OCTOBER 2017 | EVALUATION REPORT #2

The Synergy of Science and English Language Arts

Means and Mutual Benefits of Integration

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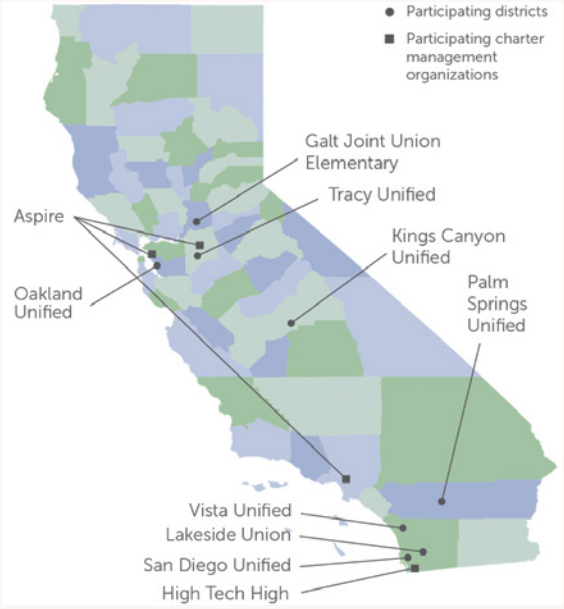
NGSS EARLY IMPLEMENTERS

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 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 Early Implementers Initiative

The S. D. Bechtel, Jr. Foundation commissions WestEd's STEM Evaluation Unit independently of the K–12 Alliance to evaluate the Initiative in the eight public school districts. The evaluation is advised by a technical working group that includes representatives of the California Department of Education and the 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.

In addition to this current Report #2, evaluators previously wrote *The Needle is Moving in California K–8 Science* (Report #1, October 2016), which describes the Initiative's early progress on three implementation goals: integrating science and ELA, integrating the sciences in middle school, and making science a core school subject. Evaluators plan future reports on these topics:

- The role of administrators in NGSS implementation (fall 2017)
- 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

The California K–8 NGSS Early Implementers Initiative (known in short as the Early Implementers Initiative) is equipping teachers to richly integrate science and English language arts (ELA). In fact, the Common Core State Standards (CCSS) as well as the Next Generation Science Standards (NGSS) clearly call for such integration.

The nature of the NGSS and their recommended instructional approaches readily enable powerful ELA learning for all students. In a dramatic departure from science instruction that emphasizes scientific information and facts, NGSS science has students working as scientists to make sense of phenomena in the natural world. The NGSS approach requires a lot of lively discussion, critical reading, and thoughtful writing and drawing. Initiative teachers have clearly demonstrated that integrated science instruction is accessible to English learners and that these learners get strong ELA benefits from science instruction.

While the Initiative equips teachers to integrate science and ELA, it does not call for *all* science instruction to be a concerted blending of science and ELA. Indeed, teachers reported that half of their science instructional time was stand-alone science.

As a member of the State Board of Education commented during an advisory board meeting for the Initiative's evaluation: "Everyone is saying you should integrate science and ELA, but *what does that actually look like in the classroom*?" This report — intended for state and district leaders, including principals — addresses that question and several others highlighted below. To get answers, the evaluation team observed all key professional development sessions and 20 classroom lessons, surveyed over 500 teachers, interviewed Initiative leaders, and more.

How much instructional time are teachers spending on integrating science and ELA?
Almost half of the elementary teachers (45 percent) and over half of the middle school teachers (52 percent) now teach 60 minutes or more per week of science that is *integrated with ELA*. When the Initiative began three years ago, a third of the elementary-level teachers were teaching *no* science integrated with ELA.

What does this integration look like in the classroom?
The heart of the report, and its Appendix A, describe in some detail eight lessons that exemplify instruction integrating science and a range of CCSS-ELA. Five of the CCSS-ELA standards are now being addressed in science by a majority of the Initiative's teachers (62 to 93 percent of teachers), and all CCSS-ELA standards are being addressed by at least some percentage of the Initiative's teachers.

How are students benefitting from the integration?
While it is beyond the scope of the current evaluation to analyze students' ELA test scores, the report contains many examples of strong student engagement and learning through science–ELA integration evaluators have seen and heard. For instance, a middle school principal was particularly impressed by the students' discussion in a class working on the phenomenon of mudslides:

> *It was a totally different science class than I'd ever seen. The kids were talking about particle size, particle structure, friction. It was like little soil scientists in there talking about why a mudslide happens, and I went, "Wow this is really something!" Just the way they talked to each other and the way they listened to each other and the way they questioned each other. It was like a college class.*

And a teacher noticed a variety of benefits of integrated instruction for the English learners in her class:

> *I noticed a huge increase in the comfort of English learners with speaking, reading, and writing when these tasks included science. They were eager to participate, express their findings, and ask more questions. The students also used higher level thinking skills and a broader vocabulary, and were more willing to take chances and try new things. This exuberance for learning spread across other subjects, and they used the vocabulary in other situations.*

How is the Early Implementers Initiative empowering teachers to integrate science and ELA?
Almost three-quarters of surveyed teachers (72 percent) now report that the Initiative has enhanced their ability to connect CCSS and NGSS instruction by "a lot" or "moderately." The Initiative has used several approaches to empower teachers to integrate science and ELA. For instance, teachers get to experience NGSS instruction as learners: They spend about half of each annual, week-long professional development session investigating science phenomena, including working with consultant scientists. The Initiative also helps teachers use several tools and strategies that promote both ELA and science learning, including: using the 5E instructional model to scaffold lessons; helping students make sense of science through writing in science notebooks; and using Claims, Evidence, and Reasoning (CER) and questioning strategies to promote critical thinking and productive writing, speaking, and listening. In addition, the Initiative is supporting teachers by directly engaging their principals.

Recommendations to administrators for supporting science–ELA integration
About two-thirds (65 percent) of Early Implementer teachers now report that their principals are "very" or "somewhat" supportive of their teaching science integrated with ELA during time allotted for ELA. On the other hand, this summer (2017), almost half (47 percent) of Initiative teachers still identified "prioritization of other school subjects" as one of their three biggest barriers to implementing the NGSS.

In order to implement the CCSS and the NGSS as intended, administrators should advocate integration of ELA and science instruction and actively support teachers in accomplishing it. At a minimum, administrators need to endorse counting integrated science–ELA instruction as some part of required ELA instructional time. In districts with prescriptive ELA programs, it is in both their ELA and NGSS interests to find ways to allow flexibility for science–ELA integration. Early Implementer administrators who observed some integrated science–ELA instruction felt much more empowered to be active promoters and supporters of integration.

Introduction

From the outset, the Next Generation Science Standards (NGSS) Early Implementers Initiative has had a strong focus on empowering kindergarten to grade 8 (K–8) teachers to integrate instruction in science with English language arts (ELA).[1] This emphasis is a response to the research-based priority that both Common Core State Standards (CCSS)-ELA and NGSS place on integrating science and ELA. While the NGSS promote integration of science with both CCSS-ELA and CCSS-mathematics, the combination of science and ELA has natural advantages, given that science practitioners engage in reading, writing, and listening.[2] This emphasis also fits with the K–12 Alliance at WestEd's substantial experience showing that integration of science and ELA benefits students and teachers.

While integration of science and ELA is valued in concept, it can be elusive to understand in practice. As a member of the California State Board of Education commented at an Initiative evaluation meeting, "Everyone is saying you should integrate science and ELA, but *what does that actually look like in the classroom?*" This report — intended for state, district, and school leaders — aims to answer that question and several others:

- How much instructional time are teachers spending on integrating science and ELA?
- What does this integration look like in the classroom?

> If I could teach science all day long, I would. I know how powerful it is. You can integrate it into everything. You can integrate all of your standards. (Grade 1 teacher)

- How are teachers and students benefitting from the integration?
- How is the NGSS Early Implementers Initiative empowering teachers to integrate these subjects?
- What should administrators keep in mind for their support of science–ELA integration?

Methods

This second report in a series of Early Implementers Initiative evaluation publications draws on the following two primary data sources:

- Observation of and interviews with 20 science case study teachers across five of the eight districts participating in the Early Implementers Initiative
- Two annual surveys of the K–8 science Teacher Leaders who have received professional learning through the Initiative (over 500 teachers):
  - Classroom Science Teaching Survey (97 percent response rate)

1 In an analysis of the agendas across all Initiative-wide professional development events, evaluators noted that 20 percent of the event time was focused on helping teachers integrate science instruction with ELA.

2 Two Early Implementers Initiative district Project Directors have written about the rationale for the integration of science and ELA advanced by the Initiative and other sources (i.e., A'Hearn, 2017; Tupper & Ochoa, 2017).

- Teacher Leadership Survey (96 percent response rate)

Please note that district Project Directors in the Initiative nominated the case study teachers as ones who are making some of the most substantial changes in their teaching in relation to the NGSS, spurred by their participation in the Initiative. The exceptionally high survey response rates suggest that this report's discussions of survey data describe the responses of almost *all* teachers in the Initiative. These teachers have been receiving substantial professional development through the Initiative. Appendix B provides the specific questions from the interviews and surveys that evaluators examined for this report.

Secondary evaluation data sources for the report are:

- Interviews with two administrators in each of the eight participating districts
- Interviews with all district Project Directors and K–12 Alliance Regional Directors
- Review of participating districts' 2016–17 annual grant reports
- Survey of all students in the classes of 40 teachers who were nominated as strong NGSS implementers
- Observation of key Initiative-wide professional development sessions, including an academy for administrators

The Argument for Integrating Science and ELA

Science taps into the natural curiosity and energy of young people, and NGSS science — because it is inquiry-based and student-centered — provides content that engages and motivates students to step up and apply themselves to challenging tasks (Gomez-Zwiep & Straits, 2013; Worth, Winokur, Crissman, Heller-Winokur, & Davis, 2009). ELA tasks, including reading complex texts, formulating arguments, constructing explanations, and defending claims, are not so daunting when they are a path to understanding something students really want to know.

The benefits of NGSS instruction, especially with purposeful integration with ELA, can include:

- Enhanced student engagement
- Improved ELA skills[3]
- Stronger critical thinking

The NGSS provide a blueprint through which students learn, based on three dimensions:

- Disciplinary core ideas (DCIs): *What* scientists know
- Science and engineering practices (SEPs): *How* scientists learn
- Crosscutting concepts (CCCs): How scientists make connections across the sciences

Accordingly, routine science instruction should be "3D," incorporating all three of these dimensions in concert.

3 Collection and analysis of ELA test scores in the NGSS Early Implementers Initiative districts is beyond the scope of the current evaluation.

Supporting English Learners

NGSS science can fuel active learning across a continuum of subjects and skills. The benefits of NGSS science are equally applicable, if not more so, for English learners (Lagunoff, Spycher, Linquanti, Carroll, & DiRanna, 2015). Although it is no longer as commonly practiced, well-meaning instructional policies in the past have excluded English learners from access to grade-level science classes to provide them with more focused language training instead. This sort of exclusionary practice has been shown to be counter-productive (Gomez-Zwiep, Straits, Stone, Beltran, & Furtado, 2011). In *Unlocking Learning: Science as a Lever for English Learner Equity*, The Education Trust-West (2017) cited several research studies, all of which support the claim that engaging in NGSS science *contributes* to the English language development of English learners. English language development researchers also agree that students without English language proficiency can learn complex scientific content.

Note that the Initiative does not call for every moment of science instructional time to be a concerted blending of science and ELA. Indeed, teachers reported in a survey that about half (51 percent) of their science instructional time was stand-alone science.

The Integration Intent of the Standards

NGSS

It's not just the Early Implementers Initiative that is advocating integration of science and ELA — the relevant standards themselves explicitly call for it. Many non-science educators are pleasantly surprised to learn that the NGSS directly assist teachers in planning integrated lessons by listing relevant CCSS-ELA and math standards at the bottom of each page (see sample NGSS page, Appendix C).

