California NGSS K-8 Early Implementation Initiative
Funded by the S. D. Bechtel, Jr. Foundation

The Needle is Moving in CA K-8 Science:

Integration with ELA, Integration of the Sciences, and Returning Science as a K-8 Core Subject

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Evaluation Update #1: Next Generation Science Standards (NGSS) Implementation in the Early Implementation Initiative (EII)

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To access this report online: http://www.k12alliance.org/docs/needle-moving-ca-k8.pdf

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Introduction

The National Research Council released the *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 Content State Standards (CCSS). The standards were completed in April 2013. As of this writing the District of Columbia and 17 states have adopted them: Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maryland, Nevada, New Jersey, Oregon, Rhode Island, Vermont, Washington, and Michigan.

The California NGSS K-8 Early Implementation Initiative

The CA K-8 NGSS Early Implementation Initiative (EII), developed as a partnership among Achieve, K-12 Alliance @ WestEd, the California Department of Education, and the State Board of Education, is a fast-start, large-scale demonstration program. The S. D. Bechtel, Jr. Foundation is supporting eight school districts to be NGSS implementation leaders in grades K-8. Under the EII, WestEd's K-12 Alliance provides professional learning (PL) and technical assistance for the following CA districts to implement NGSS and make science a core school subject: Galt Joint Union Elementary, Kings Canyon Unified, Lakeside Union, Oakland Unified, Palm Springs Unified, San Diego Unified, Tracy Unified, and Vista Unified. The Hastings/Quillin Fund supports the EII participation of two charter districts, Aspire and High Tech High. For a map of all of the participating local education agencies, see **Figure 1**.

EII spans four years, from summer 2014 through spring 2018. In the first year, 2014-2015, PL and technical assistance was provided to sets of 8-15 select teachers and administrators from each district (Core Leadership Teams, CLTs). In the second year, 2015-2016, K-12 Alliance continued to provide PL and technical assistance to the CLTs; PL also was begun with 40 to 70 Teacher Leaders (TLs) per each participating district, depending on district size. In years three and four, additional PL and technical assistance will be provided to the CLTs and TLs. Further, the districts will leverage the CLTs and TLs to provide PL for spreading beginning NGSS implementation to *all* of the districts' grades K-8 teachers who are responsible for science instruction.

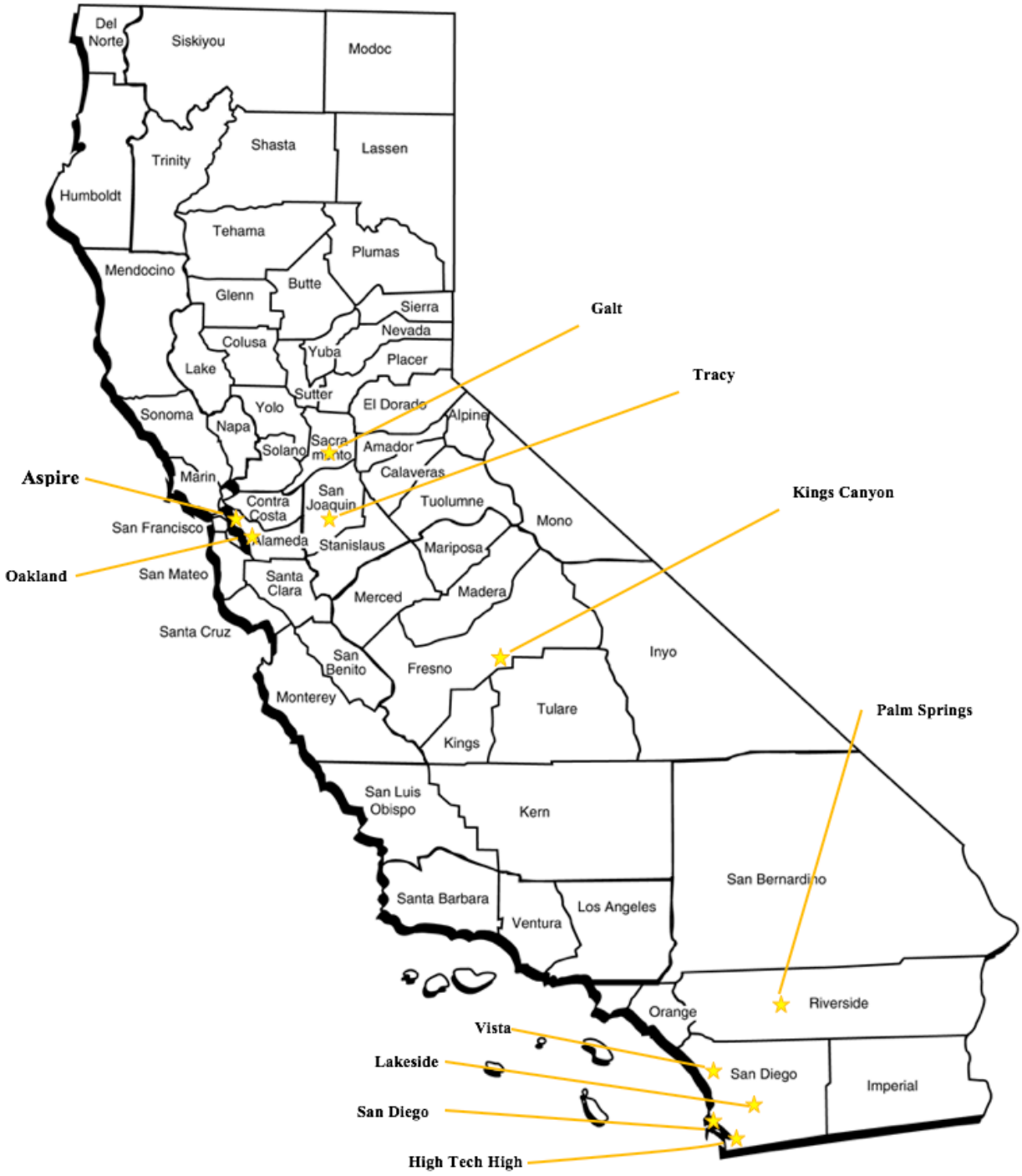


Figure 1. Map of participating EII districts and charter management organizations

Evaluation of the EII

The S. D. Bechtel, Jr. Foundation commissions WestEd's STEM Evaluation Unit independently of the K-12 Alliance to provide evaluation of the project in the eight public school districts. The evaluation encompasses five areas of focus:

1. Describe K-12 Alliance implementation for varied audiences.
2. Describe and analyze participating districts' program implementation.
3. Describe and analyze revised science teaching, student outcomes, and the leadership growth of teachers and administrators.
4. Determine NGSS activities and needs of some non-EI districts.
5. Describe participating districts' dissemination to other districts.

