

# Engaged and Learning Science

How Students Benefit from  
Next Generation Science Standards Teaching

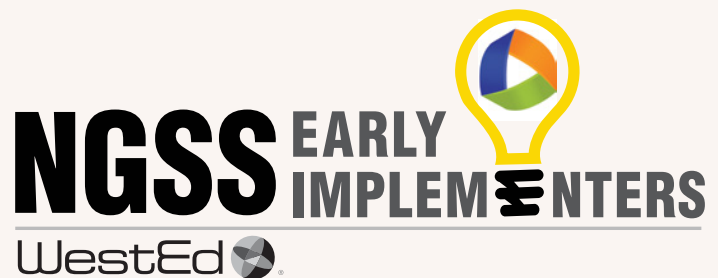
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## NGSS Early Implementers Initiative: Bringing science to life as a core subject in K–8 classrooms

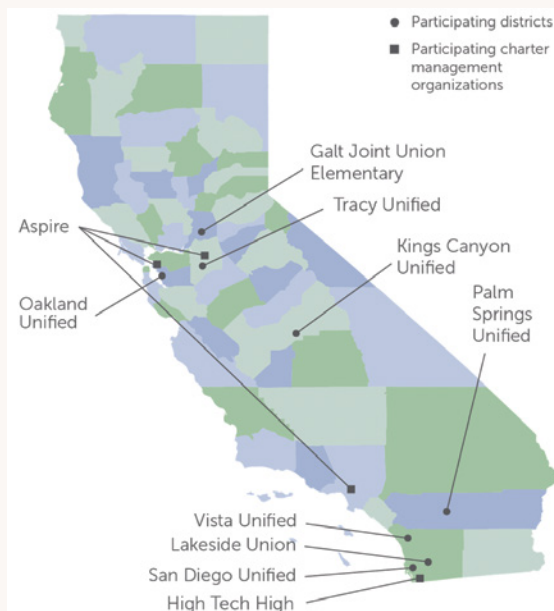
A diverse group of eight California school districts and two charter management organizations is actively implementing the Next Generation Science Standards (NGSS). Their progress, experiences, and lessons can inform others implementing the NGSS. The NGSS Early Implementers are supported by the K–12 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 2020. 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: 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](http://k12alliance.org/ca-ngss.php).



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# Contents

Evaluation of the NGSS Early Implementers Initiative	iv
Executive Summary	v
Introduction	1
<b>Evaluation Methods</b>	2
Evaluation Findings	3
<b>Stronger Student Engagement</b>	3
<b>More Inclusive Engagement</b>	5
<b>More High-Level Learning</b>	7
<b>An Extended Example of Students' Learning</b>	10
Concluding Thoughts	12
<b>Students' Views</b>	12
Students Have Opportunities to Do NGSS-Aligned Activities	13
Students Feel Able to Do NGSS-Aligned Activities	15
Students Are Gaining Positive Views of Science	16
Recommendations for Administrator Support of NGSS Teaching and Learning	18
References	20
Appendix A. Details of Evaluation Methods	21
<b>Data Sources</b>	21
<b>Student Surveys</b>	21
Appendix B. Additional Quotations from Teacher and Administrator Interviews	23
<b>Stronger Student Engagement</b>	23
<b>Engaging All Students</b>	24
<b>More High-Level Learning</b>	24
Glossary	26

List of Figures

<b>Figure 1. Teacher Leader–reported changes in classrooms implementing the NGSS</b>	8
<b>Figure 2. Principal-reported changes in classrooms implementing the NGSS</b>	8
<b>Figure 3. Claim, Evidence, Reasoning chart from case study teacher observation</b>	12
<b>Figure 4. Percentage of middle school students reporting that they learned about NGSS crosscutting concepts “sometimes” or “a lot”</b>	15
<b>Figure 5. Percentage of students in grades K–2 agreeing with statements about importance of science</b>	17

List of Tables

<b>Table 1. Percentage of students reporting they frequently had the opportunity to do NGSS-aligned activities</b>	14
<b>Table 2. Percentage of grades 3–5 and 6–8 students rating themselves “good” or “really good” at science activities</b>	16
<b>Table A1. Administration of student survey, by kind of teacher in the Initiative, student grade band, and time of year</b>	22

# Evaluation of the NGSS Early Implementers Initiative

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

- › districts' local implementation,
- › implementation support provided by 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 #6, evaluators previously released:

- › *The Needle Is Moving in California K–8 Science: Integration with English Language Arts, Integration of the Sciences, and Returning Science as a K–8 Core Subject* (Evaluation Report #1, October 2016)
- › *The Synergy of Science and English Language Arts: Means and Mutual Benefits of Integration* (Evaluation Report #2, October 2017)
- › *Administrators Matter in NGSS Implementation: How School and District Leaders Are Making Science Happen* (Evaluation Report #3, November 2017)
- › *Developing District Plans for NGSS Implementation: Preventing Detours and Finding Express Lanes on the Journey to Implement the New Science Standards* (Evaluation Report #4, February 2018)
- › *Next Generation Science Standards in Practice: Tools and Processes Used by the California NGSS Early Implementers* (May 2018)
- › *Making Middle School Science Whole: Transitioning to an Integrated Approach to Science Instruction* (Evaluation Report #5, October 2018)

# Executive Summary

Because the NGSS differ from past standards in substantive ways, NGSS instruction impacts students in substantive ways. In a dramatic departure from instruction that focuses predominantly on scientific information and facts, the NGSS move beyond textbooks to emphasize hands-on inquiry focused on real-world phenomena. The NGSS also promote deeper learning by engaging students in activities that scientists routinely do, including asking questions and defining problems, and planning and carrying out investigations. Notably, students, rather than teachers, are the primary actors in the NGSS science classroom.

This evaluation report describes the benefits that students are getting from their districts' participation in the California K–8 NGSS Early Implementers Initiative. The findings are drawn from surveys of administrators, teachers, and students; interviews with select administrators and teachers; and classroom observations of 22 case study teachers. The report also presents an extended vignette of a grade 4 lesson to illustrate the student experiences and benefits that occur in NGSS instruction.

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## Findings

The report findings indicate that students are:

- More excited about and engaged in science.
- Experiencing more inclusive participation.
- Showing evidence of higher-level learning.

These benefits extend across a diverse range of students, including those who are traditionally

underserved, such as special education students, English learners, and those who are generally low-performing or less engaged.

During classroom observations, evaluators often directly observed high levels of student engagement and learning. Further, in surveys, strong majorities of the over 1,200 responding students taught collectively by over 40 instructors reported that:

- Their teachers indeed were providing teaching that is informed by and aligned with the NGSS.
- They had become “good at” carrying out most aspects of NGSS learning.

Data in this report were collected from the hundreds of Initiative Teacher Leaders (and their students) who have participated in substantial amounts of the Initiative's professional learning. Administrator data was obtained from principals of schools with one or more of these Teacher Leaders. Results could vary for other district teachers or administrators who have received less support and professional learning.

## Student Benefits

In surveys, almost all teachers and administrators (99 and 95 percent, respectively) reported a positive change in the general quality of students' science learning. Additionally, over 90 percent of both teachers and principals also indicated that NGSS instruction is having a positive effect on the learning of traditionally low-performing students.

The report provides dozens of quotes to help readers understand the evaluation's findings and hear them from the vantage point of the Initiative's participants. Following are sample quotations that illustrate three areas of student benefits discussed in the report: (1) stronger engagement, (2) more inclusive engagement, and (3) higher-level learning.

