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Governance Brief

Supporting STEM Access, Equity, and Effectiveness

The Path to Full Implementation of the California Next Generation Science Standards

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Introduction

Science literacy for K-12 students is crucial to their success in a world in which jobs increasingly require science skills and competencies: critical thinking, experimentation, and problem-solving, to name a few. The percentage of jobs in California requiring a STEM (science, technology, engineering, and math) background grew by 19 percent from 2008 to 2018 and the state projects it will need more than one million jobs in STEM fields over the next decade.[1]

Whether California can fill this gap will depend a great deal on how well students learn the practices, skills, and mindsets of scientists and engineers. The Next Generation Science Standards (NGSS) are meant to do just that: train students to think like scientists by using teamwork, brainstorming, and problem-solving skills to answer questions about the world around them. The State Board of Education (SBE) adopted NGSS in 2013 and the Science Framework for California Public Schools (also known as the Science Curriculum Framework) was written to support implementation of NGSS in 2016. The first operational assessments designed to support the standards will take place in 2018–19.

This brief offers valuable information to district and county offices of education (also known as local educational agencies or LEAs) and board members to better understand NGSS, including best practices and challenges associated with their implementation.

In this brief you will find:

- A description of the Next Generation Science Standards (NGSS) and how they are different from previous science standards.
- An overview of the current state of NGSS implementation including the new science assessment.
- Information about the CA NGSS K-8 Early Implementation Initiative and some key best practices.
- Common challenges in implementing the standards.
- Tools that board members can use to ensure their district or county office of education is on the path to full implementation.

What are the California Next Generation Science Standards (CA NGSS)?

NGSS are standards with a purpose. The K-12 science content standards cover every grade and every scientific discipline, setting expectations for what students should know and be able to do in the discipline.[2] The standards are further explained in the Science Curriculum Framework,[3] which "offers guidance for implementing content standards."[4] The framework is used by teachers for professional development and to help visualize what NGSS instruction looks like in the classroom. In the absence of approved instructional materials, the Science Curriculum Framework has been especially important for developing NGSS-aligned lesson plans.

Definitions of Standards, Frameworks, and Instructional Materials[5]

Content Standards: What students should know and be able to do in each subject at each grade. [Education Code (EC) Sections 60604-60618]

Science Curriculum Framework: Offers guidance for implementing content standards. Frameworks describe the curriculum and instruction necessary to help students achieve proficiency, and they specify the design of instructional materials and professional development.

Instructional Materials: Materials that are designed for use by pupils and their teachers as a learning resource and help pupils to acquire facts, skills, or opinions or to develop cognitive processes. Instructional materials may be printed or non-printed, and may include textbooks, technology-based materials, other educational materials, and tests. [EC Section 60010 (h)]

State Adopted Instructional Materials: Those instructional resources which the SBE has formally 'adopted' for use in the classroom. This action is required by the California State Constitution, Article 9 Section 7.5. There are no state instructional materials adoptions for grades nine through 12. LEA governing boards have the authority and responsibility under EC Section 60400 to adopt instructional materials for use in their high schools for grades nine through 12.

The NGSS Performance Expectations include three dimensions: science and engineering practices, disciplinary core ideas, and crosscutting concepts. NGSS represents a shift in mindset from the teacher as lecturer to the teacher as facilitator. The standards de-emphasize "cookbook" experiments that have a predetermined outcome and instead have students design and conduct their own exploratory experiments through which students gather data and draw conclusions. This is one example of an instructional shift that requires a retooling of how teachers think about teaching science. Consequently, the Science Curriculum Framework has been instrumental in helping teachers redesign their lessons and their approach to teaching science. Below are the definitions of the three NGSS dimensions and how each dimension is used in an example of a performance expectation (PE).

Students who demonstrate understanding in the following example can: develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (MS-ESS1-1).

NGSS Dimensions[6]

Science and Engineering Practices (SEP): *What scientists and engineers do*

Definition: Behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems

As Presented in this PE: Develop and use a model to describe phenomena.