The evaluation has followed the progress of the EII by attending most of the project leadership planning meetings and all of the centralized professional learning events. In addition, evaluators have conducted multiple visits to each of the 8 participating districts to observe a range of district-level NGSS implementation activities. Interviews have been conducted with district Project Directors and K-12 Regional Directors. All other EII participants (i.e., CLT 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 EII evaluation publications discussing lessons and observations from the EII. Over the next two years, evaluators will continue to document the activities and the progress of the program and to share findings of interest and potential value to districts following in the footsteps of these early implementers.

NGSS Implementation in CA: Policy and Status

Science has been on the back burner in U.S. schools for decades. Even before the *No Child Left Behind Law*, 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 NGSS, state policy is clearly supportive of moving science toward core subject status. In March of this year, the CA Department of Education (CDE) recommended, and the State Board of Education (SBE) approved the following overall science assessment design:

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

The NGSS-aligned assessments are slated to be pilot tested in CA during the current, 2016-2017 academic year, followed by field testing during the 2017-2018 year, moving to a state-wide operational test in the 2018-2019 school year.

NGSS is now included in one of the state's 8 priorities that must be addressed in every district's Local Control Accountability Plan (LCAP). Priority 2 involves the implementation of ALL academic content and performance standards that have been adopted by the state. The standards that must be addressed as part of priority 2 are not just mathematics and language arts (Common Core standards) as previous requirements emphasized. While the Local Control Funding Formula (LCFF) does not require that all of these priorities be funded, or be funded equally, 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 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 NGSS now (not just when it is actually implemented), they can notify district leaders responsible for creating the LCAP that they need funding for professional development and support to transition into NGSS.[1] 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 CA. It was a break from the past discipline-specific model of instruction in those grades: earth science in 6th grade, life science in 7th grade, and physical science in 8th grade. The November 2015 draft of the CA Science Framework explained that the integrated progression "… 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). As part of the EII, all participating districts have agreed to adopt the Integrated Model.

Shifts Required to Implement 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 they are different. In a nutshell, NGSS-aligned instruction must be:

- Inquiry-based – Students gain deep understanding vs. superficially memorize facts or details. New learning is connected to prior knowledge. Teachers do not deliver information; students 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.

[1] See http://www.classroomscience.org/advocating-for-access-to-financial-support-of-science-in-your-school-and-district

- 3-Dimensional – Science content is taught while engaging in Science and Engineering Practices (what scientists do, how scientists know) and while looking through a Crosscutting Concept lens (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.

Executive Summary: Three High Leverage Implementation Strategies

This first EII evaluation publication discusses one of the major shifts above, namely the shift to integrated instruction. The integration of science and ELA is the focus of one section, and the integration of the science disciplines (i.e., earth/space, life, and physical) inherent in the MS Integrated Model is the focus of the second. Also discussed at length in this publication is a fundamental shift that is not listed above, but is equally, if not more, important: the need to teach science in the first place. In order for any of the targeted shifts to take place, 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 EII project is empowering elementary school teachers in the 8 districts to teach science in relation to Common Core subjects, particularly English Language Arts. The section also describes how teachers are reacting to and implementing the offered tools and strategies:

- 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 Common Core State Standards (CCSS).
- Teacher Leaders report improved understanding of how NGSS relate to the CCSS after only one year of participation with the Initiative.
- The two EII tools and strategies used most by teachers in their own classrooms (i.e., beyond the EII program activities) are science notebooks and questioning strategies that facilitate student discourse and sense-making.
- Teachers report 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 State Board of Education has adopted the Integrated Model as the "preferred model" for CA 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
- Provide professional learning on integrated science for teachers and administrators
- Using a "Coordinated Model" as a bridge from Discipline Specific to Integrated

Returning Science as a K-8 Core Subject. One explicit goal for each participating district of the EII is to make science a core subject. The section discusses what it means for science to be a core subject and ways that districts have made progress on this front, including:

- At the elementary level, the worst-case scenario of little or no science has nearly been eliminated among the project'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 all district teachers who provide science instruction, not just among the project's Teacher Leaders.
- Not surprisingly, the most common factor cited as prompting increases in science instruction was the training and support of the EII.
- EII 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 are based on data from the eight public school districts supported by the S.D. Bechtel Jr. Foundation; Results for charter school CMOs participating in EII will be discussed in separated reporting.

Science as a Vehicle for Teaching Common Core-ELA

K-5 teachers see that a diverse spectrum of their students love hands-on science. Therefore, many teachers *do* want to teach it, even though they are tired from the burdens of Common Core implementation, or they may be intimidated by science. The EII is empowering teachers to teach science in combination with the Common Core, and there are green shoots of teachers who are beginning to understand and pursue such connections. In fact, many report that they are spending more class time on science integrated with ELA than before.

Of course, integrating science with English-Language Arts is more than having students read about science. Rather, it is recording detailed observations, posing and responding to questions, articulating how evidence supports a point of view, and comparing explanations with peers. Teachers find that students naturally employ these skills when their attention is engaged in scientific subject matter, and that is the whole idea behind NGSS.

Science Overcomes Innovation Overload

Like their peers throughout the state, teachers in Early Implementer districts feel some degree of innovation overload aside from NGSS, particularly because the adoption and implementation for CCSS ELA and math had begun in earnest just before the start of the EII. Some districts have recently adopted new curricula, which will take considerable time and energy to master.

Despite the time required for CCSS, teachers are enthusiastic about trying the new science standards. Most EII districts have had rates of project attrition under 15%, and have had more volunteers than spaces available.

> When asked about 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), transferring to a new district (1), becoming a vice principal, (1), becoming a counselor (1), or feeling too overwhelmed (1)."
>
> One district was a recipient of 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 Race to the Top and CCSS implementation demands. However, teachers had completed a needs assessment survey previously in which they communicated a
> *strong* desire to add science to their agenda, despite the added work. Using data from the survey, the Project Director and the NGSS Core Teacher Leaders were able to persuade the union that the teachers would benefit from the Initiative.

NGSS and EII Program Goals for Integrating Science and ELA

Both the NGSS and the EII 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; NGSS makes explicit links to CCSS across all disciplines and grade bands.

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

- Disciplinary Core Ideas (DCIs, what scientists know),
- Crosscutting Concepts (CCCs, how scientists make connections among the sciences), and
- Science and Engineering Practices (SEPs, what scientists and engineers do, how scientific knowledge develops).

Most notable for this section of the report is that all eight SEPs require English language:

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 math 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 CA 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 published the California English Language Development Standards (ELD), which correspond to the CA 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 (ELs) to develop literacy in English. During EII professional development, learning some sessions focus explicitly on how NGSS implementation can address ELD standards.

In order to align with 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 Strategies and Tools

In the Early Implementation Initiative, teachers are being empowered and urged to integrate ELA with science through a range of tools and processes. 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.