*I think it's just a whole different feeling for the kids now. Because of the way the class is set up, and the way it revolves around phenomena. . . . I've talked to a lot of kids and they really like science now. (Middle school principal)*

*Parents will tell me, "Oh my gosh, my kid won't stop talking about this thing. What in the world are you guys doing in class!?" (Grade 5 teacher)*

*My school has the lowest socioeconomic status of the district. Our students crave hands-on, engaging activities. They don't tend to be kids with much prior knowledge and life experience with scientific phenomena. So, [NGSS activities] are important for them to be successful. (Elementary school principal)*

*I'd say [NGSS teaching] is positive for all, but we're reaching students that we might have not reached — giving them self-confidence and getting their interest and tying it in to their experiences. Special ed kids were very engaged. (Grade 8 teacher)*

*. . . More depth, more richness. They're getting science skills, not just facts. They're more engaged in content and models and putting it all together. . . . They're thinking about their thinking. Class discussions are better. (Grade 4 teacher)*

## Students' Views

The report also discusses the results of whole-class surveys administered to students in the K–2, 3–5, and 6–8 grade bands.

- Overall, a substantial majority of students reported frequently doing all of the 12 NGSS-aligned activities that they were asked about in the student survey.
- Additionally, at least half and as many as two-thirds of students reported that they were "good" or "very good" at each NGSS-aligned activity they were asked about.
- Even beginning in grades K–2, students had positive views about science. Students also reported speaking about their classroom science with parents and friends.

These results suggest that not only are the Initiative's Teacher Leaders providing NGSS learning activities, they are fostering student confidence and promoting stronger interest in science.

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## Recommendations for Administrator Support

The report concludes with 10 aspects of science teaching that administrators can promote and support among their teachers to enhance student engagement and learning. This concluding section also offers a few recommendations for administrators to develop the NGSS knowledge and expertise needed to provide such teacher support, including understanding the substantial instructional shifts required by NGSS, giving teachers freedom to fail as they try out these instructional shifts, and making time for teachers to collaborate on planning and teaching NGSS lessons.



# Introduction

This evaluation report discusses ways that students are being affected by their teachers' implementation of the Next Generation Science Standards (NGSS Lead States, 2013). The authors aim for this report to provide useful content for school and district administrators, leaders of science professional learning, and state policymakers.

Grounded in decades of research, the NGSS as well as the 2016 *Science Framework for California Public Schools* and the California K–8 NGSS Early Implementers Initiative all argue that NGSS teaching<sup>1</sup> is better for students than previous models of science learning that focused more on rote learning. Why? Because the NGSS move beyond textbooks to emphasize hands-on inquiry focused on the real world. The NGSS also promote deeper learning by engaging students in activities that scientists routinely do. One of the three dimensions of the NGSS, the science and engineering practices (SEPs),<sup>2</sup> lists eight such activities, including asking questions and defining problems, and planning and carrying out investigations. Notably, students, rather than teachers, are the primary actors in the NGSS science classroom.

One central feature of the NGSS is emphasis on equitable access to quality science instruction for *all* students. As explained by National Academies of Sciences, Engineering, and Medicine (2017), “Engaging students in thinking and solving

“Students are actively engaged, they’re having academic conversations about what they’re learning, they’re participating. They are sitting down and writing what they are learning in their notebooks. They’re definitely very engaged and excited about what they’re doing.” (Elementary school principal)

problems the way scientists and engineers do . . . will help them better see how science is relevant to their lives. This approach capitalizes on the natural curiosity all students have about the world around them and helps educators provide varied learning experiences that offer entry points for students from diverse backgrounds” (p. vii).

The NGSS call for students to investigate phenomena, which are occurrences in the natural or man-made world that can be observed and which cause one to wonder and ask questions. Teachers in the Early Implementers Initiative have been encouraged to choose phenomena that are relevant to students' immediate environment in order to make science more accessible for all students and increase their engagement in learning.

Over the past three years of the NGSS Early Implementers Initiative, the evaluation has been examining whether students are benefiting from NGSS implementation. The majority of

1 When we refer to *NGSS teaching*, we refer to teaching that is deeply informed by and aligned to the concepts, skills, and approaches to learning laid out by the NGSS.

2 The NGSS call for three dimensions: the SEPs (described in the introduction); the disciplinary core ideas (DCIs), which pertain to the science content (i.e., life, Earth and space, and physical sciences); and the crosscutting concepts (CCCs), which are themes common to the science disciplines as well as other content areas (e.g., patterns, cause and effect). The three dimensions help students begin to act, know, and think like scientists.



adult participants in the Initiative<sup>3</sup> (i.e., teachers and administrators) reported that, compared to pre-Initiative teaching, the NGSS teaching supported by the Initiative:

- More strongly engages students;
- Better engages all students, including low achievers and traditionally underserved populations such as English language learners and students with special needs; and
- Elicits higher-level student learning.<sup>4</sup>

Further, in surveys for grades K–2, 3–5, and 6–8, the majority of students reported that their teachers indeed are providing them with NGSS learning opportunities, and that they feel “good at” being able to do this kind of NGSS learning. They also generally had positive views of the importance of science and were interested in science outside of the classroom.

## Evaluation Methods

This sixth release in the publication series from the evaluation of the Early Implementers Initiative draws upon the following data:

- Annual surveys of two types of teachers and administrators in the eight Early Implementer districts:

- Those who have received extensive professional development and support from the Initiative (i.e., Teacher Leaders and Core Administrators<sup>5</sup>)

- “Expansion” teachers and principals who have not directly received significant professional learning or support from the Initiative but who are benefiting through the shared expertise of those who have.

- Interviews with select teachers and administrators in Early Implementer districts:

- 23 case study teachers<sup>6</sup> and 21 expansion teachers
- 11 Core Administrators, 3 expansion principals, and 1 district-level administrator

- Observations of lessons taught by 22 case study teachers<sup>7</sup>

Evaluators also had select teachers administer whole-class student surveys. The teachers selected to administer these surveys were known to be making significant efforts to implement NGSS teaching and had received extensive professional learning from the Initiative. In these surveys, students were asked about their NGSS science learning activities and how empowered they feel to do such activities.

Appendix A describes the evaluation data sources in further detail.

<sup>3</sup> It should be noted that the rich evidence provided in this brief comes from individuals at the forefront of implementation and may not be representative of teachers who have not benefited from the years of training the Initiative has provided.

<sup>4</sup> Because the new NGSS-oriented California Science Test (CAST) is just being rolled out, the evaluation is not able during the period of this project to investigate impacts on test scores.

<sup>5</sup> See the Glossary for a brief description of the roles of the Early Implementer participants discussed in this report as well as other Initiative- and NGSS-related terminology.

<sup>6</sup> Case study teachers were recruited in five of the eight participating districts to gain classroom- and teacher-level insight into NGSS implementation. District Project Directors nominated case study teachers from among Teacher Leaders, including those on the Core Leadership Team, in their districts who had received extensive support from the Initiative and who were making some of the most substantial changes in their teaching in relation to the NGSS.

<sup>7</sup> Evaluators observed one science lesson taught by each case study teacher in Years 3 and 4 of the Initiative to capture what NGSS look like in the classroom and to track growth in teacher mastery of three-dimensional NGSS instruction. Case study teachers provided the evaluators with information about their lesson plans in advance of each observation, and a brief interview was conducted with the teacher after the lesson. Observed lessons typically lasted 45 to 90 minutes.

# Evaluation Findings

Teachers, administrators, and evaluators have observed a range of benefits to students resulting from NGSS instruction. Not only have teachers and administrators reported that students are engaged in the hands-on activities that are based on the NGSS SEPs, but they have also excitedly reported that they have seen increased engagement in individual students who previously had not participated or succeeded in class. Beyond engagement, teachers recounted that their students are learning in a deeper way by making connections to other content areas, to the world outside the classroom, and to previously learned science content. Teachers also reported that students are also gaining insight into their own learning, contrasting what they thought they knew with what they have learned.