Disciplinary Core Idea (DCI): *What scientists and engineers know*

Definition: Key organizing concepts, problem solving tools, or underlying principles of a discipline

As Presented in this PE:

» Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (ESS1.A)

» This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (ESS1.B)

Crosscutting Concepts (CCC): *How scientists and engineers think*

Definition: Underlying themes that have value in all disciplines of science

As Presented in this PE: Patterns can be used to identify cause-and-effect relationships.

One of the benefits of NGSS is that they incorporate student learning within and across disciplines, making meaningful connections to English Language Arts (ELA), Mathematics, and other science courses. Results from the CA NGSS Early Implementers Initiative show promising evidence that science can bolster students' ELA skills. As WestEd authors note in their study of ELA and science integration, "a majority of teachers reported NGSS science increased motivation and engagement for all students, which in turn increased their enthusiasm for speaking, reading and writing."[7] Teachers reported that ELA skills such as reading informational texts and presenting knowledge and ideas were some of those most often integrated with science.[8] Similarly, research shows that science activities can encourage English learners to employ their new language and that Spanish-speaking students can take advantage of the many Spanish cognates in science vocabulary.[9]

Not only does NGSS instruction have built-in opportunities to reinforce ELA and math standards, the standards also support students' understanding of real-world jobs, which promotes connections to STEM careers and college pathways. "The Next Generation Science Standards constructed each performance expectation by linking concepts and practices that build coherently over time throughout K–12, thereby helping to ensure that students who meet the NGSS will be prepared to succeed in science courses in both two- and four-year institutions."[10] And for students who may not want to go on to complete studies at a four-year college and beyond, science-based jobs are still an option. Peter A'Hearn, a former regional director for the California Science Teachers Association, writes that, "there are many high-paying jobs with good benefits and room for advancement that do not require college degrees. They *do* require certifications to advance and these are heavy on the science and math of the job."[11] Making such connections to careers will be essential to fulfill the promise of NGSS and can be done through activities such as STEM day or classroom visits from science professionals. For example, the Shasta County Office of Education (COE) sponsors an annual STEM career day called "Ignite Opportunity" that is open to ninth-grade students from six counties to learn about careers in science and the pathways to those careers.[12]

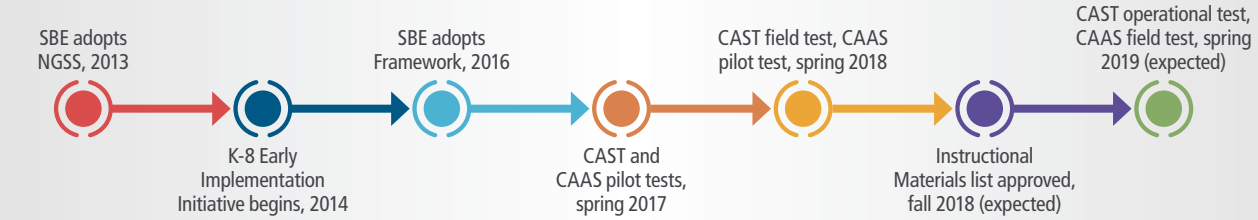
How do NGSS differ from the previous science standards?

The previous California Science Standards were adopted in 1998. In the current version, NGSS gives more attention to science as a dynamic, creative, and collaborative process rather than learning science as a collection of facts that were found using a singular and linear "scientific method," disconnected from how real scientists and engineers do their work.[13] There is also greater opportunity to integrate ELA and math standards. For example, the notion of arguing based on evidence is integral to both ELA and scientific practice.[14] NGSS were designed to mutually reinforce skills across disciplines and grade levels using Performance Expectations.[15] Irvine Unified School District provides some examples of how PEs differ between the old and new standards for middle school in the table below.[16]

