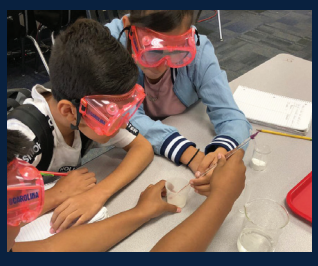
Equitable Access to Science Education in California



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INTRODUCTION

All students need a comprehensive science education, starting in the earliest years, to be prepared for productive futures, no matter what their educational and career paths will be. Science education helps young people understand the world around them, develop critical thinking and reasoning skills, and be prepared for a future increasingly centered around information and technology. From transitional kindergarten (TK) through high school, science must be treated with the same priority as other parts of the core curriculum for all students. Further, targeted efforts are needed to ensure equitable access for students who have been historically underrepresented in science education and careers.

However, the reality in California, and across the U.S., is that high-quality science education is not yet sufficiently available for all students in all schools.

California is making progress on this vision of science education for all students with its adoption of the California Next Generation Science Standards (CA NGSS) which necessitate that science and engineering be taught in every grade, TK-8, and for a minimum of three years in high school. The standards are designed so that all students receive a comprehensive science education covering disciplinary core ideas (Physical Science, Life Science, Earth and Space Science, and Engineering), crosscutting concepts, and science and engineering practices. Further, the CA NGSS shift instruction towards deeper learning, critical thinking, and problem-solving by engaging students in investigating and making sense of scientific phenomena and designing solutions in ways that are similar to how real scientists and engineers do their work.

However, the reality in California, and across the U.S., is that high-quality science education is not yet sufficiently available for all students in all schools. There are persistent gaps in access and achievement for student populations who have been historically underrepresented in science education and careers. For example, among eighth-graders in California, only 10% of low-income, 13% of Black, 10% of Hispanic/Latino, and 2% of English language learner (ELL) students scored at or above proficient on the most recent National Assessment of Educational Progress (NAEP) Science Assessment, compared to 44% of Asian and 46% of white students.[1] When taught science, low-income students are more likely to be taught by teachers who have fewer years of teaching experience, and receive less professional development and support

All students can learn science when rigorous learning goals, supported by high-quality science instruction are combined with supportive learning experiences.

in science, than teachers in more affluent schools.[2] In science, historically underrepresented students include, Black/African American, Hispanic/Latino, Native American, and other underrepresented people of color, girls, ELL, low-income, LGBTQ[3] and/or disabled students, as well as those who have not traditionally been viewed as likely to be interested or successful in science.

The root causes of gaps in student participation and achievement are often systemic inequities among schools and districts that result in large differences in student access to science learning opportunities. The California Association of Science Educators (CASE) is committed to providing equitable access to science education for every student. Equitable access is not simply providing the same resources to all students. It means providing resources and supports that meet the differentiated needs of each student. All students can learn science when rigorous learning goals, supported by high-quality instruction, are combined with supportive learning experiences. Programs and practices that increase equitable access must be built into every aspect of science teaching and learning for all students, educators, and families. Students need early and continuous access to high-quality curricula and culturally relevant pedagogy. Teachers need professional learning focused on developing the pedagogical skills required to teach science and engineering in ways that are effective for high-quality instruction and support the full range of learners in their classrooms, including explicitly addressing the needs of underrepresented students. Families need to be informed about the value of science learning and engaged in their children's education in ways that are sensitive to their community and cultural context. Perhaps most critically, district and school leaders must provide the administrative leadership, policies, and funding required to encourage and support equitable access to science education for every student.

In recent years, CASE and other experts have published numerous guides and policy recommendations mapping out paths to successful implementation of the CA NGSS. However, we must do more to call out and address the specific challenges related to ensuring that such implementation achieves educational equity in science. In this briefing paper, we outline these challenges for students, teachers, and families, and identify the actions that district administrators, school principals, and other education system leaders, can take to improve instruction and make clear that equitable access to science education is a top priority for every school and every student in California.