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## Stronger Student Engagement

In the spring 2018 survey, more than half of Teacher Leaders and expansion principals (61 and 55 percent, respectively) reported a “substantial” increase in student engagement resulting from the changes toward aligning teaching with the NGSS. Nearly all survey respondents indicated at least a “slight to modest” increase in student engagement (90 and 97 percent, respectively). Further, in over 40 teacher observations, evaluators also witnessed substantial student engagement more than half of

the time and saw students not actively engaged in only two instances.<sup>8</sup>

During interviews, many participants gave emphatic statements about the increased student engagement, such as the following:<sup>9</sup>

*They absolutely love it — never [has there been] a time in the past three years I’ve done this when students are not excited. [They’re] basically running to my class. I highly believe every single time that they are 100 percent engaged in NGSS. I would give them a 10 on level of engagement now. (Grade 3 teacher)*

*I think there’s a growing group of students who do feel more confident. My quieter kids are raising their hands and contributing an answer. I’m thinking of a couple of kids that volunteered and contributed who never did before. (Grade 6 teacher)*

When teachers and administrators were asked what aspects of the NGSS students found most engaging, a few themes emerged. They reported that the focus on phenomena piques students’ curiosity and motivates them to try to understand, as described by the following statements:

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8 Observation data was gathered from field notes taken by the evaluation staff who observed each class.

9 The evaluators had many illustrative interview comments from which to choose for every topic in this report. Interested readers can see additional quotations in Appendix B.

*I think with my students it's the phenomena and integration of phenomena, the ability to go out and question. It awakens their curiosity. They're not used to looking around and questioning things. (Grade 3 teacher)*

*I think it's just a whole different feeling for the kids now. Because of the way the class is set up, and the way it revolves around phenomena, and how there's not really an endpoint. I've talked to a lot of kids, and they really like science now. (Middle school principal)*

*Using phenomena — something in the real world that they can connect to — has been really helpful. We have a lake and trails and hills nearby. There's lots of stuff going on, so I try to incorporate phenomena like that to increase engagement. They know things are happening, but they don't know why. (Grade 7 teacher)*

The NGSS aim to increase student agency, and teachers described how students are eager to answer the questions that arise in their own minds. Teachers also reported that because students want to “figure out what's going on,” they are motivated to apply themselves and deeply engage with a reading or an investigation that will shed light on what they are trying to understand.

The NGSS help engage students more deeply in their learning by promoting peer collaboration and communication (NRC, 2015, p. 30). As they share ideas and work in groups, students can play a role in furthering one another's understanding.

The following teacher remarks describe the strong and purposeful student collaboration that has resulted from NGSS teaching:

*I started having students give each other feedback. The feedback has not just been “Great job,” or “You need to add more.” They actually give specific constructive feedback, like “You forgot about this one detail about the video. This might make your argument stronger.” They understand deeply, and they care about what they're doing, so they add more details, more information. (Grade 5 teacher)*

Another aspect of engagement that emerged with many teachers was that students' engagement and learning can be a process that does not stop at the end of a class.

*Even when they finish whatever they're going to finish, they understand that they're going to go on and build on this more and more over the years. And the students like that. (Middle school principal)*

*They are so engaged with everything that they do, that they're better learners. They're more interested in being a lifelong learner. They're more interested in thinking scientifically. They didn't even know that they could. (Grade 5 teacher)*

For example, some teachers reported that students routinely refer to their personal science notebooks for evidence recorded during previous investigations.

*We were doing an activity, and I noticed that students just started writing in their notebooks. I was like “Whoa!” Because usually you have to remind them. Then, when I was going back and reviewing, I’m seeing them open their notes on that topic in their notebooks. And they like to look back to see what they thought before. So, when we’re at the end of a unit, they’ll look back at the beginning and realize how far they’ve come. This blows my mind. (Grade 4 teacher)*

Teachers also reported that students are sharing what they have done and learned in science class with friends and family.

*Parents will tell me, “Oh my gosh, my kid won’t stop talking about this thing. What in the world are you guys doing in class!?” (Grade 5 teacher)*

*We did a lesson on collision with a wall and ball. A couple of days later, one of the teachers on duty at noon heard kids saying, “We did this for science.” During lunch the kids were trying to teach friends from other classes who hadn’t done the lesson. Like if you hit the ball, this is the angle that it goes. So, they were sharing the lesson with other students. (Kindergarten teacher)*

*On the student survey, I noticed more said they talk about science outside of class than they had in previous years. Definitely increased. . . . I did more NGSS this year than the year before. Seems like those two might go hand in hand. (Grade 6 teacher)*

## More Inclusive Engagement

Another common theme that emerged from the interviews is that NGSS teaching allows more equitable access to learning. When initially presented with phenomena, students are often captivated and very curious, and the NGSS are designed to encourage students to ask questions accordingly. Teachers reported that this initial period during which all students are pondering the phenomenon but none of them are yet able to explain it — and there are no shortcuts to the right answer — puts all members of the class on an equal playing field. They have seen that starting a lesson this way can help free students’ creativity, confidence, and willingness to engage.

*It’s funny, students are not confident in other areas, but in science we all don’t know. I ask, “Why?” and all students come up with hypotheses, all on the same level. Kids who don’t usually excel come up with great ideas. (Grade 3 teacher)*

*I think [NGSS science] gives everybody an opportunity to succeed and to be a thinker. There’s really no right or wrong answers when you’re exploring. I mean, there are in a sense, but when you’re exploring it gives them a chance to talk and explain and justify their answers [even] if they’re not necessarily the correct ones. (Grade 2 teacher)*

*One of the things that I think really sent a message to me was [seeing] the teacher work through a multiple-choice quiz with a class. The kids can come and defend*

*their answer. As soon as the teacher bubbles C — so C's the right answer — the kid said D. Then they can defend why D is the right answer. The teacher gives them credit for their ability to defend and reason with evidence why their answer, even though it's different from the teacher's, is correct. So, you take a very simple multiple-choice question, and it goes from the simplest form of learning to one of the highest forms of learning. (Middle school principal)*

Interview respondents reported that NGSS instruction strongly engages a wide range of students, including English language learners, students with special needs, and lower-performing students. Some also reported parity in engagement and learning between girls and boys. In interviews, teachers and administrators touched on possible reasons for the increased engagement of these various student groups. For instance, students are often more active in NGSS classrooms — they engage in hands-on activities and are encouraged to question and to vocalize their ideas. In addition, in NGSS lessons, academically challenging activities such as reading, learning vocabulary, and analyzing data come *after* students' interest has been engaged through a more accessible, hands-on investigation set in a real-world context. The NGSS may also be engaging a wider range of students because, as one teacher put it, "Kids love it because this kind of science is fun!"

Interview respondents shared stories about reaching different sets of students:

*This science teaching is helping English learners who struggle with vocabulary. One girl, when she's doing science, has*

*an awesome scientific mind. She can see the picture clearly but can't describe it well. But now she can draw models and label what she's drawn. And she gets her points across. English learners feel more confidence, because they don't need vocab up front. They can learn words as they go, and they remember words better. (Grade 5 teacher)*

*My school has the lowest socioeconomic status of the district. Our students crave hands-on, engaging activities. They don't tend to be kids with much prior knowledge and life experience with scientific phenomena. So, [NGSS activities] are important for them to be successful. (Elementary school principal)*

*I'd say [NGSS teaching] is positive for all, but we're reaching students that we might have not reached — giving them self-confidence and getting their interest and tying it in to their experiences. Special ed kids were very engaged in building designs for earthquake-proof buildings, making building modifications after researching it. If there was more lecture, they would have tuned out. But with NGSS, they felt more engaged and felt respected, had great ideas, and were able to share those ideas, and co-teach those ideas versus just being told. (Grade 8 teacher)*

Another teacher described how NGSS teaching is engaging the girls in her class as well as, or better than, the boys:



*People talk about girls needing to be included more in STEM, but my girls are the most active ones in the class. We just did a big engineering project, and some of my girls were the most successful. They seem as engaged or more engaged than my boys sometimes. (Grade 8 teacher)*

When asked in a survey whether student engagement of low-performing students has changed, almost half (46 percent) of Teacher Leaders and over a third of principals (35 percent) reported a “substantial” change; only 2 percent of teachers and 6 percent of principals reported “no change.”

