Shifting K-5 Science Instruction With Next Generation Science Standards Curriculum Adoption

By Margaret Harte

Introduction

A Framework for K-12 Science Education provides a foundation for the future of K-12 science education in the U.S. First released in 2011, the framework is structured to "ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science, the capacity to discuss and think critically about science-related issues, and the skills to pursue careers in science or engineering if they want to do so."[1] For elementary school teachers who have, over the last 20 years, been provided very limited support for developing scientific literacy in their students, the framework and Next Generation Science Standards (NGSS) that followed required a significant shift in how teachers approached science instruction.

The Science Framework for California Public Schools, adopted by the State Board of Education (SBE) in 2016, was a departure from prior frameworks in that it focused on what students should be able to do with their understanding of science and engineering principles and practices, rather than simply what students should know. "The new framework is designed to help students gradually deepen their knowledge of core ideas in four disciplinary areas over multiple years of school, rather than acquire shallow knowledge of many topics. And it strongly emphasizes the practices of science—helping students learn to plan and carry out investigations, for example, and to engage in argumentation from evidence."[2] The California NGSS Framework requires students to engage in sense making, becoming active participants in their own discovery of how the world works.

These new standards bring with them an increased challenge for K-5 teachers. Many elementary teachers do not feel prepared to make this transition, having little background in science instruction themselves. In a recent national study, only 33 percent of third- through fifth-grade teachers felt that they were "very well prepared" to teach science.[3] The national and California NGSS frameworks contain not only scientific concepts, but also sense-making practices to explain scientific phenomena. To implement these new standards and practices, K-12 teachers will be required to shift their thinking about how they approach science instruction, reframing instruction to have a more student-centered rather than teacher-directed approach. To make these instructional shifts, elementary teachers will require a different model for professional learning than their single-subject peers.

The goal of this governance brief is to inform school board members of various ways to engage in the adoption process by thinking about essential questions to ask and by considering proven approaches to curriculum adoption and teacher development.

In this brief you will find:

- The significance of the shifts in Next Generation Science Standards curriculum and instruction;
- Steps that can help local educational agencies determine which publisher suits the needs of their district or county office of education;
- Ways to support both teachers and students in the transition to NGSS to ensure equity and access for all students; and
- Questions for board members to consider.

Shifts in CA NGSS Instruction

In looking at science curriculum adoption, it is important for board members to understand that with the new standards comes a new model for exploration and instruction for students and teachers alike. These instructional shifts highlight the need to place students at the forefront of every lesson as the ones engaging in scientific inquiry. Gone are the days of teacher lectures or students reading out of the text as the primary models for science instruction. As instructional material is reviewed by local educational agencies (LEAs), there are some key shifts in instruction to look for in the new science curriculum:

» **Students engage with anchoring phenomena** (observable events in nature). They use these phenomena to generate questions and explore lessons that assist them in answering these questions. Lessons are learner centered, not teacher centered.

» **Students engage in science explorations** as a way to make sense of the world. They explain their understanding of these explorations through various modes (written, oral, visual).

» **Students are given time to design investigations** to explain the phenomenon, not to engage in activities that simply reaffirm an already known outcome.

» **Students have time to engage in scientific discourse** to explain their own ideas and challenge those of their peers. The materials reflect the teacher's role in facilitating argumentation, discourse, and reaching consensus.

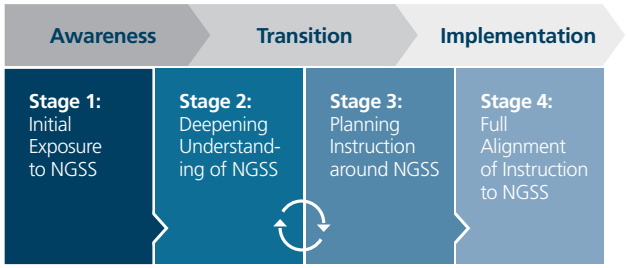
» **Diverse examples of "those who do science"** are used so students see themselves reflected in these portrayals.