Teacher Leaders are learning and trying several project tools and processes to implement NGSS that incorporate ELA:

Project Tool	Purpose
Science Notebooks	For students to write out and evolve their understanding
Claims, Evidence, Reasoning	Protocol for addressing NGSS SEPs "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 students

K-12 Alliance is familiarizing project participants with these tools during these recurring activities:

Activities	Description
Leadership Institutes	10 days per year for the Core Leadership Team
Teacher Leader Summer Institutes	Annual 1-week professional learning for Teacher Leaders
Teaching Learning Collaboratives (TLCs)	Lesson study in science, 2x per year for each participating teacher
Principal Academies	Workshops for administrators

The **Leadership Institutes** provide additional training for the Core Leadership Team of teachers and administrators and often address pedagogical issues like integrating NGSS and CCSS.

The Teacher Leader **Summer Institutes** kick off each year of the EII project 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 (TLCs) bring together same-grade teachers, typically from different schools within each of the EII 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 integration of science and ELA.

Principal Academies. After receiving instruction and being encouraged to try new things in their classrooms, some Teacher Leaders expressed reluctance, because their principals did not understand the shifts required by NGSS. The K-12 Alliance realized that educating administrators about NGSS would be required in order to change the culture of the schools. Consequently, the project scope was expanded to include every principal who had a Teacher Leader at his or her school. In project 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. This activity will be followed and then discussed in future evaluation updates.

Project tools that most support the connection of ELA with science are described below:

- **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, they learn to use their notebooks in the way they will instruct their students to do.

  The 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.

  Participating Teacher Leaders experience this first hand when presented with a phenomenon-based question, such as, "Does ice melt slower in salt or fresh water?" As students would, teachers:

  - write their prior knowledge about the phenomenon in their 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, and
    - record their evolving understanding in their notebooks.

- **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, EII 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 protocol applies well to developing a model, another NGSS SEP. The 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.** 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, 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 notebooks. The 5E Instructional Model forms the basis of every EII Teaching Learning Collaborative. Explicit connections between science and both ELA and ELD at each of the 5 lesson stages are shown in **Figure 2**.

Figure 2. Science/ELA/ELD 5E Instructional Model Template*

Use to outline from hands-on, through text, to evidence-based argument or explanation.
Science Concept and Language Learning Goals: ____
Science Practices:_____ CCC: __

*expanded by the K-12 Alliance from the original BSCS 5E Instructional Model

Phases	**Activity**	**Concept**	**ELA Connections**	**Meaningful Communication ELD (Collaborative, Interpretive, Productive)**
Engage: Prior knowledge about Phenomenon	Real phenomenon or pictures/video	Engage in prior knowledge about phenomenon	Generate ideas from prior knowledge	Collaborative discussions
Explore I: Use hands-on materials	Materials to explore phenomenon	Portion of Concept to be explored	Write observations, drawing, data, and models in notebook	Collaborative and Interpretive
Explain I: Use student interactions and discussion to support writing	Activity to explain exploration	Portion of Concept to be explained	Discussion scaffolds to promote revealing what students know so far	Collaborative and Productive
Explore 2: Deepen understanding through text or another hands-on	Activity: Hands-on or reading selection	Portion of Concept to be explored deeper	Reading for meaning, Scaffolding discussion, Writing in notebooks	Collaborative and Interpretive
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	Sufficient Support for Access	Collaborative, Interpretive and Productive

- This pattern of weaving science and ELA begins with something to understand (phenomenon) and ends with evidence for the explanation.
- The hands-on in done before reading to build knowledge to bring to the reading. Writing and academic discourse is part of every step of the sequence.
- Concepts using academic language are embedded in the explorations and discussions. “Naming” of objects used for exploration is introduced when equipment is used.

- **Questioning Strategies.** 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 project activities, EII teachers are learning ways to integrate ELA and science. A survey item asked Teacher Leaders and Core Teacher Leaders, "To what extent has the EII project enhanced your ability to make Common Core and NGSS implementation complementary or integrated?" Sixty-seven percent answered "Moderately" (33.6%) or "A lot" (33.6%). Less than 10% said "Not at all."

How Teachers Are Reacting

In surveys and at project events, teachers convey their energetic willingness to invest time and effort to implement NGSS, because students are excited and motivated.

The project's attention to NGSS Science and Engineering Practices (SEPs) fosters active, inquiry-based science in which students are presented with naturally occurring phenomenon and encouraged to question, discuss, read, and explain their thinking about the science behind it. As a result, they are engaged and excited about science class. As one Teacher Leader put it, "They love science now. It's all they want to do."

Other Teacher Leaders concur:

"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." (Teacher Leader, Classroom Science Teaching survey)

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

At a rollout training for every science teacher in another district, teachers were excited as they entered the classrooms. Teachers Leaders, who had participated in the EII program for only a year, were about to lead 80-minute sessions about 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 adds, 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.”

When asked how they felt about CCSS and NGSS, 2nd grade teachers agreed that other demands were taking a great deal of time and energy, but they had heard about NGSS from their fellow teachers and were eager to find out more. After the session, 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 Initiative, all project participants complete leadership surveys that ask about their understanding of how the NGSS relate to the CCSS. Upon joining the Initiative at the end of the 2014-2015 school year, the largest cohort of participants, the Teacher Leaders, completed their baseline leadership survey. At that time, 58% said they understood poorly, if at all, how NGSS relates to CCSS. After one year of EII participation, the percentage of TLs with little or no understanding decreased to 21%, while the percentage of those who understood thoroughly or fairly well almost doubled. See **Figure 3**.

