability Mechanisms to Track the Implementation and Efficacy of CS Education.** Include CS in future state data systems collecting enrollment and achievement data; Ensure CS enrollment and achievement data are part of the dashboard and other measures of accountability, including as a college and career readiness indicator on the Local Control Accountability Plan (LCAP); Develop assessments aligned to core CS competency standards.

7. **Ensure CS is Prioritized as a High School Graduation and College Entry Requirement.** Provide incentives for students to take CS in high school by adopting a CS high school graduation requirement; Ensure CS counts as a core course towards college admission through the UC/CSU A-G requirements, as something other than a "G" elective.

8. **Implement Large-Scale Policies and Initiatives that Address Systemic Educational Inequity Affecting Student Outcomes across Subject Areas.** Increase equity in school funding and resource allocation across schools in California; Ensure access to rigorous STEM courses across all schools in California; Improve teacher pay and reduce turnover to ensure high-quality instruction for all students across California.

CONCLUSION

California urgently needs bold and comprehensive education reform to ensure Californians are prepared to participate in the rapidly evolving global technology economy. The exponential growth of technology and innovation across all disciplines and sectors of the economy over the past several decades must be met with a significant investment in reforming the content, curriculum, and teaching in K-12 education to align with this new reality. The core concepts and practices in CS education provide foundational knowledge of computing principles, computational and algorithmic thinking, collaboration, problem-solving, and the ethical, social, and cultural impacts of computing, critical components of meaningful engagement in a technology-saturated world (CDE, 2017).

While California leads the nation in the size of its overall economic output (GDP), in the size and productivity of its technology economy, its overall population size, and in the diversity of its population, California lags behind other states on the adoption of policies to improve access to CS, on computing degree completion rates, and fulfilling the needs of the computing workforce. Further, California's inability to meet the growing demand for a skilled technology workforce and the significant racial and gender disparities in California's technology workforce threaten to have a detrimental impact on economic growth, competitiveness, innovation, and inequality, especially among communities of color. Throughout California, we are beginning to see negative consequences of the technology industry, ranging from increasing wealth and income inequality, homelessness, and displacement to ethical concerns about data privacy, the use of algorithms, and predictions about the detrimental impact of automation on low-wage individuals and communities of color (Broady, 2017). As we enter the Fourth Industrial Revolution, a period of growth driven by technology, economists indicate that that the prosperity of global economies will be based on their ability to innovate, adapt to technology-driven disruption, and ensure the education and skills of their populations. We have seen other countries, including Israel, Finland, United Kingdom, Singapore, Japan, and China implement comprehensive national strategies to prepare their citizens and their countries for the future economy (Nager & Atkinson, 2016). Numerous states in the United States have done the same, implementing CS for all, providing funding, and preparing CS teachers. It will no longer be sufficient for computing knowledge and skills, degrees, and occupations to be limited to a select few—California must take a long-term, strategic approach to preparing its students and future workforce, or risk being left behind.

This project was supported in part by a grant from the National Science Foundation (#1748316).

ABOUT US

For more information about computer science in California:

KAPOR CENTER

The Kapor Center aims to enhance diversity and inclusion in the technology and entrepreneurship ecosystem through increasing access to tech and STEM education programs, conducting research on access and opportunity in computing, investing in community organizations and gap-closing social ventures, and increasing access to capital among diverse entrepreneurs. **www.kaporcenter.org** **@kaporcenter**

#CSforCA

Computer Science for California (CS for CA) is a multi-stakeholder coalition, led by the Alliance for California Computing Education for Schools and Students (ACCESS) and housed at UCLA Center X, which aims to ensure equitable access to teaching and learning in computer science to prepare them for college, careers, and community engagement. **www.csforca.org** **@csforca**

