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Governance Brief

Supporting STEM Access, Equity, and Effectiveness:

Equitable Access to Rigorous STEAM Coursework

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In a complex and changing world, today's students need to be equipped to meet modern challenges. Learning in science, technology, engineering, art, and math—also known as STEAM—builds the knowledge and skills needed to reason through tough problems and find creative, effective, and reasonable solutions. By its very nature, STEAM supports project-based learning and fosters students' ability to think critically, communicate, and collaborate. Therefore, it is critical for all students to be exposed to a rigorous STEAM curriculum in early grades as well as in middle and high school.

This brief provides an overview of current access to rigorous STEAM coursework for California's K-12 public school students and the benefits of such access. It also offers an overview of some of the barriers to student access, opportunities presented by the implementation of new math and science standards, and questions for board members to consider. With this information, governing boards will be better able to understand access in their districts and county offices of education (COEs) and develop solutions with their superintendent, staff, and community to improve access for all and close opportunity gaps.

In this brief you will find:

- **How STEAM learning affects California's economic outlook.**
- **How integration of the arts can enrich STEM learning.**
- **The portion of California public high schools offering STEAM courses.**
- **Student groups that lack access to STEAM courses.**
- **Issues that can prevent all students from achieving access to rigorous STEM courses.**
- **Promising practices to expand access to STEAM courses and experiences.**

Why STEAM Matters

Nearly one in five jobs in the United States requires at least some education in science, technology, engineering, and math, with the growth of these jobs expected to outpace available jobs in other sectors.[1] Further, according to a 2015 report by the Public Policy Institute of California, the state faces a shortage of 1.1 million college-educated workers by 2030. Demand is expected to increase most rapidly in many high-paying occupations, including computer and mathematical science, architecture, engineering, and health care.[2] The ability to meet this demand with an educated, prepared workforce—particularly in science and engineering—is crucial to California's future economic prosperity. The benefits of strong STEAM instruction are not limited to students who choose a career in science or technology—the concepts of innovation and critical thinking are essential to any professional in the arts, business, or social sciences.

In addition, taking more advanced math and science courses during high school is associated with higher earnings and improved chances of employment in science, technology, engineering, and math fields.[3] Evidence points to especially large returns for calculus.[4] There is also substantial evidence that providing students with a well-rounded curriculum improves their likelihood of success in college and careers.

For example, a 2017 report by Education Trust–West highlighted the benefits of science and engineering courses in promoting both content and language learning for English learners,[5] with a more recent report highlighting similar benefits from math courses.[6]

Why the "A" in "STEAM"?

Teaching students in a way that fosters their creativity and ability to develop new and innovative solutions is critical to their success. When building creativity through teaching the arts, schools are not only providing a more well-rounded education but also elevating student capacity in other subject areas. For example, in a study of Learning Through the Arts, a program that provides a curriculum that integrates arts with academic subjects in elementary school, participants scored higher on math computation tests by the third year in the program than non-participants.[7] An additional study found that students in elementary schools that offered instruction in art, music, and physical education taught by specialists performed better in academic subjects than students in schools without these opportunities.[8] There is strong public support for arts in education, as 79 percent of Americans agree that incorporating the arts into education is "the first step in adding back what's missing in public education today," according to a 2005 Harris poll.[9]

Access to Rigorous STEAM Education in California

Access to rigorous coursework is defined by two factors: 1) course availability in schools and 2) the ability of students to enroll and succeed in offered courses.

Course Availability in Schools

California schools experience troubling gaps in the availability of advanced math and science classes. According to the U.S. Department of Education's Civil Rights Data Collection, California is below the national average in the percentage of schools offering an array of mathematics and science courses.[10] Only 78 percent of California public schools with any grade from seven to 12 offered classes in Algebra I, a course that includes content that builds capacity for more advanced math coursework.

Although 2,666 California public schools serve students in at least one grade from nine through 12, the University of California reports:

» **1,800 (67 percent) public schools offer at least one laboratory science** course meeting A-G requirements in grades nine through 12.

» **1,901 (71 percent) public schools offer at least one mathematics** course meeting A-G requirements in grades nine through 12; and

» **1,737 (65 percent) public schools offer at least one visual and performing arts** course meeting A-G requirements in grades nine through 12.[11]

The good news is that high school graduates are increasingly completing A-G requirements, albeit at a modest rate. From 2000–18, completion rates rose from 35 percent to 46 percent.12 Latino students stand out as making the largest gains (51 percent) in A-G completion over a 14-year period (2000–14). Nevertheless, there are significant gaps in A-G completion across schools. According to the Public Policy Institute of California, there is a 14 percentage-point A-G achievement gap between low-minority and high-minority schools (34 percent completion vs. 20 percent completion).[13,14] Moreover, the data indicate California's students of color and economically disadvantaged students are less likely to attend schools that offer these rigorous courses.

