OCTOBER 2016 | EVALUATION REPORT #1

# The Needle Is Moving in California K–8 Science

## Integration with English Language Arts, Integration of the Sciences, and Returning Science as a K–8 Core Subject

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NGSS EARLY IMPLEMENTERS

WestEd

## NGSS Early Implementers Initiative: Bringing science to life as a core subject in K–8 classrooms

A diverse group of eight California school districts and two charter management organizations is actively implementing the Next Generation Science Standards (NGSS). Their progress, experiences, and lessons can inform others implementing the NGSS. The NGSS Early Implementers Initiative are supported by the K–12 Alliance at WestEd, and work in partnership with the California Department of Education, the California State Board of Education, and Achieve. Initiative funding is provided by the S. D. Bechtel, Jr. Foundation, with the Hastings/Quillin Fund supporting participation by the charter organizations.


The Initiative spans 2014 to 2018. It focuses on NGSS implementation in grades K–8 and incorporates the integrated course model (preferred by the California State Board of Education) for middle school.

Teachers are supported with strategies and tools, including an instructional framework that incorporates phenomena-based learning. This framework aligns with the NGSS three dimensions: encompassing disciplinary core ideas, crosscutting concepts, and science and engineering practices. Using science notebooks, questioning strategies, and other approaches, students conduct investigations, construct arguments, analyze text, practice descriptive skills, articulate ideas, and assess their own understanding.

Teachers engage in science lesson studies twice each year through a Teaching Learning Collaborative. In each district, the Initiative is guided by a Core Leadership Team of Teacher Leaders and administrators who participate in additional professional learning and coaching activities. Together, this core team and an extended group of Teacher Leaders are the means for scaling NGSS implementation throughout the district.

Learn more about this multi-year initiative and access evaluation findings as well as instructional resources at k12alliance.org/ca-ngss.php.



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# Evaluation of the NGSS Early Implementers Initiative

The S. D. Bechtel, Jr. Foundation commissions WestEd's STEM Evaluation Unit to evaluate the NGSS Early Implementers Initiative in the eight participating public school districts. This independent evaluation is advised by a technical working group that includes representatives of the California Department of Education and the California State Board of Education. Evaluators investigate three main aspects of the Initiative's NGSS implementation:

- districts' local implementation,
- implementation support provided by the K–12 Alliance, and
- the resulting science teaching and leadership growth of teachers and administrators, as well as student outcomes.

This first report will be followed up next fall (2017) with two reports:

*The Synergy of Science and English Language Arts* (Report #2, October 2017), which updates and expands the current report's topic of integrating science and English language arts, including describing what such integration can look like in the classroom.

*Administrators Matter in NGSS Implementation* (Report #3, November 2017), which describes how administrators are advancing NGSS implementation in their schools and districts, how teachers' implementation is benefitting from administrator support, and how the Initiative is empowering the administrators' efforts.

Evaluators also plan 2018 reports on these topics:

- District NGSS implementation plans (winter 2018)
- Guide to tools and strategies for NGSS implementation (winter 2018)
- What middle school science integration looks like in the classroom (summer 2018)
- Teacher leadership (summer 2018)
- Changed student interest in science (summer 2018)

# Executive Summary: Three High-Leverage Implementation Strategies

This first Early Implementers Initiative evaluation publication discusses one of the major shifts required by the Next Generation Science Standards (NGSS), namely the shift to integrated instruction. The integration of science and English language arts (ELA) is the focus of the first main section, and the integration of the science disciplines (i.e., earth and space, life, and physical) inherent in the middle school integrated model is the focus of the second. Also discussed in the third and final section, as well as throughout this publication, is another fundamental shift: the need to teach science in the first place. In order for any of the targeted shifts of the NGSS to take place, K–8 teachers must devote time to teaching science on a regular basis.

Main findings in the three sections of this report are briefly described below.

## Science as a Vehicle for Teaching Common Core ELA

Based on summer 2016 data collection, this section describes how the Early Implementers Initiative is empowering elementary school teachers in the eight districts to teach science in relation to Common Core State Standards (CCSS) subjects, particularly ELA. The section also describes how teachers are reacting to and implementing the tools and strategies offered by the Early Implementers Initiative:

- NGSS-aligned science is so engaging for students that teachers are willing, and often eager, to invest the time and effort required to plan and carry out new lessons, in spite of feeling burdened with responsibilities related to the CCSS.
- Teacher Leaders report improved understanding of how the NGSS relate to the CCSS after only one year of participation with the Initiative.
- The two Early Implementers Initiative tools and strategies used most by teachers in their own classrooms (i.e., beyond the Initiative activities) are science notebooks and questioning strategies that facilitate student discourse and sense-making.
- Teachers reported spending more time on science integrated with ELA in Year 2 of the Initiative than Year 1.

## Update on the Middle School Integrated Model

The California State Board of Education (SBE) has adopted the integrated model as the "preferred model" for California middle schools. This

section outlines the reasons for this decision, highlights changes that will need to be made whether a district chooses the integrated or discipline-specific model, and shares considerations for making the transition to the new model, such as:

- Developing a detailed plan to ensure that no student will be short changed during the transition period.
- Providing professional learning on integrated science for teachers and administrators.
- Using a "coordinated model" as a bridge from discipline-specific to integrated science.

## Returning Science as a K–8 Core Subject

One explicit goal for each participating district of the Early Implementers Initiative is to make science a core subject. This section discusses what it means for science to be a core subject and ways that districts have made progress on making science a core subject, including:

- At the elementary level, the worst-case scenario of little or no science has nearly been eliminated among the Initiative's hundreds of Teacher Leaders; and there are some increases underway in science instruction minutes.
- Project Directors and Core Leadership Teams both report that science instruction now has a higher priority in their districts.
- Core Leadership Teams report that increases in science instruction time also are beginning among district science teachers at large, not just among the Initiative's Teacher Leaders.
- Not surprisingly, the most common factor cited as prompting increases in science instruction is the training and support of the Early Implementers Initiative.
- Early Implementers Initiative districts have begun to make schools science-centered beyond the formal science instruction by reaching out to parents and informal science education partners.

Findings presented throughout the report are based on data from the eight public school districts supported by the S. D. Bechtel Jr., Foundation. Results for charter school management organizations participating in the Early Implementers Initiative may be discussed in separate reporting.

# Introduction

The National Research Council released *A Framework for K–12 Science Education* in 2011. Subsequently, the Next Generation Science Standards (NGSS) were developed by a consortium of 26 states (including California), the National Science Teachers Association, the American Association for the Advancement of Science, the National Research Council, and Achieve, a nonprofit organization that was also involved in developing math and English Common Core State Standards (CCSS). The NGSS were completed in April 2013. As of September 2016, the District of Columbia and 17 states have adopted them: Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maryland, Michigan, Nevada, New Jersey, Oregon, Rhode Island, Vermont, and Washington.

## NGSS Early Implementers Initiative Participants

In the first year of the four-year Initiative, 2014–15, the K–12 Alliance at WestEd provided professional learning and technical assistance to sets of 8–15 select teachers and administrators from each district, called Core Leadership Teams. In the second year, 2015–16, the K–12 Alliance continued to provide professional learning and technical assistance to the Core Leadership Teams; professional learning also began with 40 to 70 Teacher Leaders from each participating district, depending on district size. This report is based on evaluation data from the first two years.

In years three and four, additional professional learning and technical assistance will be provided to the Core Leadership Teams and Teacher Leaders. Further, the districts will leverage the Core Leadership Teams and Teacher Leaders to provide professional learning for spreading the beginning of NGSS implementation to *all* district K–8 science teachers.

## Evaluation Methods

The evaluation team has followed the progress of the Early Implementers Initiative by attending most of the Initiative leadership planning meetings and all of the centralized professional learning events. In addition, evaluators have conducted multiple visits to each of the eight participating districts to observe a range of district-level NGSS implementation activities. Interviews have been conducted with district Project Directors and K–12 Regional Project Directors. All other Early Implementers Initiative participants (i.e., Core Leadership Team members and Teacher Leaders) have been surveyed about their understanding of NGSS and the changes they are making and witnessing in their districts and schools.

This is the first in a series of Early Implementers Initiative evaluation publications discussing lessons and observations from the Initiative. This first report focuses on one of the major shifts required by the NGSS — the shift to integrated instruction. The report begins with information and context on NGSS implementation in California and the shifts required by the NGSS. The report

then presents three sections, each focused on one of the main topics of this evaluation cycle:

- The integration of science and English language arts.
- The integration of the science disciplines (i.e., earth and space, life, and physical) inherent in the integrated model.
- The need to make science a core subject in K–8 classrooms.

# NGSS Implementation

## NGSS Implementation in California: Policy and Status

Science has been on the back burner in U.S. schools for decades. Even before the *No Child Left Behind Act*, which mandated reading and math tests for all students in grades 3 through 8 and once in high school, the emphasis of elementary school academics has been on the "basic skills" of English language arts (ELA) and mathematics. With the advent of the NGSS, state policy is clearly supportive of moving science toward core subject status. In March 2016, the California Department of Education (CDE) recommended, and the California State Board of Education (SBE) approved, the following overall science assessment design:

- Grade 5 assessment, consisting of grade 5 performance expectations *and a sampling of performance expectations from kindergarten through grade 4* (emphasis added).
- Grade 8 assessment, consisting of middle school (grades 6–8) performance expectations.
- Grade 10, 11, or 12 assessments, consisting of high school performance expectations.

The NGSS are now included in one of California's eight priorities that must be addressed in every district's Local Control and Accountability Plan (LCAP). Priority 2 involves the implementation of *all* academic content and performance standards that have been adopted by the state, including the NGSS. The standards that must be addressed as part of Priority 2 are not just the Common Core State Standards (CCSS) in mathematics and ELA, as previous requirements emphasized.

> The NGSS-aligned assessments are slated to be pilot tested in California during the current 2016–17 academic year, followed by field testing during the 2017–18 year, moving to a statewide operational test in the 2018–19 school year.

The Local Control Funding Formula (LCFF) does not require that all of the eight priorities be funded, or be funded equally, so some districts may choose to forgo providing funds for NGSS professional development because, as they see it, there is no immediate need. However, the time is now to learn about how to implement the NGSS and begin to prepare for the assessment. Because teachers are considered district stakeholders, and the state recognizes that funding needs to be spent on the NGSS now (rather than after the state assessment is in place), teachers should notify district leaders responsible for creating the LCAP that they need funding for professional learning and support to transition into the NGSS. (See http://www.classroomscience.org/advocating-for-access-to-financial-support-of-science-in-your-school-and-district). The LCAP can be revised each spring, so funding can — and should — go towards NGSS-related items at any time.