Table 1

1998 Middle School Science Standards	NGSS Middle School Science Standards
Distinguish between atoms and molecules	**Construct and use models** to explain that atoms combine to form new substances
Describe the difference between pure substances (elements and compounds) and mixtures	**Plan investigations** to generate evidence supporting the claim that one pure substance can be distinguished from another based on characteristic properties
Describe the movement of particles in solid, liquid, gas, and plasma states	**Construct an argument** that explains the effect of adding or removing thermal energy to a pure substance in different phases and during a phase change in terms of atomic and molecular motion

NGSS timeline since 2013 adoption



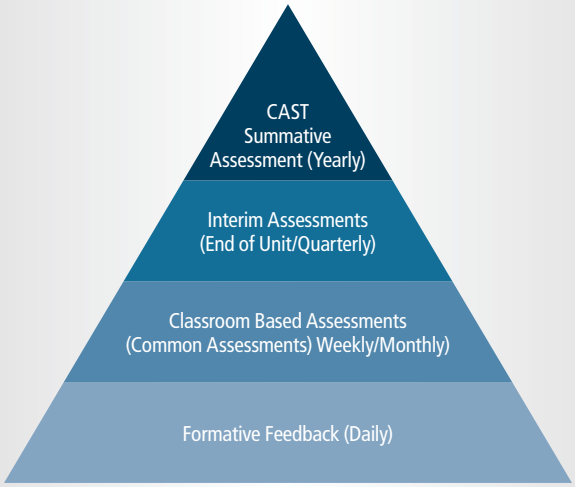
The current state of NGSS implementation

Although NGSS implementation in California began in 2013 with its adoption by the SBE, six years later, LEAs are still waiting for a list of approved instructional materials—due to be approved midway through 2018–19. Some LEAs may be able to forge ahead by developing their own materials. Those that lack the staffing capacity to conduct a materials review may be hampered and may opt to wait to purchase materials after the SBE releases its approved list, scheduled for late 2018. Notwithstanding this lack of an approved materials list and that materials adoption by LEAs has been uneven across the state, student assessment based on the new standards and the inclusion of the results of this assessment in the accountability system has continued to move forward. The assessment, the California Science Test (CAST), has been field tested with all eligible students and will be operational in spring 2019. Following the release of the 2018 California School Dashboard, CDE will begin development of a proposed Science Indicator on the Dashboard, which will be based on the results of the CAST (see following section).17 Above is a timeline since the 2013 adoption of NGSS by the State Board.

How will the new California Science Test assess student performance?

The CAST and the alternative assessment for students with special needs, the CAA for Science or CAA-S, were designed based on NGSS. As such, the assessments will promote the same types of learning as NGSS. Students will be tested in grades five, eight, and once in high school.[18] Considering that the CAST is new, schools are at various stages of NGSS implementation, and the approved materials list is forthcoming—it is expected that there may be a transition period to get an accurate sense of how students are faring in science. The CAST has three parts: (1) 32 to 45 standard items which may be multiple choice, drag and drop, or fill in the blank; (2) Two to three performance tasks; and (3) either another performance task or six or seven discrete items.[19] The assessment is designed to take approximately two hours. The CAST is meant to be a summative assessment for determining what students have learned—not a periodic assessment for informing ongoing instruction during the school year. At the same time, the assessment results should inform teacher practices for the following year. **Figure 1** represents how the CAST factors into the different types of science assessments students are given during a school year:

Figure 1: Balanced Assessment Pyramid[20]



LEA Implementation Indicators for NGSS

Achieve, Inc. is a nonprofit educational organization contracted by the 26 states that took the lead in implementing the new science standards. Achieve has developed materials and strategies to facilitate NGSS implementation in LEAs. One project has been to develop Implementation Indicators to help LEAs monitor their progress.[21] These indicators may be used to craft new or adapt existing strategies to prioritize science education and understand systemic issues associated with improving science outcomes.[22]

While there are 13 indicators, board members might find it helpful to delve into two examples that are particularly relevant to their role. See table 2 on next page.