Access to Offered Courses

Even when students of color and economically disadvantaged students attend schools offering these classes, they are less likely to enroll in them. This outcome is likely due to a variety of factors, including a lack of previous preparation, limited or nonexistent advising, or lack of learning supports (such as tutoring or extended learning) that can help students succeed in challenging courses.[15]

Policy

School and district policies can also impede students from taking more rigorous courses despite good grades and test scores. One way this is seen is in math misplacement; that is, when students are not placed in classes for which they are qualified and for which they have adequately met prerequisites. Evidence shows that math misplacement disproportionately affects students of color.[16] In a joint CSBA and Silicon Valley Community Foundation brief on the subject, the cause of math misplacement was determined to

result primarily from the "overreliance on subjective factors to make placement decisions."[17] To address this issue, parents and students need clear criteria on how a district places students in math courses as well as information on the process to appeal an inappropriate placement. To avoid math misplacement, schools can also audit students' course placement within the first month of school to ensure that misplacement has not occurred.[18]

Math misplacement creates a leak in the STEAM pipeline for students, whether their post-secondary plan is to attend community college, university, or go directly into the workforce. For students attending college, whether two- or four-year, if they have been misplaced in high school they may spend unneeded time in college satisfying basic skills courses which are non-degree applicable.[19] A 2017 executive order by the chancellor of the California State University system changed how students make up for entrance requirements. Remedial courses will be eliminated in favor of "stretch" courses, and summer "early start" programs will be offered starting in 2019.[20] This move toward greater access is a positive development, but math misplacement may still hinder student success. If students are insufficiently challenged in middle and high school, they will likely be unprepared for the rigors of post-secondary coursework.

Staff Capacity

Staff capacity can be a significant factor in a school's ability to offer rigorous and quality courses. According to the U.S. Department of Education (DOE), 34 percent of public high schools with high-minority student populations had one or more vacancies in difficult-to-staff teaching positions, nearly double that of low-minority public high schools.[21] Of public high schools that had at least one difficult-to-staff teaching position, the most common subjects were mathematics (9.1 percent) and physical sciences (8.4 percent).[22]

In California, the number of teachers who have math and science credentials has been declining.[23] Nationally, teachers of STEM subjects are the second most likely to leave the profession. According to the DOE, "both beginning and veteran teachers are more likely to quit when they work in districts with lower wages and when their salaries are low relative to alternative wage opportunities, especially in high-demand fields like mathematics and science."[24] When the DOE examined what would make "leavers" come back to teaching, of equal weight were the ability to maintain teaching retirement benefits and a salary increase.[25]

While the teacher shortage in California is a common refrain, the shortage of minority teachers is particularly acute. Research shows that teacher diversity matters when it comes to student learning. When female students have female instructors in math and science, they demonstrate increased participation, higher grades, and are more likely to continue coursework in STEM. Race matters in teacher–student relations as well.[26] Researchers hypothesize that same-race teachers may be able to make material more culturally relevant to students and provide role models for them. Perception is also an issue. For example, among students with similar test scores, white teachers tend to assign white students to gifted programs at higher rates than black students.[27]

To integrate STEM and the arts, schools need arts capacity as well, yet California teachers receive little or no arts training in elementary teacher education programs. Teachers earning their credentials between 1970 and 2004 may not have had any arts training at all. Since 2004, teacher candidates have had basic training in arts education, but not to the same extent as before 1970. This minimal arts training can limit a teacher's toolbox in making math and science creative and engaging for students.

Underrepresentation in Advanced STEM and AP Courses

According to 2015–16 data from the Civil Rights Data Collection, California's African American, Latino, and American Indian/Alaska Native students are underrepresented in advanced STEM and AP courses (see Table 1).[28]

Looking at enrollment in a few benchmark STEM courses reveals how many of California's public school students are taking advanced courses in math and science.[29] While Hispanic and African American students are enrolled in biology at or above the state average, their enrollment is not as robust in chemistry and Algebra II. American Indian students are underrepresented in all three courses (see Table 2).