On November 6, 2013, the SBE adopted the NGSS integrated model as the preferred model for science instruction for middle grades (6, 7, and 8) in California. It was a break from the past

discipline-specific model of instruction in those grades: earth science in grade 6, life science in grade 7, and physical science in grade 8. The November 2015 draft of the California Science Framework explained that the progression of learning in the NGSS integrated model "is intentionally designed to allow students to slowly build up knowledge and skills in all three dimensions [of the NGSS: disciplinary core ideas, science and engineering practices, and crosscutting concepts]." The integrated model is more like a spiral curriculum where students build on their knowledge and revisit skills and concepts they previously learned, but at a more complex level (Bruner, 1960). As part of the Early Implementers Initiative, all participating districts have agreed to adopt the integrated model.

## Shifts Required to Implement the NGSS

The new science standards require major shifts in instructional practice. Before a district can make meaningful progress in NGSS implementation, district leaders must understand how different the standards are and how teachers should adjust their instruction to teach the standards. In a nutshell, NGSS-aligned instruction must be:

- Inquiry-based. Students gain deep understanding rather than superficially memorizing facts or details. New learning is connected to prior knowledge. Teachers do not just deliver information; students are prompted to make sense of what they experience and construct their own understanding. All students make their own progress toward full understanding.
- Real-world. Lessons begin with exposure to naturally occurring phenomena (e.g., phases of the moon, ice melts and refreezes, some seeds can be carried by the wind). Engineering design is used to address real-world problems.
- Three-Dimensional. Science content is no longer taught in isolation. It is taught through engaging in science and engineering practices (doing what scientists do to investigate and understand phenomena) and while looking through a crosscutting-concept lens (e.g., seeing patterns) to make connections among the sciences.
- Integrated. The authentic context of phenomena and engineering integrates relevant science disciplines, rather than artificially separating physical, earth, and life sciences. Other subjects, such as ELA, figure naturally into the processes of scientific investigation, discovery, and problem solving.

# Science as a Vehicle for Teaching Common Core English Language Arts

K–5 teachers often see that a diverse spectrum of their students love engaging in hands-on science. Therefore, many elementary school teachers *do* want to teach it, even though they may be tired from the burdens of Common Core State Standards (CCSS) implementation or intimidated by science. The Early Implementers Initiative is empowering teachers to teach hands-on science in combination with the CCSS, particularly with the English language arts (ELA) standards. And there are green shoots of teachers who are beginning to understand and pursue such connections. In fact, many of the teachers in districts participating in the Early Implementers Initiative report that they are spending more class time on science integrated with ELA than before.

Of course, integrating science with ELA is more than just having students read about science. Rather, it involves having students record detailed observations, pose and respond to questions, articulate how evidence supports a point of view, and compare explanations with peers. Teachers often find that students naturally employ these ELA skills when their attention is engaged in scientific subject matter.

During the first two years of the Initiative, the WestEd evaluation team collected data about how teachers in the eight NGSS Early Implementers Initiative districts are learning how to teach hands-on science in combination with the ELA CCSS, including their use of tools and strategies offered to them through the Initiative.

## Science Overcomes Innovation Overload

Like their peers throughout the state, teachers in Early Implementer Initiative districts feel some degree of innovation overload aside from the NGSS, particularly because the adoption and implementation of the CCSS in ELA and mathematics began in earnest just before the start of the NGSS Early Implementers Initiative. Adding to the possible feeling of innovation overload, some districts have recently adopted new CCSS curricula, which will take considerable time and energy for teachers to master.

Despite the time that required for understanding and implementing the CCSS, teachers in the Early Implementer Initiative districts are generally enthusiastic about trying the new science standards. Most Early Implementer Initiative districts have had rates of project attrition under 15 percent, and have had more volunteers than spaces available. When asked about the ease of recruiting Teacher Leaders, one Project Director responded,

> *I'd say teachers are actually quite willing and enthusiastic to become Teacher Leaders. When I have had to replace someone, I've found another teacher very quickly, and they all seem motivated and excited to get a chance to be a part of the team and try this new science on. . . . The reasons people have dropped have been retirement (N=1 teacher), transferring to a new district (1), becoming a vice principal (1), becoming a counselor (1), or feeling too overwhelmed (1).*

One district received a Race to the Top grant just prior to joining the Initiative. At the announcement of the NGSS grant, teacher union leaders expressed strong concern about teacher workload, in light of the existing Race to the Top and CCSS implementation demands. However, teachers had previously completed a needs-assessment survey in which they communicated a strong desire to add science to their agenda, despite the added work. Using data from that survey, the Project Director and the NGSS Core Teacher Leaders were able to persuade the union that the teachers would benefit from the NGSS Early Implementers Initiative.

## NGSS and Early Implementers Initiative Aim to Integrate Science and ELA

Both the NGSS and the Early Implementers Initiative advocate the integration of science with Common Core subjects, particularly ELA. In fact, the NGSS were purposefully developed to work in tandem with the CCSS — the NGSS make explicit links to CCSS across all disciplines and grade bands.

The most significant shift of the NGSS is the move away from a one-dimensional focus on scientific facts to three-dimensional instruction that encompasses:

- Disciplinary core ideas (what scientists know).
- Crosscutting concepts (how scientists make connections among the sciences).
- Science and engineering practices (what scientists and engineers do, and how scientific knowledge develops).

All of the eight science and engineering practices of NGSS require English language arts skills:

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 argument from evidence.
8. Obtaining, evaluating, and communicating information.

Three-dimensional, NGSS-aligned learning creates a science classroom where students explore, examine, and explain how and why naturally occurring phenomena happen, and design solutions to problems, much as scientists and engineers do in the real world. In this authentic context, students develop and apply scientific understanding **as well as ELA and mathematics understanding and abilities.** To support this integration, each and every one of the new science

standards lists connections to relevant CCSS. Take, for example, the CCSS connections for the grade 2 California NGSS standard PS1-4, "Matter and Its Interactions":

**Common Core State Standards Connections: ELA/Literacy —**

**RI.2.1** Ask and answer such questions as *who, what, where, when, why,* and *how* to demonstrate understanding of key details in a text. (2-PS1-4)

**RI.2.3** Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text. (2-PS1-4)

**RI.2.8** Describe how reasons support specific points the author makes in a text. (2-PS1-4)

**W.2.1** Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., *because, and, also*) to connect opinion and reasons, and provide a concluding statement or section. (2-PS1-4)

In 2012, the California State Board of Education (SBE) published the California English Language Development (ELD) Standards, which correspond to the California CCSS and specify that English language skills should be developed and used, "in the context of fostering intellectually and discourse-rich, meaningful interactions." ELD standards address the special challenges faced by English learners to develop literacy in English. In professional learning offered through the NGSS Early Implementers Initiative, some sessions focus explicitly on how NGSS implementation can address ELD standards.

In order to align with the NGSS and do justice to both science and ELA, integration must be more than reading about the solar system during English class. In an NGSS-aligned classroom, students participate in learning sequences in which they investigate and actively use language to construct scientific understanding, and as a result, their learning relative to both subjects is deepened.

## Providing Teachers with Professional Learning and Tools

In the Early Implementers Initiative, teachers are being empowered and urged to integrate ELA with science through a range of tools and professional learning institutes and activities. They learn how NGSS-aligned science provides an authentic context for students to develop and assess their understanding by constructing arguments, analyzing text, practicing descriptive skills, articulating ideas, developing academic language, and assessing their own understanding. It is a two-way street: literacy enhances science understanding and science enhances literacy skills.

### *Professional Learning*

The K–12 Alliance offers professional learning institutes and activities (Figure 1) for educators and administrators involved in the NGSS Early Implementers Initiative. Many of these trainings include learning about integrating science and ELA.

Figure 1. NGSS Early Implementers Initiative professional learning activities

| Institutes and activities | Description |
|---|---|
| Leadership Institutes | 10 days per year for the Core Leadership Teams |
| Teacher Leader Summer Institutes | Annual one-week professional learning for Teacher Leaders |
| Teaching Learning Collaboratives | Lesson study in science, two times per year for each participating teacher |
| Principal Academies | Workshops for administrators |

The **Leadership Institutes** provide additional training for the Core Leadership Teams of teachers and administrators from each participating district, and often address pedagogical issues like integrating the NGSS and CCSS.

The **Teacher Leader Summer Institutes** kick off each year of the Early Implementers Initiative with a week of NGSS-aligned pedagogy and adult-level science content sessions. Pedagogy sessions cover three-dimensional instruction and integration of science and ELA, while content sessions model what these practices might look like in a science classroom.

**Teaching Learning Collaboratives** bring together same-grade teachers, typically from different schools within each of the Early Implementer Initiative districts, to spend one day planning and another day co-teaching and debriefing an NGSS-aligned lesson with a project-trained facilitator. Lessons designed are three-dimensional and often include specific attention to the integration of science and ELA.

**Principal Academies.** After receiving instruction and being encouraged to try new strategies and activities in their classrooms, some Teacher Leaders expressed reluctance because their principals did not understand the shifts required by the NGSS. The K–12 Alliance realized that educating administrators about the NGSS would be required in order to change the culture of the schools. Consequently, the scope of the NGSS Early Implementers Initiative was expanded to include support for every principal who had a Teacher Leader at his or her school. Through Principal Academies in Initiative Years 3 and 4, administrators will come to understand that NGSS science provides multiple authentic opportunities to apply CCSS-ELA and ELD standards in the context of science. These academies will be observed and then discussed in future evaluation updates.

## *Tools and Strategies for Integrating Science and English Language Arts*

Through the various professional learning opportunities described above, Teacher Leaders are able to learn and try several Initiative tools and strategies (Figure 2) to incorporate ELA when implementing the NGSS.

Figure 2. Tools for integrating science and English language arts

| Initiative tool | Purpose |
|---|---|
| Science notebooks | For students to write out and evolve their understanding |
| Claims, evidence, and reasoning | Protocol for addressing NGSS science and engineering practices "engaging in argument from evidence" and "constructing explanations" |
| 5E instructional model | Structure for NGSS-aligned lessons |
| Questioning strategies | To guide student inquiry and communication |
| Training in ELD | To maximize reach to all student |

**Science notebooks.** At the start of each Summer Institute, all participating teachers receive science notebooks. Throughout the weeklong professional learning, they alternate between the role of student and teacher, first exploring and developing understanding about science content, and then discussing pedagogical implications of the new standards. Whenever they are in the student role, teachers learn to use their science notebooks in the way they will instruct their students to do.