## More High-Level Learning

Teacher Leaders and administrators overwhelmingly reported that students in NGSS classrooms are gaining both a deeper understanding of science and important skills in communication, critical thinking, and teamwork. In the NGSS classroom, for instance, students are frequently called upon to use language to formulate and share their ideas. Effective NGSS instruction prompts students to record their thoughts, questions, and predictions in their notebooks; engage in student-to-student discourse to question and learn from one another; develop and label models to conceptualize and explain scientific phenomena; and conduct close reading to answer their own questions.

The following administrators’ remarks illustrate the contrast between NGSS learning and the more rote science learning that took place pre-NGSS:

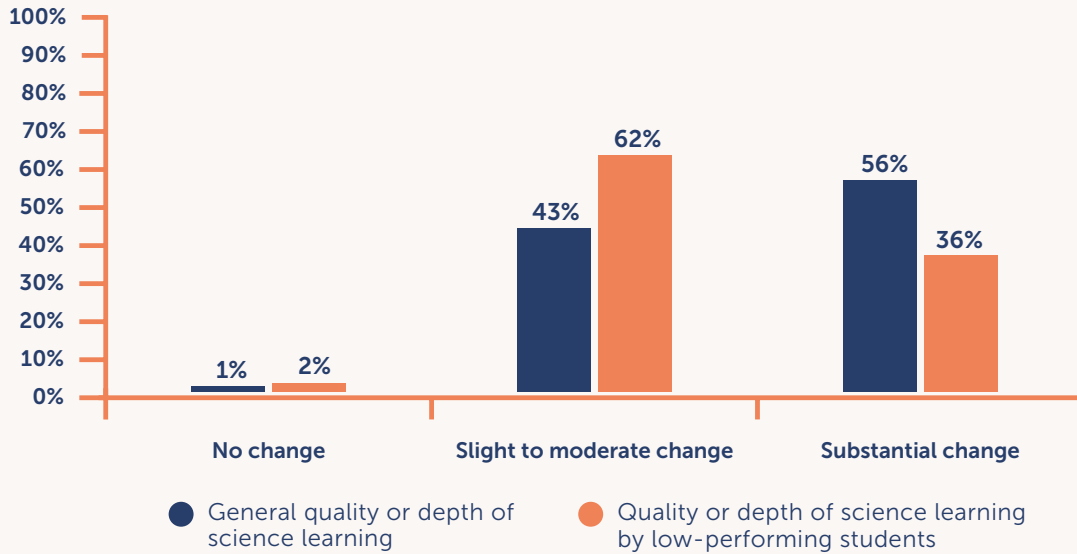
*The thing I love about this is that I think we’re doing the right thing. For a long time, I thought in education we weren’t*

*doing things for the right reasons, we were doing it because we wanted the kid to bubble the right letter on the test. But it isn’t like that anymore — this is about showing your work, explaining your work. And even if your work and your answers when you’re explaining your work aren’t correct, you still are going through a process, like scientists would go through. And that’s okay because now you go back and you revise it and then you come back and you get another opportunity to explain your reasoning. I think it’s going to pay off big time for these kids. (Middle school principal)*

In surveys, teachers and principals in Early Implementer districts were asked if they had seen any change in the quality of student learning in classrooms implementing the NGSS. Almost all (99 percent of teachers and 95 percent of principals) reported seeing a positive change in the general quality of science learning, with about half (56 percent and 42 percent, respectively) reporting “substantial” positive change, as shown in Figures 1 and 2. While teachers’ and administrators’ survey responses indicate a somewhat lesser impact for low performers (36 percent and 34 percent, respectively reported seeing a “substantial change” in low-performing students’ learning), over 90 percent of both teachers and principals indicated that NGSS instruction is having at least a “slight to moderate” positive effect on these students’ learning. Further, many interviewed teachers recounted instances of individuals in their classes, who previously were rarely engaged or were struggling to learn, participating in class and gaining skills and confidence from NGSS instruction.

**Figure 1. Teacher Leader–reported changes in classrooms implementing the NGSS**

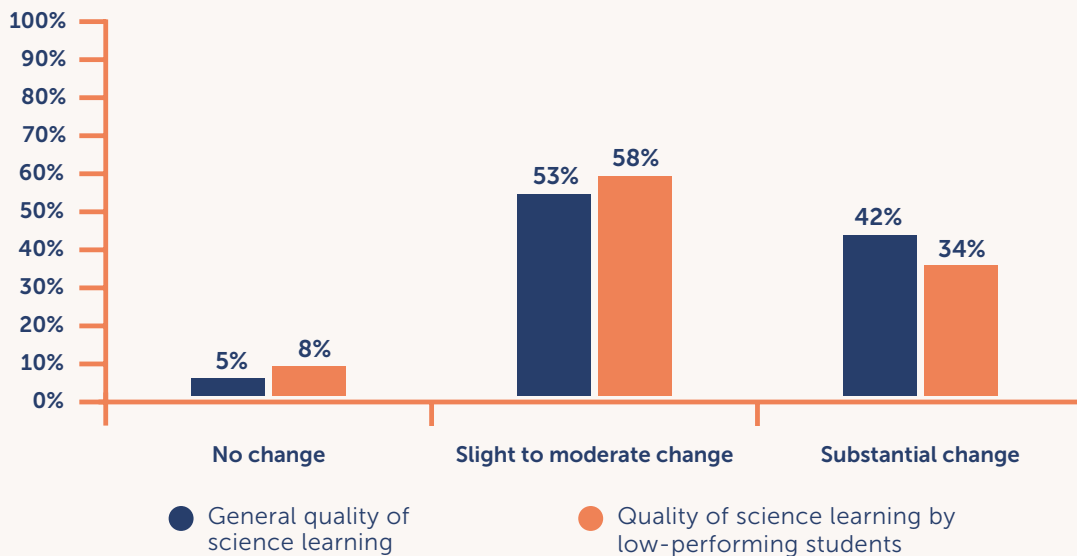
*As a result of changes you have made toward teaching NGSS, how much of the following changes have you seen in your students?*



Source: Teacher Leader Classroom Science Teaching Survey, administered by WestEd in 2017–18 (N=293).

**Figure 2. Principal-reported changes in classrooms implementing the NGSS**

*What kind of changes, if any, have you noticed in students in classrooms implementing the NGSS*



Source: Survey for Principals, administered by WestEd in 2017–18 (N=65).