Table 2

Strategy	Board action
Community Communication	**Give regular, clear updates on:** » Implementation timeline » Changes to student work and classroom design » Current implementation challenges » Changes to formative and interim assessments
	Share information on: » Knowledge expectations at the end of each grade » How NGSS are different from previous science standards » How community can support NGSS
	Solicit feedback from parents through: » Board visits to school science night or LEA-wide science fair
Management	**Establish a science leadership team (LEA office, educators, and administrators):** » Leadership team should partner with other LEAs and other education networks to share information
	Create and publicize a science strategic plan that involves:[23] » Educator and school leader professional learning; instructional material selection; assessment implementation; and funding and resources for sustainable implementation

What are some lessons from NGSS Early Implementer districts?

The K-12 Alliance and WestEd embarked on an NGSS Early Implementers Initiative in 2014 involving eight districts and two charter schools in California.[24] They have published several reports on their progress. Highlighted below are two of the best practices particularly relevant for board members.

Support the Development of an LCAP Committee for NGSS. If science is to be an LEA priority, it needs to be incorporated into the Local Control and Accountability Plan (LCAP). The LCAP provides visibility, accountability, and funding for a district's strategic goals. An educator from one of the Early Implementer districts remarked in the WestEd annual report that having an NGSS LCAP Committee "allowed the voice of science to be heard more clearly and more often."[25] This committee should involve educators and administrators and educate them on how to use LCAP funds to support NGSS. As one project director noted, being a part of the LCAP process was being "at the right place, at the right time, with a plan."[26] Board members can play an important role in encouraging educators to take part in the LCAP process.

Support Teacher and Administrator Professional Learning. NGSS require a change in educator mentality from that of a "sage on the stage" to a "guide on the side." This change cannot happen simply through an isolated workshop or webinar. Deeper teacher learning involves sustained duration, expert support and coaching, and utilizes active learning.[27] Furthermore, getting schools on board with teacher professional learning will require principal and administrator professional learning to be able to properly support teachers. For example, the K-12 Alliance concluded that "in the absence of explicit 'permission' from their administrators, some Teacher Leaders were unwilling to experiment with NGSS in their classrooms."[28] Principal professional development can create the conditions for teacher success and should be considered when drafting a district professional learning budget.

What are some of the challenges with implementing NGSS?

Instructional Materials and the Williams Act

The State Board is scheduled to release an approved list of instructional materials for K-8 by December 2018. LEAs will be responsible for reviewing materials for grades 9-12 to ensure they are NGSS-compliant. Unlike the older standards, there will be more flexibility if LEAs wish to use materials outside of the approved SBE list.[29] No formal waiver process will be in place. Teachers may use open source/online and free materials to teach NGSS if they wish. Teaching NGSS-compliant content will require more time on the part of LEAs due to this flexibility. To aid this transition, NextGen TIME is a resource that educators may use to review materials for their alignment with NGSS.[30]

Educators looking for NGSS-aligned textbooks may find that many of the available texts are based on the older standards. Achieve, Inc. has developed a guide for educators to sort through some of the NGSS-related claims made by textbook publishers.[31] School board members can play an important role by setting benchmarks and a timeline for timely adoption of materials as an LCAP goal. Communication with the county office of education will be essential to ensure a successful rollout of these materials. For CSBA members, Sample Board Policy 6161 has some general guidance on the adoption of instructional materials including ensuring the diversity of an advisory committee for this purpose.[32]

Board members should be familiar with the Williams Act, which mandates that all students in a class have access to current instructional materials. If materials are online, schools need to ensure that students have access to the internet outside of class (public library or school library computer access is not enough) or that a printed reproduction/PDF is provided. Schools can assist with the cost of home internet access, provide devices, and/or provide copies; however, printed copies are not enough to make up for a physical textbook shortage in class. The county office of education is responsible for ensuring that the district is complying with the Williams Act.[33]

Funding for Professional Learning

The 2018–19 state budget included nearly $400 million for STEM promotion, including teacher recruitment, but no funds were earmarked to provide science teachers with professional learning on NGSS. Jessica Sawko, executive director of the California Science Teachers Association, says that without dedicated funds, "It means that a lot of that work to advocate for using funds [for professional development] is going to have to happen at the local level."[34] While instructional materials are an important part of the equation, selecting NGSS instructional materials, designing experiments, and teaching students to think like scientists all depend on teacher professional learning. As a recent post in *Classroom Science* argued, "just because the LCAP tells your district or local school site administrators to consider NGSS implementation in their spending plan, and the Dashboard reports what your district is doing, it doesn't mean your administrators have a good idea of how much to spend or what to spend it on."[35] Board members must take an active role in soliciting educator and administrator input so that NGSS materials and support is properly funded.