Participating Teacher Leaders experience this firsthand when presented with a phenomenon-based question, such as, "Does ice melt slower in salt or fresh water?" As students would, teachers engage in various activities, many of which integrate ELA skills:

- Write their prior knowledge about the phenomenon in their science notebooks.
- Verbally ask and answer questions and compare their understanding with peers.
- Conduct an experiment and record data.
- Construct models of their thinking.
- Read relevant text to answer their own questions about the phenomenon.
- Record their evolving understanding in their science notebooks.

> The science notebooks are for "sense-making." That is, they are to be used by students as a scientist would, to write their developing understanding about scientific phenomena. When observing students with different levels of science notebooking experience, clear differences can be seen in their narrative and descriptive abilities.

**Claims, evidence, and reasoning.** Science is evidence-based. When presenting or discussing the science and engineering practices, such as constructing explanations or engaging in argument from evidence, NGSS Early Implementers Initiative leaders consistently return to emphasizing these three requirements. A student needs to articulate a claim (e.g., an answer to an investigative question), provide relevant and persuasive supporting evidence (e.g., "My evidence supports the following explanation."), and clearly connect the evidence to scientific reasoning. This claims-evidence-reasoning protocol applies well to developing a model, another NGSS science and engineering practice. A student's model illustrates her claim or understanding of what is happening. The evidence is drawn into the model, and the reasoning might include a prediction based on the

model or an explanation of what changed when new information was obtained. Even when drawing a scientific model, students are learning and practicing ELA skills.

**The 5E instructional model.** The 5E instructional model forms the basis of every NGSS Early Implementers Initiative Teaching Learning Collaborative. Based on the constructivist approach to learning, which says that learners build new ideas on top of old ideas, the 5E instructional model is student-centered, driven by student questioning and discussion. At each stage of the lesson (Engage, Explore, Explain, Elaborate/Extend, and Evaluate), students practice and develop literacy skills. They record and discuss their prior knowledge of a phenomenon, compare and present their thinking to their peers, conduct investigations, read texts, and revise their understanding in their science notebooks. Explicit connections between science and both ELA and ELD at each of the five lesson stages are shown in Figure 3, which is provided as it is currently drafted and being presented in the Initiative. The template explains each phase of the 5Es and, for each phase, helps teachers map out the kinds of science lesson activities that are appropriate, how explicitly science content is addressed at that phase, and the nature of ELA and ELD connections that can be addressed.

Figure 3. Science/English language arts/English language development 5E instructional model template

| Phase | Activity | Concept | ELA connections | Meaningful communication ELD (collaborative, interpretive, productive) |
|---|---|---|---|---|
| **Engage:** Prior knowledge about phenomenon | Introduce real phenomenon or pictures/video | Prior knowledge about phenomenon | Generate ideas from prior knowledge | Collaborative discussions |
| **Explore 1:** Use hands-on materials | Use materials to explore phenomenon | Portion of concept to be explored | Write observations, drawings, data, and models in notebook | Collaborative and interpretive |
| **Explain 1:** Use student interactions and discussion to support writing | Activity to explain exploration | Portion of concept to be explained | Scaffold discussions to help students explain what they know so far | Collaborative and productive |
| **Explore 2:** Deepen understanding through text or another hands-on material | Activity: Explore hands-on or reading selection | Portion of concept to be explored more deeply | Read for meaning, scaffold discussions, write in notebooks | Collaborative and interpretive |

| Phase | Activity | Concept | ELA connections | Meaningful communication ELD (collaborative, interpretive, productive) |
|---|---|---|---|---|
| **Explain 2:** Discuss and write final evidence-based argument with multiple lines of evidence | Activity: Write claim and evidence to explain original phenomenon | Portion of concept to be explained | ELA writing standard Evidence-based argument | Interpretive and productive |
| **Extend** | Apply ? | | | |
| **Evaluate** evidence from student work | Science understanding ELA goal | Strength of evidence Communication clear | Provide sufficient support for access | Collaborative, interpretive, and productive |

- The figure's pattern of weaving science and ELA begins with something to understand (phenomenon) and ends with evidence for the explanation.
- The hands-on activity is done before reading to build knowledge to bring to the reading. Writing and academic discourse is part of every step of the 5E instructional sequence.
- Concepts using academic language are embedded in the exploration and explain steps. "Naming" of objects used for exploration is introduced when equipment is used.

*Source:* Expanded by the K–12 Alliance from the original BSCS 5E instructional model (2016).

**Questioning strategies.** In the Early Implementers Initiative, teachers are coached to be very aware of the way they facilitate lessons. They learn questioning strategies to keep their instruction inquiry-based and student-centered. That is, rather than provide answers to student questions, teachers respond with their own thought-provoking questions: "What do you think could be going on?" "How do you know?" "How could you find out about that?" The aim is to strongly and adeptly elicit productive student talk. Teachers report that students are much more motivated and learn more when they have a chance to be curious about a phenomenon and construct their own understanding about it.

**Training in English language development (ELD).** ELD has been a focus at each of the annual Summer Institutes, as well as at most of the trainings for the district leadership team members. Participants experienced firsthand the importance of ELD when exposed to a mock lesson in a language other than English. The presenter contrasted a five- to ten-minute lesson that relied solely on verbal communication with one that incorporated visual aids, hands-on group work, and peer-to-peer discussion, all hallmarks of the NGSS-aligned classroom. In subsequent pedagogy sessions, ELA and ELD connections to NGSS are emphasized, illustrating that science provides authentic opportunities for English learners to engage in the required collaborative, interpretive, and productive activities that foster skill acquisition in speaking, listening, reading, writing, and language.

Through these key tools and Initiative activities, teachers in the Early Implementers Initiative are learning ways to integrate ELA and science. A survey item asked Teacher Leaders and Core Teacher Leaders, "To what extent has the Early Implementers Initiative enhanced your ability to make CCSS and NGSS implementation complementary or integrated?" A total of 67 percent of respondents answered "Moderately" (33.6 percent) or "A lot" (33.6 percent). Less than 10 percent said "Not at all."

## How Teachers Are Reacting to NGSS Implementation

In surveys and at Initiative events observed by evaluators, many teachers have conveyed their energetic willingness to invest time and effort to implement NGSS, because students are excited and motivated by hands-on science learning. As one Teacher Leader noted in a classroom science teaching survey administered in (August 2016), "Last year, I was excited to use new NGSS ideas and strategies in my classroom. Additionally, I was newly motivated to think about science differently, which extended to a higher student excitement level."

In addition, some Core Teacher Leaders expressed surprise that at the end of a recent district professional learning session on the NGSS, teachers not participating in the Early Implementers Initiative approached them at the end of the sessions, saying, "This is great!" and "I want to do this with my class."

At one district's rollout training for every science teacher, teachers were enthusiastic about attending professional learning sessions led by their peers. Teachers Leaders, who had participated in the Early Implementers Initiative for only one year, were about to lead 80-minute sessions about the NGSS. In the kindergarten room, a Teacher Leader explained to the group of over 30, "What's nice is that this isn't an add-on, not extra work; CCSS are built right in. Your science notebooks are the way to bring in writing and reading into science." She added, referring to the kindergarten science

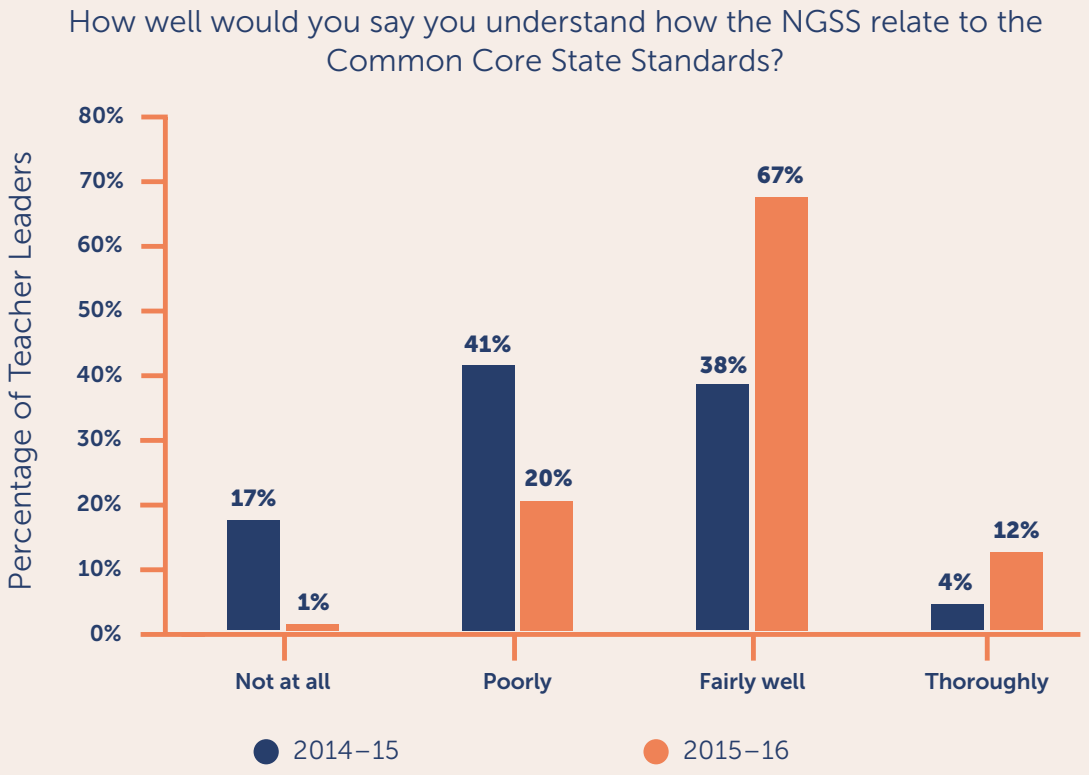
content relating to forces and motion, "You don't have to do that [she names a fictional story that the kindergarten teachers are evidently tired of] reading — don't we all love that one? Now we can put science 'pushes and pulls' into English."

After the session, when asked how they felt about the CCSS and the NGSS, a group of grade 2 teachers told evaluators that other demands were taking a great deal of time and energy, but they had heard about the NGSS from their fellow teachers and were eager to find out more. In response to a question about the many instructional priorities elementary teachers must navigate, a principal said, "Yes, elementary teachers do feel overwhelmed with Core Content, but they see NGSS as a breath of fresh air. The message is going out that science needs to include reading, writing, speaking, and listening, which lends itself to integration of ELA." She added, "They used to read things in ELA that were fiction and created misconceptions, and then science class was spent unlearning the incorrect information."

## Understanding NGSS and CCSS Integration

At the end of each year of the Early Implementers Initiative, all participants complete leadership surveys that ask about their understanding of how the NGSS relate to the CCSS. Upon joining the Early Implementers Initiative at the end of the 2014–15 school year, the largest cohort of participants, the Teacher Leaders, completed their baseline leadership survey. At that time, 58 percent said they understood poorly, if at all, how the NGSS relate to the CCSS. After one year of Early Implementers Initiative participation, the percentage of Teacher Leaders with little or no understanding decreased to 21 percent, while the percentage of those who understood thoroughly or fairly well almost doubled (see Figure 4).