Student Needs and Barriers to Equitable Access

The clearest examples of inequitable access to science education in California are often found in schools and districts serving large populations of low-income students, students of color, and/or ELLs. These high-poverty, high-need schools often lack sufficient facilities, equipment, instructional materials, and teacher expertise to offer a comprehensive science curriculum to all students.[4] Further, in these communities, as well as many others, elementary schools may have set aside science instruction to dedicate more time for students to reach proficiency in English Language Arts (ELA) and math,[5] while middle and high schools may have placement policies that deem students who are struggling in ELA or math as unready to participate in challenging science coursework. Recent research indicates that science learning can support rich language development and provide opportunities for more active classroom participation by ELL students.[6] In addition, CA NGSS-aligned high school courses require few mathematical concepts beyond Algebra 1 or Math 1.[7]

There are also more subtle problems affecting science education for underrepresented students whether they are in high-poverty, high-need schools or not. Educators and families may fail to encourage underrepresented students' interests and participation in science because of their own implicit biases about who becomes a scientist or engineer. This can result in lower expectations about underrepresented students' aptitude for and access to more rigorous science instruction. In addition, because of limited diversity in the science teacher workforce[8] and in science careers more broadly, underrepresented students may not have access to mentors and role models from their communities who could help inspire them to pursue science and engineering.

To remedy these circumstances, underrepresented students need the following changes and improvements in science education:

Developmentally appropriate, rigorous science coursework at every grade level.

The CA NGSS necessitate science and engineering be taught in every grade TK-8 and a minimum of three years in high school to build understanding and skills systematically year on year. The standards shift instruction away from memorizing facts to hands-on investigation and discovery through students making sense of phenomena they observe in their lives. To realize the promise of these new standards, the following curricular shifts are needed:

Elementary school (TK-5)

Early science learning is important for all students, but especially for underrepresented students who are less likely to be exposed to science through their families and communities. Research confirms that science achievement gaps in 8th grade begin even before students enter kindergarten.[9] Beginning in TK and kindergarten, elementary students must be actively engaged in high-quality science learning during every school day for an amount of time that is commensurate with time spent on other core subjects. This should be accomplished through a balance of dedicated science instruction, and integrated approaches that weave together science, ELA and math instruction, including for English learners. Indeed, research has demonstrated science learning and English

Photo Credit: Groundswell Coastal Ecology

Language Development (ELD) instruction are mutually reinforcing.[10] Participation in high-quality science education in a student's formative years helps develop favorable attitudes towards science.[11] In addition, science standards in the elementary grades serve as the foundation for knowledge progression in later grades. Increasing early access to science eliminates gaps in learning, better preparing students for middle and high school science.

Middle school (6-8):

The transition to middle school is often when student interest in science declines.[12] The inquiry-based learning of the CA NGSS is well-suited to adolescent development needs. In addition, middle school offers ample opportunity to integrate instruction across the science disciplines, and with other subject areas, in order to engage students in learning around issues of important personal and community concern. At the same time, placement and tracking practices that begin in middle school decrease access and limit opportunities for underrepresented students. All students must have equitable access to the full range of CA NGSS middle school science course content. Policies and practices that rely on student achievement scores in math or course grades in other subjects for placement in science should be eliminated. Students placed in lower tracks in middle school have less access to rigorous curriculum throughout their later education. Further, tracking signals to students that they are not "good" at science, when they may just need more time and opportunity to develop their academic interests towards forming an enduring disposition to science.

Policies and practices that rely on student achievement scores in math or course grades in other subjects for placement in science should be eliminated.

High school (9-12)

Science placement and tracking practices, along with fundamental inequities in facilities, staffing, and other resources, can be even more problematic in high school if they result in underrepresented students not accessing coursework that meets admissions requirements for selective colleges. To be consistent with the design of the CA NGSS and to ensure equitable access to science, graduation requirements for all students should include at least three years of science, rather than the current state minimum of two years. All students must have access to a comprehensive science program as defined by the CA NGSS, and all science pathways must be able to lead to the most advanced courses, including all "A-G courses" required to be eligible for admission to California public universities. Science courses identified as introductory or remedial that do not provide grade-appropriate content should be eliminated, and students should not be allowed to replace CA NGSS core subject courses with health science or other science or technology electives that are not CA NGSS-aligned. While these elective courses are valuable to students' overall education, they are not equivalent to the content of CA NGSS courses and may not satisfy college admission requirements. Parallel efforts to ensure equitable access to advanced math and computer science courses are essential as well, as these can be gateway courses to progress in science and college readiness. Science taught within career technical education (CTE) courses also should be CA NGSS-aligned to support effective instruction and ensure students can move seamlessly between CTE and other pathways. For science programs made up in part or entirely of dual enrollment coursework, it is critical that the approach to teaching and learning is consistent with the standards. These changes will, of course, require additional resources for school facilities, materials, and staffing, but such investments must be made to achieve equitable access to science education for all students.