One possible source of funding are Student Support and Academic Enrichment Grants, part of the Every Student Succeeds Act (ESSA) under Title IV-A. ESSA is a wide umbrella of funds that can support STEM education and NGSS implementation in various ways. ESSA funds can support technology infrastructure, which is a barrier to access for many students. Funds can be used to support a well-rounded education, which includes STEM and computer science support. ESSA funds can also be redirected to Title II to support teacher training.[36] Each district will receive at least $10,000 under Title IV-A for 2018–19 and while this may be insufficient to support professional learning needs, it may pool funds with other districts or county offices of education to develop consortium resources such as a professional learning network or an interdistrict professional learning day. The county office of education is a good resource to coordinate and promote interdistrict events.

LEA Science Course Requirements and Equity

A glaring issue for many LEAs in NGSS implementation is that the new standards necessitate three science courses in high school while many LEAs only require two courses for graduation. Beyond course requirements is the issue of access to science courses. According to Children Now, 37 percent of California public high schools do not offer physics and 25 percent do not offer chemistry. The most recent science assessment in 2015 also showed disparities among student groups with 46 percent of white students showing proficiency in science while only 13 percent of African-American students and 10 percent of Latino students demonstrating proficiency. California, by the most recent measure, ranks 42nd in student performance in science.[37] Access to science courses will be crucial to bring California up to the national standard and fill the growing need for STEM jobs in the world's fifth-largest economy.

What more can board members do to ensure their LEA is on the path to full NGSS implementation?

While board members may use the 13 District Implementation Indicators to gauge their LEA's progress, both Science Partnership and San Diego Unified School District have developed some strategic planning tools that may prove useful.

Develop a Plan

Science Partnership, a multiyear collaboration that includes the Alameda COE, Cal State East Bay, and the California Science Project, developed a *Guide to District Action for NGSS*.[38] Its recommendations for an effective NGSS planning process are to:

» Designate a facilitator who is knowledgeable about both the NGSS and LEA processes.

» Involve LEA and site administrators, teachers, and community members, so that action plans will have strong stakeholder buy-in and coherence with other initiatives.

» Focus on one readiness phase at a time so as not to overwhelm stakeholders. This can be done in smaller committees, depending on the organization of the LEA.

» Start by grounding the conversation in the current state of the LEA, and then move forward on decisions for the future.

» Begin with areas of the LEA that are more advanced, then scale out from there. For example, one grade band may be more established in terms of leadership teams, progressions, and professional development, so it makes sense to start with planning for that grade band before tackling the other grades.

» Integrate objectives with the overall vision of the LEA and align NGSS implementation with other initiatives as much as possible.

Set Goals

San Diego USD, one of the Early Implementer Districts, has developed district-level goals that provide an example of how to support NGSS implementation.[39]

Goal 1 Closing the Achievement Gap

» Elementary schools ensure adequate (amount and configuration) time provided for NGSS learning which includes a full year of science offered every year

» In middle (6-8) and high school, students receive a full course of NGSS instruction

» Ensure TK classrooms have access to science learning opportunities

» Develop and implement LEA-wide science content formative and varied assessments/benchmarks to provide student learning data and inform classroom instruction

» Middle and high schools ensure that course admittance is determined by appropriate measures (e.g. math scores should not be used for science course admittance)

» Provide access to science courses for students with behavioral issues

» Provide targeted support services to help high-needs students engage in and succeed in science coursework