Figure 4. Year-over-year increase in Teacher Leaders' understanding of the NGSS



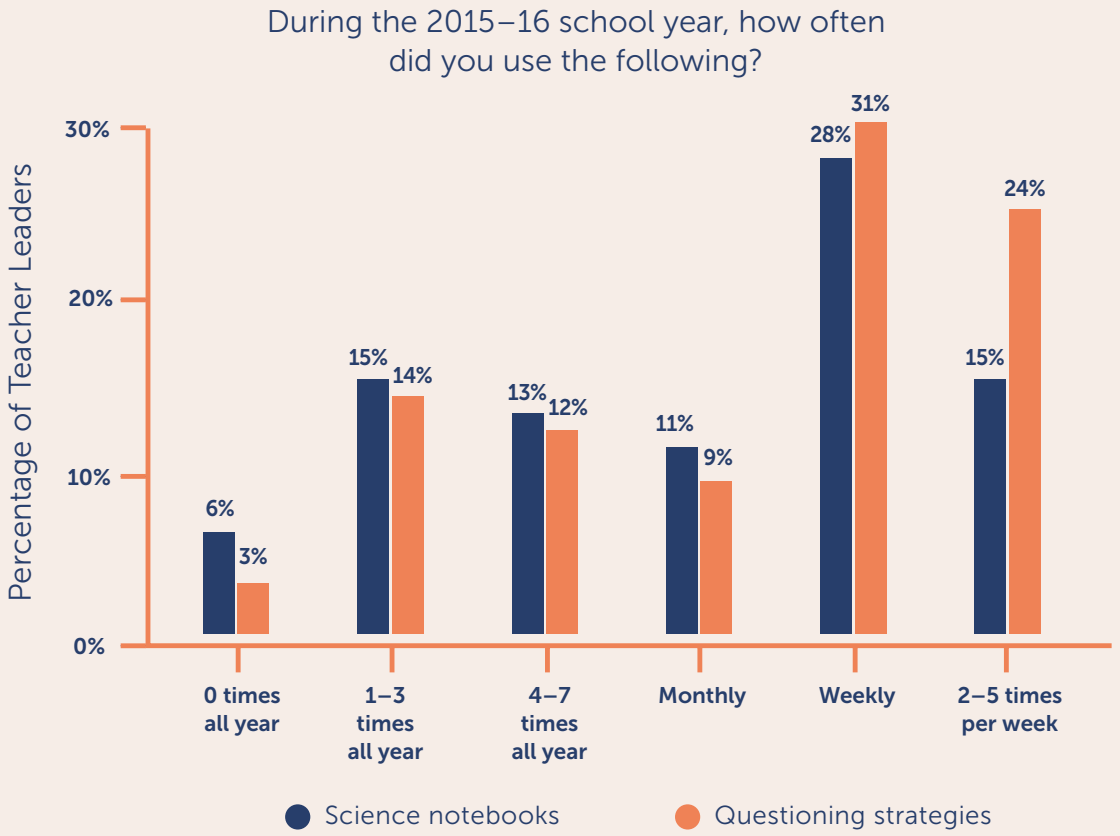

*Source.* From Teacher Leader leadership surveys, administered summer 2015 and 2016 (N=447 and 386, respectively). Teacher Leaders were asked, "How well would you say you understand how NGSS relate to the Common Core State Standards?"

Core Teacher Leaders have reported a similar increase in NGSS understanding over three years. In their baseline year of 2013–14, one-half (33 of 66) reported that their understanding of the relationship between the NGSS and the CCSS was completely lacking, and one-third rated it poor (23 of 66). Only 3 percent (2 of 66) said they thoroughly understood the relationship between the NGSS and the CCSS. By the end of their first year, every Core Teacher Leaders understood how the NGSS relate to the CCSS at least to some extent, with almost half reporting that they understood fairly well or better. In year three, interestingly, Core Teacher Leaders understanding did not improve nearly as much. The most notable change was that those who rated their understanding as poor reduced by half, from 29 percent to 13 percent.

## Using the Initiative Tools and Processes in the Classroom

K–5 Teacher Leaders were surveyed about their use of the following Initiative tools *beyond* Initiative-sponsored activities: the 5E instructional model, questioning strategies to elicit student thinking, and science notebooks for student sense-making. One year after being

Figure 5. Two strategies used the most outside of the Initiative's sponsored activities




*Source:* Responses of K–5 Teacher Leaders to the Classroom Science Teaching Survey, administered in July and August 2016 (N=312). Teacher Leaders were asked, "During the 2015–16 school year, how often did you use the following?"

introduced to those most favored tools, almost half (43 percent) used science notebooks and more than half (55 percent) used questioning strategies on a weekly basis or more often outside of Initiative-sponsored activities such as the Teacher Learning Collaboratives (see Figure 5).

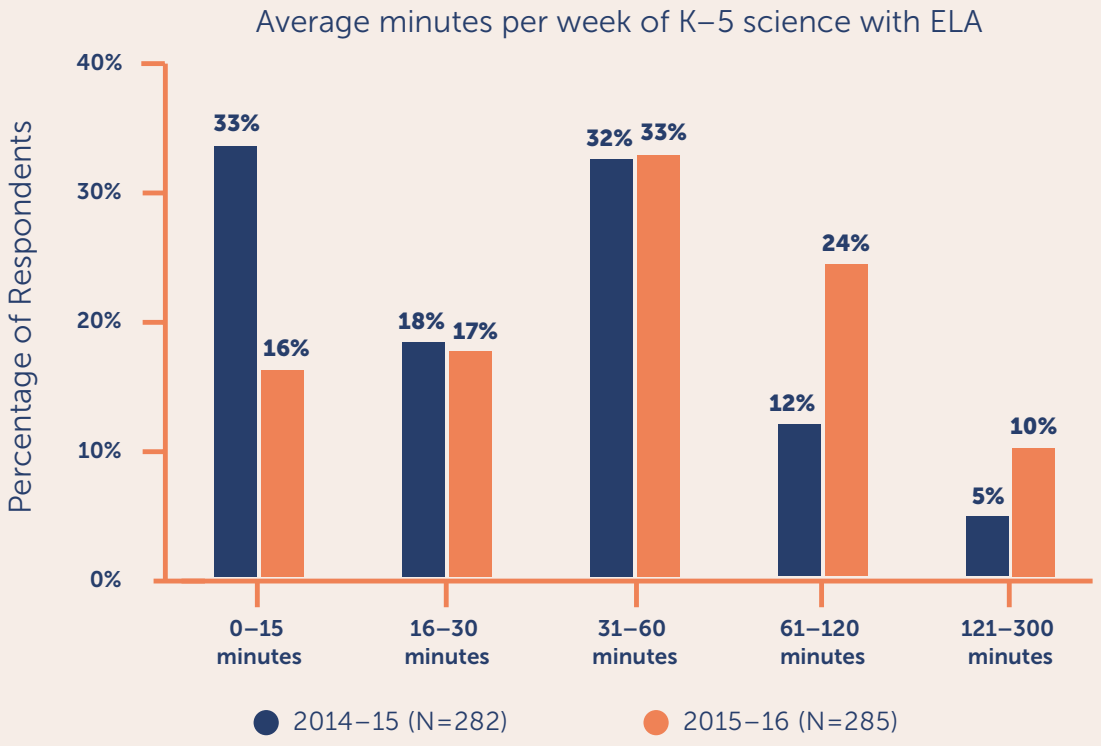
However, only 14 percent of Teacher Leaders reported using the 5E instructional model to design lessons one or more times per week. More than half (53 percent) said they used 5E lessons less than four times during the 2015–16 school year.[1]

## Boosting Time Spent Teaching Science

Teachers participating in the Early Implementers Initiative have significantly increased the amount of time they spend teaching science integrated with ELA. Early Implementers Initiative teachers completed a survey at the end of Year 2 of the Initiative in which they were asked the average number of minutes per week they taught science integrated with ELA in 2014–15 and in

1 The claims, evidence, and reasoning tool is not discussed because teachers were not asked about their use of the tool in the 2014–15 school year.

Figure 6. Average time per week spent teaching science integrated with ELA




*Source:* Classroom Science Teaching Survey, taken by Core Teacher Leaders and Teacher Leaders, July and August 2016.

2015–16. While a third of K–5 teachers (94 out of 282) reported teaching virtually no science integrated with ELA (zero to 15 minutes per week) during the 2014–15 school year, the following year that percentage was cut in half, to about 16 percent (45 out of 285 teachers; see Figure 6).

A follow-up survey question asked, "If your answers changed for 2014–15 versus 2015–16, please describe the strongest reason(s) for the changes in science instruction time." Some of the answers that referenced ELA in particular include:

> *I enjoyed incorporating science into English language arts time. The shift was easy and efficient. The students were captivated and inquisitive.*

The number of K–5 teachers who spent 1–2 hours per week teaching science integrated with ELA doubled between the 2014–15 and the 2015–16 school years, as did the number who spent more than 2 hours on science and ELA together.

> *I increased my science integration during ELD and my Spanish language arts.*

> *I felt more confident in including ELA with science.*

> *[Through] involvement in this grant, [I] increased knowledge of NGSS and integration in ELA instruction.*

*Schoolwide commitment to science increased, and science became the focus of my integrated ELD block.*

*I have learned how to integrate science and literacy through the work with this grant, along with the changes in the standards that require that integration.*

Employing ELA skills is an inherent component of the NGSS Early Implementers Initiative. As part of their professional learning, K–5 teachers are learning to use tools and strategies that facilitate the integration of science and ELA. As a result, they are finding it easier to make time for science in their already full school days. Heading into Year 3 of the Early Implementers Initiative, the evaluation team will continue to monitor how science supports ELA instruction and how ELA supports the instruction of NGSS science in the participating eight school districts.

# Update on the Middle School Integrated Model

The integrated model of science instruction and learning enables students to "figure out" phenomena in the world around them by applying engineering design and multiple science disciplines in an integrated way. The NGSS advocate for this integrated approach to science, as reflected in some key NGSS features:

- The NGSS call for routinely basing science instruction on authentic phenomena around us, which can be fully explained best by examining all of the science disciplines involved.
- One of the three NGSS dimensions is cross-cutting concepts, which link all disciplines and can be a vehicle for integrating them (e.g., "patterns," "scale, proportion, and quantity").

That is, two shifts required by the NGSS are that science education should reflect the interconnected nature of science and it should focus on deeper understanding of content and its application.