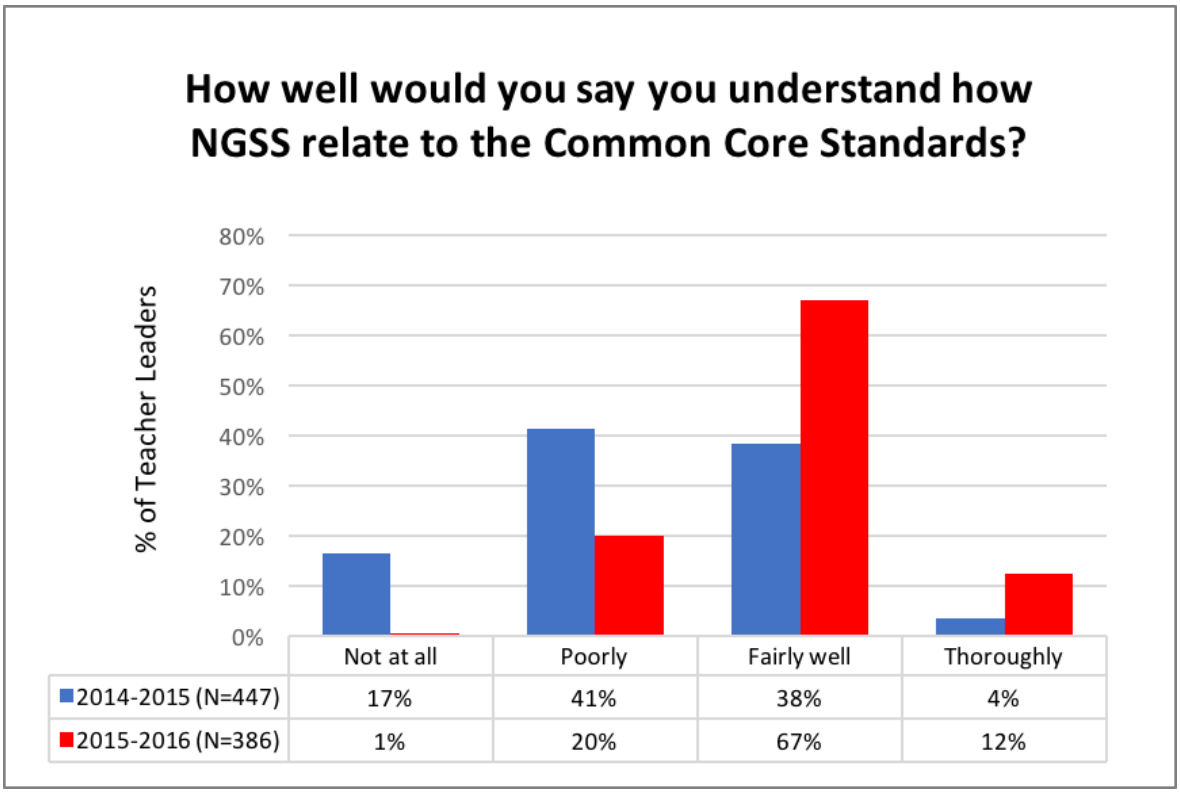


Figure 3. From Teacher Leader leadership surveys, administered summer 2015 & 2016. N=447 & 386, respectively.

Core Teacher Leaders (CTLs) have reported a similar increase in NGSS understanding over three years. Data from their baseline year of 2013-2014, indicate that a third reported that their understanding of the relationship between NGSS and CCSS was completely lacking (33 of 66), and another third rated it poor (23 of 66). Only 3% (2 of 66) said they thoroughly understood. By the end of their first year, every CTL understood how NGSS relate to CCSS to some extent, and almost half felt they understood fairly well or better. In year three, Interestingly, CTL 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% to 13%.

Bringing the Tools and Processes into the Classroom

K-5 Teacher Leaders were surveyed about their use of 5E Lesson Planning, questioning strategies to elicit student thinking, and science notebooks for student sense-making **beyond** project-sponsored activities. One year after being introduced to those more favored tools,

almost half (43%) used notebooks and more than half (55%) used questioning strategies on a weekly basis or more often. See **Figure 4**.

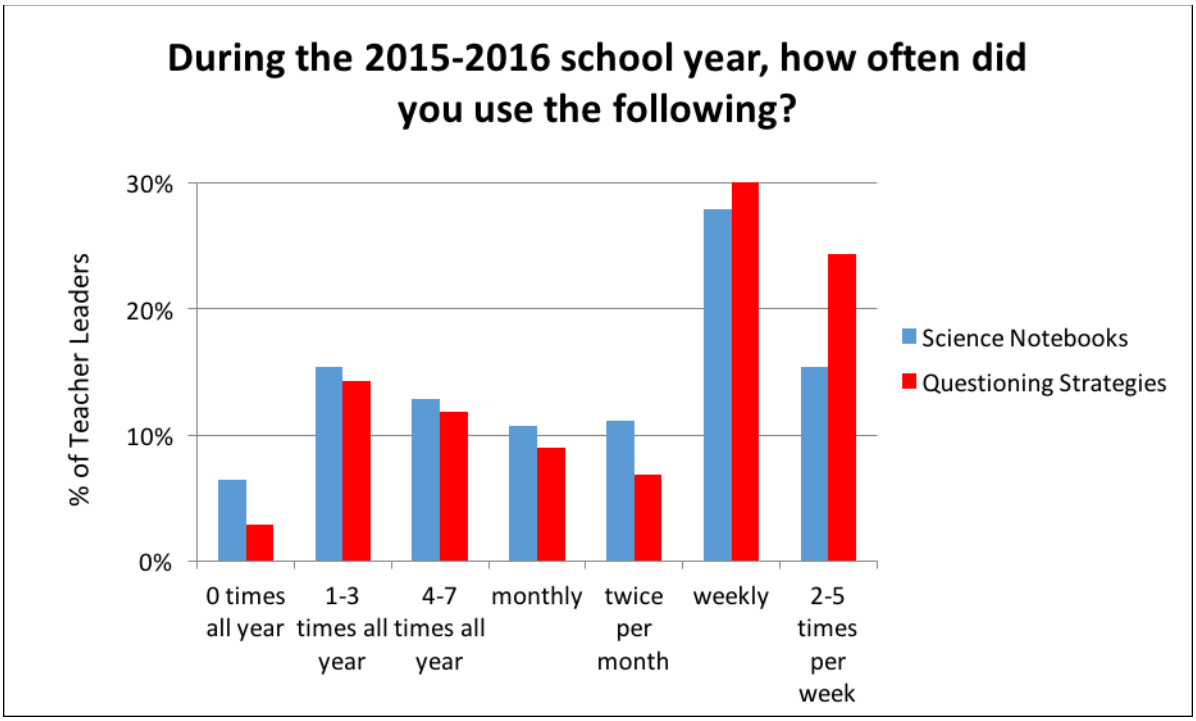


Figure 4. Responses of K-5 Teacher Leaders to the Classroom Science Teaching Survey, administered July-August 2016. (N=312)

Outside of project sponsored activities, such as the TLC, only 14% of Teacher Leaders report using the 5E instructional model to design lessons one or more times per week. More than half (53%) say they used 5E lessons less than four times during the 2015-2016 school year.[2]

Boosting Time on Science

In fact, teachers participating in the EII have significantly increased the amount of time they spend teaching science integrated with ELA. EII 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 2014-2015 and in 2015-2016. While a third of K-5 teachers (94 out of 282) reported teaching virtually no science integrated with ELA (0 to 15 minutes per week) during the 2014-2015 school year, the following year that percentage was cut in half, to about 16% (45 out of 285 teachers). See **Figure 5**.

The number of K-5 teachers who spent 1-2 hours per week teaching science integrated with ELA doubled between the 2014-2015 and the 2015-2016 school years, as did the number who spent more than 2 hours on science and ELA together.

[2] The claims, evidence, and reasoning tool was not included in this chart because teachers were not asked about their use of the tool in the 2014-2015 school year.