From Professional Development to Professional Learning

Professional learning needs to be "embedded in science content, giving teachers an experience in grappling with the science."[4] Before adopting new curriculum, as part of stages one and two of the NGSS implementation process (Figure 1), teachers will need professional learning opportunities to dig deeper into NGSS, its pedagogical and instructional shifts, and have time to reflect on their own practices. Without understanding why instructional shifts were necessary to prepare all learners for a 3D model of learning, districts and county offices of education run the risk of purchasing new textbooks without changing instructional practices of teachers or learning opportunities by students. Before LEAs ask teachers to pilot CA NGSS-adopted programs, professional learning opportunities on the pedagogical and instructional shifts will be needed to improve instruction and help foster more equitable outcomes.

The statewide rollout of NGSS has occurred as a phased-in process since 2014. Most LEAs are still in stages one or two. Even the best curriculum will not have everything that is necessary for teachers to transition to stage four of NGSS implementation.[5] Many teachers lack confidence in their own scientific understanding to fully engage students in the NGSS. Thus, ongoing professional learning opportunities will be important in supporting equitable access to all students. "Professional learning refers to planned and organized processes that actively engage educators in cycles of continuous improvement guided by the use of data and active inquiry around authentic problems and instructional practices."[6] Current research shows that ongoing long-term collaborative learning opportunities are what are necessary to truly change the practices of teachers.

Figure 1: The CA NGSS Implementation Pathway



Source: San Diego County Office of Education

Just as there are significant shifts to how students approach the learning of scientific concepts embedded within CA NGSS, the instructional shifts required of teachers is just as great. For many elementary school teachers, this transition will require a tremendous amount of collaboration, planning, and professional learning opportunities (stage three). Having limited exposure during pre-service course work to NGSS pedagogy, narrowed experience with scientific content in undergraduate work, and less and less time in class to develop science instructional methods and practices, elementary school teachers' professional learning needs are unique when compared to science-specific content teachers in middle and high school.

California has many models for what these types of collaborative, ongoing professional learning projects could look like. Tapping into ongoing learning opportunities through the state's University of California and California Subject

Matter Projects can be a good place for LEAs to start. For example, the UC system, Sacramento Area Science Project (SASP), and partner districts developed multi-year professional learning models to support teachers as they implement NGSS through projects like iStar (a collaboration between UC Davis, the SASP, and Davis and Dixon Unified School Districts) and iSEE (a collaboration between SASP, Elk Grove Unified School District, Folsom Cordova Unified School District, and Sacramento State University).

There are also ongoing countywide programs, such as the San Diego County Elementary Science Academy, whereby, over multiple years, teachers "continue to deepen their understanding of the instructional shifts of NGSS while implementing phenomena-based lessons with an emphasis on student discourse." Countywide programs allow teachers to "plan with grade-level colleagues across the county, collect and analyze student work, and apply their learning in the classroom."[7] Reaching out to and accessing regional colleges, subject matter projects, and county offices of education can allow smaller LEAs to pool resources when looking at longer-term professional learning models.

Table 1: Instructional Shifts—Utilizing Professional Learning Opportunities (Stage 3—pre pilot)

Moving From	Moving Toward
Teaching of discrete facts	Exploring and explaining new phenomena using explanatory models
Teacher explaining the content	Students exploring and investigating phenome-na to come up with their own explanations
Reading and learning about science alone	Engaging with sci-entific practices to explain phenomena
Assessing students' recall of discrete facts	Assessing students using the 3D model, looking at students' ability to explain ideas and argue from evidence

Adapted from 2016 California Science Framework

As LEAs look for ways to support teachers through ongoing professional learning opportunities, it is important to ensure that key instructional shifts in curriculum are reflected in professional learning.

While there are many teacher professional learning programs for NGSS, board members should prioritize those that (1) engage educational staff in a cycle of continuous improvement by using multiple data sources and active inquiry, and (2) reflect continuous professional learning through follow-up, feedback, and reflection to support implementation in the classroom.