Notably, it is the NGSS dimension of SEPs that most explicitly overlaps with the CCSS.[4] The Early Implementers Initiative strongly attends to the SEPs because, in a dramatic departure from traditional science instruction that emphasizes scientific information and facts, the NGSS have students engaging in practices that scientists use to make sense of phenomena in the natural world. Even a quick glance at the eight SEPs listed below readily suggests practices that address and integrate a range of ELA skills:

1. Asking questions and defining problems
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 and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Moreover, the new California Science Test (CAST), slated to be fully implemented by the 2018–19 school year, requires substantial writing. One principal from a school participating in the Initiative remarked, "Last year, during our summer NGSS leadership training, we got to see

4 For an illustration of how the NGSS SEPs relate to the CCSS, see Appendix D: Commonalities Among the Practices in Science, Mathematics, and English Language Arts.

what some of the new assessments may look like, and the amount of writing I saw floored me."[5]

CCSS-ELA and California English Language Development Standards

Early in the Initiative, some teachers experienced resistance from their administrators when merging science with ELA or English language development (ELD). "It was as if I was trying to sneak science into the school day or steal time away from ELA instruction," said one teacher. In fact, integrated teaching is fully consistent with the intent of the CCSS and the California English Language Development (ELD) Standards (California Department of Education, 2014, 2015). Appendix E provides more information about how these standards call for integration.

5 To see a practice science test, go to http://www.caaspp.org/practice-and-training/index.html and select the "Student Interface Practice and Training Tests." After entering, select grade 5 and/or 8.

Evaluation Findings

How Much Time Are Teachers Spending on Science and ELA?

When they joined the Early Implementers Initiative, the participating elementary school teachers were faced with the challenge of making room for something new and substantial in their already busy teaching schedules. Most had their hands full learning the new California CCSS. However, the agreement for districts joining the Early Implementers Initiative was that they would make science a core subject, on par with ELA and math.

Teachers found they could make time for science by integrating it with the subject they spent the most time teaching, ELA. This seemed a logical approach, given that the NGSS SEPs strongly involve a range of ELA skills. Most of the 328 Early Implementer elementary teachers in 2016–17 found ELA/ELD to be the content area most conducive to integrating NGSS science.[6] As one grade 2 teacher said:

> *The reality is, in order to effectively integrate NGSS, you have to look at it like that's your content. So, if you want to do informative writing or you want to do opinion writing, which is "claim and evidence" writing in science, or you want to even do research, when you use the NGSS as your content, it allows you to meet many, many standards. (Grade 2 teacher)*

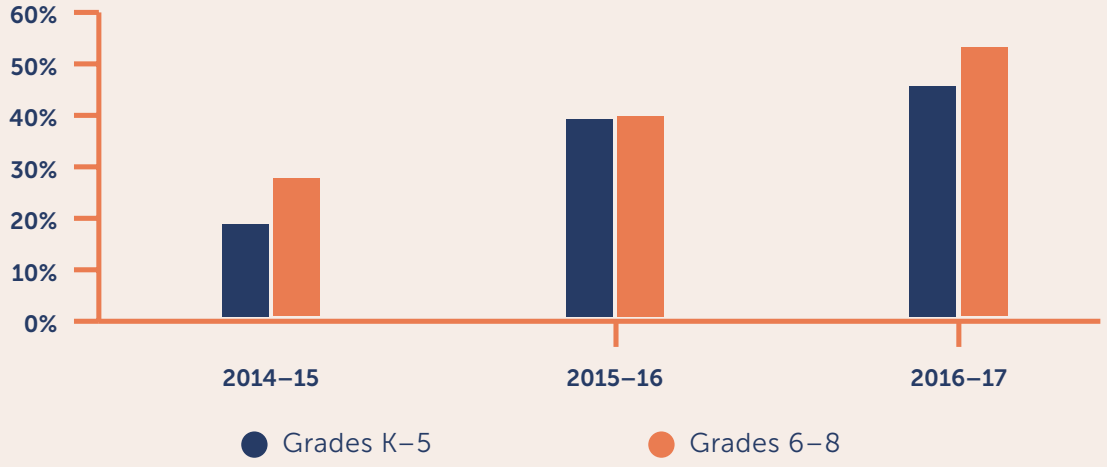
With each subsequent year of the initiative, K–5 teachers have reported spending more minutes teaching science integrated with ELA/ELD. In the beginning of the Initiative (the 2014–15 school year), one-third (33 percent) of elementary teachers reported teaching virtually *no* science integrated with ELA. By 2016–17, that percentage decreased to 8.5 percent. Figure 1 shows that for both middle and elementary school, the percentage of teachers teaching over 60 minutes of science integrated with ELA has increased since the start of the Initiative.

In 2016–17, all K–8 teachers were asked if they were teaching more science than they had taught the previous year. Fifty-five percent said yes. When asked to identify the strongest influences for this change, 35 percent chose "Understanding how to integrate science with CCSS-ELA standards" or "Understanding how to integrate science with ELD standards" in their top four reasons (out of 19 options). In fact, 80 percent of all participating teachers reported that they now understand "fairly well" or "thoroughly" how the NGSS relate to the CCSS-ELA.

Teachers' understanding of the SEPs, the NGSS dimension that is most central to science–ELA integration, has also increased. Over the last three years, the Initiative has made substantial progress in empowering teachers to use the SEPs. At the beginning of the Initiative, almost two-thirds of teachers (63 percent) reported not understanding the SEPs (i.e., they stated that they understood "not at all" or "poorly"). In 2017, almost all teachers

6 K–5 teachers reported that in 2016–17, 51 percent of their science instruction time was spent on stand-alone science, 31 percent was integrated with ELA/ELD, 12 percent was integrated with math, 7 percent was integrated with history/social studies, and 6 percent was integrated with another subject (August 2017 Classroom Science Teaching Survey).

Figure 1. Percentage of teachers teaching over 60 minutes of science integrated with ELA per week, 2014–15 to 2016–17



Source: Classroom Science Teaching Survey administered by WestEd in 2014–15 (N=316), 2015–16 (N=318), and 2016–17 (N=389).

(93 percent) reported understanding the SEPs "fairly well" or "thoroughly."

Teachers reported that they taught the entire range of CCSS-ELA during integrated instruction. As Table 1 illustrates, five CCSS-ELA standards emerged as especially conducive to integration.

What Does Instruction Integrating the NGSS and CCSS-ELA Look Like?

During the 2016–17 school year, evaluators visited and interviewed a total of 20 case study teachers in five of the eight Early Implementer school districts. To varying extents, all of the observed lessons addressed ELA, typically through emphasizing student engagement in the NGSS SEPs.[7] Further, some teachers volunteered science lesson plans in which target ELA standards had been expressly identified.

Following are four examples of rich science–ELA integration seen by the evaluators (Appendix A provides four additional examples). The first four examples in this section are descriptions of grade-level classroom lessons, and the final example in this section is a schoolwide instance in which an administrator led her middle school faculty in addressing writing across the curriculum, with science as the impetus.

Teachers reported that they taught the entire range of CCSS-ELA during integrated instruction.

Table 2 is an index showing the grade level of each classroom example in the main report and the appendix. The table also shows how each example links to the main ELA standards. The ELA standard for Language is not included in the table because it was not as prominent a feature in the observed science lessons.[8]

7 Evaluators were pleasantly surprised that they universally saw a synergy of science and ELA, particularly given that evaluators observed each teacher only once and they made no special request for the lesson focus or approach other than scheduling evaluators for a day on which there would be an NGSS lesson.

8 However, as shown previously in Table 1, the Language standard of Vocabulary Acquisition and Use was addressed by 64 percent of Early Implementer teachers.

Table 1. Common Core State Standards for English Language Arts that teachers addressed while integrating science with ELA during the 2016–17 school year

Answer choices	Responses Percentage of teachers	Responses Number of teachers
Reading: Literature	30%	110
Reading: Informational Text*	93%	340
Reading: Foundational Skills (K-5)	28%	103
Reading: History/Social Studies (6-12)	12%	43
Reading: Science and Technical Subjects (6-12)	28%	103
Writing: Opinion Pieces (K-5)/Arguments (6-12)	34%	124
Writing: Informative/Explanatory Texts	76%	277
Writing: Narratives	15%	53
Writing: Production and Distribution of Writing	12%	45
Writing: Research to Build and Present Knowledge	46%	166
Writing: Range of Writing	14%	50
Speaking & Listening: Comprehension and Collaboration	62%	227
Speaking & Listening: Presentation of Knowledge and Ideas	72%	263
Language: Conventions of Standard English	26%	93
Language: Knowledge of Language	19%	68
Language: Vocabulary Acquisition and Use	64%	233
Unsure	1%	5

Source: 2017 Classroom Science Teaching Survey administered by WestEd.
* Values in gray exceed 50 percent.
Note: Teachers were asked to check all that apply to the following question: "Which Common Core State Standards for English Language Arts did you address while integrating science with ELA during the 2016–17 school year?" These results are based on the survey responses of 419 K–8 teachers in the Initiative.

Table 2. Classroom examples of integrated instruction featured in this paper

Grade	Reading	Writing	Speaking and Listening	Science domain	Where to find the example
K		X	X	Physical, Engineering	Paper
1			X	Life	Appendix A
1	X	X	X	Life	Appendix A
2	X	X	X	Life, Engineering	Appendix A
3		X	X	Earth & Space, Engineering	Paper
6	X			Life, Earth & Space	Appendix A
7		X		Life, Earth & Space	Paper
8		X	X	Earth & Space	Paper

Observed NGSS Lesson: Kindergarten

In this kindergarten NGSS lesson observed by a WestEd evaluator, students conduct a hands-on investigation of the following phenomenon: Children can get hot and sunburned under the sun. Their focus question was, "How can we protect ourselves from the sun?" This NGSS lesson addresses the disciplinary core idea (DCI) *Physical Science 3.B: Conservation of Energy and Energy Transfer*. Students engaged in the science and engineering practice (SEP) of *Planning and Conducting Investigations*, and attended to the crosscutting concept (CCC) of *Cause and Effect*. At the same time students engaged in those NGSS practices, the teacher carried out this science and engineering lesson in ways that also had students engaged in the ELA standards described below.

Speaking and Listening: Comprehension and Collaboration. After watching and having students *discuss and describe*[9] what they noticed in a video showing sunburned children, the teacher asks, "How could they protect themselves from the sun? *Tell* your partner." Students animatedly engage in *collaborative conversations* with each other. The class then takes a short walk outside the classroom; they *talk about* where there is hot sun and where there is protection. A student points out that awnings provide shade. Returning to the classroom, the students eagerly *discuss* whether it matters what material the awning is made of.

The teacher gives small groups of students a popsicle stick structure with a penny inside. Group members *tell each other* the reasons they think one of several provided materials (felt, foam, paper, foil) will best protect the penny. They clearly have experience working in groups, evidenced by their ability to *compare ideas and listen* to one another. Group members must come to *agree* on one material to test that they predict will work best.

Writing: Informative/Explanatory Texts. Before they can begin to build, group members *draw or*

9 Student actions that represent ELA skills are highlighted in italics.

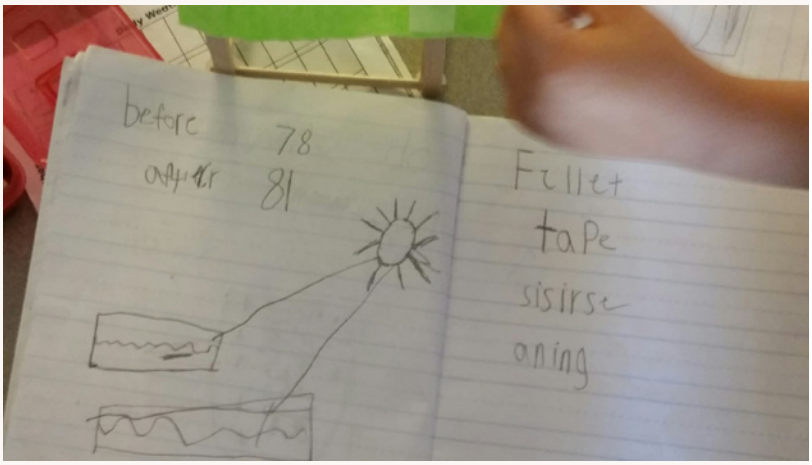
write in their notebooks what they will need to build an awning to keep a penny from getting hot. After cooperatively building the awnings, all students *draw* their designs, and more proficient writers also include *labels*. Before going to recess, students place their shelters under a heat lamp. Using a hand-held temperature gun, students measure the temperature of a protected penny (the experimental group) and an unprotected penny (the control group). They record their pennies' temperatures in a data chart.