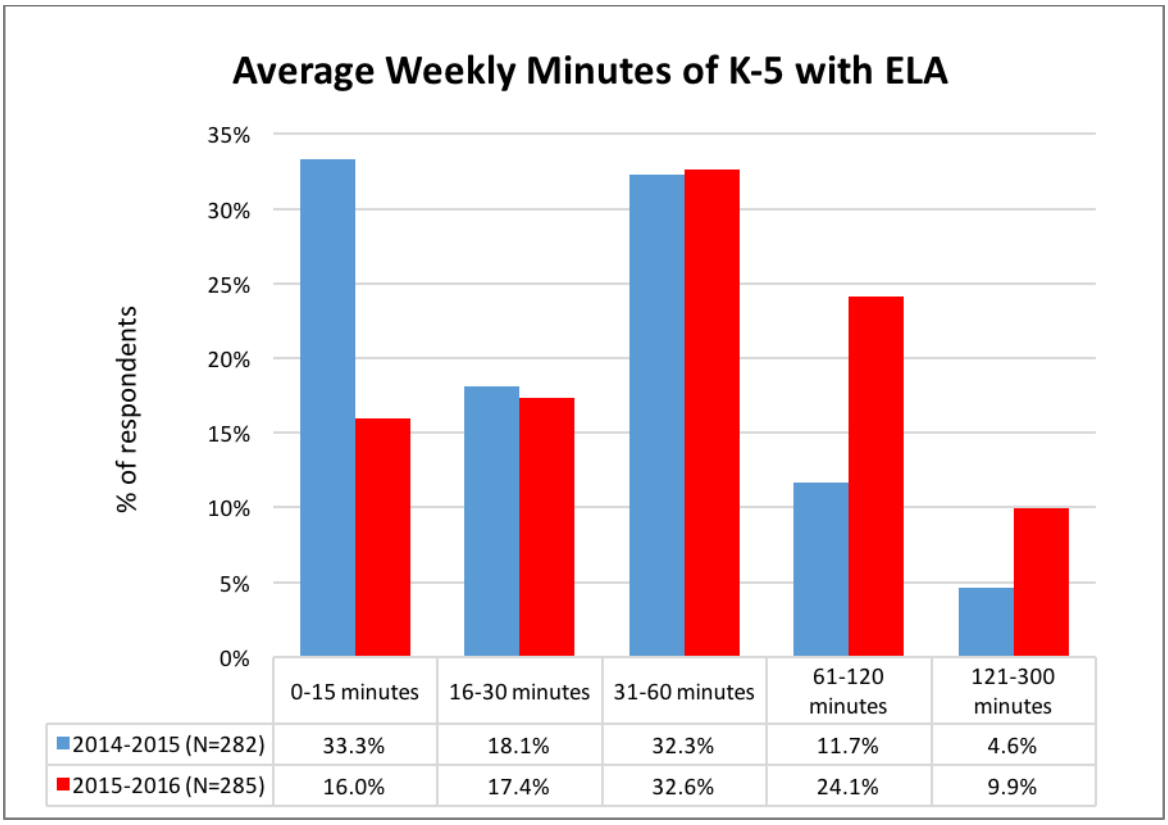


Figure 5. Classroom Science Teaching Survey, taken by CTLs and TLs, July-August 2016.

A follow up survey question asked, "If your answers changed for 2014-2015 versus 2015-2016, 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 were inquisitive.*
>
> *I increased my science integration during ELD and my Spanish language arts. I felt more confident in including ELA with science.*
>
> *Involvement in this grant; increased knowledge of NGSS and integration in ELA instruction*
>
> *School wide commitment to science, integrated ELD block K-5*
>
> *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.*

Update on the Middle School Integrated Model

The NGSS advocate integrated science, as reflected in some key NGSS features.

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

Correspondingly, 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. The State Board of Education (SBE) agreed with the Science Expert Panel's recommendation that middle grade science should be integrated to meet these shifts. The EII project embraced this preferred model so that students could "figure out" phenomena in the world around us by applying multiple science disciplines and engineering design in an integrated way. Arguments for the Integrated Model also include that, because it permits building knowledge in all science disciplines and engineering each year, past learning is connected and applied to further development in each succeeding unit or year.[3]

During recent decades in California and the U.S., middle and high school science has been taught in discipline specific courses, most often with earth in grade 6, life science in grade 7, and physical science and astronomy in grade 8.[4] 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.

However, the California State Board of Education and the Instructional Quality Commission (2016) advocates moving from a discipline-specific model to an integrated model for middle school (Williams, 2016); the SBE voted in November 2013 to make the Integrated Model the "preferred" California model. In so doing, the SBE endorsed the learning progressions found in NGSS that are a continuum of content from K-12. With the Integrated Model, there are no "gaps" in the progressions. Students explore life, earth and space science, physical science and engineering uninterrupted because the disciplines are addressed each year.

Every EII district is pursuing the Integrated Model in which all science disciplines are treated in each of grades 6, 7 and 8. **Table 1** (see next page), excerpted from this most recent June 28, 2016 Public Review version of California Framework document, lays out the grade-by-grade contrast in content between the two models.

[3] 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.

[4] Perhaps the last earnest California attempt at achieving an integrated model for science in middle and high schools was in the 1990s. Both the U.S. Dept. of Ed. and the National Science Foundation supported the California Department of Education in helping 100 California secondary schools to pioneer an integrated model for science content in the Scope, Sequence and Coordination project (Atkins, Helms, Rosniek & Siner, 1997).

Table 1. Comparison of Middle Grades Where DCIs are Primarily Addressed in the Two Middle School Models

	Disciplinary Core Idea		Subtopic	Preferred Integrated			Discipline Specific		
				6	7	8	6	7	8
Earth & 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 & Body Systems	X				X	
			Photosynthesis & Respiration		X			X	
	2	**Ecosystems: Interactions, Energy, and Dynamics**			X			X	
	3	**Heredity: Inheritance and Variation of Traits**	Sexual v. 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 & Collisions	X		X			X
			Heat & Heat Flow	X					X
			Potential Energies & Gravity			X			X
	4	**Waves and Their Applications in Technologies for Information Transfer**				X			X
ETS	**Every course includes integrations with ETS**			X	X	X	X	X	X
SEP	**Every course utilizes all 8 SEPs**			X	X	X	X	X	X
CCC	**Every course highlights all 7 CCCs**			X	X	X	X	X	X

*ETS = Engineering, Technology, and Applications of Science
*SEP = Science and Engineering Practices
*CCC = Crosscutting Concepts

Notice the changes to be taught by teachers at a given grade. For example, a 7th grade 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. The Appendix to this section of the report 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 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 strong shifts in pedagogy linked to 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;
- need to confer with colleagues across grade levels to articulate grade-to-grade scope and sequences; and
- work with administrators to help parents and community members understand the Integrated Model.

Both models require school-wide if not district-wide changes by all middle grade science teachers. In the case of the Integrated Model, the EII district plans address ways to transition from the current topic at each grade to the topics represented in the Integrated Model and provide PL to all teachers, not just the participants who receive larger amounts of EII professional development.

EII Professional Learning for Science Integration

The EII is providing Teacher Leaders with professional learning about integrating the sciences during these project activities, further described below:

EII Activities	Description
Leadership Institutes	10 days additional training for the Core Leadership Team of teacher leaders and administrators
Content Cadres (during Summer Institutes (SIs))	At the annual, week-long professional learning, Teacher Leaders spend 50% of the SI week in grade-level content cadre.
Teaching Learning Collaboratives (TLCs)	Lesson study comprised of 2, 2-day cycles per school year

Content Cadres comprise 50% of the week-long Summer Institute for Teacher Leaders that kicks off each year of the EII project, the rest of which 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 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; and
- increase teachers' understanding of specific grade level content specified in NGSS and pedagogical approaches to teaching science.