Special Education

Students with physical or cognitive disabilities need science learning environments and instructional strategies that do not create barriers, but rather enable multiple means of knowing, doing, and expressing understanding. Universal Design for Learning (UDL) is one of several promising approaches to redesign instructional practice to make science education inclusive and accessible for all students. Teachers need opportunities for collaboration with special education experts and other systemic supports to develop these inclusive practices and attend to specific student learning needs.

Culturally-competent instruction that makes science learning accessible and meaningful to students' lives and futures.

The CA NGSS are built on the idea that students learn science better when it is taught in ways that demonstrate its relevance to their daily lives and real-world concerns about their family, community, environment, health, etc.[13] Underrepresented students need to see their identities and interests respected and reflected in science education. The CA NGSS emphasize phenomenon-based, problem-centered instruction, providing many opportunities to honor underrepresented students' identities and foster agency and belonging by connecting academic content to students' home cultures, local communities, and environmental and social justice concerns. Underrepresented students also need inclusive strategies that value different cultural perspectives and build from them. These needs highlight the importance of providing equity-centered professional learning to support educators in developing culturally sustaining pedagogy and increasing representation within the science teacher workforce.

Family and community engagement to support student learning in and out of the classroom.

It is important that all students have support from their families and communities to encourage learning and success. Schools must shape outreach efforts to effectively inform families of underrepresented students about the value of science learning and make schools welcoming places for all families. More efforts are also needed to incorporate learning opportunities outside of school into classroom instruction, through connections to community-based educational programs and cultural activities, museums and other informal science institutions, and mentors. Scientists and community members who represent historically marginalized student populations can serve as important role models for all students. Schools can also do more to help underrepresented students access additional opportunities for creative, hands-on science learning through out-of-school time programs and internships. Students and families need to be more informed about these opportunities, and financial support must be available to ensure equitable opportunity for all students to participate.

Photo Credit: Photo by Alexander Grey on Unsplash

Teachers' Needs to Improve Practice in Support of Underrepresented Students

The CA NGSS call for teachers to facilitate more student-centered, locally relevant learning that enables young people to think on their own, problem solve, communicate, and collaborate, as well as dive more deeply into disciplinary core ideas. For most teachers at all grade levels, shifting to more student-centered, equity-centered pedagogy requires significant new professional learning, more time to redesign curricula and collaborate with other teachers, and additional resources for specialized facilities, equipment, and materials. For elementary teachers, who tend to have more preparation in ELA and math than in science, professional learning also needs to help deepen science content knowledge. To deliver more effective science education for underrepresented students, teachers need:

High-quality curriculum materials and equity-centered professional learning that supports teachers in developing more culturally competent, student-centered, and cross-disciplinary science instructional practices.

Equity-centered professional learning can help teachers recognize where their expectations and implicit biases may be contributing to inequitable science learning experiences for some students, and provide teachers with strategies for more culturally sustaining pedagogy. Teachers also need clear guidance and access to high-quality, CA NGSS-aligned curriculum kits, assessment tools, and

other instructional resources, so they can focus on teaching, not spend time searching for materials. Professional learning, curriculum materials, and assessments, must help teachers build their skill and efficacy in several key areas, such as:

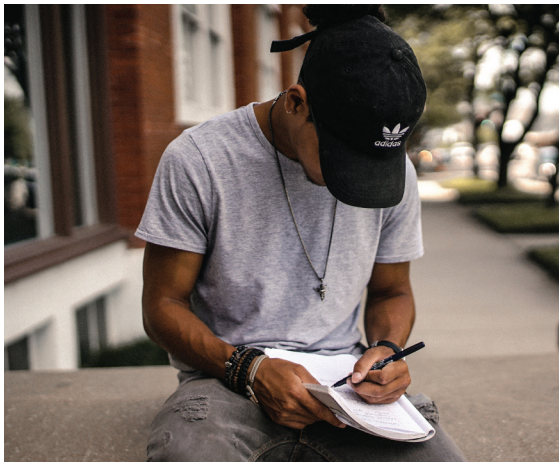
- Supporting open communication and collaboration, and managing healthy debate in the classroom, to allow diverse student voices, values and experiences to be expressed;
- Helping students develop a "growth mindset"[14] by creating learning experiences and classroom communities that allow space for students to struggle, take risks, fail and iterate on solutions, without feeling shame or suffering adverse assessment consequences;
- Connecting academic content to students' everyday interests and knowledge, especially to create phenomenon and problem-based learning activities that relate to students cultural, community, environmental, and social justice concerns;
- Delivering integrated instruction that uses science as the foundation for instruction in ELA, ELD, math or other subject areas;
- Designing science learning tasks and instruction to offer universal accessibility for a wide range of learners, including students with special education needs; and
- Developing accessible, culturally-competent classroom assessment practices that allow students to demonstrate their understanding of CA NGSS ideas, concepts and practices through multiple modes of performance.