The following remarks by interviewees illustrate the kinds of higher-level learning that are happening in NGSS classrooms where curiosity is encouraged and valued:

*Before NGSS, a lot of it was, "Let's demo the experiment on the overhead." The kids would scribble a little picture in their notebook, and that was the science lesson for the day. Engagement was not high. I'm telling them what to write and they'll forget it by next Tuesday. Now it's hands on. They're experimenting, trying things. They ask questions and want to answer their questions. They're seeking out ways to do that. (Kindergarten teacher)*

*Where I see the biggest shift is in students' depth of learning. The way we're asking them to explain and what we want them to understand is taking them to that deeper knowledge. Students can explain, for example, not just physics, but the link to the biological system of an animal. Not memorizing Newton's Laws but figuring out how they apply to a biological system. (Grade 8 teacher)*

*Things are connected. You reflect, see how things that come before link to the things at the end. More depth, more richness. They're getting science skills, not just facts. They're more engaged in content and models and putting it all together. In their notebooks, they're able to go back and look at a model and explain from*

*that what they used to know and how that's different. They're thinking about their thinking. Class discussions are better. They're asking questions of me, and of other kids — not just sitting there. (Grade 4 teacher)*

*NGSS bring a level of rigor in student independence and thinking... For example, my own first grader's teacher is not NGSS trained, but the kindergarten teacher is. The kindergarten students were designing lab activities about pushes and pulls and, even when they didn't have all the words, recording data on whiteboards with a group of peers, with descriptions of vocabulary to talk about what they saw. Compare that to my daughter who was copying a diagram of the body and recording notes and regurgitating facts about the body. Huge difference! Kindergarteners were doing more critical thinking than first graders. (Middle school principal)*

Students are not only gaining science-related skills and knowledge, but NGSS instruction is also benefiting their learning in English language arts (ELA).<sup>10</sup> Teachers reported that their students are sustaining higher levels of reasoning and analysis in science class, reading more complex texts, putting their ideas into more detailed writing, and more consistently backing up their written and verbal assertions with specific evidence.

<sup>10</sup> Evaluation Report #2, *The Synergy of Science and English Language Arts* (2017), extensively describes the means and mutual benefits of cross-subject integration that were observed by the evaluators.

## An Extended Example of Students' Learning

The following vignette presents a lesson taught by a case study teacher whose participation in the Initiative began as a member of the Core Leadership Team in the 2014–15 school year. The lesson was observed by an evaluator toward the end of the fourth year of the Initiative. The vignette illustrates how teacher-student discourse<sup>11</sup> can effectively elicit student engagement and learning.

In this grade 4 lesson observed by an evaluator, students were designing and conducting an investigation of whether or not the speed at which objects are moving affects energy transfer during collisions. In her usual way, the Core Teacher Leader structured each part of the lesson to maximize the degree to which students could formulate their own ideas and pursue their own questions. As the teacher said, she made a point of letting students “discover on their own and teach each other.”

The lesson begins with a video showing close-ups of a series of collisions (a man's face with a soccer ball, two people chest bumping, a car and a truck, etc.). The teacher has students talk at their tables about what they remember about collision from prior lessons. The table groups talk, and some students are seen referring to their notebooks. Then, the teacher facilitates a brief whole-class discussion about energy transfer. She asks questions such as, “How do you know where the energy went?”

A student explains, “There's energy in your hand. If you're using a ball, when you hit it, the stored energy turns into action energy in the ball.”

The teacher counters, “How do you know it turns into action energy?”

Student: “When the ball starts moving, it's action.”

Teacher: “Can anyone add to that?”

Student: “If a car hits another car, and it hits another car and that one hits another car, the energy transfers from the first car, to the next car, to the next car.”

Teacher: “Ok, you know how energy transfers in collision. Now we're going to throw in speed. Does speed make a difference? Take 30 seconds and talk in your group. Do you think speed makes a difference? And maybe how you know?”

Table groups share their ideas.

Teacher: “Ok, write this question in your notebooks: Does speed make a difference in energy transfer? Once you've written the question, your answer is going to be your claim. Please write your answer underneath.”

Teacher: “You're going to create a model. You're going to pick items that I'll show you, and you're going to draw a model of how you are going to gather evidence to support or disprove your claim.” She holds up all kinds of objects kids can use: whiffle balls, golf balls, pennies, marbles, frisbees, tennis balls. “I want you to pick two or three items, three max, that you'll use to change the speed of your first item into the second or third item. How will speed change and how will energy transfer? Draw your model now, add labels, and show arrows predicting how the energy will

11 For more on questioning strategies to promote student discourse and learning, see the special report: *Next Generation Science Standards in Practice: Tools and Processes Used by the California NGSS Early Implementers* (2018). <https://www.wested.org/resources/next-generation-science-standards-in-practice/>

transfer." Students individually create their own model and write a prediction in their notebooks.

Teacher: "Now you're going to compare models and talk about ideas in your science group.

Remember, you're trying to test your claim — does speed matter? You want to pick the model for the group."

A student asks, "Do you make another model if you mess up?"

Teacher: "Yes, you can always change your model."

Teacher: "You're going to need to collect some data. If you say speed matters and there's a difference in the way energy moves, you have to prove it. How are you going to prove it? You have to collect data. I want you to think about: If I do this, this happens. I want you to try to make a table — some of you are really good at this — this goes with this. I'm going to walk around and if you need it, I might give you a little hint to help with your tables. Once you do all that, I want you to record in your notebook what happened. Did you have any patterns? You can draw a model of what happened. Questions?"

Soon all groups are actively implementing their plans, testing the influence of speed on energy transfer in collisions. Some students begin by rolling balls into each other without recording the outcome. But after a few minutes all are becoming more controlled and methodical, measuring the distance that the items roll after they have collided.

After about thirty minutes, including a five- and a two-minute warning, the teacher asks the groups to stop. "Would anyone like to be so brave, be a leader, and explain if speed matters when energy is being transferred? How does energy transfer at different speeds? I'd like you to use your data. If you want to show your data under the projector, you can."

A student walks to the front of the room and places her notebook under the overhead projector.

The teacher comments, "Oh! She set up a table! But I can't tell which is fast and slow."

Student: "I put an 'S' and an 'F.'"

Teacher: "Ok! What did you do?"

Student: "We collided two balls."

Teacher: "What did you measure?"

Student: "The distance the balls went. There's four distances. The slow one is 4 centimeters. The fast is 28, 32, and 52 centimeters. When you go faster, the more stored energy there is. So it goes farther."

Another student put his notebook under the projector and explained his team's investigation. The teacher exclaims, "These are great! Great data! Now, I'm going to give you a poster. This is new, so I'll walk you through it. This is 'Claim, Evidence, Reasoning.' You're going to put your evidence on the left."

She shows a sample chart on screen (see Figure 3).

The teacher gives a large blank sheet of paper to each table. The students work to transfer their claim and the evidence they collected onto the large sheet. She explains, "At the bottom you're going to connect the two. It's called reasoning. 'Yes, speed makes a difference in energy, or no it doesn't because...'. You're going to use your numbers there: 'Because when it went slow, it went this far, when it went fast, it went this far.' I want to see something about stored energy in there too."

At the end of the class, students hand in their posters.

Teacher: "On Monday we'll finish the posters and write our CERs in our notebooks."

Figure 3. Claim, Evidence, Reasoning chart from case study teacher observation

Does speed make a difference in energy transfer?	
Evidence	Claim
1.	Yes, speed does make a difference in energy transfer.
2.	OR
3.	No, speed does NOT make a difference in energy transfer.
Reasoning (HOW does speed make a difference in energy transfer?)	

Source: Replica of a teacher worksheet used in a lesson observed by an evaluator in April 2018.

### Concluding Thoughts

This lesson was chosen because it includes pedagogy that resulted in high levels of student engagement and learning. For example, the teacher began the lesson with open-ended questioning that prompted students to talk first in groups and then as a whole class about what they remembered or knew about energy transfer. Such questioning strategies elicited student sharing that went beyond factual recall to explanation, complete with students sharing examples that illustrated their thinking. Starting the lesson with group discussion created an accessible entry point to the topic for all students.