At least one of the two teachers 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 Cadre member represents one of the three disciplines: life, earth and space science, and physical science.

Teaching Learning Collaboratives (TLCs) bring together same-grade teachers, typically from different schools in the EII district, to spend one day planning and another day co-teaching, debriefing, and adjusting an NGSS-aligned lesson with a project-trained facilitator. Exploring how to integrate the sciences is one of many things that participants are tackling during the TLCs.

How Districts and Teachers Are Reacting

Statewide, there is a wide mix of reactions to the idea of switching from the discipline-specific model to the Integrated Model, from enthusiasm, to angst, to resistance.[5] Participation in the EII required the districts to agree to implement the Integrated Model. The initial stages require developing some detailed transition plans. The EII participants are experiencing a wide mix of

[5] 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-EII districts that attended a spring 2016 EII event providing NGSS implementation ideas, all but one district had decided to pursue the Integrated Model, and the other district was undecided.

reactions to the first couple of years of the journey. The EII districts currently vary in status on the progression from discipline-specific, to coordinated, to fully integrated models.

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.

Complex Transition Plans

For example, eighth grade under the Discipline Specific Model is physical science. In the Integrated Model, that discipline would now only comprise about one-third of the school year, as the rest of the content moves 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 very unrealistic to fully develop all the knowledge and pedagogy, as well as develop student centered lessons necessary to convert everything all in one swoop.

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

The following short vignette is the story told by one EII principal about some of the work involved in forging and carrying out a such a transition plan. The school is a small one having a single science teacher per grade. Notice in **Table 1** that during the second transition year, both 7th and 6th grade teachers need to teach about cells in life science, because this content will move from 7th to 6th grade under the Integrated Model.

> ***The importance of PLCs initially and throughout****. We had to start on this before the EII project began, while we were applying to be included in the project. It became the biggest focus of our science teachers' weekly PLC (professional learning community) meetings on each Wednesday, when we have early student release for teacher professional development.[6] Those PLCs have continued to be key throughout the years for getting the many necessary things figured out [for integration].*
>
> ***The importance of PD from EII****. But I wonder what would have happened even with all that PLC work and time without also having the EII provide help at the Cadres with new content knowledge, pedagogy, and how to integrate; and without also having my participation along with the districts' Science Director involved in the EII Core Leadership Team for our district.*

[6] Most California districts now have schedules during contracted time for teachers to participate in teacher-led PLCs; the aim for PLC time is a professional development focus, 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 EII project has supports the district's standing PLC structure as a mechanism to leverage EII conversations and decisions.

Table 2. Example of Three-Year District Plan for Transitioning Middle School Science from the Discipline Specific to the Integrated Model

	6th Grade	7th Grade	8th Grade
Year 1 2015-2016 '98 Standards/NGSS	Heat (NGSS) Weather/Climate Natural Resources/**Human Impact** (NGSS) Geology	Cells/Organisms (NGSS) Genetics Evolution/Earth History **Ecosystems** NGSS)	Chemistry (NGSS) Physics Astronomy (NGSS)
Year 2 2016-2017 NGSS with Content Shifts	Heat (NGSS) Weather/Climate Natural Resources/Human Impact (NGSS) **Cells/Organisms** (NGSS)	**Cells/Organisms** (NGSS) Ecosystems (NGSS) **Chemistry** (NGSS)	**Chemistry** (NGSS) Physics – **Waves and Energy** (NGSS) Astronomy (NGSS) **Engineering** (NGSS)
Year 3 2017- 2018 Full Implementation of Integrated NGSS model	Heat (NGSS) Weather/Climate Natural Resources/Human Impact (NGSS) Cells/Organisms (NGSS) **Engineering** (NGSS)	Ecosystems (NGSS) Chemistry (NGSS) **Natural Resources/Geology** (NGSS) **Human Impact** (NGSS) **Engineering** (NGSS)	Physics – Waves and Energy (NGSS) Astronomy (NGSS) Engineering (NGSS) **Evolution – Genetics, Earth History** (NGSS) **Human Impact** (NGSS)

***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 7th grade life science teacher **loves** teaching cells and really didn't want to let go of this topic. And the 6th grade 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 7th grade teacher still gets to teach it for one more year. But the 7th grade teacher also had to seriously help the grade 6 teacher with cells that same year. It was a win-win. The following year, the 7th grade 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 6th grade.' At the same time, the teacher was getting excited about teaching some new things, and, like the 6th grade 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.*

***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.

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

The principal pointed out that her school had some advantages and disadvantages in making this transition compared to some other middle schools. Advantages were that grade 6 received a full period of science instruction throughout the year versus some middle schools where grade 6 can be a mathematics and science combination; such teachers already are grappling with implementing Common Core mathematics and would be hard pressed to deal with changing science as well. Having only one teacher per grade also made this 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 7th and 8th grade 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 (61%) of middle grade science teachers in EII reported that the Initiative had enhanced their ability to integrate the sciences (physical, earth, life) "moderately" or "a lot". While that means a strong majority felt the EII project was helpful, at this project midpoint one-third of participants still felt that the project only enhanced their ability "a little" (30%) or "not at all" (9%).

In a summer 2016 evaluation survey, over 100 teachers of grades 6, 7 and/or 8 wrote comments when asked, "Describe your biggest challenge(s) in transition to the Integrated

Model." Below are the most common topics raised with the percentage of respondents who elected to focus their answer on that topic, followed by sample remarks. Only one percent (1%) of respondents wrote that there were "no challenges."

17% lack of existing curricula and/or science material resources
16% specific science topic transitions that pose a challenge for the respondent 12% lack of content knowledge required by the revised courses
10% time needed to learn, plan and implement changes
7% collaborating with other teachers to effect the transition
7% identifying real-word phenomena authentically involving multiple disciplines

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 categories cover about 70% of the comments offered. The other 30% of the comments focused on topics that garnered attention from one to five percent (1- 5%) 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 (6%) 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 connection 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 EII districts are about to venture into full middle school integration where much or all of the year's instruction involves addressing real-world phenomena that involve multiple science disciplines in a connected way. Most EII 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 [2016-2017], 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 cored 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% 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.*

Appendix: 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 discipline-focused model), because:

- it provides opportunities for all students to learn about the nature of science and its relationship to engineering design;
- it builds knowledge in all 3 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 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); and

- 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.

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; Performance expectations, 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 (PEs) or disciplinary core ideas (DCIs) organized by discipline (as it is in the discipline model)

California Science Framework, Draft 2 (June 2016)

Much more rationale is given for why to use an Integrated Model than in the previous draft. They make more explicit their focus on using the crosscutting concepts (CCCs) from NGSS as the basis for units of teaching and provide evidence for why to focus on CCCs 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 vs. 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 of all three dimensions of the NGSS. Integrated science courses do allow for this interdisciplinary approach and the application of all dimensions of NGSS including the disciplinary core ideas (DCIs), crosscutting concepts (CCCs), and science and engineering practices (SEPs).