Further, the California State Board of Education (SBE) agreed with the Science Expert Panel's recommendation that middle grade science should be integrated to meet these shifts required by the NGSS. The SBE voted in November 2013 to make the integrated model the "preferred" California model for science instruction and learning. In so doing, the SBE endorsed the learning progressions found in the NGSS that are a continuum of content from K–12. The Early Implementers Initiative embraced the preferred integrated model, and every Early Implementers Initiative district is pursuing this model in which all science disciplines are treated in each of grades 6, 7, and 8.

With the integrated model, there are no "gaps" in the progressions. Students explore life science, earth and space science, physical science, and engineering uninterrupted because the disciplines are addressed each year. Therefore, the integrated model of science[2] more readily permits building knowledge, connecting past learning, and further developing understanding in each succeeding unit or year.

## Integrated Model Versus the Discipline-Specific Model

During recent decades in California and the United States, middle and high school science has been taught in discipline-specific courses, most often with earth science in grade 6, life science in grade 7, and physical science and astronomy in grade 8. While the upcoming *California Science Curriculum Framework* will provide districts with the option of retaining an alternative discipline-specific model, schools electing to continue that model will still need to make significant changes to enhance connections among the sciences.

Table 1, excerpted from the June 28, 2016, Public Review version of the California Framework document, lays out the grade-by-grade contrast in content between the two models.

2 Integration can also refer to the relationship of sciences and other school subjects, such as ELA; however, this section of the report focuses only on how science teaching integrates science and engineering disciplines.

Table 1. Comparison of science topic treatment across grades 6–8 in the integrated and discipline-specific models

| | Disciplinary core idea | | Subtopic | Preferred integrated | | | Discipline specific | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 6 | 7 | 8 | 6 | 7 | 8 |
| **Earth and space** | 1 | Earth's place in the universe | Universe, stars, solar system | | | X | X | | |
| | | | History of planet earth | | | X | X | | |
| | 2 | Earth's systems | Water cycle, weather, climate | X | | | X | | |
| | | | Rock cycle, Plate tectonics | | X | | X | | |
| | 3 | Earth and human activity | Global climate change causes | X | | | X | | |
| | | | Resources availability | | X | | X | | |
| | | | Natural hazards | | X | | X | | |
| | | | Resource consumption | | | X | X | | |
| **Life** | 1 | From molecules to organisms: structures and processes | Cells and body systems | X | | | | X | |
| | | | Photosynthesis and respiration | | X | | | X | |
| | 2 | Ecosystems: interactions, energy, and dynamics | | | X | | | X | |
| | 3 | Heredity: inheritance and variation of traits | Sexual versus asexual reproduction | X | | | | X | |
| | | | Mutations | | | X | | X | |
| | 4 | Biological evolution: Unity and diversity | | | | X | | X | |
| **Physical** | 1 | Matter and its interactions | Atoms, molecules, states of matter | | X | | | | X |
| | | | Chemical reactions | | X | | | | X |
| | 2 | Motion and stability: Forces and interactions | | | | X | | | X |
| | 3 | Energy | Kinetic energy and collisions | X | | X | | | X |
| | | | Heat and heat flow | X | | | | | X |
| | | | Potential energies and gravity | | | X | | | X |
| | 4 | Waves and their applications in technologies for information transfer | | | | X | | | X |
| **Engineering, technology, and applications of science** | Every course includes integration with engineering, technology, and applications of science | | | X | X | X | X | X | X |
| **Science and engineering practices** | Every course utilizes all 8 science and engineering practices | | | X | X | X | X | X | X |
| **Crosscutting concepts** | Every course highlights all 7 crosscutting concepts | | | X | X | X | X | X | X |

*Source:* Excerpted from the June 28, 2016, Public Review version of the *California Science Curriculum Framework* document (California State Board of Education).

Notice the changes to be taught by teachers at a given grade. For example, a grade 7 teacher who formerly taught only life science will now also be able to teach physical science and earth and space science to deepen student understanding of the phenomenon. Appendix A provides more description of the integrated model and the arguments for using it.

## Coordinated Science: Between Discipline-Specific and Integrated

The recent draft *California Science Curriculum Framework* notes that it is possible to have all disciplines taught every year but not have fully integrated science (California State Board of Education, 2016). That is, schools or teachers could teach some of each discipline each year without doing so in a way that requires making vital connections between them. The document terms such compartmentalized curricula as "coordinated science" and points out that it should be viewed as a potential transition stage between the discipline-specific model and the integrated model, rather than a fulfillment of the integrated model.

## Challenges of Converting to the Integrated Model

Moving to the NGSS is much more than a minor shift from business as usual. For both integrated and discipline-specific models, teachers and administrators will need to consider the significant shifts in pedagogy linked to the phenomenon-based instruction and student-centered learning required by the NGSS. In addition, teachers in the integrated model might need to:

- Learn content knowledge in disciplines they have not been teaching and for which they may not have been prepared.
- Confer with colleagues across grade levels to articulate grade-to-grade scope and sequences.
- Work with administrators to help parents and community members understand the integrated model.

Both models require schoolwide, if not districtwide, changes by all middle grade science teachers. In the case of the integrated model, the Early Implementers Initiative district plans address ways to transition from the current topic at each grade to the topics represented in the integrated model and to provide professional learning to all teachers, not just the participants who receive larger amounts of Early Implementers Initiative professional learning.

## Early Implementers Initiative Professional Learning for Science Integration

The Early Implementers Initiative is providing Teacher Leaders with professional learning about integrating the sciences through various Initiative activities, as outlined in Figure 7.

Figure 7. Early Implementers Initiative professional learning activities for Teacher Leaders

| Early Implementers Initiative activities | Description |
|---|---|
| Summer Leadership Institutes | 10 days additional training for the Core Leadership Team of Teacher Leaders and administrators |
| Content Cadres (during Summer Institutes) | At the annual, week-long professional learning, Teacher Leaders spend 50 percent of the Summer Institute week in grade-level Content Cadres. |
| Teaching Learning Collaboratives | Lesson study composed of two two-day cycles per school year |

**Content Cadres within Summer Leadership Institutes.** The Content Cadres comprise 50 percent of the week-long Summer Institute for Teacher Leaders that kicks off each year of the Early Implementers Initiative. The rest of the Summer Institute focuses on NGSS-aligned pedagogy. Led by teams of experts, including a university or business scientist and two expert teachers, Content Cadre sessions:

- Provide hands-on lessons that model the NGSS in the classroom and allow Teacher Leaders to take on the role of student.
- Include a field site visit that illustrates the focal content in an authentic phenomenon context.
- Increase teachers' understanding of grade-level content specified in the NGSS and of pedagogical approaches to teaching science.

At least one of the two expert teachers leading the Content Cadre is at the grade level of the participants (for middle school, one of the teachers has to be a middle school teacher). For ensuring a focus on integrated science, each Content Cadre member represents one of the three disciplines: life science, earth and space science, and physical science.

**Teaching Learning Collaboratives** bring together same-grade teachers, typically from different schools in the Early Implementers Initiative district. The teachers spend one day planning and another day co-teaching, debriefing, and adjusting an NGSS-aligned lesson with an Initiative-trained facilitator. Exploring how to integrate the sciences is one of many topics that participants tackle during the Teaching Learning Collaboratives.

## How Districts and Teachers Are Reacting to Integrated Science

At the California Science Teachers Association annual conference, evaluators observed a wide mix of reactions to the idea of switching from the discipline-specific model to the integrated model[3] — from enthusiasm, to angst, to resistance. Participation in the Early Implementers Initiative required the districts to agree to implement the integrated model. The initial stages require developing detailed transition plans. The Early Implementers Initiative participants are experiencing a wide mix of reactions to the first couple

3 The authors do not have data on the status of integrated-model adoption among all California districts. However, it is interesting to note that among 10 non-Early Implementers Initiative districts that attended a spring 2016 Early Implementers Initiative event providing NGSS implementation ideas, all but one district decided to pursue the integrated model, and the other district was undecided.

of years of the journey. The Early Implementers Initiative districts currently vary in status on the progression from discipline specific, to coordinated, to fully integrated models.

## Complex Transition Plans

Transition plans must account for a variety of factors and occurrences that could result from moving from a discipline-specific model to an integrated model. For example, under the discipline-specific model, physical science is taught in grade 8. In the integrated model, that discipline would now only comprise about one-third of the grade 8 school year, as the rest of the content is moved to earlier grades. Therefore, the students caught in this transition would head to high school with an inadequate preparation in physical science.

Further, from the teacher perspective, it is unrealistic to fully develop all the knowledge, pedagogy, and student-centered lessons necessary to convert to the integrated model all in one swoop.

Typically, Early Implementers Initiative districts are developing multi-year transition plans. For example, an article by the Project Director of the Early Implementers Initiative Palm Springs district briefly described school options for either a "fast" (three-year) or "slow" (four-year) transition plan (A'Hearn, 2015). Table 2 is a sample three-year district transition plan that was presented at a spring 2016 symposium sponsored by Early Implementers Initiative, BaySci, and the California Science Project for administrators from non-Early Implementers Initiative districts who were interested in implementing the NGSS.

> Why can't a district or school instantaneously switch from the discipline-specific to the integrated model from one year to the next? If this switch were instantaneous, the resulting science education of all middle school students would have major gaps in content.

Table 2. Example of three-year district plan for transitioning middle school science from the discipline-specific to the integrated model

| | Grade 6 | Grade 7 | Grade 8 |
|---|---|---|---|
| Year 1<br>2015–16<br>1998 Standards/<br>NGSS | Heat (NGSS)<br>Weather/Climate<br>Natural Resources/ **Human Impact** (NGSS)<br>Geology | Cells/Organisms (NGSS)<br>Genetics<br>Evolution/Earth History<br>**Ecosystems** (NGSS) | Chemistry (NGSS)<br>Physics<br>Astronomy (NGSS) |
| Year 2<br>2016–17<br>NGSS with<br>content shifts | Heat (NGSS)<br>Weather/Climate<br>Natural Resources/ Human Impact (NGSS)<br>**Cells/Organisms** (NGSS) | **Cells/Organisms** (NGSS)<br>Ecosystems (NGSS)<br>**Chemistry** (NGSS) | **Chemistry** (NGSS)<br>Physics — **Waves and Energy** (NGSS)<br>Astronomy (NGSS)<br>**Engineering** (NGSS) |
| Year 3<br>2017–18<br>Full implementation<br>of NGSS<br>integrated model | Heat (NGSS)<br>Weather/Climate<br>Natural Resources/ Human Impact (NGSS)<br>Cells/Organisms (NGSS)<br>**Engineering** (NGSS) | Ecosystems (NGSS)<br>Chemistry (NGSS)<br>**Natural Resources/ Geology** (NGSS)<br>**Human Impact** (NGSS)<br>**Engineering** (NGSS) | Physics — Waves and Energy (NGSS)<br>Astronomy (NGSS)<br>Engineering (NGSS)<br>**Evolution — Genetics, Earth History** (NGSS)<br>**Human Impact** (NGSS) |

*Source:* Presented by a district-level curriculum specialist at the February 2016 NGSS Early Implementers Initiative Symposium for Administrators in California Districts Seeking Ideas for Implementing NGSS. Bolded terms are topics that undergo some of the most substantial shifts among the middle grades during the three-year transition plan.