APPENDIX

DEFINITIONS, METHODOLOGY, & DATA SOURCES

- **Definition of Computing and Computer Science:** Computing is a broad term defined by the Association for Computing Machinery as "any goal-oriented activity requiring, benefiting from, or creating computers… including five sub-disciplines of computer science, computer engineering, information systems, information technology and software engineering." Computer science is defined by the Association for Computing Machinery as the "study of computers and algorithmic processes, including their principles, their hardware and software designs, their implementation, and their impact on society." The terms computing and computer science are used interchangeably throughout this report.
- **Definition of "Underrepresentation" and "Underrepresented Students:"** In this report, the term "underrepresented" is used to describe student populations from racial/ethnic or gender groups which are traditionally underrepresented in computing education, degree completion, the tech workforce, and entrepreneurship/venture capital, relative to their percentage in the state population, specifically Black, Latinx, Native American/Alaskan Native/Native Hawaiian students in California. Underrepresentation varies across computing contexts and stages and in this report, we focus on underrepresentation in K-12 computer science education. While significant disparities exist within Asian and Pacific Islander populations, data are not disaggregated to better understand which Asian sub-groups are over and underrepresented in computing education.
- **Classification of Computer Science Courses:** In the analyses contained in this report, we include the following courses under the classification of "computer science:" AP Computer Science A (2470), AP Computer Science AB (2471), CTE AP CS A (4641), AP Computer Science Principles (2472), CTE AP Computer Science Principles (4640), Exploring Computer Science (4634), Computer Programming (2451), Computer Science (2453), IB Computer Science (2465), Computer Programming and Game Design (4616), Computer Programming for Solving Ap (4619), Database Design and SQL Programming (4631), Network Engineering (4604), Network Security (4646), Robotic Technologies (4647). These courses are grouped into three categories: Introductory CS, AP CS A, and AP CS P. Additional courses that were related to the use of computers but not classified as CS, including Digital Literacy (4632), Computer Literacy (2450), and Office Systems and Technologies (4615), among others, were not classified or included as computer science courses in this report (Source: California Department of Education, CALPADS Course Codes).
- **Data Sources for Computer Science Course Access, Enrollment, Trends, and Success:** Introductory computer science access and enrollment data are accessed from the California Department Education data from the 2016-17 school year, the most recent data available (Figures 1, 2, 4, and 5). Data from 2017-18 were available, but due to recoding of CTE courses into larger groupings, they do not allow for distinguishing between courses defined as computing or non-computing. AP Computer Science access data (Figures 1, 3, and 4) use California Department of Education data from the 2016-17 school year, which is the most recent data available. AP Computer Science enrollment and success data (Figures 6, 7, 8, 9, 10, and 11) use College Board's AP Program and Participation Data from the 2017-2018 school year, the most recent data available (Sources: California Department of Education, CS enrollment (2016-17); College Board AP Program and Participation Data (2018).
- **Total Number of California High Schools:** n=1,837. Includes active schools with EdOps codes: TRAD (Traditional), SSS (State Special School), and ALTSOC (Alternative School of Choice) schools serving 9th, 10th, 11th, and/or 12th graders, including traditional high schools, elementary-high combination, and intermediate/junior high. Excludes all schools with EdOps Codes: COMM (County Community Day), COMMDAY (Community Day), CON (Continuation), JUV (Juvenile Court), OPP (Opportunity), SPEC (Special Education), SPECON (District Consortia Special Education), & YTH (Youth Authority). Nine schools were included which are now closed, but they had primary and CS enrollment in 2016-17 (Source: California Department of Education, Public Schools and Districts, 2016-17).
- **Total Number of California High Schools Offering CS:** Utilizes the 2016-17 Computer Science course availability data Includes the unique number of high schools offering any of the courses classified as CS (n=712), the number of schools offering Intro CS (n=577) and the number offering AP CS (n=341) divided by the total number of high schools in California, with the exclusions outlined above. The totals between Intro CS and AP CS do not sum to the total number of schools since there is some duplication between schools that offer Intro and schools that offer AP CS. In the trend graph of CS offerings by year, the counts *are duplicated* and cannot be summed.
- **Percentage of High Schools offering Any CS and AP CS, by County:** Calculated using the total number of high schools in each California county which offer a CS course (numerator) divided by the total number of high schools in the county.
- **Classification of Urban vs. Rural:** Counties with less than 50% of the population living in rural areas are classified as urban; counties with 50 to 100% percent living in rural areas are classified as rural (Source: Census, 2010).