Giving further opportunities to share ideas with their table groups allowed students to vocalize and clarify their thoughts and to learn from each other. Before carrying out their investigations, students individually developed models to represent their current understanding (prediction) of the lesson topic, the impact of speed on energy transfer. This important step required all students to access and record their prior knowledge, which

facilitated them truly making sense of new information gained during the investigation. It also served as food for reflection after the lesson, when students were able to gain appreciation for how much their understanding had grown.

Finally, having students design, plan, and carry out their own investigations was highly engaging for students and fostered development of scientific skills that will be useful in future learning (the SEPs, such as asking questions, planning and carrying out investigations, analyzing and interpreting data). Through this inquiry-based, hands-on experience, students learned in a way that was both more inclusive and more impactful than traditional instruction.

### Students' Views

The results presented thus far have been based on views obtained from teachers and from classroom observation by evaluators. To complement those data sources, evaluators also used whole-class surveys to obtain views directly from students.

Surveyed students were from classrooms of teachers who were known to be making particularly significant efforts toward NGSS teaching; therefore, the following responses may not be reflective of all students across the participating Initiative districts. These whole-class surveys asked students how frequently their teachers provided opportunities for them to participate in NGSS-aligned learning activities, their confidence level at doing NGSS-aligned learning activities, and their views on the importance of science.

### *Students Have Opportunities to Do NGSS-Aligned Activities*

In a spring 2017 survey, students in grades 3–8 reported on the science instruction they received during the 2016–17 school year.<sup>12</sup> Specifically, they were asked how frequently they did each of 12 NGSS-aligned activities, all of which reflect the NGSS dimension of SEPs.

A substantial majority of students within grades 3–5 (66 percent) and grades 6–8 (93 percent) reported doing all 12 NGSS-aligned learning activities frequently.<sup>13</sup> These results suggest that the NGSS Early Implementer teachers who have participated in significant professional learning from the Initiative are consequently transforming their instruction to provide NGSS-aligned learning activities for their students.

More specifically, Table 1 indicates that at least three-fourths of students (75 percent or more)

reported frequently doing more than half of the activities (seven and eight of the 12 activities at grades 3–5 and 6–8, respectively). Further, for the other activities, a significant majority of students (at least two-thirds or more) also reported doing them frequently.

Students in the K–2 grade band answered a small set of questions about their science class. Their responses suggest that their teachers' instructional methods were consistent with NGSS approaches.<sup>14</sup> Specifically, over 80 percent of K–2 students agreed with each of the following statements.

*When we do science in school:*

- › *We make things.*
- › *We work in groups.*
- › *We go outside.*
- › *It's OK to make mistakes.*

The grades 6–8 survey in spring 2018 also asked students to indicate how often their class addressed the NGSS dimension of crosscutting concepts (CCCs).<sup>15</sup> Figure 4 indicates that, for each of the seven CCCs, a substantial majority of students (73–89 percent) reported learning about them frequently (“frequently” represents the survey response options of “a lot” or “sometimes”). These results suggest that the NGSS Early Implementer teachers at the middle grades who have participated in significant professional learning from the Initiative are transforming their instruction to include instruction about the NGSS CCCs.

12 This question was not asked in the survey for grades K–2. Survey piloting demonstrated that the students in this age group were not able to reliably understand the question.

13 We have defined “frequently” by the following student response options on the survey: “sometimes” or “a lot” for grades 3–5, and “every two weeks,” “weekly,” or “almost daily” for grades 6–8.

14 The lengthier items were not included in the survey for grades K–2 for two reasons: survey piloting demonstrated that these young students were not able to reliably understand some questions, and the K–2 survey had to be much shorter than the ones for grades 3–5 or 6–8 in order for students to be able to get through the entire survey.

15 This survey question will be included in future administration of the survey for grades 3–5. The question will not be included for the grades K–2 survey because survey piloting revealed that, while other data sources indicated students in K–2 did have some instruction involving the substance of the CCCs, the students in this grade band could not reliably recognize the names used for those concepts.

Table 1. Percentage of students reporting they frequently had the opportunity to do NGSS-aligned activities

NGSS-aligned activity	Grades 3–5 >75% <sup>a</sup> of students	Grades 3–5 >66% <sup>b</sup> of students	Grades 6–8 >75% of students	Grades 6–8 >66% of students
Write in your science notebook	X		X	
Talk or work in groups	X		X	
Use evidence to support a claim	X		X	
Come up with explanations	X		X	
Talk about results from investigations	X		X	
Ask questions	X		X	
Plan investigations	X			X
Record observations		X	X	
Connect science to the real world		X	X	
Develop and use models		X		X
Do investigations		X		X
Define problems		X		X

Sources: Student Science Interest Survey administered by WestEd in spring 2017 in grades 3–5 (N=396) and grades 6–8 (N=801).

Note: "Frequently" is defined by the following student response options on the survey: "sometimes" or "a lot" for grades 3–5, and "every two weeks," "weekly," or "almost daily" for grades 6–8. The other answer choices for grades 3–5 were "never" and "not much," and for grades 6–8 were "never," "less than monthly," and "monthly."

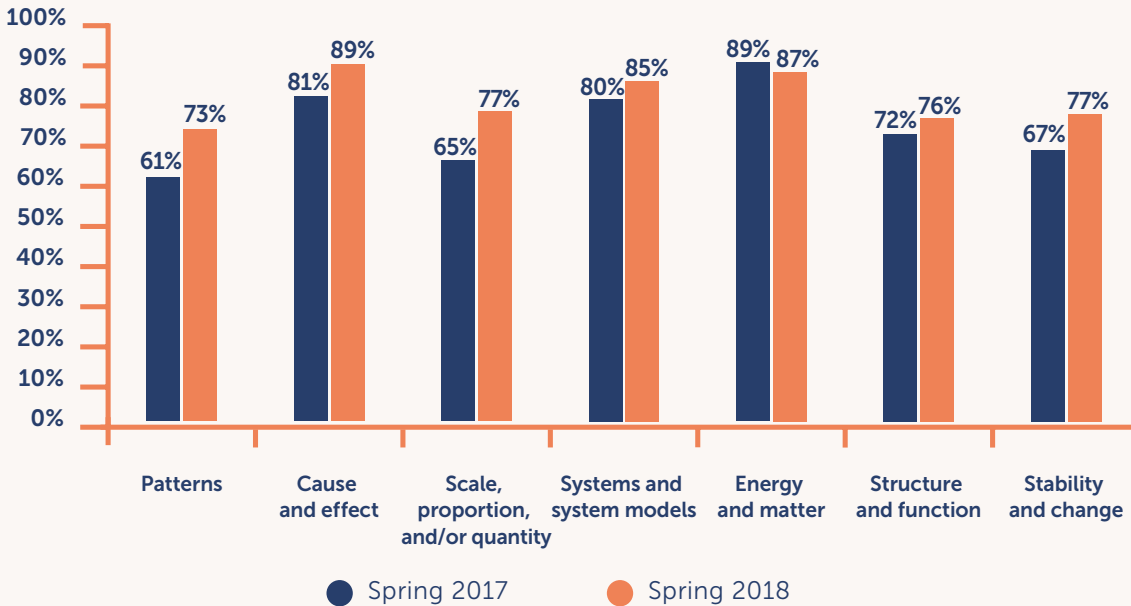
<sup>a</sup> >75% = 75–93%

<sup>b</sup> >66% = 66–71%



Figure 4. Percentage of middle school students reporting that they learned about NGSS crosscutting concepts “sometimes” or “a lot”

How often did your science class learn about the following things this year?



Source: Grade 6–8 Student Science Interest Survey, administered by WestEd in spring 2017 (N=793) and spring 2018 (N=710). Note: Other answer choices were “never,” “not much,” and “I don’t know.”