# Transition Plan Vignette

The following vignette is the story told by one Early Implementers Initiative principal about some of the work involved in forging and carrying out such transition plan. The principal's school is small, with just a single science teacher per grade.

**The importance of school-based professional learning communities (PLCs).** *We had to start on [thinking about the integrated model] before the Early Implementers Initiative began, while we were applying to be included in the Initiative. It became the biggest focus of our science teachers' weekly PLC meetings on each Wednesday, when we have early student release for teacher professional development.* Those have continued to be key throughout the years for getting the many necessary things figured out [for integration].*

**The importance of professional learning from the Early Implementers Initiative.** *I wonder what would have happened even with all that PLC work and time without also having the Early Implementers Initiative provide help at the Cadres with new content knowledge, pedagogy, and how to integrate — and without also having my participation along with the district's science director involved in the Early Implementers Core Leadership Team for our district.*

**Getting a teacher to let go of old, favorite content.** *The integrated model calls for cells to be taught in grade 6 instead of 7.** But my grade 7 life science teacher loves teaching cells and really didn't want to let go of this topic. And the grade 6 earth and space teacher was intimidated by it for some reason and really did not want to go there. The need to transition over several years turned out to be a blessing. I pointed out that the grade 7 teacher still gets to teach it for one more year. But the grade 7 teacher also had to seriously help the grade 6 teacher with cells that same year. It was a win-win. The following year, the grade 7 teacher initially was caught off guard by the reality of not being able to teach cells anymore and quipped, "I put myself out of business last year by helping the grade 6 [teacher]." At the same time, the teacher was getting excited about teaching some new things, and, like the grade 6 teacher, had some help from colleagues who used to teach it. If you look through the entire transition plan, there are similar stories to tell for each and every switch going on, of how much planning, work, learning, and processing has to happen to transition.*

> "And don't forget figuring out how science equipment and materials need to be reallocated. That was a big and strange challenge."

**Reallocating science equipment and materials.** *First everyone had to be transparent about what they actually already had. One teacher kept gradually "remembering" that they had pieces of equipment in various drawers and cupboards to make them available to the teacher who was going to use them in the new model. It took my low-key involvement in some meetings to inventory everything and figure out where it should now be. And since sometimes more than one grade is teaching a topic during the transition, when and how two different teachers had them had to be synchronized. All of this is extra work, and time was needed to make the integrated model happen.*

* Most California districts now have schedules during contracted time for teachers to participate in teacher-led PLCs. The aim for PLC time is professional development; however, meetings also can attend to more administrative matters. At the middle school level, more than one configuration could exist, such as all science teachers, all teachers at a grade level (multi-subject meetings), or all teachers of a specific science discipline. A teacher might participate in these different PLCs on a rotating schedule. The Early Implementers Initiative supports the districts' standing PLC structure as a mechanism to leverage Early Implementers Initiative conversations and decisions.

** Notice in Table 2 that during the second transition year, both grade 6 and 7 teachers need to teach about cells in life science, because this content will move from grade 7 to grade 6 under the integrated model.

The principal pointed out that her school had some advantages and disadvantages for making this transition compared to some other middle schools. Advantages were that grade 6 in her school received a full period of science instruction throughout the year, whereas some middle schools have a mathematics and science combination in grade 6. (Such teachers already are grappling with implementing CCSS mathematics and would be hard pressed to deal with changing science as well.) Having only one teacher per grade at her school also made the transition to an integrated model easier to process and operationalize in some ways.

However, the fact that none of her teachers teach classes for more than one grade also is a disadvantage; if a teacher is teaching some grade 7 and 8 classes, it would be easier to process grade 7 and 8 content shifts.

## Teacher Leaders Describe Challenges in Implementing the Integrated Model

Sixty-one percent of middle grade science teachers in Early Implementers Initiative districts reported that the Initiative had enhanced their ability to integrate the sciences (physical, earth and space, and life) "moderately" or "a lot." While that means a majority felt the Early Implementers Initiative was helpful, at the Initiative midpoint one-third of participants still felt that the Initiative only enhanced their ability "a little" (30 percent) or "not at all" (9 percent).

In a summer 2016 evaluation survey, over 100 teachers of grades 6, 7, and/or 8 were asked to "Describe your biggest challenge(s) in transition to the integrated model." Below are the most common topics raised in the responses to that question (with the percentage of respondents who elected to focus their answer on that topic), followed by sample remarks. Only one percent of respondents wrote that there were "no challenges."

- Lack of existing curricula and/or science material resources (17 percent)
- Specific science topic transitions that pose a challenge for the respondent (16 percent)
- Lack of content knowledge required by the revised courses (12 percent)
- Time needed to learn, plan, and implement changes (10 percent)
- Collaborating with other teachers to effect the transition (7 percent)
- Identifying real-word phenomena authentically involving multiple disciplines (7 percent)

*I cannot use the textbook as much as previously and need to innovate lessons.*

*It was difficult finding natural, authentic integration; some of it felt forced.*

*How much about chemical elements goes into earth science lessons about minerals?*

*My biggest challenge is not being comfortable with content in all three disciplines.*

*Having to develop my own integrated lessons takes a great deal of time.*

*I don't have enough opportunities to engage with colleagues in this type of thinking.*

*There are so many possible phenomena, but it's hard to figure out good ones.*

The above topics cover about 70 percent of the comments offered. The other 30 percent of the comments focused on topics that garnered attention from one to five percent of the respondents:

- Addressing NGSS three dimensions
- Developing conceptual flows
- No assessments available
- Addressing engineering design
- Transition plan details
- Developing engaging student activities
- Understanding integration

As illustrated by the following comments, six percent of participants commented that they disagree with some aspect of integration as they perceived it:

> *To integrate mutations into a unit about waves or force and motion is artificial at best. I am not convinced that forcing those connections is best for students.*

> *Students learn best from experts in their field. I am concerned that revising course for integration could dilute the academic rigor in middle school.*

> *I miss my pure love of biology.*

## Now Coordinated, with Examples of Full Integration

A few Early Implementers Initiative districts are about to venture into full middle school science integration where much or all of the year's instruction involves addressing real-world phenomena that involve multiple science disciplines in a connected way. However, most Early Implementers Initiative districts are at the "coordinated" stage of integration wherein they have mostly separate treatment of each discipline occurring every year, but often include some first attempts at connecting the disciplines. Here are sample statements from districts' summer 2016 grant reports:

> *For the upcoming year [2016–17], the decision has been made to put all efforts toward integrating instruction throughout the year. The greatest challenge has been addressing the passion the middle school teachers have for the science they have been teaching for many years. And it will take "out-of-the-box" thinking and a willingness to try new ways of instructing that may or may not meet immediate success.*

> *One specific thing we will focus on this year is incorporating our core middle school teachers (teaching science along with another core subject). These teachers have been in math PLCs and other math professional development, so this year we will make sure they are included in science.*

> *We are using phenomena in environmental science and citizen science curricula to forge authentic integration opportunities, based on local ecologies.*

> *We now have seven units of study available per grade and they are being used in*

*75 percent of middle schools with varying degrees of fidelity. Ongoing professional development so far is insufficient; in some cases deep learning and shifts in deeply rooted attitudes need to take place. We will concentrate next year on particular sites to create scalable tools, protocols, and structures for the integrated approach.*

*This year we had all of the topics shifted, but they were not integrated in the sense of most teachers making connections between topics. For next year, we are requiring that at least one unit make strong connections among the disciplines; this is especially challenging for the grade 6 and 7 teams and we will need to strongly support them.*

# Returning Science as a Core Subject

One explicit goal for each participating district of the Early Implementers Initiative is to make science a core subject. This section discusses what it means for science to be a core subject and ways that districts have made progress on this front.

## Science Has Not Been a Core Elementary School Subject

Implementing the NGSS at the elementary level must address something more basic than changing how and what science is taught. The first issue is *whether* science is taught. A WestEd study found that 40 percent of California elementary teachers spend 60 minutes or less on science instruction per week (Center for the Future of Teaching and Learning at WestEd, 2011).

The latest national survey commissioned by the National Science Foundation on the status of science teaching found similar findings across the country (Banilower et al., 2013):

- The percentages of teachers in grades K–3 and 4–6 who taught science "some weeks, but not every week" were 41 percent and 32 percent, respectively. In contrast, 99 percent of elementary teachers across all grades said they taught mathematics all or most days, every week.
- The number of minutes per day that teachers at grades K–3 and 4–6 reported teaching science were 19 and 24 minutes, respectively. In contrast, these same teachers spent 89 and 83 minutes per day on reading/language arts and 54 and 61 minutes daily on mathematics.

> There may be several reasons why science has not been a core subject in California elementary schools for well over a decade, but one that is easy to point to is the *No Child Left Behind Act*, passed in 2002. As SBE member Trish Williams wrote in 2016, "Time given to science took a back seat to more time given by districts to English language arts and math to avoid the high-stakes consequences of not meeting annual yearly progress as defined by the No Child Left Behind law. Science education was collateral damage."

## In Early Implementers Initiative Districts, the Needle Is Moving

Despite the second-tier status of science in California schools and the large barrier that it represents to enhancing science education, Early Implementers Initiative districts are moving the needle. This section of the report will discuss the following:

- Project Directors and Core Leadership Teams both report that science instruction now has a higher priority in their districts.
- At the elementary level, the worst-case scenario of little or no science has nearly been eliminated among the Initiative's hundreds of Teacher Leaders; and there are some

increases underway in science instruction minutes. Core Leadership Teams report that increases in science instruction time also are beginning among all district teachers who provide science instruction, not just among the Initiative's Teacher Leaders.

- Not surprisingly, the most common factor cited as prompting increases in science instruction was the training and support of the Early Implementers Initiative.
- Early Implementers Initiative districts have begun to make schools science centered beyond the formal science instruction by reaching out to parents and informal science education partners.