- **Definition of "High-URM" and "Low-URM" Schools:** Adapting from the UCLA Civil Rights Project's work on racial segregation in schools, the categories used in this report include "Low-URM" schools (0-50% of the school's student population is Black, Latinx, or Native American) and "High-URM" schools (91-100% of the student population is Black, Latinx, or Native American). Categories were intentionally kept the same as the categories in an analysis of California's CS access and equity in 2012-13, in order to examine yearly comparisons. Data are presented for all URM categories, but when comparing categories "high URM"reflects the largest category (e.g., 91-100% URM), while "low URM" reflects the lowest category (1-50% URM; Source: Kucsera & Flaxman, 2012; Martin et al., 2015).
- **Definition of "High-Income" and "Low-Income" Schools:** In this report, the socioeconomic demographics of schools are determined by the percentage of the school's student population who qualify for Free/Reduced-Priced Lunch (FRPL). The categories used in this report are quartiles (1-25% 26-50%, 51-75%, and 76-100%) and data are reported for all categories, with "high-income" defined as the first quartile (1-25% FRPL) and "low-income" defined as the fourth quartile (76-100% FRPL). These definitions are consistent with the National Center for Education Statistics classifications of high-poverty and low-poverty schools. Categories were intentionally kept the same as the categories in an analysis of California's CS access and equity in 2012-13, in order to examine yearly comparisons (Source: National Center for Education Statistics, 2018).
- **Percentage of URM and FRPL Schools Offering CS Courses:** These analyses were calculated by dividing the number of high schools in each URM/FRPL category offering computer science courses (numerator), by the total number of high schools in each URM/FRPL category (denominator) to demonstrate the percentage of high schools in each category which offer computer science.
- **Percentage of URM students with Access to CS Courses:** These analyses were calculated by summing the total number of Black, Latinx, and Native American high school students who attend a school which offers CS courses (numerator) by the total number of Black, Latinx, and Native American high school students attending high schools in California (denominator; defined above as TRAD, SSS, and ALTSOC schools).
- **Trends in Gaps to CS Courses by School FRPL and URM Demographics:** Utilized the percentage of schools offering CS and AP CS courses by FRPL quartile recorded in the 2014-15 and 2016-17 CDE enrollment datasets. This comparison is intended to give a summary of where changes have occurred but cannot control for the changing demographics of schools since 2014 (e.g., the number of schools that fall into each category in 2014) (Sources: California Department of Education, CS enrollment (2014-15; 2015-16; 2016-17).
- **Total High School Enrollment:** n=1,829,577. Includes all students in grades 9 through 12 across the 1,837 high schools included in the analysis. Eighty-four of these high schools had no primary enrollment data. The total number of all high school students across the state of California, including all school types is: 1,939,323. (Source: California Department of Education, Primary Enrollment, 2016-17).
- **Total Computer Science Course Enrollment:** The total of number of students enrolled in courses with single-course coded CS course is 54,277, including both Intro CS courses and AP CS courses offered in 2016-17 and recorded in the CDE enrollment dataset. Enrollment is counted once in the Fall and enrollment totals are duplicated since one students can be enrolled in more than one CS course. This number does not include courses categorized by multiple course codes (e.g., one course coded under multiple course codes), which totals 70,844. This number also does not include enrollment in schools with EdOps codes which were excluded in the analysis, and does not include CS course enrollment among 6-8th grade students, of which there were 19,892 students enrolled in a CS course in 2016-17 (roughly 1% of all 6-8th graders in California's schools).
- **State Ranking in AP CS Participation:** AP participation rankings by state are calculated using the total number of students who took an AP CS A or AP CS P exam in 2018, divided by the number of K-12 students in the state. There are minor differences in the number of students taking the exam versus enrolling in the course, but the College Board only provides test-taking data (Source: College Board, 2018).
- **State Ranking in AP CS YOY Growth:** The growth rate in AP CS participation is calculated by examining growth in total number of students taking AP CS A and AP CS P from 2017 to 2018. Reduce skewed rankings by state population size, only states with over 1,000 test-takers were included in growth rankings (Source: College Board, 2017-18).
- **Definition of AP Passage Rates:** Passage rates in AP Computer Science are defined as the percentage of test-takers who scored a 3, 4, or 5 on the exam (Source: College Board, 2018).
- **State Ranking in Passage Rates:** Passage rates by state were calculated by dividing the number of AP CS A and AP CS P test-takers who scored a 3 or higher, by the total number of AP CS A and AP CS P test-takers. To reduce skewed rankings by state population size, only states with over 1,000 test-takers were included in growth rankings (Source: College Board, 2018).