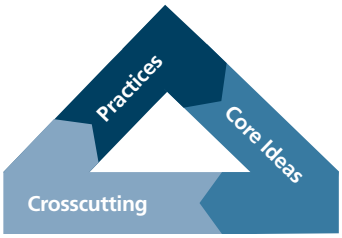
Determining Criteria for Decision Making

As part of the state curriculum standards revision process, the Instructional Quality Commission (IQC) is tasked with reviewing instructional materials for alignment with state standards. The Commission's recommendations are then forwarded to the SBE for approval. In 2018, the SBE determined that 29 out of the 34 science curriculum programs submitted for review met the following criteria:

1. Alignment with CA NGSS Three-Dimensional Learning (i.e., scientific practices, disciplinary core ideas, crosscutting concepts)
2. Program Organization
3. Assessment
4. Access and Equity
5. Instructional Planning and Support[8]

One of the main requirements for instructional materials meeting the SBE criteria was aligning with the three dimensions of NGSS. The three dimensions are the pillars that make up the foundation for the performance expectations or standards (Figure 2). The scientific practices, disciplinary core ideas, and crosscutting concepts reflect the three dimensions that students will engage with as they work toward the performance expectation.

Figure 2: NGSS Three-Dimensional Model



Source: Next Generation Science Standards

It is important to note that the IQC team was not tasked with determining the suitability of the programs for LEAs or how well each program aligned with each of the five categories outlined. To determine which publisher(s) to pilot, the LEA will need to engage with all relevant local stakeholders to develop an adoption process. Under LCFF, if an LEA wishes to adopt instructional materials outside of the 29 approved programs, it may do so without a waiver from CDE.

As a way to support LEAs in this process, in December 2018, the NGSS Collaborative (comprising the California County Superintendents Educational Services Association-Curriculum and Instruction Steering Committee Science Subcommittee, California Science Project, California Science Teachers Association, K-12 Alliance @ WestEd, CDE, and State Board of Education) introduced the California Tool for Instructional Materials Evaluation (CA TIME). Many county offices of education have and continue to offer trainings to district leaders as they move forward with NGSS-aligned curriculum adoptions. The process and recommended toolkit can be found in the resources section of this brief. It is important, before beginning the adoption process, that LEAs review their goals and focus on what priorities have been identified before beginning the NGSS adoption process.

Figure 3: California Tool for Instructional Materials Evaluation steps

Development of Local Educational Agency Lens

Inclusion of Stakeholders

Ensuring teachers have adequate resources based on local identified needs in order to support student transition to CA NGSS is essential. To that end, LEAs should first reach out to their community to form a committee of stakeholders, composed predominantly of teachers, as they move forward in the adoption process. Each LEA is different and has unique strengths and needs. The strengths and needs of students, teachers, parents, and the community will need to be explored, identified, and taken into consideration when looking at any new adoption. The focus of developing an LEA lens may begin by looking at what the committee feels students will need to engage in NGSS learning. Committees may ask questions such as, "What kinds of talk, tasks, and tools do students need in order to fully engage in meaningful forms of science learning?"

It is important for LEA adoption committees to take their time during this process, as it will help in determining what teachers and students need from the curriculum and beyond. LEAs should ask themselves questions such as, "What elements do we feel are essential in new science curriculum?" and "What supports do we think our teachers and students will need for the curriculum?" No one adoption will fulfill every need or goal, but this process can be an effective way to focus the committee's attention, as well as identify elements that may need to be supported in other ways outside of the adoption process. Once the LEA's vision and priorities have been highlighted, a rubric can be developed to focus on those priorities. The committee should also determine how various elements will be weighed in its decision-making.

Focus Resources

When developing an LEA lens, adoption committees should look at what resources are available compared to the list of priorities made as part of the curriculum adoption process. According to Achieve, a nonprofit group tasked with leading the development of the standards by the states, "eighty-six percent of teachers identified instructional materials as a resource critical for implementing the standards... providing teachers with the resources they need will be critical to meeting the promise of the NGSS to improve science education for all students."[9] Curriculum adoption materials needs and professional learning plans should be included in the Local Control and Accountability Plan revision process, keeping in mind that this adoption will be with the LEA for eight years.

When considering the adoption of new instructional resources, LEAs need to consider more than just materials available for hands-on projects. For example, if the integration of the English Language Arts/English Language Development Framework and NGSS is a priority, adoption committees might ask questions such as, "Does the LEA have the reading material to support that type of integration?" ; "Does the

staff have the necessary support and training to plan cohesive storylines around that type of integration?" ; and "How much time and support will teachers be given for collaboratively planning a cohesive and comprehensive program?" The need for training and materials in an LEA that is in stage three, or planning instruction (Figure 1), around CA NGSS with staff who have been attending professional development and working collaboratively over time will be much different than LEAs who are in stages one or two and are still focusing on deepening their understanding of the shifts necessary to fully implement NGSS. Knowing what resources teachers already have and what types of supports are available is critical in determining planning and implementation needs going forward.