Figure 4 further illustrates that, for six of the seven CCCs, more students (between 4 to 12 percent more) indicated having frequent opportunities to learn the CCC during the 2017–18 school year than in the prior school year. These data suggest that NGSS Early Implementer teachers have likely been increasing their instruction on these CCCs over time.

### Students Feel Able to Do NGSS-Aligned Activities

While the prior discussion suggests that Initiative teachers are now providing NGSS-aligned learning activities for students, the surveys also investigated how confident students feel about their

ability to engage in those activities. Specifically, students were asked, “How good do you think you are at these things?”

The spring 2018 survey results for grade bands 3–5 and 6–8 indicate that, for each NGSS-aligned activity, at least half and as much as two-thirds of students felt able to effectively engage in the activities (see Table 2). That is, they felt that they were “good” or “very good” at the activity. Overall, slightly more students in grades 6–8 reported that they were “good” or “very good” at the science activities.

As for the K–2 grade band, on one similar question included in their survey, 75 percent of students agreed with the statement “I am good at science.”



Table 2. Percentage of grades 3–5 and 6–8 students rating themselves “good” or “really good” at science activities

NGSS-aligned activity	Grades 3–5 From 64–67% students	Grades 3–5 From 56–60% students	Grades 3–5 From 47–54% students	Grades 6–8 From 64–67% students	Grades 6–8 From 56–60% students	Grades 6–8 From 47–54% students
Talking or working in groups	X			X		
Asking questions	X					X
Making a plan to solve a problem	X				X	
Developing and using models		X		X		
Writing in a science notebook			X	X		
Recording observations			X	X		
Using evidence to support a claim			X	X		
Coming up with explanations			X		X	
Reading about science			X		X	
Using mathematics			X		X	

Sources: Student Science Interest Survey, administered by WestEd in spring 2018, grades 3–5 (N=366) and grades 6–8 (N=687).  
Notes: Other answer choices on the survey were “not good” and “okay.”

These results suggest that not only are grades 3–8 teachers providing NGSS learning activities, they seem to be doing so in ways that engender student confidence at being able to do them. At the same time, there remains room for further improvement, since one-third to half of students only felt “okay” or even “not good” about their ability to do these science activities.

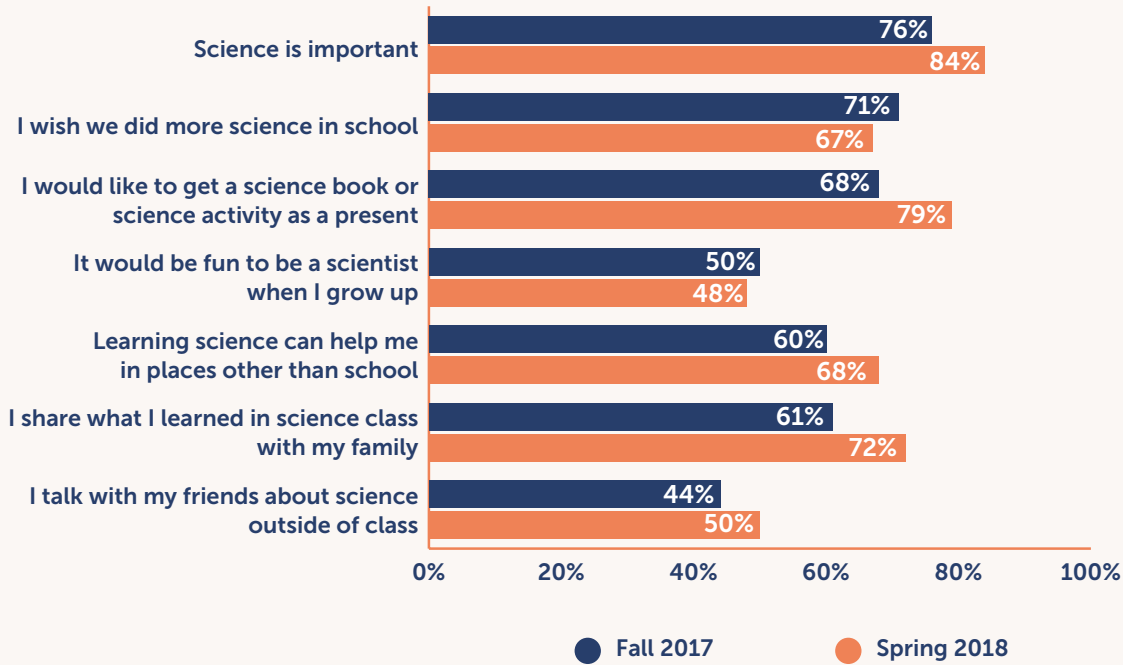
### Students Are Gaining Positive Views of Science

Even beginning in grades K–2, when science typically has been taught quite infrequently, students with teachers who have been immersed in professional learning from the Initiative had positive views about science, and increasingly so over time.

Figure 5 displays a series of statements related to students’ views of the importance of science as well as their engagement with science in school and in their lives. The percentages of students who “agreed” with a statement (by choosing a “thumbs-up” image) was greater in spring 2018 than in fall 2017 on five of the seven statements. These increases over the course of the 2017–18 school year may be a result of their teachers’ science instruction throughout the year.

Initiative leaders were particularly pleased to see that teachers’ NGSS implementation may be influencing students to be interested in science beyond their time in the classroom; that is, in spring 2018, students indicated they talked about science with both friends (50 percent) and family (72 percent).

Figure 5. Percentage of students in grades K–2 agreeing with statements about importance of science



Source: Student Science Interest Survey, Grades K–2, administered by WestEd in fall 2017 (N=223) and spring 2018 (N=231).

At the same time, both Initiative leaders and evaluators acknowledge and are puzzled that the percentages of students who “wish we did more science in school” and thought “it would be fun to be a scientist when I grow up” slightly declined over the school year. However, a strong majority of students did want more science in school (about 70 percent) and about half had interest in being a scientist someday. The results on these two questions also slightly declined over the school year in the grades 3–5 and 6–8 surveys (not included in Figure 5).

Overall, results from a larger set of parallel questions for grades 3–5 and 6–8 surveys also indicated similarly positive student views of science. However, the changes in views over the school year in grades 3–5 were less universal (the number of students who agreed with the statements increased for only half of the items) and the sizes of the increases were smaller (the increases ranged from only 1–5 percentage points compared to 6–12 percentage points in grades K–2).

# Recommendations for Administrator Support of NGSS Teaching and Learning

*Teacher quality is one of the most important influences in student achievement and learning (Darling-Hammond, 2005).<sup>16</sup>*

When talking about influencing students, teachers clearly play a major role in their learning. Therefore, these recommendations for administrators begin with a focus on cultivating and supporting teacher behavior that will maximize student engagement and learning in the NGSS classroom. These recommendations are based on evaluation findings and key strategies from the professional learning provided by the Initiative.

Administrators should encourage teachers to do the following:

- Create lessons that *begin* with exposure to phenomena that inspire student curiosity and discussion *before* presenting more challenging learning experiences that enable students to figure out the phenomena or design solutions to problems. These more challenging learning experiences might include vocabulary, reading, writing, or data analysis that are couched in the context of the phenomenon.
- Elicit student prior knowledge and make connections between the intended learning and that knowledge.
- Focus on all three of the NGSS dimensions in their teaching, so that students have opportunities to master practices (SEPs) and make connections (CCCs) as well as gain understanding of scientific concepts (DCIs).
- Incorporate more hands-on activities in which students formulate the claim or question they are investigating, and, when possible, design all or part of the investigations themselves.
- Move beyond just the rote learning of knowledge or facts to focus on learning as a path to discovery, or “figuring things out” — with students perhaps in different places on that path, but all moving toward understanding.
- Allow students to engage in sense-making. Begin with an exploration or investigation involving student discussions, data gathering and analysis, and preliminary explanations, followed by reading to enable them to expand their explanations.
- Enable student-to-student discourse using partners, small groups, and whole-class discussions. Small-group or partner discussions encourage participation of all students and allow them to process their ideas in a safer context than the full class. This provides an easier entry point for traditionally underserved students, particularly English learners,

<sup>16</sup> As cited in the *2016 Science Framework for California Public Schools* (California Department of Education).

who can learn concepts and vocabulary from their peers.<sup>17, 18</sup>

- Link science learning experiences with Common Core State Standards and 21st century skills so that students develop habits for lifelong learning, such as critical thinking and problem solving.
- Make time in each unit, if not each lesson, for reflection and metacognition so that students become aware of their own progress.