After recess, the protected and unprotected pennies' temperatures are again measured and recorded. The before and after temperatures are placed on a number line, with much *conversation* about which temperatures are the highest. Concluding the lesson, the teacher leads students in an active *discussion* of the following questions: "What did you observe?" "Do you see patterns in these numbers?" "Was your awning successful? How do you know?"

Directing students back to their notebooks, the teacher then asks, "Did your prediction match your observation? Which material or materials worked best to kept the pennies cool? If you did this investigation next week, what would you change?"

Observed NGSS Lesson: Grade 3

Having already learned about the water cycle, discussed weather and weather hazards, and tested a variety of materials to see if they absorb or hold back water, in this grade 3 NGSS lesson, students designed a solution for a house in danger of being damaged by a flood. The lesson addressed the NGSS DCI of *Earth and Space Science 3.B: Natural Hazards*; the SEP of *Planning and Carrying Out Investigations*; and the CCC of *Structure and Function*. Half of the students in the class were English learners.



Speaking and Listening: Comprehension and Collaboration, Presentation of Knowledge and Ideas. The class *watches a video* of flood waters doing damage to residential areas, in some cases sweeping houses away. The teacher tells students they are going to build protections for their own "houses." Each group of four gets a plastic 12 x 6-inch tub and a small plastic "house" with an open doorway. They can choose five items in any combination from the materials provided — cotton balls, gravel, sand, and sand bags — to protect the house from water. The challenge: "Which items would you use and where would you put them in the tub to keep water out of your house for one full minute?"

Students individually choose and *write* in their notebooks a list of the five items they want. They then find others with the same plan and form teams. Team members *present their ideas* to their teammates and the groups *collaborate* to create designs, *draw* their plans, get their materials, and build their protections. Before testing, students are instructed to *write a prediction* of what they think they will see when the designs are tested.

Then, one by one, each tub is brought to the front of the room, the group *presents to the class* what they did and why. The group then prepares to *record* in their notebooks what they observe

during the minute that their design is tested. For each test, the tub is put under the document camera, the teacher puts a dry rock inside the house, a student starts the one-minute timer, and the teacher adds water. After each test, the teacher holds up the rock so everyone can see if it is wet, and the class *comments* on how well the design worked.

After all the tests, the whole class *discusses* what they observed about the materials and designs, and students *compare this information with the predictions they wrote* in their notebooks. The students have many ideas, and there is an animated *discussion* in which students *make claims* about why water got through some designs and not others.

Writing: Informative/Explanatory Texts, Research to Build and Present Knowledge. Before the class ends, the teacher asks the class to *write* in their notebooks what did and did not work, based on what they observed. The students also describe how they would change their designs in the future.

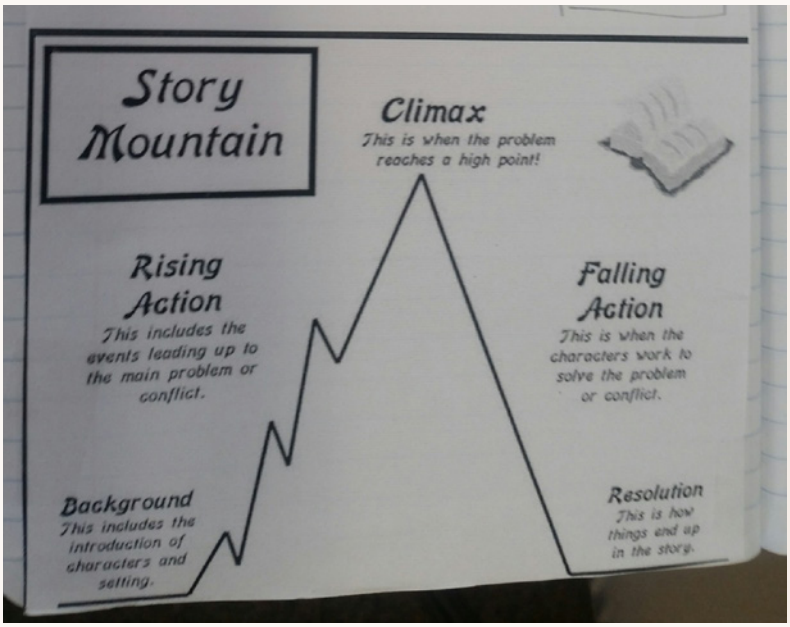
Observed NGSS Lesson: Grade 7

This middle school unit on coral bleaching integrates math as well as ELA. The DCIs addressed are *MS-LS2 Ecosystems: Interactions, Energy, and Dynamics* and *MS-ESS3 Earth and Human Activity*; the SEPs include *Analyzing and Interpreting Data* and *Obtaining, Evaluating, and Communicating Information*; and the CCC employed is *Stability and Change*.

Writing: Informative/Explanatory Texts, Narratives. The class is learning about the phenomenon of coral bleaching. Over three weeks, they have been *recording in their notebooks* their growing understanding of what coral needs to survive and the causes of coral bleaching in preparation for a story that they will write. The group has observed shells and chalk in different percent solutions of vinegar to *investigate* hazards of ocean acidification that corals face and watched video clips about the hazard of sedimentation. After *graphing* 20 years of ocean temperatures, students *discuss* patterns they notice in the data. Then they *read and annotate* a timely news release about scientists having discovered the worst Great Barrier Reef coral bleaching in recorded history. Students *discuss* the article in small groups and then as a class.

In their science notebooks, they each draw a model, including *pictures, labels, and explanations*, to represent their current understanding of coral bleaching. The model must answer two questions: (1) When coral is bleached, what happens to the coral and the algae, and why? and (2) Why is the ocean temperature warming?

Finally, to demonstrate their understanding in a summative assessment, students *write a narrative* about coral bleaching, following the story planner shown in the photograph, which was provided to the science class by an ELA teacher.



Observed NGSS Lesson: Grade 8

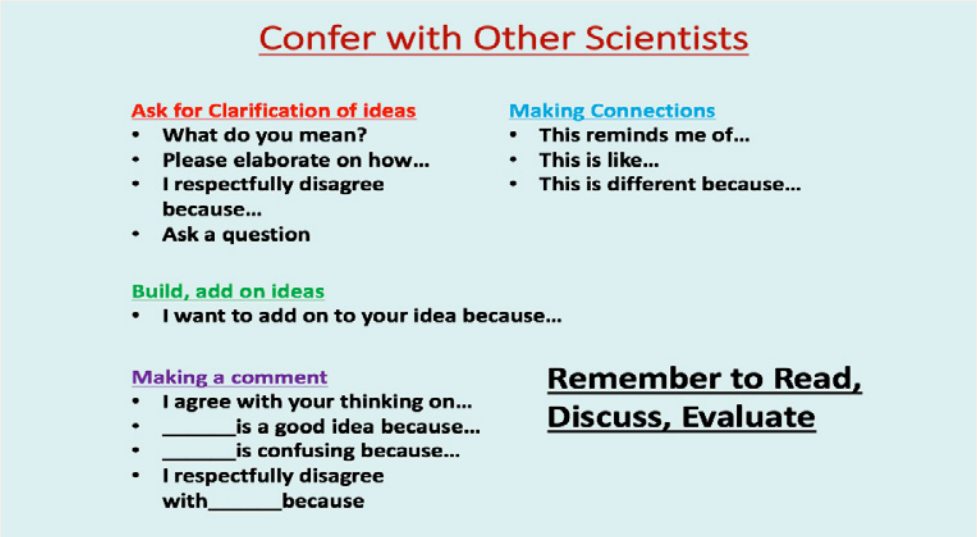
This grade 8 class recently investigated why the moon can be seen during the day. This particular lesson focuses on "investigating moon patterns." The lesson incorporates the DCI of *MS-ESS1 Earth's Place in the Universe*; the SEP of *Engaging in Argument from Evidence*; and the CCC of *Patterns*. The students are grouped so bilingual students can support English learner classmates. According to the teacher, "The kids verbally express themselves at an eighth-grade level, but their writing and reading skills are much lower." One way the teacher pays special attention to students' literacy and language abilities is by providing them with sentence frames, a type of scaffolding for English learners recommended in the California ELD Standards.

Speaking and Listening: Comprehension and Collaboration. Class begins with a video showing the moon phases. After watching, students record in their science notebooks what they noticed and what they wonder, which they then share with the rest of the class. One group of primarily Spanish-speaking students *discuss in Spanish* the patterns in the moon phases they noticed. Others *call out their thoughts and questions*, which include: "I noticed the moon is spinning." "I wonder if the moon is orbiting and spinning along with the Earth." "Is the moon a shadow of the Earth?" "Is the moon changing form? Going from a whole to a half to a quarter?" The teacher tells the group that many of these questions are very relevant to what they will be doing in this unit. Today they will be looking for patterns in the hours that the moon rose and set from data they collected for a two-month period in their "moon journals."

Writing: Arguments. As students *discuss* patterns in the data with their group and *write* their observations in their notebooks, they are asked to keep one of three claims in mind: "The moon is always visible in the night sky," "The sun and the moon are never visible in the sky at the same time," or "The moon rises and sets in predictable patterns." They are going to use evidence from the data to either *support or refute one of the claims* and create a Claim, Evidence, Reasoning (CER) chart in their groups. The teacher prompts the class to think about how much evidence they need to support or refute a claim. He also provides a sentence frame that can be used for a reasoning statement: "The claim ___ is valid/invalid because ___. This is based on the specific evidence of ___ (be specific)."

Groups energetically *compare and debate* ideas in their groups before *recording* their CER charts on their group posters and in their individual science notebooks. They will *present* these posters to the class tomorrow, and following the sentence stems and discussion starters listed in the classroom "Confer with Other Scientists" schema (Figure 2), they will *discuss* one another's evidence and reasoning, and *suggest* potential revisions or additions to their charts.

Figure 2. Classroom schema: Conferring with other scientists



Source: Developed by a grade 8 teacher observed by the evaluation team.

Observed NGSS Program: Middle School Writing-Across-the-Curriculum Program

This example describes the birth of a schoolwide writing-across-the-curriculum program, based on the SEP *Engaging in Argument from Evidence.*

Administrators at the 2017 Early Implementers Summer Institute were offered a session entitled *Keeping Science at the Core with a Schoolwide Writing Focus*. The presenter was a principal of a middle school with 100 percent of students receiving free and reduced-price lunch and a high percentage of English learners. She shared that the previous year she decided to make writing the focus for her site. She had been concerned that her students, particularly English learners, would not be prepared for the upcoming state science test: "Our students know a lot but they're used to responding verbally or in pictures, and if the assessment is asking you to also be able to put those ideas into writing without scaffolds, then we really want the students to be prepared for that."

Her goal was to help teachers of all subjects enhance the role of writing in their courses. She related that "they all needed to know how to help students construct a strong response. I wanted them to work on Claim, Evidence, and Reasoning [CER]." (CER is based on the NGSS SEPs, primarily *Engaging in Argument from Evidence,* and has been emphasized as a teaching strategy in Early Implementer training.) Since the English and history teachers at her school were not familiar with this approach to writing, the principal decided that the first steps needed to focus on making language common across the curriculum. She wanted there to be a consistent expectation for students regardless of the class they were in.

She advised attendees, "Grade-level meetings are a perfect place for teachers to look at the CCSS connection boxes at the foot of the NGSS standard pages [see Appendix C]. ELA and math teachers don't get to see the NGSS standards very often." Her site teams worked in professional learning communities (PLCs) and she provided extra professional development training time. The faculty

focused on how to teach students to produce a topic sentence and a conclusion. They also developed a writing prompt in science and calibrated and scored together. The principal described the work of the site teams:

> *There were lots of aha moments: The students' paragraphs were not strong. The teachers' prompts were not open-ended enough and didn't elicit evidence. We all wondered, "Do we revise the rubric? What do we do?"*

> *We realized we needed practice in writing good prompts. . .In the test, there's no teacher interaction — there's just an empty response box for students to write. We need to prepare students to do that on their own without scaffolds. Not everything is a test score. But students can be easily discouraged, especially English learners. They need the tools to be able to be independent writers.*

How Are Teachers and Students Benefiting from Integration?