Increased time and support for planning and collaboration.

In addition to upfront needs to adjust and learn new pedagogical skills, the CA NGSS also demand new kinds of ongoing instructional preparation. Developing instructional strategies that actively engage all students, and connecting content to issues and problems relevant to students lives, can add complexity to lesson planning. In addition, the integrated instruction that is critical to effective implementation of the CA NGSS requires more time for deep collaboration with colleagues in other subject areas. In elementary school, where time is limited to teach all subjects separately, teachers need to build capacity to integrate instruction with science as the core, as well as to incorporate science content in ELA and math instruction. In middle and high school, integrated instruction across science disciplines and with other subject areas, helps engage students in learning complex ideas. But while such integrated instruction is increasingly essential, support for it is virtually absent in many schools where teachers already have insufficient prep periods and are overloaded with administrative demands. Major shifts in policy and resources are necessary to increase time for teacher preparation and collaborative planning to provide instruction that fully delivers on the promise of the CA NGSS.

Ongoing access to coaching and leadership support.

For professional learning to be most effective, it must be ongoing and largely job-embedded, with the support of mentor teachers, coaches, and principals.[15] Therefore, districts must invest in hiring and training



science coaches and school leaders who themselves are well-versed in the CA NGSS and equity-centered instruction.

Funding for specialized resources for science instruction.

Science, perhaps more than other subjects, requires costly lab facilities and equipment, consumable materials, and opportunities for experiential learning outside of the classroom. In addition, to fully align with the CA NGSS, basic curriculum materials need to be updated or replaced, and new performance-based assessments need to be developed. While there are many creative teaching approaches that can compensate for lack of access to such specialized resources, ongoing resource inequities ultimately compromise student learning opportunities and lead to some of the most problematic disparities in access to rigorous, advanced science coursework.

District and School Leaders Must Make Equitable Access to Science Education a Top Priority

District and school leadership are essential to deliver high-quality science education for all students. Systemic changes are needed to support deep and lasting shifts in instructional practices and student learning experiences. Administrators must make clear–through their messaging, policy choices, and resource commitments–that science education is a top priority and that they will target policies and resources to ensure equitable access to science education. Recent evaluation findings from the California NGSS K-8 Early Implementation Initiative, a large, multi-district, multi-year initiative in California bears this out:

Findings and recommendations for K-8 science administrators from the California NGSS K-8 Early Implementation initiative

Administrators are spurring NGSS implementation most often in the following ways:

- Communicating science as a priority.
- Providing flexibility for teachers to try the substantial instructional shifts of the NGSS.
- Increasing teacher–teacher and administrator–teacher collaboration.
- Providing resources for science instruction.

Recommendations for administrators:

- District administrators should provide school administrators with NGSS-sensitive protocols for classroom observations and include a regular focus on science in districtwide meetings of site administrators.
- Site administrators must convey that it is beneficial for teachers to teach science at the elementary level, encourage experimentation by all science teachers in shifting to NGSS science, support teachers in getting needed science supplies, and develop the ability to observe effective NGSS instruction in the classroom.

Source: Iveland, A., Tyler, B., Britton, T., Nguyen, K., & Schneider, S. (2017). Administrators Matter in NGSS Implementation: How School and District Leaders Are Making Science Happen. San Francisco, CA: WestEd.

As a first step, both district administrators and school principals must embrace professional learning for themselves to build their own knowledge of the CA NGSS and understand how its pedagogical shifts look in practice. Subsequently, they can lead the way to more equitable access by championing changes in structures, goals, practices, and policies.

Recommendations for School District Administrators and Principals to Champion Equitable Access to Science Education

DISTRICT ADMINISTRATORS

Establish district-level science leadership structures and goals.

NGSS Leadership Teams can be instrumental when they have responsibility to set district-wide goals and strategies for achieving equitable access to science education for all underrepresented students. District goals and strategies must address science learning at every grade level and be included as a core component in every Local Control Accountability Plan (LCAP). These goals should also be mirrored in school-level plans, budgets, data collection, and accountability metrics. Investments must be targeted to eliminate inequities in school staffing, course offerings, facilities, and other key resources available to underrepresented students.