## Priority of Science in Districts

Through the course of the Early Implementers Initiative thus far, participants report that science has become a higher priority. The Project Directors in the eight districts and two charters were asked: "On a scale of 1–10 with 10 being very high priority, what is the priority of science in your district/charter?" Answers ranged from 6 to 9 for science (as a contrasting benchmark, they indicated that the priority of ELA was 10). Project Directors indicated that these ratings were higher than they would have reported two years ago (i.e., prior to the Initiative). Here are examples of the evidence that they provided for their ratings:

> *Teachers in responding to our own district surveys indicate a desire to move science instruction forward in priority.*

> *The school board has made time to hear presentations on the science professional development that we are doing.*

> *The superintendent and assistant superintendent have consistently made time available to discuss science instructional minutes and making science a core subject.*

> *We have board policies, funding, staffing, but also systemic supports for science programming.*

> *Beyond the Early Implementers grant-funded PD, the board has tripled the budget for other science PD in our small district over three years, from $8K to $27K.*

In an annual survey, the districts' Core Leadership Teams for the Initiative similarly were asked about the priority of science in their districts during Initiative Year 2 (2015–16).

> *Teacher members of the Core Leadership Teams (N = 70) agreed that: "Science instruction was a priority at my school" (73 percent); and "Teachers at my school were encouraged by administrators to teach science" (77 percent).*

> *Administrator members of Core Leadership Teams (N = 37) similarly agreed that: "Improving science was a priority in my school(s)" (76 percent); and "Teachers in my school(s) were encouraged by the administration to teach science" (84 percent).*

## Increasing K–5 Science Minutes

Clearly, in order for a district to make the key instructional shifts needed to implement the NGSS, adequate time must be devoted to science instruction. In most, if not all, of the Early Implementers Initiative districts, this meant an increase in minutes spent teaching science as compared to the start of the Initiative. When asked about the 2015–16 school year, about two-thirds of the members of the districts' Core Leadership Teams related that:

> *"Most [emphasis added] teachers in my school(s) devoted more instructional time to teaching science compared to previous years."*

That is, 61 percent of teachers and 72 percent of administrators on the Core Leadership Teams agreed with the above statement.[4] Similarly, the hundreds of grade K–5 Teacher Leaders in the Early Implementers Initiative agreed with a statement that they personally spent more time on science in Initiative Year 2 than they did in Year 1.

Based on an end-of-year survey by hundreds of Early Implementers Initiative Teacher Leaders and Core Teacher Leaders (N = 285, an 85 percent response rate), data in Figure 8 indicate that the biggest change in science minutes at the elementary level was a dramatic decrease **in teachers who teach no or little science** (i.e., 0–15 minutes weekly).[5] One-fifth of K–5 teachers (21 percent) reported teaching only 0–15 minutes of stand-alone science during the first year in the Initiative (2014–15) while only one-tenth (10 percent) still reported spending such little science time in the Initiative's second year (2015–16).[6]

The data from the survey (Figure 8 on page 31) also indicate the following:

- The proportion of teachers spending an inadequate 16–30 minutes on science also decreased, from 16 to 11 percent.
- Correspondingly, the proportion of **K–5 teachers spending a modest 31–60 minutes per week on science** increased from 27 to 33 percent.
- One quarter of teachers (25 percent) spent 1–2 hours on stand-alone science, and this value was about the same from Years 1 to 2.
- The proportion of teachers spending 2–5 hours on science increased from 9 to 15 percent.

> The total average number of minutes per week for stand-alone science increased from 40 minutes to 57 minutes in grades K–2, and from 72 to 82 minutes in grades 3–5. These changes are increases of 42 and 14 percent, respectively.

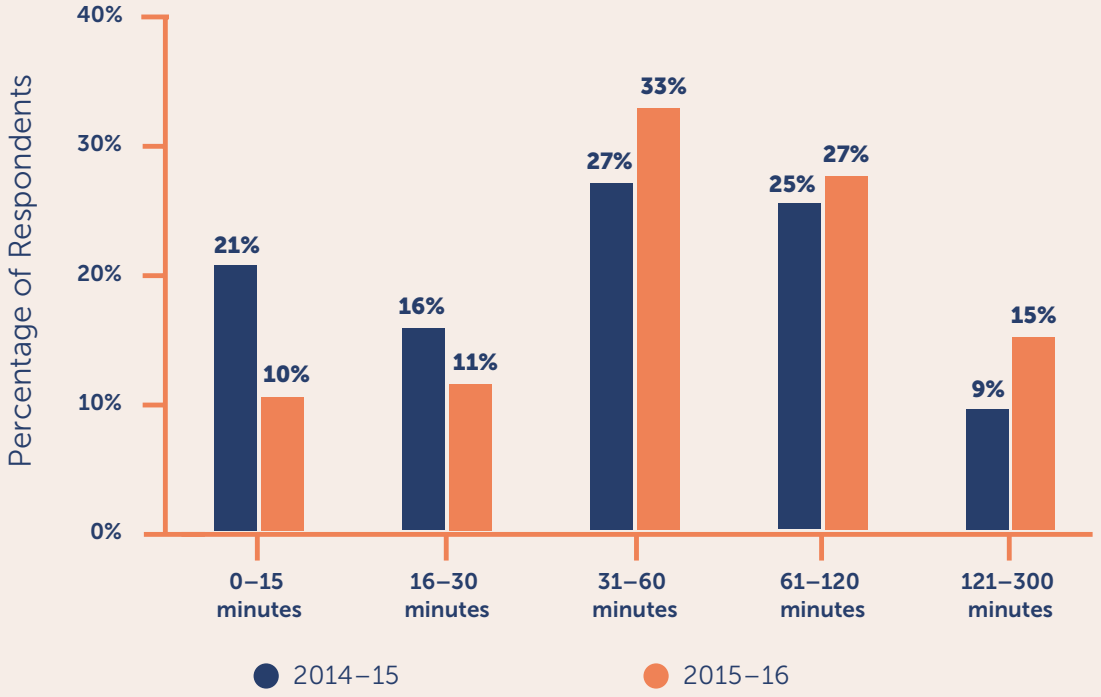
In an open-ended question, teachers who reported an increase in science instruction time were asked to describe the most influential factors that prompted the change. Below are the four most frequent factors described in the teachers' writings (accounting for 76 percent of their comments), listed in order of the percentage of teachers mentioning them:

4 Keep in mind that the referent teachers in the question stem are all of the districts' teachers responsible for science instruction, not just the Core Teacher Leaders and Teacher Leaders in the Early Implementers Initiative.

5 Given that middle schools generally have the same class time periods for any school subject, little increase in science minutes generally is expected for these schools. The situation in grade 6 is less clear, as described later.

6 Teachers also were asked to report how much time they taught science through the vehicle of English language arts (versus stand-alone science instruction). Those values were reported earlier in this report; the patterns of findings are similar to those presented here.

Figure 8. Average weekly time spent on K–5 stand-alone science instruction




*Source:* Responses of Core Teacher Leaders and Teacher Leaders on the Classroom Science Teaching Survey, administered summer 2016 (N=285).

- Instruction and support from the Early Implementers Initiative (46 percent)
- Increasing science by integrating with English language arts (13 percent)
- Increased confidence in teaching science (9 percent)
- Changes in district guidance or expectations (8 percent)

Given that the major influence in teachers spending more time teaching science is the instruction and support received through the Initiative, non-Early Implementers Initiative districts interested in enhancing science instruction should consider that providing some professional learning could be essential. Here are some illustrative comments:

*I feel more confident and find the NGSS more fun to teach!*

*The NGSS Early Implementers trainings really helped me to understand the science concepts and the process involved in learning science.*

*Planning lessons with the support of the Teaching Learning Collaborative group has encouraged me to dabble with new science lessons.*

*I saw so many connections with the ELA CCSS and was able to plan to integrate science into each day.*

*Our district guidelines now allow for integration of science with other subjects.*

## The Murkiness of Science Instruction in Grade 6

Statements on the status of science as a core subject in grade 6 are difficult to make. In some school districts, grade 6 may be located within a K–6 elementary school. In such schools, science may suffer versions of the same general barrier to science teaching as in all other elementary school grades.

On the surface, it is easy to assume that all science teachers in middle schools teach science every day. In grade 6, however, science can be part of a "block" course — that is, it can be officially combined with another school subject (e.g., mathematics or language arts) and only receive a portion of the class period. Some Early Implementers Initiative districts in that situation are implementing plans to have science be a stand-alone course in grade 6, such as the following example, related by a Project Director:

> *At grade 6, six areas of the district offered science on a wheel, or as a half year of science grouped with social studies, or as a block with literacy or math; therefore, science was not a daily occurrence. District leaders made an announcement that all principals need to move to a year of stand-alone science. Two schools have already made the change.*

Project Directors in some other districts feel that only a little headway has been made thus far on this challenge of converting science instruction from a block course to a science-only course. They encounter resistance to this structural change for such reasons as reluctance to divert time from other subjects to science, or lack of science background among some grade 6 teachers.

The status of science at grades 7 and 8 is more likely to be yearlong courses, but there are occasional exceptions. For example, there are Early Implementers Initiative districts in which a single teacher addresses science and mathematics as a block course. Science might not get an equivalent share of the pie; and if the assigned teacher is a mathematics teacher, the pie's ingredients may not be of the same quality or quantity. Another issue occurs in schools where health or family life is taught as part of a life science yearlong program.

It is worth noting that the grade 8 summative assessment in science will measure performance expectations in grades 6, 7, and 8. As mentioned previously in this report, the assessment will field test assessment items in 2017–18 and be fully operational in 2018–19.

## Making Science Explicit in the Local Control and Accountability Plan

District leaders are using a variety of policies and practices to make science more of a priority, including making science explicit in the Local Control and Accountability Plan (LCAP).

Without district resource allocations, efforts to spread NGSS science beyond the Initiative's Teacher Leaders to all of a district's teachers will be limited or stymied. During 2016, members of several districts' Core Leadership Teams successfully influenced their districts' LCAP committees

to strengthen the position of science. They have achieved the stipulation of funds for expenditures such as the following: teacher stipends, science instructional resources, expanding parent information nights for science, and providing science professional learning beyond the grant requirements.

In addition to making sure that LCAP decision-makers are explicitly allocating Bechtel grant funds to science expenditures in their proposal, Core Leadership Team members also are making sure that districts are allocating at least their own required matching funds for science, which increase over the grant years. Further, some Core Teacher Leaders have been successful in garnering science allocations beyond the required matches.

A key contributor to some Core Leadership Teams' success in gaining traction for science in the LCAP was the existence of the detailed NGSS implementation plans that they developed with the technical assistance of the K–12 Alliance. During Year 1, in the midst of many days of discussion spent on formulating and updating these plans, participants sometimes were fatigued and discouraged, wishing that they instead could spend the time "doing" something.

Now, in retrospect, forging such plans was pivotal, not only for processing with LCAP committees, but also for tracking and catalyzing district implementation efforts.