> *Students are way more engaged, and they're excited about learning. I see it in the ELD group. I see when they're going home and looking at what we learned that day. They come back and give me more information. That makes me excited to continue. (Grade 1 teacher)*

In interviews with evaluators, teachers almost universally volunteered that their students are having fun in NGSS science class. They like to talk with their classmates, build, investigate, and make sense of natural phenomena. They remind their teachers when it is time for science and even complain if a science lesson is postponed; they want to keep their science notebooks at the end of the year; they talk about what was done or learned in a past science lesson, and sometimes bring up links to the current instruction.

> I'm seeing a lot higher engagement. I'm seeing kids who never spoke in class take risks now, they are raising their hands. They are participating. (Grade 8 teacher)

In a spring 2016–17 survey, the majority (69 to 85 percent) of students said that they liked learning science.[10] Correspondingly, evaluators independently witnessed a strong level of student engagement when visiting case study teacher classes during the 2016–17 school year.[11] One evaluator wrote:

> *The fifth grader groups could barely contain themselves waiting for their turn in front of the class to test the effectiveness of their team's homemade water filter. There was a loud hum as many students talked quietly about why they thought some other group's filter worked*

10 Students were asked how they felt about learning science. Eighty-four percent of grade K–2 students chose a smiley face (rather than a sad or neutral face), 85 percent of grade 3–5 students chose "like" (which was the highest option on a 3-point scale), and 69 percent of grade 6–8 students chose "like a lot" or "like somewhat" (which were 4 and 5 on a 5-point scale).

11 In 12 out of 20 classes the level of engagement was high or very high; in seven classes students were moderately engaged; low student engagement was seen in only one lesson.

well, or not, and as they strategized a redo on their whiteboards of how they might change their own filter.

When students are given a chance to be curious and investigate their own wonderings, science provides fodder for enthusiastic group work and discussion, that can lead to improved performance and fewer behavior issues. A grade 6 teacher remarked, "I was very worried about classroom management when we first started this, but my students are doing what we're asking, and they're excited."

During interviews, Early Implementer teachers were asked whether the NGSS have affected student performance. Every teacher believed that students' ELA skills were improving. Administrators were noticing improvement as well:

I'll give you an example. I walked into a class where there were probably 30 students, of which 12 to 14 were special ed students. And the phenomenon the teacher was working on was mudslides. It was a totally different science class than I'd ever seen. The kids were talking, but not, "Well it rains and all the water. . ." They were talking about particle size, particle structure, friction. I mean it was like little soil scientists in there talking about how come a mudslide happens, and I went, "Wow this is really something!" Just the way they talked to each other and the way they listened to each other and the way they questioned each other. It was like a college class. (Middle school principal)

A majority of teachers reported that NGSS science increases motivation and engagement for *all* students, which in turn increases their enthusiasm for speaking, reading, and writing.

A majority of teachers reported that NGSS science increases motivation and engagement for *all* students, which in turn increases their enthusiasm for speaking, reading, and writing. For example, an evaluator heard the remarks below at one of the Initiative's lesson study days (called Teaching Learning Collaboratives) as a teacher team was reflecting on how well a jointly taught lesson had worked. The elementary school teachers were silently looking through students' notebooks to see what they had written about the hands-on activity. Everyone was startled a bit when the host teacher blurted out, with quite some emotion:

I can't believe this. I haven't seen this student attempt to write a sentence all year! This sentence is not good at all as a sentence. But she tried. She wanted to try. Science can make them pay attention and want to try, because they really want to share their thinking. This is why I do hands-on science, even though it's a lot of work to do it and to learn how to do it. (Elementary school teacher)

The real-life context of science can help even reluctant readers and writers to improve ELA skills; it can fuel broader learning for both native speakers as well as English learners. Early Implementer teachers are seeing first hand that English learners are far more capable than they had realized:

I noticed a huge increase in the willingness of English learners to take more

chances and feel more comfortable speaking, reading, and writing when these tasks included science. They were eager to participate, express their findings and ask more questions. The students also used higher-level thinking skills, a broader vocabulary, and were more willing to take chances and try new things. This exuberance for learning spread across other subjects and they were able to use the vocabulary in other situations. (Grade 2 teacher, 2016–17 Classroom Science Teaching Survey)

Challenges to Integrating Science and ELA

While most Early Implementer teachers are teaching significantly more science, many are reporting that science still is not as highly valued as ELA and math in their districts and schools. In fact, almost half (47 percent) of the elementary teachers in a summer 2017 survey chose "prioritization of other school subjects" as one of their three biggest barriers to implementing the NGSS. More than a quarter of teachers (27 percent) "disagreed" that improving science instruction was a priority at their school.

In a survey of all project teachers, 73 percent chose "lack of time for planning" as one of their three biggest barriers specific to integrating CCSS and NGSS instruction. Many are in the demanding process of learning a new ELA or math curriculum, and some have very prescriptive daily schedules that leave little leeway for quality science teaching, as illustrated by this grade 2 teacher comment: "My principal has asked us to do a major writing cycle that can't be integrated. And now it's also up to us to develop our own math curriculum, merging two that the district tried so far. It's so time consuming."

Further, as there are no adopted instructional materials for science aligned with the NGSS, Early Implementer teachers are planning and preparing their own science units.[12] Teachers require time out of the classroom, ideally in collaboration with one another, to simply grapple with the instructional shifts required by the NGSS. The opportunities that teachers have to work with their peers in this way varies greatly across schools. When asked how much of their regular professional learning community time was spent on science, interviewed elementary school teachers' responses varied from regularly to little or none. It also can be challenging for middle school science teachers to find time for collaborating with ELA and mathematics teachers, and vice versa. Said a grade 8 science teacher:

The English and math teachers seem overwhelmed with delivering their own standards and curricula, so the last thing that they seem interested in, right now at least, is working with me on some integrated or interdisciplinary topic. I think my ELA buddies would laugh and cry at the same time if I were to say, "Let's try to do a unit together." I think they'd say, "It's a great idea, not this year." Maybe in a few years, things will settle down. (Grade 8 teacher)

12 Over half of the teachers (51 percent) chose "lack of curriculum/instructional materials" as one of the biggest barriers to integrating science and ELA.

How the Early Implementers Initiative Is Supporting Integration

WestEd's K–12 Alliance has made integration of science with ELA a major aspect of all Early Implementer professional learning. In 2017, almost three-quarters of the teachers (72 percent) reported that the Initiative has enhanced their ability to connect CCSS and NGSS instruction "moderately" or by "a lot."

Appropriately, the training provided to Early Implementer participants models the NGSS approach to instruction. Like their students, teachers have been encouraged to explore and engage with the new standards as they feel prepared to do so. They have not been pressured to master the standards all at once, and this has encouraged experimentation and learning. One elementary school principal characterized the changes she had seen this way: "Teachers are more confident, collaborative. They are willing to take risks. They have a growth mindset as a result of the Early Implementer grant."

Equity and Access

The NGSS directly advise against pulling English learners, special education students, and other sometimes marginalized students out of science class in order to provide them with targeted services. In every convening attended by participants from all eight districts, the Early Implementers Initiative has provided at least one session to raise awareness about how to meet the needs of *all* students, particularly English learners and students of different cultural backgrounds.

Enlisting and Empowering Principals

Successfully implementing the NGSS requires professional learning for administrators as well as teachers. Teachers need to know that they have "permission" to experiment, to integrate, and to make mistakes along the way. Beginning in the 2015–16 school year, administrators were provided with their own workshops during annual Initiative-wide institutes. With their peers, they discussed pedagogical shifts of the NGSS and learned how to support their teachers. Details of how the Initiative is empowering principals are described in an evaluation report to be released in fall 2017.

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Content Cadres

When teachers are asked to identify the most powerful experiences from the Early Implementer trainings, a majority cite the Content Cadres. For half of each annual weeklong Summer Institute, teachers are students of adult-level NGSS science taught by a "cadre" consisting of one university scientist or professional and two K–8 expert science teachers, one of whom teaches the target grade level. The grade-specific groups investigate phenomena using sense-making notebooks, hands-on experiments, readings, and videos. The groups also engage in a lot of small and large group discussion. The sessions are designed to model three-dimensional NGSS instruction to help teachers better understand the content and plan lessons for their own students, including strategies to integrate ELA (e.g., notebooking, readings).

Initiative Tools and Practices

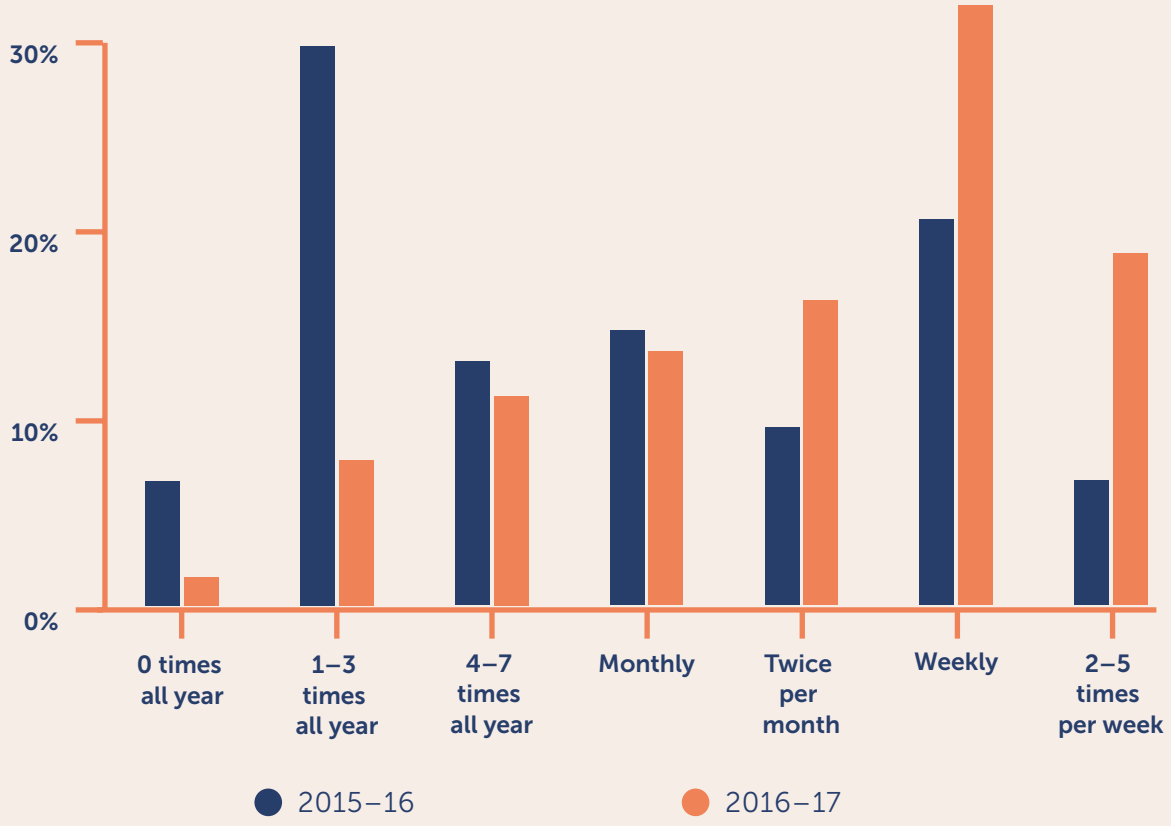
The K–12 Alliance has provided particularly intensive instruction on the use of four tools and practices that support the integration of science and ELA instruction. A large majority of teachers involved in the Initiative now profess a good understanding of sense-making science notebooks; the 5E instructional model; questioning strategies; and Claims, Evidence, and Reasoning (CER; more detailed information about these tools and practices is provided in Appendix F). From 75 to 92 percent of teachers claim that they understand how to use these tools "fairly well" or "thoroughly." In 2016–17, when teachers were asked to identify the tool or practice of most value to them, notebooks were the most commonly chosen tool (46 percent of teachers).