Partner with science institutions and professional development experts that can provide guidance, resources and leadership assistance to develop and support the district CA NGSS leadership team and implementation plan.

Build the commitment and capacity of principals and other site-based administrators to lead equity-centered improvements in science instruction.

Engage school board members, local and state policymakers, and other education leaders in regular discussions about how to achieve more equitable access to science education.

Substantially increase funding for teacher professional development focused on equity-centered science instruction and assessment, including more time for planning and collaboration, and access to support from coaches who are experts in science and equity.

Create and staff science leadership positions, e.g., Teacher on Special Assignment (TOSA), Coaches, Lead Teachers, to signal the district's commitment to science education and lead equity-centered shifts in science pedagogy. Focus on recruiting science leaders who have demonstrated expertise in CA NGSS instruction and reflect the diversity of the district's student population.

Change curriculum and placement practices and policies that limit underrepresented students' opportunities for participation and advancement in science education. Key policy changes should include:

- Increase science education in elementary schools, by encouraging daily science instruction at every grade level for an amount of time that is commensurate with time spent on other core subjects, supporting integrated instruction, and ensuring other instructional and assessment practices are consistent with full implementation of the CA NGSS.
- Increase high school graduation requirements to include three years of science, and ensure that all science education pathways can lead to college readiness and coursework aligned to California public university admissions requirements.
- End district and school practices and policies that depend on scores/grades in math or other subjects for placement into science courses. Cross-reference CA NGSS and Common Core State Standards (CCSS) for math[7] to ensure that prerequisites for science courses are not more advanced than necessary.

- CA NGSS models can be implemented to ensure that all science pathways are fully standards-aligned, while also supporting students with advanced abilities and articulating to Advanced Placement (AP) courses. Eliminate tracking practices (including honors courses used as tracking), that often prematurely limit underrepresented students opportunities to advance to the highest levels of science coursework.

Provide specialized materials, facilities and hiring incentives to ensure schools serving underrepresented students are equipped and staffed to offer a complete curriculum of rigorous science learning and laboratory courses. Develop partnerships with local colleges and universities to offer dual or concurrent enrollment opportunities that can ensure high school students, especially those in under-resourced schools, have access to advanced science coursework.

PRINCIPALS

Establish and support science teacher leadership roles, e.g., Teacher Leaders, Coaches, Mentors, to assist all teachers in making the instructional shifts required by the CA NGSS and developing more equity-centered pedagogy.

Provide explicit permission, time and flexibility for teachers to allow collaboration and experimentation to develop curricula, courses, and assessments that integrate ELA, math and science standards centered around locally-relevant phenomena and problems. This should include substantial attention to integrating ELD and science, given the large number of ELL students in California schools and how conceptual understanding developed through hands-on science can motivate ELL students to participate in peer talk and develop their academic vocabulary.

Ensure the full inclusion of all students in science education by:

- Placing students in science courses based on interest or measured aptitude in science, not performance in math or other courses.
- Eliminating master scheduling practices that pull out students for supplemental instruction, such as English learner support or special education services, during science instruction.
- Encouraging collaboration and co-teaching, especially between science and special education, and between science and ELD, given that separate instruction has often reduced these students' access to science.

Use all means available to strengthen professional learning in science by:

- Conducting administrator walk-throughs and other observation and feedback mechanisms for science instruction as non-evaluative opportunities to share and debrief teacher practices.
- Providing release time to allow teachers to observe high-quality science instruction in other classrooms, and to attend conferences and workshops to build cultural competence, learn how to integrate science and ELD instructional strategies, develop performance-based assessments, and build other skills for equity-centered science education.
- Increasing time and supports for teachers to revamp lesson plans to deliver improved, equity-centered, CA NGSS aligned instruction, including embedded lesson study.

- Including school guidance counselors in training about CA NGSS instructional approaches and course pathways so they can offer guidance that supports equitable course taking by students.

Build connections to science learning opportunities beyond the classroom. Teachers need support to identify science learning opportunities in their students' home communities, develop effective partnerships with local community organizations and informal science institutions and industry, and connect these resources to classroom instruction. Such connections help students see the relevance of science to issues in their communities and expand access to meaningful hands-on science learning experiences, role models and mentors.

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