CITATIONS

Baller, Di Battista, Dutta & Lanvin (2016). The Global Information Technology Report: Innovating in the Digital Economy. World Economic Forum.

Broady, K. (2017). Race and Jobs at High Risk to Automation. Joint Center for Political and Economic Studies.

Bureau of Labor Statistics (2017). Occupational Employment Projections: 2016-26.

Bureau of Labor Statistics (2016). The High Tech Industry: What is it and Why it Matters to Our Economic Future.

California Department of Education (2019). Computer Science Strategic Implementation Plan.

California Department of Education (2017). Statewide Enrollment by Ethnicity and Grade, 2016-17.

California Department of Education (2017). California K-12 Computer Science Standards.

California State University (2019). 2019-2020 CSU Undergraduate Impacted Programs Matrix.

Campaign for College Opportunity (2016). Needed: Sy(STEM)ic Response: How California's Public Colleges and Universities are Key to Strengthening the Science, Technology, Engineering, and Math (STEM) and Health Workforce.

Code.org/CSTA (2018). 2018 State of Computer Science Education: Policy and Implementation.

College Board (2014, 2015, 2016, 2017, 2018). AP Program Participation and Enrollment Data, 2015-18.

CompTIA (2018). Cyberstates: California.

Computing Research Association (2017) Generation CS: Computer Science Undergraduate Enrollments Surge Since 2006.

Darling-Hammond, L. (2004). Inequality and the Right to Learn: Access to Qualified Teachers in California's Public Schools. Teachers College Record, 106 (10), p. 1936–1966.

EdBuild (2019). 23 Billion.

Edley, C. & Kimner, H. (2018). Education Equity in California: A Review of "Getting Down to Facts II"

Education Trust-West (2015). The STEM Teacher Drought: Cracks and Disparities in California's Math and Science Teacher Pipeline.

Florida, R. (2018). The Extreme Geographic Inequality of High-Tech Venture Capital.

Forbes (2018). Fortune 500 Companies.

Kapor Center/ACCESS (2017). Computer Science in California's Schools: 2016 AP CS Results and Implications.

Kucsera, J. & Flaxman, G. (2012). The Western States: Profound Diversity by Severe Segregation for Latino Students.

Martin, A., McAlear, F., & Scott, A. (2015). Path Not Found: Disparities in Access to Computer Science in California's High Schools.

Nager & Atkinson (2016). The Case for Improving U.S. Computer Science Education. Information Technology and Innovation Foundation.

National Center for Education Statistics (2012). Bachelor's Degrees Conferred by Degree Granting Institutions, by Field of Study and State or Jurisdiction: 2010-11 (Table 368).

Phillips, C, Lytle-Hernandez, K, Bryan, I. (Forthcoming). California Diversity in High Tech. Partially adapted from the California State University.Undergraduate Degrees granted by Discipline Division and Ethnic Group, Systemwide, 2017-2018. [Table]. University of California. Undergraduate Degrees by Discipline, 2017-2018. [Table]. UCLA Bunche Center for African American Studies [Editor].

Rangarajan, S. (2018). Here's the Clearest Picture of Silicon Valley's Diversity Yet. It's Bad. But Some Companies are Doing Less Bad. Reveal News.

Schwab, K. (2016). The Fourth Industrial Revolution. What it Means, How to Respond. World Economic Forum.

Scott, A., Kapor Klein, F., McAlear, F., Martin, A., & Koshy, S. (2018). The Leaky Tech Pipeline: A Comprehensive Framework for Understanding and Addressing the Lack of Diversity Across the Tech Ecosystem.

UCOP (2019). A-G Policy Resource Guide.

U.S. Bureau of the Census (2016). Current Population Survey, Number and Percentage of People in Poverty by State Using 3-year Average (2014-2016), Table 5.