While all four tools support science and ELA integration, CER is a practice explicitly specified in both the NGSS and the CCSS. In all three content areas — science, ELA, and math — students' ability to evaluate the relevance and reliability of evidence and then use that evidence to logically support an assertion is key (see Appendix D).[13] Figure 3 shows that teachers' use of CER increased significantly between the 2015–16 and 2016–17 school years. Over two-thirds of teachers (67 percent) reported using the CER strategy at least twice per month; almost two-fifths (18 percent) reported using CER two to five times each week. Similar patterns were obtained for the other tools and practices most relevant to science–ELA integration.

Over three-fourths of teachers reported using notebooks and questioning strategies at least twice per month during the 2016–17 school year and almost half of the teachers reported using the 5E instructional model at least twice per month. Further, the percentage of teachers using notebooks and the 5E instructional model frequently (i.e., "2-5 times per week") increased by 10 percentage points from 2015–16 to 2016–17.

13 In science, the SEP *Engaging in Argument from Evidence* requires students (and scientists) to use evidence and reasoning to defend their own claims and models or to evaluate the claims and models of others. Similarly, in ELA, students "cite textual evidence when writing or speaking to support conclusions drawn from the text." In math, students "construct viable arguments and critique the reasoning of others."

Figure 3. Frequency at which teachers have their students use evidence and reasoning to support a claim



Source: Classroom Science Teaching Survey administered by WestEd in 2015–16 (N=318) and 2016–17 (N=404). Teachers were asked, "How often did you have students use evidence and reasoning to support a claim?"

Recommendations

Administrators play a critical role in enabling teachers to successfully integrate science and ELA in their classrooms. About two-thirds (65 percent) of Early Implementer teachers in the 2016–17 school year reported that their principals were "very" or "somewhat" supportive of them teaching science integrated with ELA during time allotted for ELA. Both teachers and district Project Directors in the Initiative have related testimonials of administrator support (e.g., Rammer, Hayes, & Woods, 2017). Only 11 percent of teachers chose "lack of support from administrators" as one of their three biggest barriers to implementing the NGSS.

Derived from many interviews with administrators, teachers, and Project Directors involved in the Early Implementers Initiative, the following recommendations briefly identify how site administrators and district office staff can foster more and better science integration in classrooms. Some of the recommendations are for supporting science in general because unless appropriate NGSS instruction is happening in the first place, there will not be opportunities to explicitly integrate science and ELA. All of the recommendations below are discussed in an upcoming evaluation report on administrators' roles in NGSS implementation slated for publication in fall 2017.

Unless administrators at least sanction that it's both acceptable and beneficial for elementary teachers to integrate science during designated ELA/ELD time, some K–5 teachers will not address science in any significant way. Witnessing the effects of the NGSS on students' ELA learning can influence how administrators feel about integration. For instance, an elementary school principal noted that a teacher had requested doing an integrated science–ELA lesson for her required annual performance observation.[14] The principal was delighted to see that not only were students engaged but they were also speaking in ways that explicitly fulfilled expected ELA standards:

> About two-thirds (65 percent) of Early Implementer teachers in the 2016–17 school year reported that their principals were "very" or "somewhat" supportive of them teaching science integrated with ELA during time allotted for ELA.

> *They were talking in complete sentences, listening to what each other said, and building upon each others' comments. You have to realize that our students score well below district average on ELA. I was happily surprised to see them speaking this well. Earlier, I had heard the teachers discussing science and ELA integration during the lesson-planning day that I observed as part of the Initiative. But seeing these students and the teacher in action made it sink in for me.*

14 Over two-thirds (69 percent) of teachers last year reported that they would be "very" or "somewhat" comfortable with teaching a science lesson for their elementary school principal's observation for their annual performance evaluation.

Table 3. Administrator recommendations for supporting science–ELA integration

Recommendation	Site administrator	District office staff
Actively advocate (beyond sanctioning) science–ELA integration, including within designated ELA time at the elementary school level	x	x
For prescriptive district ELA programs, allow flexibility for integrating science		x
Support and fund teachers in getting needed hands-on science supplies	x	x
Discuss science–ELA integration during principal reviews		x
Observe some strong science–ELA integration onsite or at another school	x	
Actively encourage regular grade-level teacher PLCs and middle school science departments to work on science–ELA integration; at middle school, encourage cross-subject PLC	x	
Give teachers freedom to experiment	x	
Recognize that active NGSS science instruction can be noisy, messy, etc.	x	
Provide school administrators with classroom observation protocols (not for teacher performance review) that are sensitive to NGSS science instruction; provide professional development for using them		x
Regularly put science and science–ELA on agenda for standing, districtwide meetings of building administrators		x

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Appendix A. Additional Examples of Integrating Science and ELA in the Classroom

Observed NGSS Lesson: Grade 1a

In this grade 1 lesson, students engage in the NGSS science and engineering practice (SEP) *Obtaining, Evaluating, & Communicating Information* and use the crosscutting concept (CCC) *Patterns* to determine and describe how baby animals are similar and different from their parents (the disciplinary core ideas [DCIs] addressed are *Life Science 3.A: Inheritance of Traits* and *Life Science 3.B: Variation of Traits*). All 19 students in the class are English learners whose first language is Spanish. They learn language arts and math in Spanish, while English language development (ELD) and science are taught in English. The teacher makes science the focus of later ELD lessons, because she has found that it keeps everyone interested, including herself. In ELD, the group will return to the science concepts, but the teacher will focus on English language development by repeating words and sentences and allowing students to practice through partner-share, chants, and sentence frames.

Speaking & Listening: Comprehension & Collaboration, Presentation of Knowledge & Ideas. This science lesson begins with a brief exploration of students' prior knowledge. The teacher prompts the students to "*write* in your science notebook information that you already know about animals. *Draw* a picture of the animal and its body parts. Add some color and some details." Some students *label* their drawings in Spanish. The students first *talk* in their groups and then the teacher asks questions to prompt the whole group to *share their ideas*. "Why do they have fur?" "How does it use its beak?" The class then *watches a video* which displays a series of baby animals with one or more parents. At the end of the video, the teacher says, "I noticed a pattern: You said 'Aw!' over and over. Why did you make that sound? What was the same in every picture?" As students *call out* ideas, the teacher asks clarifying questions, such as, "Was that in every picture?" "How do you know the baby animal belongs to the parent?" She assures the class that they will have another chance to watch the video and look again for a pattern.

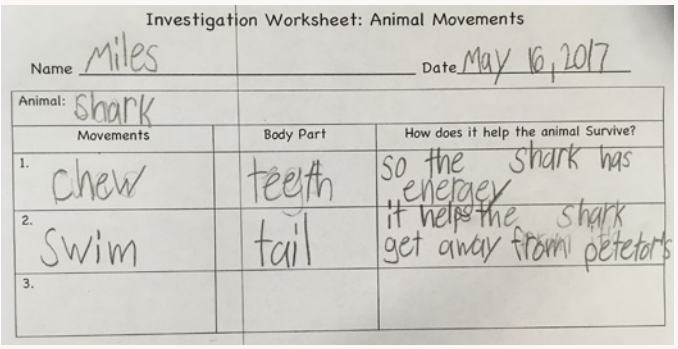
The class then watches a video of the book *Are You My Mother?* about a baby bird who encounters several animals, and even machines, while searching for his mother. The words and illustrations are projected on screen so that the children can follow along. The teacher gives students a chance to *talk* about what they have seen: "Who was the main character?" "Who were other characters in the story?" "Why wasn't the dog the baby's mother?" Students energetically *share ideas* which demonstrate that they understood the story and that

parents and baby animals share physical traits. The class concludes after students spend a few minutes writing new information about baby and parent animals in their notebooks.

Observed NGSS Lesson: Grade 1b

A class of grade 1 students is learning about the different external body parts animals have and how those parts make them move in ways that help them survive. The lesson addresses the DCI *Life Science 1.A: Structure and Function;* the SEP *Obtaining, Evaluating, and Communicating Information;* and the CCC *Structure and Function.* The teacher is a dedicated supporter of integrating science with multiple subjects, particularly ELA. She makes a point of having students explore science topics during reading time and work on their writing, speaking, and listening skills during science time.

Writing: Informative/Explanatory Texts. The lesson begins with students sitting in their table groups. Each group has chosen an animal to research. The teacher asks the class to *draw*



Investigation Worksheet: Animal Movements

Name Miles Date May 16, 2017

Animal: Shark

Movements	Body Part	How does it help the animal Survive?
1. Chew	teeth	so the shark has energey
2. Swim	tail	it helps the shark get away from petetor's
3.		

and write in their science notebooks what they know about their animals' body. Then the teacher provides an organizer that prompts students to consider what body parts the animal uses to move and how the movements help the animal survive. Students then get paper plates for their tables (the "plate habitat") to hold toy animals that correspond to the animals they each have chosen to research. They *write and draw* further observations about the body parts of their animals in their notebooks.

Speaking and Listening: Comprehension & Collaboration, Presentation of Knowledge and Ideas. The class then comes together on the carpet at the front of the room to watch a brief video that shows how a variety of animals move (e.g., run, climb, swim, fly, slither). They *share* their observations with the whole class: "They crawl." "Bees have thin legs." The teacher asks clarifying questions and records their observations in scaffolded sentences on a poster, leaving space at the end of each sentence: "A penguin waddles ___." "A tiger pounces ___." She asks them to think about what part a dolphin uses to jump out of the water. The class *works together to fill out the rest of the sentences* identifying the "structure" the animal uses to do each action, such as flippers, legs, and feet. "What parts do all the animals on the plate habitat use? How can this help them survive, or 'stay alive?'" Then the teacher shares with the class some exemplary writing in which students used scientific vocabulary. The students will need to be making these kinds of observations about their chosen animal and *writing* in a similar way in their animal research reports later in the unit.

Speaking and Listening: Comprehension & Collaboration, Presentation of Knowledge and Ideas. At the end of the class, the teacher plays a game with the class. She chooses an animal, and the students need to *ask questions* (such as, "Does it have wings for flying?" "Does it have claws for digging?" "Does it have fins for swimming?") to gain information and make an educated guess about which animal she chose. When the chosen animal was a frog, the "all about expert" (the

student who had chosen that animal for their research report) *tells* the class several details about frogs, including their body parts and how they use them. This is repeated for other animals, and it is evident that students are proud of their expertise. The teacher encourages the class to include such interesting things when they *write their reports.*

Writing: Narratives. The assignment is to *write* from the perspective of the animal. Using all they are learning about their animals, students are to imagine what it would be like to be that animal, to move around and take care of their survival needs in their environment, and then *write a story* describing that experience. As an example, the teacher says, "You might pretend that there is a traveler visiting the elephants in the Savannah. You might talk to the traveler about looking for shelter and looking for a place to find your food."

Observed NGSS Lesson: Grade 2

This two-hour long lesson is part of a unit on living things in the school garden that has lasted for six weeks of daily science. The 20-year veteran bilingual teacher finds it "critically important to integrate throughout the different subjects." She says she makes sure that each lesson builds on the last and that she stays flexible so that she can do things that interest her students. Today's lesson addresses the DCI *Life Science 2. Interdependent Relationships in Ecosystems,* the SEPs *Developing* and *Using Models* and *Obtaining, Evaluating, and Communicating Information,* and the CCC *Structure and Function.* The students have diverse reading levels, spanning K to above grade 6; there is one English learner in the group.

Speaking and Listening: Comprehension & Collaboration, Presentation of Knowledge & Ideas. The class begins with a whole group *discussion* of what students know about how plants grow. They have learned a little bit about pollinators and have agreed as a class that pollination is a topic they want to include in the *research books they are writing.* The teacher *asks questions* that lead students to consider what else they might need to find out before designing and building a pollinator, such as "Do all flowers look the same?" "How is pollen spread from one flower to another?" The class brings their science notebooks out to the garden where they draw and point out to one another what they notice about the different flowers in the garden. The group returns to the classroom, and students have a *detailed discussion* about the pollinators they saw; the different shapes, colors, and textures of flowers; and where they saw pollen. Then the teacher announces that the class will have time to do more research.