However, one Project Director noted that while making science explicit in the LCAP is necessary, it may not be sufficient:

Policies and practices that make science a priority:

- Communicating expectations and guidelines to all elementary teachers that the amount of science instruction should be increased.
- Sanctioning the acceptability of teaching science as part of meeting ELA requirements
- Conveying a preference to not pull students out of science instructional time for non-essential reasons.
- Encouraging teacher professional learning communities to devote time to science.

***Although LCAP and budget-related decisions include science/NGSS in documents, slide presentations, and during budget meetings, the follow-through of budgeted funds remaining dedicated to science implementation requires considerable and constant nudging through advocacy and diligent watchfulness.***

## Making Substitute Teachers Available for Science in the Face of Shortages

The Early Implementers Initiative funds substitute teachers so Initiative teachers can be released for professional learning.[7,8] But a general lack of

7 In grant Years 3 and 4, districts take up more of these costs directly with nongrant funds in order to increase buy-in toward institutionalizing the costs of science professional learning by the end of the grant.

8 It is important to note that the Early Implementers Initiative does not advocate that elementary science should be limited to being in the service of ELA. In order to adequately address NGSS science, there needs to be additional science instructional time beyond what would be considered ELA time. For example, if science is a core subject, it has to be more than just reading about science to count as ELA time.

substitutes in every district and an acute lack in some is preventing teachers from fully participating in the Initiative's professional learning activities. At about half of the dozens of Core Leadership Team and Teacher Leader events observed by the evaluation team across all the districts, one or more teachers could not attend at the outset or were called back to their school because of a substitute problem. District Project Directors are learning to vie with other system demands on the substitute pool in order to increase support for their teachers to attend. In a way, Project Directors' ability to ameliorate the problem is an indicator of the degree to which districts are making science a stronger priority; in some instances, professional learning projects in other subject areas have now been made to accept some substitute shortages instead of assigning substitutes to them first and then seeing which substitutes are left for the science initiative.

Project Directors have used strategies such as the following to enable their teachers to participate in Early Implementers Initiative professional learning:

- **Being very proactive in advance scheduling of events in order to get first claim on the substitute pool.** For example, a Project Director remarked in late spring 2016, "I just locked in all of our Core Leadership Team meeting days for the entire fall of next school year, and I'm the first administrator in the system to have any requests for substitutes on those days."
- **Moving Initiative events to dates known to have better substitute availability.** For example, a Project Director had noted substitute availability on an originally scheduled Initiative meeting date. As the meeting drew closer, other projects were making a priority claim that exceeded the substitute pool and put the science meeting in jeopardy. The Project Director, who regularly monitors the pool and saw this developing, decided to do extra work to reschedule the meeting rather than risk losing the battle for substitutes on that day.
- **Working with administrators to cover classes with other staff if a planned substitute fails to show up.** At one Core Leadership Team meeting observed by evaluators, a teacher was emailed by her principal to return to her school. A substitute for a non-science teacher had not shown up and the principal wanted to switch the Core Teacher Leader's substitute to the other teacher's class. The Project Director contacted the principal to discuss the situation; the principal was able to find another solution that permitted the science teacher to stay for the Core Leadership Team meeting.

## Becoming Science-Centered Schools

While the Early Implementers Initiative focuses most strongly on changing the formal science instruction of all teachers to meet the demands of the NGSS, districts are encouraged to pursue a broader view of science as a core subject. Districts' strategic plans for the Early Implementers Initiative include such expansive items as:

- Outreach to increase parent awareness of and buy-in of NGSS implementation, through teacher emphasis on science during back-to-school nights and getting on the agenda events for parents during the year.
- Outreach to the broader community about the NGSS and science education.
- Working to involve area organizations to enhance both formal and informal science education for their students.

For example, one district Project Director convened a dozen prominent science organizations in the region to promote making field trips

more educational, and to explore ways for those organizations to work with the district's science teachers in their classrooms. The Project Director cast a wide net to varied organizations including military facilities, science museums, and environmental organizations such as a zoo and a conservation society.

Parent and community outreach can be essential rather than value-added. In some districts, there has been parent resistance to the integrated model in the middle grades; parents argued that the standing discipline-specific model is inherently more rigorous and better for preparing their children for college. District leaders have actively worked to dispel parents of this view. In one district, for example, project leaders were able to have the superintendent send a letter to all parents letting them know that the integrated model is rigorous and, in fact, is the preferred model of the California State Board of Education.

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# K–8 NGSS Early Implementers Initiative Glossary

**Administrator Symposium** — Annual regional event sponsored and delivered by BaySci, the K–12 Alliance, and California Science project. Helps administrators in non-Early Implementers Initiative districts begin to plan NGSS implementation.

**Core Leadership Team** — Group of 3–5 administrators and 5–8 teachers at each district. The Core Leadership Team meets with their Project Director and Regional Project Director for six Technical Assistance Days during each school year to plan and lead all Early Implementers Initiative activities.

**Core Teacher Leader** — Teacher member of the Core Leadership Team. Provides professional learning to Teacher Leaders and other teachers in their district. Provided leadership at Early Implementers Initiative Summer Leadership Institutes.

**K–8 NGSS Early Implementers Initiative** — Four-year Initiative (summer 2014 to spring 2018) supporting implementation of the NGSS by eight public school districts and two charter management organizations in California. Developed by the K–12 Alliance at WestEd in collaboration with the California State Board of Education, California Department of Education, and Achieve, the Early Implementers Initiative builds capacity of participating local education agencies to fully implement the NGSS in grades K–8.

**The K–12 Alliance** — A WestEd program of science education leaders and professional learning providers who plan and deliver all projectwide activities for the Early Implementers Initiative.

**Local Control and Accountability Plan (LCAP)** — The LCAP is a critical part of the new Local Control Funding Formula (LCFF) for school districts in California. Each school district must engage parents, educators, employees, and the community to establish these plans. The plans will describe the school district's overall vision for students, annual goals, and specific actions the district will take to achieve the vision and goals.

**Principal Academy** — For principals of every Teacher Leader. Delivered by the Early Implementers Initiative leaders (Regional Project Directors and Project Directors) to foster understanding of the shifts in teacher practice required to implement the NGSS in the classroom.

**Professional Learning** — Contemporary terminology for professional development that emphasizes interactive learning strategies rather than rote learning techniques where information is delivered to relatively passive listeners.

**Professional Learning Community (PLC)** — Not directly part of Early Implementers Initiative. Regular teacher-led meetings for professional development on topics of their choice.

**Project Director** — Responsible for leading all Early Implementers Initiative activities for the district and representing the district at monthly Initiative-wide planning meetings.

**Regional Project Director** — Member of WestEd's K–12 Alliance staff assigned to provide leadership and support to one or two Early Implementers Initiative districts.

**Summer Institute** — Weeklong professional learning event held every July to August, attended by all Initiative participants, some as leaders (Regional Project Directors, Project Directors, Core Leadership Team members) and others as learners (Teacher Leaders).

**Teacher Leader** — 40–60 teachers in each Early Implementers Initiative district. Teacher Leaders joined the Initiative one year after the Core Teacher Leaders.

**Teaching Learning Collaborative** — Lesson study activity brings together three to four same-grade Early Implementers Initiative teachers from different schools within the district. Teachers plan and teach a lesson to two classrooms of students. Each Teacher Leader participates in two Teaching Learning Collaboratives per year.

**Technical Assistance Day** — Meeting of the Core Leadership Team, facilitated by the K–12 Alliance Regional Project Director, to plan NGSS implementation in the district. Six days per school year.

# Appendix A. More about the Integrated Model and the Case for It

The California State Board of Education prefers the NGSS integrated model of middle school science over the discipline-focused model, because (Williams, 2015):

- It provides opportunities for all students to learn about the nature of science and its relationship to engineering design.
- It builds knowledge in all three disciplines in each year so that past learning is connected to, applied, and further developed in each subsequent unit or year, providing the best opportunity for students to develop deeper understanding and transferable, usable knowledge (spiral curriculum).
- K–5 integrates science, so doing so in middle school as well is a smoother transition.
- Real-world science is integrated.
- Parts of each discipline require knowledge from a different discipline to be learned fully (integration is necessary).
- In the discipline-specific model, the content covered in each grade level is not balanced, with the heaviest content load at the youngest grade level.

Following are highlights of how the first two drafts of the California Science Framework call for the integrated model.

## California Science Framework, Draft 1 (November 2015)

The integrated model focuses more on the "big ideas" that cut across the science disciplines (the crosscutting concepts), rather than the specific disciplines or content. The integrated model is intentionally designed to allow students to slowly build up knowledge and skills in all three dimensions of the NGSS: disciplinary core ideas, science and engineering practices, and crosscutting concepts. The integrated model is more like a spiral curriculum where students are building on their knowledge and revisiting things they previously learned, but at a more complex level (Bruner, 1960). The integrated model is arranged so that prerequisite knowledge that students must learn is taught alongside more complex applications of that material. In this way, students are able to gain a deeper understanding of the content because they are engaged in more cognitively demanding tasks — applying what they learn rather than rote memorization of facts (related to Bloom's taxonomy).

Units of study are organized around larger ideas and guiding questions rather than individual performance expectations or disciplinary core ideas organized by discipline (as is the case in the discipline-specific model).

## California Science Framework, Draft 2 (June 2016)

In the second draft of the California Science Framework, much more rationale is given about why to use an integrated model than in the previous draft. The document makes more explicit the focus on using the crosscutting concepts from the NGSS as the basis for units of teaching. Draft two also provides evidence for why to focus on crosscutting concepts and practices rather than science disciplines due to the integrated nature of science research and practice, which students will face in those disciplines in the future. Additionally, contrasts are drawn between integrated versus coordinated science courses. Coordinated science courses seem more similar to the discipline-specific model in that they tend to focus on one science subject area (discipline) at a time, with little effort made to emphasize connections across disciplines and content. In these courses students may learn about multiple science disciplines each year, but little interdisciplinary content is addressed and students are typically not afforded the opportunity to apply all three dimensions of the NGSS. Integrated science courses do allow for this interdisciplinary approach and the application of all dimensions of the NGSS, including the disciplinary core ideas, crosscutting concepts, and science and engineering practices.

A comparison in the cognitive level of the previous (1998) standards and this new integrated model is made in the second draft of the California Science Framework, which highlights how much more cognitively demanding and developmentally appropriate the NGSS are, especially if using the integrated model.

NGSS EARLY IMPLEMENTERS
WestEd

# The Needle Is Moving in California K–8 Science

EVALUATION REPORT #1

## Integration with English Language Arts, Integration of the Sciences, and Returning Science as a K–8 Core Subject


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