Computer Science

While nationally there is increased attention to expanding computer science access, the most recent data show California has a long way to go to increase access and competency. Only 49 percent of K-12 schools offer computer programming courses and only 39 percent of those courses meet UC/CSU A-G requirements.[30] Sixty-five percent of public high schools offer no computer classes, even basic computer literacy courses.[31] To expand computer science offerings, staffing will have to be markedly increased. There is a persistent computer science teacher shortage, with the number of instructors remaining flat at about 3,000 from 2000–16.[32]

Table 1: 2015-16 Enrollment in Calculus, Physics, AP Math, and AP Science, by Ethnicity					
Ethnicity	**% of CA Student population**	**Calculus**	**Physics**	**AP Math**	**AP Science**
Latino	54.0%	33.2%	44.7%	29.3%	30.5%
White	24.1%	28.3%	26.3%	30.0%	30.3%
Asian or Filipino	11.4%	29.8%	18.7%	32.3%	30.8%
African-American	5.8%	3.3%	5.2%	3.2%	3.3%
Two or more races	3.1%	4.1%	3.6%	3.8%	3.8%
American Indian or Alaska Native	0.6%	0.5%	0.6%	0.5%	0.5%
Native Hawaiian or Pacific Islander	0.5%	1.0%	0.8%	0.8%	0.9%

Table 2: 2015-16 Enrollment in Algebra II, Chemistry, and Biology by Ethnicity				
Ethnicity	**% of CA Student Population**	**Algebra II**	**Chemistry**	**Biology**
Latino	54.0%	49.9%	48.5%	52.9%
White	24.1%	26.0%	25.4%	24.3%
Asian or Filipino	11.4%	13.3%	15.7%	12.1%
African-American	5.8%	6.0%	5.7%	6.1%
Two or more races	3.1%	3.3%	3.4%	3.2%
American Indian or Alaska Native	0.6%	0.7%	0.6%	0.6%
Native Hawaiian or Pacific Islander	0.5%	0.8%	0.8%	0.7%

One benchmark for computer science access and equity is participation in the Advanced Placement (AP) Computer Science A and the AP Computer Science Principles tests (see Table 3). Asian students represent 53.6 percent of students taking the AP exam, while they make up less than 11 percent of the student population. Latino students are over 53 percent of the student population, but less than 13 percent of exam takers. Only 1.7 percent of African American students take the AP Computer Science exam, while they compose 6.2 percent of the public school population.

Table 3: 2017 AP Computer Science Test Participation[33]		
Ethnicity	**Computer Science A**	**Computer Science Principles**
Asian	5,031 (49%)	2,917 (34.1%)
White	2,795 (27.2%)	2,126 (24.8%)
Latino	1,469 (14.3%)	2,677 (31.3%)
Two or More Races	571 (5.6%)	418 (4.9%)
African American	138 (1.3%)	207 (2.4%)
Native Hawaiian or Pacific Islander	25 (0.2%)	23 (0.3%)

Standards Implementation: An Opportunity

Mathematics

The California Mathematics Framework, adopted by the State Board of Education (SBE) in 2013, offers students two high school pathways that, assuming no interruptions, place students in Precalculus by 12th grade.[34] While the traditional pathway of Algebra I > Geometry > Algebra II > Precalculus can still be followed, an integrated pathway is also an option. A Math I to III course sequence substitutes for the first three courses listed previously. The CDE also has options for summer bridge courses and double-up options that bring students to Precalculus by grade 12. When looking at an accelerated pathway, there are more options, including taking Algebra in eighth grade or creating hybrid Math I/II and Math II/III courses to prepare students to take Calculus by 12th grade.

An opportunity to capitalize on the growth of STEM careers while satisfying the A-G requirements is to offer Statistics in lieu of Calculus or Precalculus. One career path that makes heavy use of statistics is data science. According to salary tracking website Glassdoor, "data scientist" has been the top job in the U.S. from 2015–18, with a median base salary of $110,000 and more than 4,524 job openings in 2018. While this career path often requires an advanced degree, a data analyst position does not, and has a median base salary of $60,000, with more than 4,700 openings in 2018.[35]

Science

The Next Generation Science Standards (NGSS) were adopted by California in 2013. While districts are still learning how to best implement them, the standards offer opportunities to rethink how to increase access to science courses. Science course sequencing is an area where schools can innovate. As with math placement, boards should encourage transparency about science placement and sequencing, and consider how this will impact students' college readiness and competitiveness.