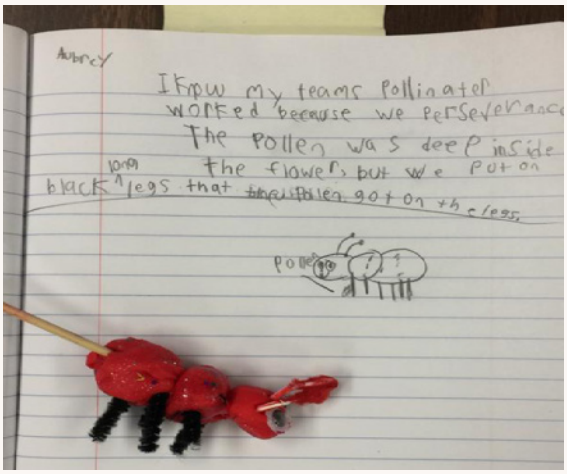
Reading (for Informational Text) and Writing (Research to Build and Present Knowledge). Students start to *conduct research* individually or in small groups, *watching videos or reading books.* The teacher offers a video about caterpillars for those who are interested. Many children are *taking notes and drawing pictures* in their notebooks. After almost half an hour, the teacher draws the students back together. Many are eager to share what they have learned about pollinators that the class has not yet discussed. As students *share new information,* the teacher records it on the board. Then class is dismissed for the day. The teacher plans to resume the lesson in the morning, because she doesn't want to interrupt the students' enthusiasm. She knows from experience that they will come in with more ideas after thinking about this all afternoon and night. The lesson will begin with the class *sharing new thoughts.* Then the students will draw designs in their

notebooks, and then work *collaboratively* to build their pollinators. In another lesson after building, the groups will test their pollinators and collect evidence that will inform modifications to their designs and contribute to their research books.

Observed NGSS Lesson: Grade 6

Students are learning about thermohaline ocean circulation and how it affects plankton productivity and whale migration in the Pacific Ocean. The lesson addresses the DCIs *MS-LS2 Ecosystems: Interactions, Energy, and Dynamics* and *MS-ESS2 Earth's Systems;* the SEP *Obtaining, Evaluating, and Communicating Information;* and the CCC *Systems and System Models*). Previously, students made models of ocean currents using small tanks and colored water of varying temperature and/or salinity. Based on that learning and what they knew about whales from previous lessons, they created initial models of whale migration.

Reading (for Informational Text, for Literacy in Science and Technical Subjects), Writing (Text Types and Purposes). The goal of today's lesson is for students to find multiple *sources of information* to improve and support their whale migration models. The teacher does a quick review of their "rules of evidence" poster, which states



that sources should be known and reliable (preferably from .gov or .edu domains), that students should be able to find the same information from more than one reliable source, and that they should consider whether the author or website has a *biased perspective.* She further reminds her students that when sifting through a variety of sources, they should *evaluate the information's* relevancy and persuasiveness in supporting their claims.

Appendix B. Methodology, Survey Questions, and Interview Protocols

The evaluation team's mixed-methods documentation and study of the NGSS Early Implementers Initiative primarily draws upon the following data sources:

- Surveys, to quantitatively investigate all participants' activities
- Interviews and observations, for a more in-depth, qualitative understanding of NGSS implementation by select teachers and administrators

As noted in the Introduction of the report, there were several additional, secondary sources of data.

This appendix contains the specific data-collection instruments used to gather data for this report. Three relevant interview protocols are included in their entirety in this appendix. For the surveys, to reduce the size of the appendix, only the specific questions that were analyzed for this report are included. Full survey instruments will be released in summer 2018; in the meantime, any queries to see entire survey instruments can be directed to the evaluation's project director, Burr Tyler, at btyler@wested.org.

All instruments were created specifically for this evaluation of the Early Implementers Initiative. However, in designing the surveys, evaluators consulted relevant off-the-shelf instruments on science teaching and teacher leadership development. All instruments were developed in an interactive process including review by Initiative leaders and stakeholders. Instruments were piloted with relevant project participants.

Survey Questions

Retrospective Teaching Learning Collaborative Survey (administered in August 2016 and August 2017)

- DURING THE **2014–2015** SCHOOL YEAR, how often did you use the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) to design lessons?
- DURING THE **2014–2015** SCHOOL YEAR, how often did you use questioning strategies (e.g., teacher-to-student; student-to-student discourse) to elicit student thinking?
- DURING THE **2014–2015** SCHOOL YEAR, how often did you use science notebooks specifically for student sense-making?
- DURING THE **2014–2015** SCHOOL YEAR, how often did your science lessons incorporate NGSS SEPs (Science and Engineering Practices)?
- To what extent did your TLC experiences in the 2015–2016 School Year empower you to

be able to use the following project tools and practices on your own next year (should you wish to use them)?

- How to use the 5E instructional model to design and teach lessons
- How to use questioning strategies (e.g., teacher-to-student; student-to-student discourse) to develop student understanding
- How to use science notebooks for student sense-making
- How to use Claim, Evidence, Reasoning (CER) to advance student thinking

- Please pick the project tool or practice from the list below that you learned the most about from your TLC experiences during the 2016–2017 school year.
  - Conceptual flows, 5E Instructional Model, Phenomena, Questioning Strategies to Elicit Student Thinking, Looking at Student Work with Colleagues, Student Notebooking, Claim, Evidence, and Reasoning (CER)
- Describe how the TLC experience helped you understand this project tool or practice.
- Choose a second tool or practice and describe in detail what you learned during the TLC experience that helped you better understand that tool or practice.
- Describe something specific you plan to do differently in your classroom next year as a result of your TLC experiences in the 2016–2017 school year.

Classroom Science Teaching Survey (administered in August 2016 and August 2017)

- During the 2016–2017 school year, which answer best reflects the average weekly time that you taught science integrated with English Language Arts (ELA)?
- During the 2016–2017 school year, which answer best reflects the average weekly time that you taught stand-alone science (i.e., science not integrated with another subject)?
- During the year before last, THE 2014–2015 SCHOOL YEAR, which answer best reflects the average weekly time that you taught science integrated with English Language Arts (ELA)?
- Did you teach notably more or less science this year (2016–2017) compared to last year (2015–2016)?
- Please identify up to FOUR of the strongest influences for this change:
  - Involvement in the Early Implementation Initiative (EII)
  - Involvement in another project related to science
  - Understanding of the Next Generation Science Standards (NGSS)
  - Understanding how to integrate science with English Language Development (ELD) standards
  - Understanding how to integrate science with Common Core English Language Arts (ELA) standards
  - Understanding how to integrate science with Common Core Mathematics standards
  - Understanding how to teach engineering design
  - Change in school focus (e.g., increased/decreased focus on ELA, math, science, etc.)
  - Change in district focus (e.g., new curriculum)

- Change in administrator (e.g., principal) support for teaching science
- Change in grade
- Change in classroom
- More/less opportunity to collaborate with other teachers
- Access to instructional materials and/or lesson ideas
- Access to science supplies and equipment
- Students' response to science
- OTHER:

> Please choose one from the list above and explain how it influenced the change in the amount of science you taught during the 2016–2017 school year.

> If you taught science integrated with a subject other than ELA, Math, or History/Social Studies, please indicate what subject below:

> Which Common Core State Standards for English Language Arts did you address while integrating science with ELA during the 2016–2017 school year? (Select all that apply.)

- Reading: Literature
- Reading: Informational Text
- Reading: Foundational Skills (K–5)
- Reading: History/Social Studies (6–12)
- Reading: Science and Technical Subjects (6–12)
- Writing: Opinion Pieces (K–5)/Arguments (6–12)
- Writing: Informative/Explanatory Texts
- Writing: Narratives
- Writing: Production and Distribution of Writing
- Writing: Research to Build and Present Knowledge Writing: Range of Writing
- Speaking & Listening: Comprehension and Collaboration Speaking & Listening:
- Presentation of Knowledge and Ideas
- Language: Conventions of Standard English
- Language: Knowledge of Language
- Language: Vocabulary Acquisition and Use
- Unsure

> During the 2016–2017 school year, how often did you have students engage in the following Science and Engineering Practices (SEPs)? Please do NOT count activities occurring in the EII Initiative's facilitated TLC days.

- Ask questions
- Come up with explanations
- Use evidence and reasoning to support a claim
- Record observations
- Evaluate information
- Talk about results from investigations
- Define problems (engineering)

> During the 2016–2017 school year, how often did you do the following in your own classroom? Please do NOT count activities occurring on the EII Initiative's facilitated TLC days.

- Use science notebooks specifically for student sense-making
- Use the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) to design lessons

- Use questioning strategies (e.g., teacher-to-student, student-to-student discourse) to elicit student thinking
- Use Claim, Evidence, and Reasoning (CER) to advance student thinking

- Which project tool or practice from the list below was most valuable to you during the 2016–2017 school year?
  - Student Notebooking
  - Conceptual Flows
  - 5E Learning Sequence
  - Looking at Student Work with Colleagues
  - Questioning Strategies to Elicit Student Thinking
  - Claim, Evidence, and Reasoning (CER)
- Please describe how it enhanced your science teaching in the space provided.
- To what extent has the Early Implementation Initiative (EII) enhanced your ability to connect Common Core and NGSS instruction?
- Please identify up to THREE of your biggest challenge(s) for integrating Common Core and NGSS instruction:
  - NONE
  - Lack of curriculum/instructional materials
  - Lack of support (from administrators, other teachers)
  - Lack of familiarity with NGSS
  - Lack of familiarity with CCSS
  - Lack of understanding of the relationship between NGSS and CCSS
  - Need to know how to plan (lessons, conceptual flows, etc.)
  - Lack of resources/materials/supplies
  - Lack of time for planning
  - Lack of opportunity for collaboration
  - OTHER:
- During the 2016–2017 school year, how often did you do the following in your own classroom? Please do NOT count activities occurring in the EII project's facilitated TLC days.
  - Incorporate NGSS Science and Engineering Practices (SEPs) during instruction

Teacher Leadership Survey (administered in August 2015, August 2016, and August 2017)

- In the 2013–2014 school year, how well would you say you understood:
  - How NGSS relate to the Common Core State Standards?
- How well would you say you understand:
  - The Science and Engineering Practices (SEPs) within NGSS and how they are used during instruction
  - Using science notebooks specifically for student sense-making
  - Using questioning strategies (e.g., teacher-to-student, student-to-student discourse) to elicit student thinking
  - Using Claim, Evidence, and Reasoning (CER) to advance student thinking
  - How NGSS relate to the Common Core State Standards
  - How NGSS relate to the Common Core State Standards for ELA
  - How NGSS relate to the Common Core State Standards for Math

Interview Protocols

Case Study Teacher Interview #1 Protocol

Part 1: Background Information

The first set of questions ask for general information about your background and teaching experience, as well as the context of your classroom and school.

1. Can you please describe your background related to teaching? *(Probe: How long have you been teaching? How many years have you taught in your current school and district? How many years have you taught at your current grade level?)*
2. Do you have any formal education in science? *(Probe: Did you have a science methods class? What areas of science do you feel strongest in? What areas do you feel you could learn more about?)*
3. Describe the context of your classroom this year. What are the student demographics (ethnicity, English language learners, income level, etc.)?
4. How is your school day structured (specifically, when is science taught, for how long [minutes] and how often)? Is your time to teach science flexible (or is there a set time by the school/district that you must stick to)? How many students/classes do you work with directly?
5. How are PLCs organized in your school? How often and for how long do you learn about/discuss science in PLCs *(Probe: ELEMENTARY — how does this compare with other subjects)*? What does the process of a PLC look like (e.g., What kinds of things do you do? Do you follow a predefined protocol?)? Do you engage in any other collaboration with other teachers on science?
6. Is your school administration supportive of your teaching NGSS? What role, if any, has your principal played in supporting NGSS implementation in your school or district? **Ask only Core TLs**: Have you and your principal used the observation protocol from the K–12 Alliance? (Follow up: May we have the contact information for your principal to inform them of what your participation will involve?)
7. Are there any issues that affect the amount of time you are able to devote to science? *(If they need examples: lack of support from admin, other teachers, competing initiative(s), new curriculum, CCSS, scheduling.)*

Part 2: Your Experience with the Early Implementers Initiative

This next set of questions relates to your participation in the Early Implementers Initiative and your experiences and thoughts on what you have learned so far.