LEA Data to Determine Strengths and Needs

Achieve recommends reviewing student data longitudinally and among subgroups to look for achievement gaps. The sets of data that an LEA decides to use will be determined by that district's or county office of education's lens and identified priorities. The data collected from the California Science Test (CAST) 2017–18 field test will be limited in that it will give LEAs "preliminary indicators"—an initial baseline as to how students are performing in their application of CA NGSS—but which should not be used alone in determining the needs of an LEA or student performance. Several years of CAST operational testing will be needed to be able to draw reliable conclusions about students' science mastery. Looking at how various subgroups performed in previous years on the California Assessment of Student Performance and Progress in English language arts (ELA) and math will be important as LEAs consider what types of supports teachers and students will need. Are there needs based on the LEA's analysis that may be unique as evidenced by the data? What supports will be put in place, based on the ELA/math scores, to ensure equitable access to science instruction?[10]

Determining Which Publishers to Pilot

Once the LEA has determined its lens, identified resources, and reviewed data, a timeline can be set for paper screening of adopted curriculum. LEA administrators should request representative samples from each of the publishers and begin a paper screening using the rubric designed based on the identified needs, priorities, and resources (available and needed) determined by a review of the data. The rubric will be used to narrow down the criteria for each curriculum to determine which publishers to pilot. The paper screening process should highlight the priorities of various stakeholders as teachers, administrators, parents, and community members come together to review the proposed adoption. In addition to looking at instructional supports for various demographics, committee members should also review how well each publisher allows students in their LEA to engage in the scientific practices highlighted in CA NGSS. As stated earlier, the state adoption review committee did not determine the quality of the resources, but rather the evidence that the curriculum is aligned with the CA NGSS. In addition to supporting the unique needs of the LEA, adoption committees should also look at how well they feel each publisher supports the instructional shifts and practices that align with CA NGSS 3D instruction.

Practices for K-12 Science Classrooms[11]

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in arguments from evidence
8. Obtaining, evaluating, and communicating information

*From the CDE's *Science Framework for California Public Schools, Kindergarten Through Grade Twelve*

Equitable Access

The achievement gap between various demographic groups in STEM subjects, as well as access to quality STEM instruction, continues to be an ongoing issue in California schools. In many cases, the gap in instructional opportunity and quality becomes more dramatic when looking at access to scientific literacy instruction when compared to other subjects. To implement the instructional shifts necessary for scientific literacy development in students, many schools have found that the time dedicated to science instruction needs to be increased. The more time dedicated to science, the more likely students are engaged in inquiry.[12] When given limited amounts of time, or limited freedom to extend time when needed for an investigation, teachers are more likely

to revert to old modes of science instruction. More often than not, schools that have limited access to quality science instruction are also the same schools that have student populations not represented in STEM fields. Given the need for quality materials and teacher development, equitable access to high-quality science instruction needs to be a priority for an LEA. A plan in keeping with the board's wishes for how to ensure that all students have access to a fully implemented CA NGSS program needs to be articulated.[13]

The focus on shifts necessary for scientific literacy requires teachers to commit more time to science instruction. The amount of time extended to elementary students is a matter of equity and access. For these students, limiting early science learning opportunities leaves them unprepared for science courses in middle and high school, which can exacerbate future inequities in interest, course-taking, and achievement in STEM.[14] Attending to time committed, both in the daily schedule of classrooms as well as professional learning opportunities for educators, will be an important factor for districts and county offices of education.

Conclusion

During this period of transition and adoption of both the CA NGSS standards and curriculum, school districts and county offices of education have a wonderful opportunity to increase student engagement and learning by implementing key shifts in instructional practices. The process of determining an LEA vision, diving deep into student data to look at needs, and focusing on equity and access will allow school districts and county offices to focus on steps for developing more student-centered science classrooms. Building capacity among the teaching staff is one of the most consequential steps in that implementation process. Once fully implemented, the CA NGSS will help ensure that all of California's students are able to think critically and appreciate the beauty in the world around them.