» Elementary schools ensure interventions and pull-out programs do not happen during science instruction

Goal 2 Access to a Broad and Challenging Curriculum

» LEA engages in NGSS implementation planning and documents the resulting plan with annual goals and objectives

» Ensure all classrooms have resources to order/replenish science materials/consumables at end of year

Goal 3 Quality Leadership, Teaching, and Learning

» Provide ongoing and regular professional learning on K-12 NGSS

» Provide targeted on-going professional learning for K-12 teachers to develop skills in integrating CCSS and NGSS

Goal 4 Positive School Environment, Climate, and Culture—with Equity at the Core and Support for the Whole Child

» No specific recommendations

Goal 5 Parent and Community Engagement with Highly Regarded Neighborhood Schools that Serve Students, Families, and Communities

» Provide an LEA NGSS leadership team that includes teachers, administrators, parents, and community members

» Ensure students have access and provide resources and supports to science-related enrichment activities that go beyond NGSS classroom instruction (science family nights, festivals, special electives, clubs, outdoor experiences, etc.)

» Increase the number and percentage of students from underrepresented groups who participate in science enrichment programs

Goal 6 Well-Orchestrated LEA-Wide Support Services and Communications

» No specific recommendations

Conclusion

Board members should expect the full transition to NGSS to take several years of planning and reforms that address curriculum, teaching practices, instructional materials, and assessments.[40] This requires a commitment to teacher and administrator professional development and giving them time to make the transition to the three-dimensional framework of NGSS. Course sequences in middle and high school will need to be reviewed to determine the best options for the LEA to meet NGSS and University of California and California State University A-G entrance requirements. Board members can work to include teachers and the community in the planning process, provide funding for professional development and materials, and ensure that superintendents elevate science's profile in the LEA.

Questions for Board Members

» What might our LEA do to ensure that deep professional learning in science is offered for teachers and administrators?

» What is our LEA's plan for reviewing NGSS instructional materials? How are we communicating that with schools?

» What will be our LEA's strategy for communicating the CAST results to parents? How will we contextualize the results?

» Which schools or groups are at risk of receiving inequitable resources in science due to lack of staffing, courses, materials, or learning experiences?

» What are our superintendent and principals doing to promote STEM? Could a goal be set for LEA-wide events per year dedicated to STEM? How might our county office of education promote our STEM events?

» In addition to the CAST, how can our LEA determine whether efforts to teach based on the new standards are helping students meet the NGSS goals?

Additional Resources

CSBA Research and Policy Briefs. Includes governance briefs and fact sheets on pertinent educational topics, available at bit.ly/2On8Glu.

» Research Spotlight: Science as a Lever for English Learner Equity (April 2017). bit.ly/2Q8D4gk

» Supporting the California Next Generation Science Standards (November 2016). bit.ly/2R6aZI8

» A New Formula For Science Success in California Classrooms: California rolls out Next Generation Science Standards curriculum

GAMUT Online Includes the following sample policies and administrative regulations for subscribers, available at www.gamutonline.net.

» BP/AR 6161.1 – Adoption of Instructional Materials

» AR 6162.51 – State Academic Achievement Tests

Communications & Implementation Toolkits from the California Alliance for Next Generation Science Standards (CA4NGSS). The CA4NGSS facilitates collaboration among education, business, government, and community leaders to support effective and timely implementation of NGSS throughout California. As a member, CSBA is supporting the development of communication toolkits for multiple stakeholders, including a District Leader Toolkit. cdefoundation.org/cde_programs/ca-4-ngss/

Teacher to Parent Communication Videos from the California Science Teachers Association (CSTA). www.cascience.org/ngss/communications-tools

Leveraging ESSA to Promote Science and STEM Education in States from Achieve. www.achieve.org/science-and-stem-in-essa

Strengthening Science Education and Environmental Literacy Through Local Control: A Toolkit to Help Develop Your District's Local Control Accountability Plan (LCAP) from the Lawrence Hall of Science at UC Berkeley. bit.ly/2ObnKT9

Endnotes

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