8. I learned from your Leadership survey that you joined the EII Initiative in _____. Have there been any major Initiative events that you missed? *(Probe for clarification of anything we don't know.)*
9. Have you participated in any additional science-related professional development events this year or last year that were not part of the Initiative *(e.g., other initiative in the district, conference)*?
10. What are some of the most impactful things you have learned from the Early Implementers Initiative? How have they affected your teaching?
11. What tools or strategies from the Initiative do you now use and how have they affected your teaching? *(If they need examples: conceptual flow, 5E instructional model, sense-making notebooks, questioning strategies, using student discourse, developing instruction around phenomena.)*

12. How would you say students are reacting to NGSS instruction?

13a. *[For MIDDLE SCHOOL]* How would you describe the integration of the science disciplines in your teaching?

13b. *[For ELEMENTARY SCHOOL]* I want to ask about integration of science with other subjects, especially ELA, so I'm going to ask two ways: How much of your ELA instruction is integrated with science? How much of your science is integrated with ELA? Do you integrate science with subjects other than ELA? *(If so, ask same questions for other subject(s)).*

14. Would you say you've experienced an increase in your knowledge of science content through your involvement with the Early Implementers Initiative? If so, please explain.

15. Would you say you've experienced an increase in your knowledge of pedagogy? If so, please explain.

IF TIME

- [MIDDLE SCHOOL] Can you please describe where your school is in the transition to the integrated model?
- What role has engineering played in your teaching of science?
- Describe your larger school context. Are the overall student demographics in line with your specific classroom's?

Case Study Teacher Interview #2 (End of Year) Protocol

June 2017

Part 1: 2016–17 School Year Overview and Updates

The first set of questions asks about an overview of your classroom, school, and larger community context, and a brief recap of your experiences and thoughts on the school year.

1. **Optional/delete: [Provide recap of what we already know about their context]** Is there any additional information about your classroom or school context this year that you think is relevant for us to know about?
2. Was there anything about your classroom or school context this year that affected your implementation of NGSS?
3. **Optional:** What EII events did you participate in since our last interview and what are some of the most impactful things you learned from them? How did they affect your teaching this year?
4. Have you participated in any additional science-related professional development events in the last few months *(e.g., other project or PD in the district, conference, etc.)*?
5. Did your use of tools or strategies from the Initiative change from the beginning of the year to the end? *(If they need examples: conceptual flow, 5E instructional model, sense-making notebooks, questioning strategies, using student discourse, developing instruction around phenomena.)*
   a. **Probe:** If so, how/why?
6. Have you taken on any leadership roles since the EII started (both as part of the EII and outside of it)?
   a. **Probe:** If so, please describe.
7. Since our last interview, have you engaged in any kind of collaboration with other teachers outside of EII events (*PLCs, School-wide meetings, informal collaboration, etc.)*?
   a. **Probe:** How has this affected the implementation of science in your or other teachers' classrooms? (Can you give me an example?)

8. Have you noticed any spread in NGSS implementation among teachers at your school who are not part of the Initiative?
   a. **Probe:** Were you involved in helping these teachers implement NGSS? If so, how?
9. **[ELEMENTARY ONLY]** Would you say you are spending more time on science this year? If so, where is the time coming from? How are you making time for more science during the school day?
   a. **Probe:** How would these answers compare to what you would have said at the end of last year?

Part 2: Integrating NGSS Science with ELA & MS Integrated Science Model

This next set of questions asks about the integration of NGSS science with Common Core and English/Language Arts. [MIDDLE SCHOOL ONLY] This part also asks about your experience with the MS Integrated Science Model.

10. Did you intentionally integrate ELA and science this year?
    a. **Probe:** How? When? **(Get concrete details)** Do you use any particular tools or strategies when integrating science and ELA? Can you please describe (or send me) an example of a lesson or unit that you taught in the last few months that integrated 2 or more science disciplines?
    b. **Elementary only Probe:** Do you do this during science time or ELA time? (How much science is integrated in time for ELA and how much ELA is integrated into science time?)
    c. **Probe:** Are some ELA standards easier to incorporate into science? If so, which ones?
    d. **Probe:** Do you see this integration of science and ELA affecting student ELA skills?
    i. **Probe:** If so, please elaborate: What have you observed? Why do you believe that NGSS science has influenced student skills?
    ii. **Probe:** Do you think NGSS science has affected or will affect students' ELA test scores?
11. **[MIDDLE SCHOOL ONLY]** How would you describe the integration of the science disciplines in your teaching since our last interview?
12. **[MIDDLE SCHOOL ONLY]** Can you please describe (or send me) an example of a lesson or unit that you taught in the last few months that integrated 2 or more science disciplines?
13. **[MIDDLE SCHOOL ONLY]** Because of the Integrated Model, do you need to teach some science content that you have not taught before?
    a. **Probe:** If so, what content? How do you feel about this? How did you or how are you preparing for this?
14. Are you following a scope and sequence that lays out what you're doing/not doing in your grade level?
    a. **Probe:** If so, where did it come from? Are other teachers in your school/district following this as well? (Be sure to get a copy of whatever they have.)

Part 3: Role of District Leaders and Administrators

This last set of questions asks about your experience with district leaders and administrators related to NGSS implementation, both as part of the EII and outside of the Initiative.

15. Please describe how, if at all, your school administration affected your teaching of science this year. How about the district administration?

16. How do you get the consumable materials you need to teach NGSS science AND who pays for it? **[get concrete details]**
    a. **Probe:** Do you have access to the NON-consumable supplies and equipment you need?
    b. **Probe:** Is there district money or school money available for these materials? What is the process to access those funds? Is the access to those funds equitable (all teachers can use them)?
17. Please describe how, if at all, your EII Project Director has affected your teaching of science this year.
    a. **Probe:** Have you had any one-on-one interaction with the Project Director to help with your own teaching?

Administrator Interview #1 Protocol

May–June 2017

Part 1. What They Know

1. Which of these Initiative events have you attended?
    a. Summer institute 2015 (admins were invited for a day, to get some background and see ts in Cadre) (no probe)
    b. (CLT only) Administrator Symposia (March/April or Nov 2016) (**Probe:** What was your role at the event?)
    c. Principal Academy in Summer Inst 2016 or during 2016–17 school year (**Probe:** What was your role at the event? What do you remember/what did you learn from it?)
    d. District or school PD about NGSS (**Probe:** What was your role at the event? What do you remember/what did you learn from it?)
    e. TLCs (**Probe:** What was your role at the event? What do you remember/what did you learn from it?)
2. In the last three years, have you received PD or info about NGSS or supporting science in general from any other source(s)?
3. Please briefly describe your understanding of:
    a. What you feel are important differences between NGSS instruction and traditional science instruction
4. Please briefly describe your understanding of:
    a. What support or conditions teachers need in order to teach science and the NGSS (Note how many of these they include: time to plan, time/opp'ty to collaborate with other teachers, permission to experiment, access to NGSS-aligned curriculum/lessons, access to materials to use in class)
5. What are some things you are doing to support science teaching and NGSS implementation *because of this Initiative?*
    a. How does this compare to how you were willing or able to support science before this Initiative?
    b. Are there any additional things that you hope to do next year?
6. Are there things about how YOUR performance is evaluated that make it difficult for you to support science teaching? (**Probe:** How about your working conditions? Work load?)
    a. Things that empower you to support it?

Part 2. Teachers and Students

7. Are any of the teachers at your school on the CLT? Are there any TLs? If yes:
    a. How many?
    b. What, if any, impact from the Initiative have you seen on these individuals? (Probe

re leadership, instructional practices, collaboration.)

c. Have you heard other admins talking about the impact of NGSS on teachers or students?

8. Have you seen NGSS science lessons being taught? If yes:

   a. Where/how?

   b. Did you notice the infusion or integration of ELA or math?

   c. What was your impression of the NGSS lesson? [probe re content, activity (level)]

   d. How did students respond? (Listen for: Were students learning?)

9. Have you seen science being used as the context for teaching ELA or math, that is, an ELA or math lesson that used science as a context? If yes:

   a. Where/how?

   b. What was your impression? (Probe re how different from "regular" ELA/math lesson without use of science.)

   c. How did students respond? (Listen for: Were students still learning ELA/math?)

10. (For building administrators only) Has obtaining, paying for, or preparing supplies or consumables to teach science affected the willingness of teachers to teach science?

Part 3. District and School Process

11. How well do you think the district is promoting science as a core subject?

   a. What strategies have worked best so far to advance this effort?

   b. What funding avenues, if any, have been explored to support this effort? (with principals, probe re school level as well as district)

   c. What still needs to be done?

   d. What have been the biggest barriers or challenges?

   e. What are some things a principal or an administrator can do to support the school in making science a core subject?

12. (FOR 6–8 ONLY, including admins of elementary school that include 6th grade) Where would you say the district (or your school) is in the process of transitioning to the Integrated Model?

   a. What have been the biggest barriers or challenges? (probe re 6th grade)

   b. What still needs to be done?

13. Where would you say the district (or your school) is in spreading NGSS to all teachers (not just the Teacher Leaders)?

   a. What strategies have worked best so far to advance this effort?

   b. What funding avenues, if any, have been explored to support this effort?

   c. What have been the biggest barriers or challenges?

   d. What still needs to be done?

Appendix C. Sample NGSS Page Showing Connections to CCSS

The NGSS explicitly show connections to the Common Core State Standards (CCSS). For example, the following page for grade 4 physical science, 4-PS3, lists relevant CCSS-ELA and CCSS-mathematics standards at the bottom of the page.

Figure C1. Sample NGSS page: 4-PS3 Energy

4-PS3 Energy

4-PS3 Energy

Students who demonstrate understanding can:

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.
- Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
- Apply scientific ideas to solve design problems. (4-PS3-4)

Disciplinary Core Ideas

PS3.A: Definitions of Energy
- The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
- Light also transfers energy from place to place. (4-PS3-2)
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)

PS3.C: Relationship Between Energy and Forces
- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)

PS3.D: Energy in Chemical Processes and Everyday Life
- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ETS1.A: Defining Engineering Problems
- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)*

Crosscutting Concepts

Energy and Matter
- Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering and Technology on Society and the Natural World
- Engineers improve existing technologies or develop new ones. (4-PS3-4)

Connections to Nature of Science

Science is a Human Endeavor
- Most scientists and engineers work in teams. (4-PS3-4)
- Science affects everyday life. (4-PS3-4)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels: **K.PS2.B** (4-PS3-3); **K.ETS1.A** (4-PS3-4); **2.ETS1.B** (4-PS3-4); **3.PS2.A** (4-PS3-3); **5.PS3.D** (4-PS3-4); **5.LS1.C** (4-PS3-4); **MS.PS2.A** (4-PS3-3); **MS.PS2.B** (4-PS3-2); **MS.PS3.A** (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.B** (4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.C** (4-PS3-3); **MS.PS4.B** (4-PS3-2); **MS.ETS1.B** (4-PS3-4); **MS.ETS1.C** (4-PS3-4)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1	Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)
RI.4.3	Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)
RI.4.9	Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)*
W.4.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
W.4.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4)
W.4.8	Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)
W.4.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1)

Mathematics –

4.OA.A.3	Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *(4-PS3-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Source: Achieve, Inc. (2013).
See also https://www.nextgenscience.org/how-to-read-the-standards for How to Read the Next Generation Science Standards.

At the base of each NGSS standard a CCSS connection box lists related ELA and math standards. The box below is from the previous NGSS page.