New science standards also require professional learning for teachers, presenting an opportunity to invest in resources that emphasize creativity and an equity mindset. Although instructional materials are an important part of the equation, professional learning helps teachers shift their mindsets, creating the opportunity to broaden the scope of science learning to incorporate the arts, integrate with math and English language arts learning, and develop strategies to reduce achievement gaps.

While STEAM integration can happen throughout grades K-12, it most naturally happens in K-5, given the elementary school model of a self-contained classroom with one teacher who can easily incorporate subjects from across the curriculum into the lesson. This arrangement also poses challenges, as primary teachers need to be able to pivot across subjects, and—as the newer standards emphasize—to be able to work with colleagues to integrate learning across subjects and grade levels.

Computer Science

In September 2018, the SBE approved the first-ever computer science standards for California. This move is part of a national trend to fill the massive job gap in computer programming and engineering. As mentioned previously, data science is an in-demand field, but its needs pale in comparison with the need for software engineers, which topped 29,000 in 2018. The SBE has released guidelines for computer science standards that address both the employment demand and the connection of computer science to STEAM.[36] The draft standards use creativity as one of the core elements of computer science education and emphasize that the final standards should look "past the role of users of computing technology toward active creators and innovators, engaged with computer science as an artistic and collaborative endeavor."[37] Creativity and collaboration are part of computer science, reinforcing the active, creative learner that NGSS promote.[38]

Promising Practices

Science and Art. NGSS promote creativity by asking students to develop their own solutions to problems. Education Closet has created videos on how to integrate dance into lessons about energy as one way to bridge science and art.[39] The lessons do not require an arts education background and are simple ways to diversify lessons and bring out students' creativity. Another strong trend in science education is the use of makerspaces, where children learn science in the context of building something through 3D printing, computer simulation, or construction. Makerspaces can be leveraged through community and corporate partnerships. For example, San Joaquin County Office of Education works with urban and rural schools to bring students to a fabrication lab in Stockton that uses laser cutters, 3D printers, and computer numerical control machines.[40]

Math and Art. The Armory Center in Pasadena and Pasadena Unified School District have developed a free program called "Artful Connections with Math" that includes lesson plans for second- and third-grade teachers. These lessons involve engaging students on topics such as how to

depict numbers, how to understand fractions, and the connections between math and art in bar graphs. Experiences like these create additional opportunities for collaboration between math and art departments within a school. As researcher Michelle Land suggests, art educators can use their skills and art theory about colors and shapes to inform math lessons on data visualization. Bending circuits, analyzing musical compositions, and developing engineering prototypes are also areas for math and art faculty collaboration. [41]

Summer Learning. Summer can be an opportunity to promote STEAM and reduce summer learning loss. A study of ninth-graders found that two-thirds of the achievement gap between economically disadvantaged students and their more affluent counterparts "could be explained by what happened over the summer during the elementary school years."[42]

Schools can use the summer to develop creative STEAM experiences and help students get ahead in STEAM courses. CSBA has developed resources for STEAM summer learning, including a district planning guide and a "Guide for Regional Partners in California" to identify with what organizations districts and county offices of education can collaborate on STEAM learning.[43]

Conclusion

In this brief, we have highlighted the importance of STEAM for the future of California and its students, and the importance of ensuring access to these courses as basic requirements for college and career success. Providing a quality STEAM education and ensuring access to these rigorous courses requires important decisions about resources and policy. In addition to materials and supplies, STEAM access involves recruiting and retaining teachers as well as providing professional learning—for example, to help existing teachers gain the skills to teach statistics or calculus in schools that do not currently offer these subjects. It also requires school policies on math and science placement, course sequencing designed to ensure students are not inappropriately or inadvertently left out of the pipeline, and it takes investments to ensure all students have the support they need to succeed in rigorous courses. Efforts can be enhanced by partnering with community organizations that can help support real-life STEAM experiences and learning, and that can contribute resources of time, experience, and materials. Participating in decisions about resources and policy, as well as fostering the community relationships necessary to build useful partnerships, are part of what school boards do for their districts and counties.

Questions for Board Members to Consider

1. What are the district's or COE's STEM and arts staffing needs?
2. What does district or COE data tell us about course-completion patterns among different student groups?
3. What are the district's or COE's policies on math placement in middle and high school that may be hindering student success?
4. What might we do to promote integrated teacher professional learning for math, science, and the arts to better engage students?
5. What are the district or COE summer needs and can STEAM be used to reduce summer learning loss?
6. What might the district or COE do to promote STEAM in its science fair, art shows, and districtwide learning events?

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