A comparison in the cognitive level of the previous (1998) standards and this new Integrated Model is made, which highlights how much more cognitively demanding and developmentally appropriate NGSS is, especially if using the Integrated Model. (This same section is also included in the introduction to the Discipline Specific Model.)

Returning Science as a Core Subject

Science Has NOT Been a Core Elementary School Subject

Implementing 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).

There may be several reasons why science has not been a core subject in CA elementary schools for well over a decade, but one that is easy to point to is the *No Child Left Behind* assessment, passed in 2002. As SBE member Trish Williams wrote earlier this year, "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." (Williams).

- The percentages of teachers at grades K-3 and 4-6 who taught science "some weeks, but not every week" were 41% and 32%, respectively; in contrast 99% of elementary teachers across all grades said they taught mathematics all or most days, every week.
- The numbers 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.

In EII Districts, the Needle IS Moving

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

- At the elementary level, the worst-case scenario of little or no science has nearly been eliminated among the project'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 all district teachers who provide science instruction, not just among the project's Teacher Leaders.
- Not surprisingly, the most common factor cited as prompting increases in science instruction was the training and support of the EII.
- EII 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 EII 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?" As a contrasting benchmark, the priority of ELA is 10. Answers ranged from 6 to 9 for science. Project Directors felt that these ratings were higher than two years ago. 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 EII 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 (CLT) for the project similarly were asked about the priority of science in their districts during project year two (2015-2016).

> Teacher members of the CLTs (N = 70) agreed that: "Science instruction was a priority at my school" (73%); and "Teachers at my school were encouraged by administrators to teach science (77%).
>
> Administrator members of CLTs (N = 37) similarly agreed that: "Improving science was a priority in my school(s)" (76%); and "Teachers in my school(s) were encouraged by the administration to teach science" (84%).

Increasing K-5 Science Minutes

Clearly, in order for a district to make the key instructional shifts needed to implement NGSS, adequate time must be devoted to science instruction. In most, if not all, of the EII districts, this meant an increase in minutes spent teaching science as compared to the start of the Initiative. In fact, changes in instructional time are taking place. About two-thirds of the members of the districts' Core Leadership Teams (CLT), when asked about the 2015-2016 school year, related that:

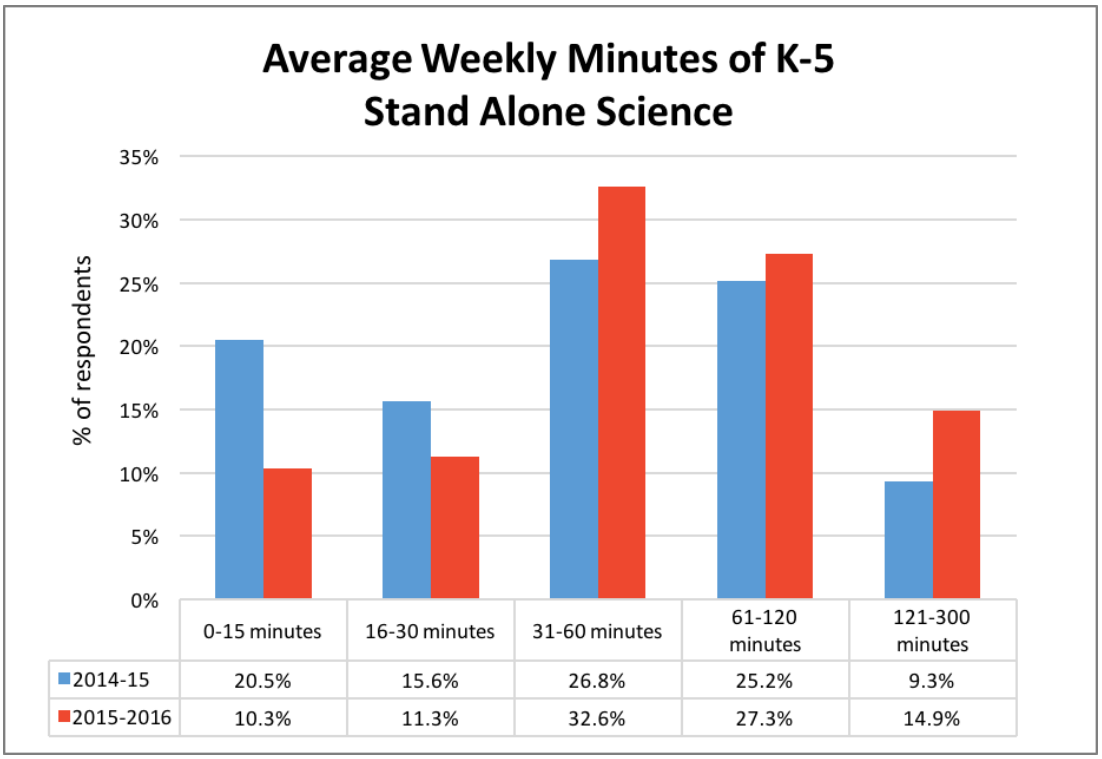
> "**Most** [emphasis added] teachers in my school(s) devoted more instructional time to teaching science compared to previous years".

That is, 61 percent of teachers and 72 percent of administrators on the Core Leadership Teams agreed with the above statement.[7] Similarly, the hundreds of grade K-5 Teacher Leaders in the

[7] 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 EII.

EII agreed with a statement that they personally spent more time on science in project Year 2 than they did in Year 1.[8]

Based on an end-of-year survey by hundreds of EII Teacher Leaders and Core Teacher Leaders (N = 285, an 85% response rate), data in **Figure 6** 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.[9] One fifth of K-5 teachers (20%) reported teaching only 0-15 minutes of standalone science during the first year in the project (2014-2015) while only one tenth (10%) still report spending such little science time in the project's second year (2015-2016).



	0-15 minutes	16-30 minutes	31-60 minutes	61-120 minutes	121-300 minutes
2014-15	20.5%	15.6%	26.8%	25.2%	9.3%
2015-2016	10.3%	11.3%	32.6%	27.3%	14.9%

Figure 6. Responses of Core Teacher Leaders and Teacher Leaders, Classroom Science Teaching Survey, administered summer 2016. N=285.

The data in **Figure 6** 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;

[8] 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.

[9] 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.