Common Core State Standards Connections:
ELA/Literacy —

Rl.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)

Rl.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)

Rl.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)*

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4 -PS3-3),(4 -PS3-4)

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Mathematics —

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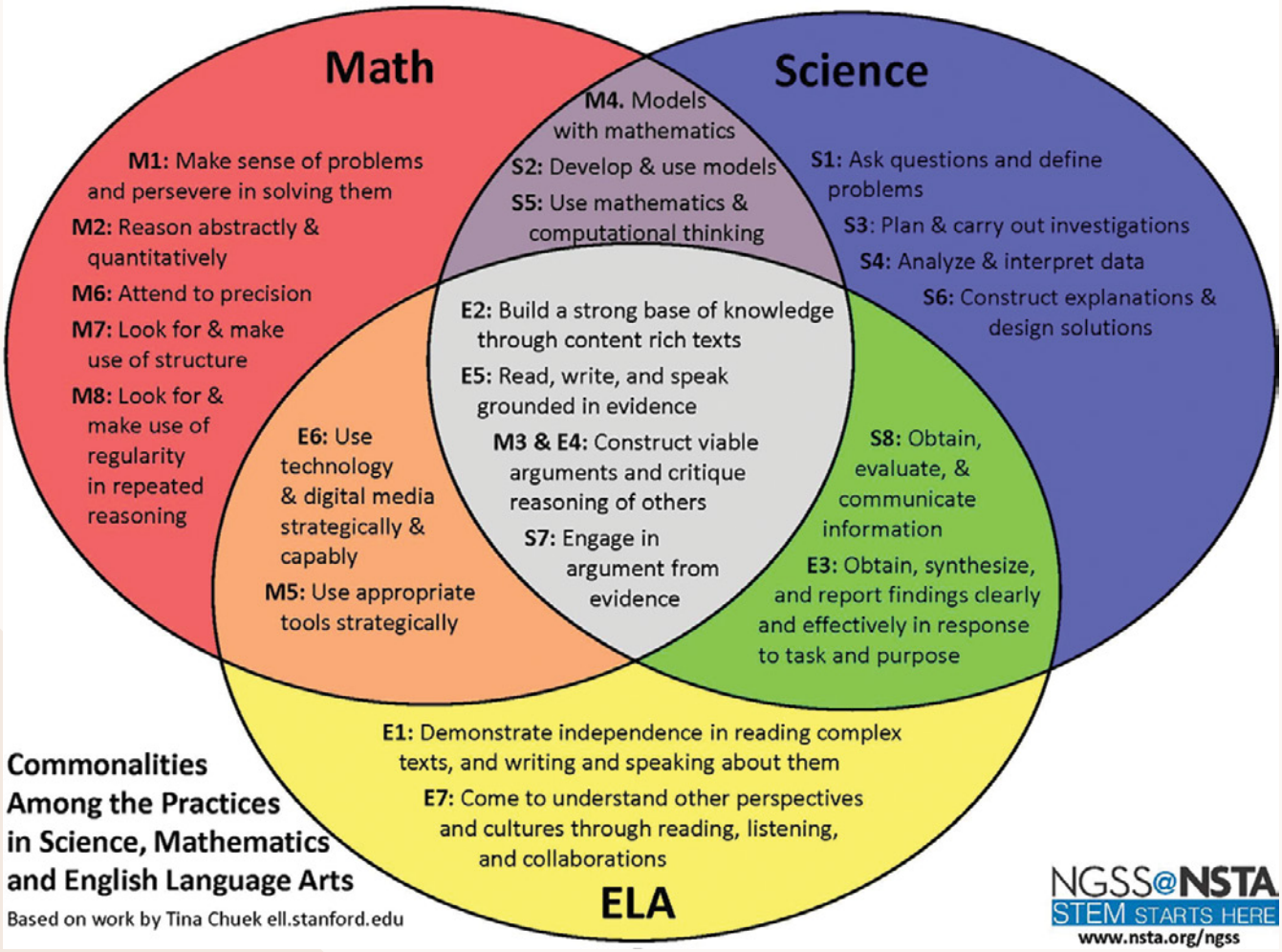
Appendix D. Commonalities Among the Practices in Science, Mathematics, and English Language Arts

This figure shows the relationship of practices in NGSS and CCSS-ELA and CCSS-mathematics.

Figure D1. Commonalities among the practices in science, mathematics, and English language arts



Appendix E. CCSS-ELA and California ELD Call for Integration of Science and English Language

Both the CCSS-ELA and California ELD Standards directly acknowledge the importance of building content knowledge, including science knowledge, when learning English language skills. Further, the California ELA/ELD Framework outlines three new emphases in the California CCSS for ELA and Literacy:

1. Content-rich informational texts
2. Responding and arguing from textual evidence
3. Complex texts and academic language

Science is a content area where all three of these emphases can be practiced. For instance, these emphases are often integrated throughout the steps of a typical NGSS lesson, such as the following lesson:

- Students first express, in writing and/or talk, their curiosity about a natural phenomenon.
- They then explore relevant scientific concepts, sometimes through an informational text or video relating to the phenomenon.
- After taking in the new information, students engage in discussion, making claims inspired by what they have seen or read.
- During this typically animated discussion, students learn and employ new science vocabulary.
- Alternatively, students may write their claims, evidence, and reasoning in their notebooks before the small-group or whole-class discussion.
- Next, they write once again in their science notebooks, clarifying for themselves their new understanding about the science related to the phenomenon.
- The lesson can be extended with a video, hands-on experiment, or further reading.
- As students' understanding evolves, so does their use of appropriate academic language.

In addition, the California CCSS-ELA clearly articulate that learning subject-area content is a crucial component of mastering ELA skills:

> *Part of the motivation behind the interdisciplinary approach to literacy promulgated by the Standards is extensive research establishing the need for college and career ready students to be proficient in reading complex information text independently in a variety of content areas. Most of the required reading in college and in workforce programs is informational in structure and challenging in content. . .The Standards are not alone in calling for a special emphasis*

> *on informational text. The 2009 reading framework on the National Assessment of Education Progress (NAEP) requires a high and increasing proportion of informational text on its assessment as students advance through the grades. (California Common Core State Standards ELA & Literacy in History/Social Studies, Science, and Technical Subjects, p. 3)*

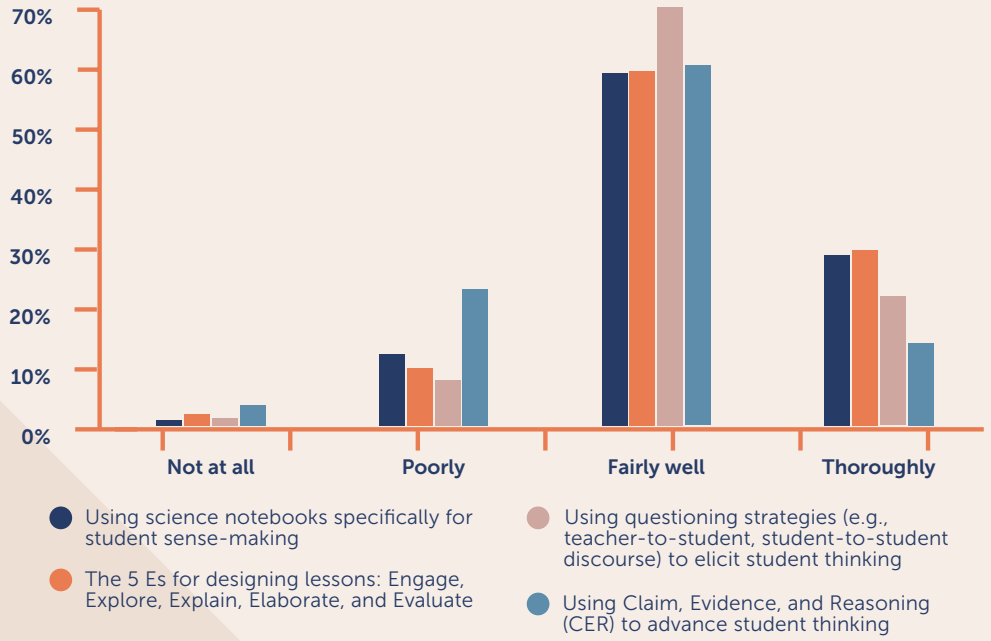
The California ELD Standard document similarly asserts, "The CA ELD Standards are not to be used in isolation from the CA CCSS for ELA/Literacy and other content standards during academic content instruction" (California English Language Development Standards, p. 10). The California ELA/ELD Framework direct that English learners should engage in "instruction that promotes content and language learning *in tandem* in all disciplines, including ELA, mathematics, social studies, science, the fine arts, and other subjects" (California ELA/ELD Framework, p. 11; emphasis added) and that English learners should "have full access to a multi-disciplinary curriculum, including those subjects" (ELD Standards). The California ELA/ELD Framework further specifies that English learners benefit from both *integrated* ELD lessons, in which the focus is content-specific, and *designated* ELD lessons, in which English language learning is emphasized.

Appendix F. Tools and Practices Used in NGSS Early Implementers Professional Learning to Support Integration

Figure F1 illustrates that a large majority of teachers now profess to have a good understanding of notebooks, the 5E instructional model, questioning strategies, and Claims, Evidence, and Reasoning (CER). From 75 to 92 percent of teachers claim that they understand how to use each of these tools "fairly well" or "thoroughly." When asked to identify the tool of most value to them in the 2016–17 school year, teachers chose notebooks (46 percent) far more than any other tool.

These four tools and practices are described in detail below.

Figure F1. Teachers' understanding of tools used to support integration of science and ELA



Source: 2016–17 Teacher Leadership Survey administered by WestEd (N=387). Teachers were asked, "How well would you say you understand the following?"

Sense-Making Science Notebooks

Science notebooks are a centerpiece of NGSS implementation that Early Implementers have been learning about since the first Initiative convening. The primary purpose of notebooks is for students to record their thoughts, wonderings, observations, findings, and evolving understanding. The secondary purpose is for teachers to see evidence of that understanding to help inform their planning of classroom activities that elicit student thinking and advance student learning. Early Implementers learn that the purpose of notebooks is *not* student evaluation. The notebook belongs to the student, just as a scientist's notebook belongs to the scientist.

Four "essences" of sense-making notebooks should regularly be recorded by the student:

- *Prior knowledge*. I think, I predict, I hypothesize
- *Gathering data*. I saw, I observed, I measured
- *Making sense of data*. I think ____ because. . .; The data graph shows. . .; Based on the evidence. . .
- *Metacognition*. ____ helped my thinking because. . .; I wonder. . .; My thinking has changed. . .

Questioning Strategies

Teachers are coached to be very aware of the way they facilitate discussion to elicit productive student talk. Early Implementers learn questioning strategies to keep instruction inquiry-based, so that students are prompted to actively construct meaning for themselves. That is, rather than provide answers to student questions, teacher respond with their own thought-provoking questions, such as, "What do you think could be going on?" "How do you know?" "Do you agree with X? Why?" "How could you find out about that?" Besides fostering meaningful student engagement with the content, this questioning strategy encourages increased and improved teacher–student and student–student discourse.

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 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; share ideas with peers; conduct investigations; read texts, watch video clips, or otherwise take in new information; and revise and articulate their new thinking.

Claims, Evidence, and Reasoning

Like the 5E instructional model, the use of Claims, Evidence, and Reasoning (CER) in instruction has become extremely popular, and for good reason. The three elements together help students meet the overarching goals of NGSS: developing in-depth understanding of content and developing key skills related to communication, inquiry, and problem-solving. The three elements are:

- *Claim*. For students to generate a claim, they need to be asked a thought-provoking question and/or exposed to a phenomenon that inspires their curiosity. Initially, they bring prior knowledge to bear when forming their claims:

"I'm not sure why that is happening, but I think it might be _____." Over time, after students learn more by conducting investigations, reading, talking with peers, or watching informative videos, their claims are based on accumulating evidence.

- *Evidence.* Evidence can come from investigations, observations, discussions, and reading of reliable sources. Students must be able to identify evidence that is appropriate for their claim and present the evidence so that it lends convincing support to their claim.
- *Reasoning.* This is generally the most challenging of the three for students. Reasoning is used to connect the evidence to the claim, show why the evidence chosen is appropriate, and clarify the scientific thinking behind the claim and the evidence.

Similarly, the CCSS-ELA aim for students to identify and use evidence when reading literature and informational texts and when writing opinion, informative, and research texts. One of seven capabilities of a literate individual listed in the CCSS-ELA is, "They value evidence."

NGSS EARLY IMPLEMENTERS
WestEd

EVALUATION REPORT 2

The Synergy of Science and English Language Arts

Means and Mutual Benefits of Integration

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