Questions for Board Members

LEAs are able to allocate money toward new instructional materials adoptions and professional development based on goals as determined by the LCAP. Currently, there is no timeline by which LEAs must adopt CA NGSS-aligned curriculum, nor is there extra funding allocated to do so. LEAs will need to keep in mind that any adoption decision made will have an impact on the LCAP as well as classroom instruction that will last for years. As LEAs move forward toward full implementation of CA NGSS, board members should ask:

1. What stage of NGSS implementation is the LEA in?
2. What has been the focus of professional learning opportunities for grades K-5 teachers to prepare for this transition and what professional learning opportunities will be ongoing?
3. What type of facilitated collaboration (e.g. professional learning communities) has been established to support teachers in making these instructional shifts?
4. What is the timeline for NGSS-adopted materials in the LCAP? Does the LCAP need to be updated? How will that impact the budget?
5. What site-level data is being used to make decisions about priorities around science?
6. Is the LEA in Williams Compliance? (The Williams Act ensures that all students have equitable access to a quality education, i.e., textbooks, decent facilities, trained teachers.) How will students access content at home? Is this method available to all students? Will the LEA require a change in policy regarding Supplemental Resource Approval?

Additional Resources

Next Generation Science Standards: https://bit.ly/2QiaRay

Understanding NGSS—San Diego County Office of Education San Diego https://bit.ly/2moXFnF

2016 California Science Framework https://bit.ly/2pwdalk

National Framework for Science Education (2011) https://bit.ly/2n0u0l7

Instructional Materials Resources from CDE https://bit.ly/2nWcbUl

CDE Science Report https://bit.ly/2ozZBdw

Instructional Shifts- More of this, Less of this https://bit.ly/2olezyl

NGSS Adoption and Implementation Workbook https://bit.ly/2xOGJLW

California NGSS Toolkit for Instructional Materials Evaluation (TIME) https://bit.ly/2oCCbEl

Elk Grove Unified School District—iSEE Program https://bit.ly/2na1rBD

Endnotes

1 California Department of Education. (2016) *Science Framework for California Public Schools, Kindergarten Through Grade Twelve*. Retrieved from: https://bit.ly/2pwdalk

2 Nielsen, N., Schweingruber, H., Wilson, S. (2015). Committee on Strengthening Science Education through a Teacher Learning Continuum. Board on Science Education Teacher Advisory Council Division of Behavioral and Social Sciences and Education. The National Academies of Sciences, Engineering, Medicine. Retrieved from: https://bit.ly/2ozyQ95

3 Banilower, E., Nelson, M. Smith, S., Trygstad, P. (2013). *The Status of Elementary Science Education: Are We Ready for the Next Generation Science Standards?* Horizon Research. Retrieved from: https://bit.ly/2mlReSa

4 Reiser, Brian. (2013). *What Professional Development Strategies Are Needed for Successful Implementation of the Next Generation Science Standards?* K-12 Center at ETS. Retrieved from: https://bit.ly/2ndxzEv

5 San Diego County Office of Education. Science Professional Development. Downloaded on September 30, 2019 from: https://bit.ly/2oCnroZ

6 See Endnote 1

7 See Endnote 4

8 See Endnote 5

9 See Endnote 5

10 See Endnote 1

11 California Department of Education. (2018). Instructional Quality Commission Advisory Report: Science Instructional Materials Adoption. Retrieved from:https://bit.ly/2o1S5b1

12 Achieve.org. (2017). *Lessons Learned from Early Implementers*. Retrieved from: https://bit.ly/2nU11zk

13 See Endnote 12

14 California County Superintendents Educational Services Association. (2019). California NGSS Toolkit for Instructional Materials Evaluation. Retrieved from: https://bit.ly/2oCCbEl

15 See Endnote 1

16 See Endnote 2

17 WestEd. (2018). *Developing District Plans for NGSS Implementation: Preventing Detours and Finding Express Lanes on the Journey to Implement the New Science Standards*. Retrieved from: https://bit.ly/2TL7tmk

18 National Research Council of the National Academies. (2013). Monitoring Progress Toward Successful K-12 STEM Education. Retrieved from: https://bit.ly/2n9ZrcA

Margaret Harte is an elementary science specialist for Dixon Unified School District, an education consultant for the Yolo County Office of Education, and an Innovation Fellow at the UC Davis Center for Community and Citizen Science.