- One quarter of teachers (25%) spent 1-2 hours on standalone science and this value was about the same from Years 1 to 2; and
- The proportion of teachers spending 2-5 hours on science increased from 9 to 15 percent. [10]

The total average number of minutes per week for standalone 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% of their comments), listed in order of the percentage of teachers mentioning them:

46%	instruction and support from the EII project
13%	increasing science by integrating with English Language Arts
9%	increased confidence in teaching science
8%	changes in district guidance or expectations

Given that the major influence in teachers spending more time teaching science is the instruction and support received through the Initiative, non-EII districts interested in enhancing science instruction should consider that providing some professional development 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 TLC group [Teaching Learning Collaborative] 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 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's easy to assume that all science teachers in middle schools teach science every day. At grade 6, however, science can officially be combined with another school subject (e.g., mathematics or language arts) and only receive a portion of the class period. Some EII

[10] This report's values cannot be directly compared to the studies cited earlier (i.e., Center for the Future of Teaching, 2011; Banilower et al., 2013). Those surveys asked a single question about science teaching while the current evaluation asked respondents about time for standalone science, science during ELA, and science during mathematics. The notion here is that the best indicator for the topic of whether science is a core subject is the measure of standalone science, reported above.

districts in that situation are implementing plans to have science be a standalone course in sixth grade, 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 standalone science. Two schools have already made the change.*

Project Directors in some other districts feel that only a little headway has been made on this challenge, thus far. 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 seven and eight is more likely to be year-long courses, but there are occasional exceptions. For example, there are EII 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 year long program.

It is worth noting here that the 8th grade 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 2017-2018 and be fully operational in 2018-2019.

Making Science Explicit in the LCAP

District leaders are using a variety of policies and practices to make science more of a priority. Two more particularly important policies or practices that districts commonly are advancing to increase science as a priority are now discussed.

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 such expenditures as these: 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 are being successful in garnering science allocations beyond the required matches.

A key contributor to some Core Leadership Teams' success in gaining tracking 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:

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.

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 doing science as part of meeting ELA requirements;[12]**
- **conveying a preference *not* to pull students out of science instructional time for whatever reasons; and**
- **encouraging teacher Professional Learning Communities (PLCs) to devote time to science.**

Making Substitute Teachers Available for Science in the Face of Shortages

The Initiative funds substitute teachers to release project teachers for professional development.[11] But a general lack of substitutes in every district and an acute lack in some is preventing teachers from fully participating. At about half of the dozens of CLT and TL 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 increase support for their teachers to attend. In a way, Project Directors' ability to ameliorate the problem is an indicator of districts making science a stronger priority; in some instances professional development projects in other subject areas have been made to share the burden in addressing this problem. Project Directors have used such strategies as those below.

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 CLT 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 project events to dates known to have better substitute availability. For example, a

[11] In grant years 3 and 4, districts take up more of these costs directly with non-grant funds in order to increase buy-in toward institutionalizing the costs of science PD by the end of the grant.

[12] It is important to note that the EII project does not advocate that elementary science should be limited to being in the service of ELA. In order to adequate 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 it to count as ELA time.

Project Director had noted substitute availability on an originally scheduled project 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 CLT meeting.

Becoming Science-Centered Schools

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

- outreach to increase parent awareness of and buy-in to 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 NGSS and science education; and
- 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 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 complained 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; in fact, it is the preferred model of the State Board of Education.

Future EII Evaluation Updates

There will be a series of evaluation updates over the final two years of the Initiative. Topics that are under consideration include the following. (Project year in parentheses following each entry indicates when evaluation data likely will first be available to adequately discuss the topic for publications.)

- *Leadership Growth* (includes the following) (Y2, already available):
    - Co-Construction by District Project Directors and K-12 Alliance Staff
    - Leadership Team Members Already Taking More Leadership Actions
    - Value-Added District and State Science Capacity for the Future
- *Spread to All Teachers* (includes the following) (Y3):
    - Beginning Special NGSS Outreach Sessions to Prepare the Way
    - Tapping Existing District Professional Development for Science
- *The District Plan* (process and product) (Y2, already available)
- *Update(s) on Project-Wide Implementation of the Integrated Model*, Including a look at credentialing issues (end Y3+)
- *What Does the Integrated Model look like in the Classroom?* (end Y3)
- *What Does Science integrated with ELA look like in the Elementary Classroom?* (end Y3)
- *Update(s) on Student Energy for Science Overcoming Teacher Fatigue from Common Core* (Y3)
- *Update(s) on Science as a Core Subject* (includes building community support) (end Y3+)
- *The Status of NGSS Implementation* (e.g., 3D, phenomena, project level) (end Y3+)
- *Full EII Impact of Lighthouse Activities (*including K-12 Alliance*)* (end Y3+)
- *How to Leverage Administrators and How Administrators Can Leverage Change* (including superintendent/Board turnover) (end Y3+)
- *What does NGSS look like in the classroom?* (Y3+)
- *Biggest Changes among Case Study Teachers* (end Y3+)
- *Participant Views of Most Impactful EII Components and their Costs* (Y4)
- *Changed Student Interest in Science* (Y4)
- *Contrasts on implementation between EII and non-EII districts interested in NGSS* (Y4)
- **Guide to District Implementation** (documents and describes major project activities and provides key tools and processes, not a “How To” manual) (Y3+)

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K-8 NGSS Early Implementer Initiative Glossary

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

Core Leadership Team (CLT) – Group of 3-5 administrators and 5-8 teachers at each district. The CLT meets with their Project Director and Regional Director for six Technical Assistance Days during each school year to plan and lead all EII activities.

Core Teacher Leader (CTL) – Teacher member of the Core Leadership Team. Provides professional development to Teacher Leaders and other teachers in their district. Provided leadership at EII Summer Institutes.

K-8 NGSS Early Implementation Initiative (EII) – Four-year project (summer 2014 to spring 2018) supporting implementation of NGSS by 8 public school districts and 2 charter management organizations in CA. Developed by K-12 Alliance at WestEd in collaboration with State Board of Education, CA Department of Education, and Achieve, the EII builds capacity of participating LEAs to fully implement NGSS in grades K-8.

K-12 Alliance – A WestEd program of science education leaders and professional development providers who plan and deliver all project-wide activities.

Local Control and Accountability Plan (LCAP) – The LCAP is a critical part of the new Local Control Funding Formula (LCFF) for school districts in CA. 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 EII project leaders (RDs and PDs) to foster understanding of the shifts in teacher practice required to implement NGSS in the classroom

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

Professional Learning Community (PLC) – Not directly part of EII project. Regular teacher-led meetings for professional development on topics of their choice.

Project Director (PD) – Responsible for leading all EII activities for the district and representing the district at monthly project-wide planning meetings.

Regional Director (RD) – Member of WestEd's K-12 Alliance staff assigned to provide leadership and support to 1-2 EII districts.

Summer Institute – Week-long professional learning event held every July-August attended by all project participants, some (Regional Directors, Project Directors, Core Leadership Team members) as leaders and others (Teacher Leaders) as learners.

Teacher Leader (TL) – 40-60 teachers in each EII districts. Joined the project one year after the Core Teacher Leaders.

Teaching Learning Collaborative (TLC) – Lesson study activity brings together 3-4 same-grade EII teachers from different schools within the district. Teachers plan and teach a lesson to two classrooms of students. Each Teacher Leader participates in 2 TLCs per year.

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