In order to support teachers in carrying out the kinds of NGSS instruction and planning activities listed in the bulleted recommendations above, administrators also need to develop their own knowledge, expertise, and practices related to the NGSS. Accordingly, administrators should:

- Recognize that the NGSS call for significant shifts in pedagogy that will not be mastered overnight and that teachers need to be allowed the freedom to “fail” as they try out the new standards.

- Provide quality professional learning on NGSS three-dimensional instruction and offer ongoing opportunities for teachers to add to their understanding of the NGSS.
- Make a point of becoming educated about the shifts required by the NGSS. Talk with other administrators, as well as teachers, to advance a collective understanding and vision for your school or district.<sup>19</sup>
- Make time for teachers to collaborate to plan lesson ideas, including and especially identifying appropriate phenomena around which lessons can be planned.<sup>20</sup>
- When observing classroom instruction, focus primarily on student engagement and learning through the “figuring out” of phenomena, use of three dimensions for sense-making, and opportunities for student-to-student discourse.
- When observing classroom instruction, focus on student behavior more than on teacher practice.

17 In *Unlocking Learning: Science as a Lever for English Learner Equity* (2017), The Education Trust–West 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 cited in that report also agree that students without English language proficiency can learn complex scientific content.

18 See also evaluation report #2, *The Synergy of Science and English Language Arts* (2017): <https://www.wested.org/resources/synergy-of-science-and-english-language-arts/>

19 A helpful tool for becoming educated about the shifts required by the NGSS is the science walk-through, briefly described in an evaluation report produced jointly with the Early Implementers Initiative leadership, *Next Generation Science Standards in Practice: Tools and Processes Used by the California NGSS Early Implementers* (2018): <https://www.wested.org/resources/next-generation-science-standards-in-practice/>

20 For more information about phenomena, including lists of grade-appropriate examples, see evaluation report *Next Generation Science Standards in Practice: Tools and Processes Used by the California NGSS Early Implementers* (2018).

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# Appendix A. Details of Evaluation Methods

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## Data Sources

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

➤ Annual surveys of two types of teachers and administrators in the eight Early Implementer districts: (1) participants who have received extensive professional development and support from the Initiative (i.e., Teacher Leaders), and (2) “expansion” participants who have not directly received significant professional learning or support from the Initiative but who are benefiting through the shared expertise of those who have. These surveys were the following:

- Teacher Leader Classroom Science Teaching Survey (N=420)
- Survey of expansion teachers (N=985)
- Survey of expansion principals (N=64)

➤ Interviews with select teachers and administrators in Early Implementer districts:

- 23 case study teachers<sup>21</sup>
- 21 expansion teachers

- 11 Core Administrators
- 3 expansion principals
- 1 district-level administrator
- Observations of lessons taught by 22 case study teachers<sup>22</sup>
- Student surveys (see details below)

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## Student Surveys

Evaluators had select teachers administer whole-class student surveys, as outlined in Table A1.<sup>23</sup> All of the teachers who were chosen to administer these student surveys were known to be making significant efforts to implement NGSS teaching and had received extensive professional learning from the Initiative. These teachers had been nominated by their districts’ respective Project Directors to be studied in the evaluation as case study teachers who were implementing NGSS, and they were either Core Teacher Leaders or Teacher Leaders in the Initiative. (Not all of these nominees became case study teachers.) Student surveys were administered three times: the end of the 2016–17 school year and the beginning and end of the 2017–18 school year.

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21 Case study teachers were recruited in five of the eight participating districts for the purpose of gaining classroom- and teacher-level insight into NGSS implementation. District Project Directors nominated case study teachers from among Teacher Leaders in their districts who had received extensive support from the Initiative, and who were making some of the most substantial changes in their teaching in relation to the NGSS.

22 Observation data was gathered from field notes taken by the evaluation staff who observed each class.

23 Different surveys were created for each grade band to make the language appropriate for the targeted grade bands. All surveys required 10–15 minutes to complete. The content of questions generally was parallel across the set of surveys. Surveys for K–2 were administered by paper and pencil while surveys for grades 3–5 and 6–8 were administered online.

Table A1. Administration of student survey, by kind of teacher in the Initiative, student grade band, and time of year

Grades	Administration	TEACHER GROUP* <i>Core Teacher Leaders:</i> Teachers	TEACHER GROUP* <i>Core Teacher Leaders:</i> Students	TEACHER GROUP* <i>Teacher Leaders:</i> Teachers	TEACHER GROUP* <i>Teacher Leaders:</i> Students	Total: Teachers	Total: Students
<b>K-2</b>	Spring 2017	4	84	4	95	8	179
<b>K-2</b>	Fall 2017	2	42	8	181	10	223
<b>K-2</b>	Spring 2018	2	42	8	189	10	231
<b>3-5</b>	Spring 2017	6	166	10	238	21	404
<b>3-5</b>	Fall 2017	9	215	6	145	15	380
<b>3-5</b>	Spring 2018	8	216	7	209	15	425
<b>6-8</b>	Spring 2017	4	437	8	380	16	817
<b>6-8</b>	Fall 2017	4	117	7	577	11	694
<b>6-8</b>	Spring 2018	4	141	7	625	11	766

Note: About half of the teachers whose students took the student surveys were case study teachers.

\*Core Teacher Leaders are the Teacher Leaders (TLs) on the district Core Leadership Team. TLs are all of the other teachers participating in the Early Implementer Initiative professional learning activities.

Lines of questioning in the student surveys included:

- Student reports on the kinds of science learning opportunities provided by their teachers, and how empowered they feel to learn science

- Student views about learning science in school
- Student views about the importance of science for their lives



# Appendix B. Additional Quotations from Teacher and Administrator Interviews

The evaluation team had difficulty choosing from the large number of informative teacher and administrator quotes collected during interviews conducted over the last two years of the Initiative. Additional quotes are provided here to offer a fuller picture of the state of NGSS student learning according to individuals who have been implementing the NGSS in their schools.

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## Stronger Student Engagement

*I've noticed when I have them write on anything scientific, students are much more engaged, even if it's some scientific writing assignment. They are much more engaged in learning. (Grade 3 teacher)*

*My kids are ecstatic every time I say, "Okay let's get out our science notebooks, and this is what we're going to do today." They just really, really love it. (Grade 2 teacher)*

*In one lesson sequence, students had to design how to use a ramp to go around soccer players and score a goal. I have a*

*kiddo — IEP [Individualized Education Plan] — he is on the spectrum, super reserved; when in groups, he won't participate usually. When they were trying to figure out how to score a goal, he was super hesitant. But he figured out a way before others in his group. (Kindergarten teacher)*

*Before, I was delivering: "Here's what you need to do." And then I would just go around and kind of make sure everybody was doing the lab correctly, following the procedures step by step. But now ... I enjoy seeing the kids discover more ... There have been some moments where I literally saw kids go, "Wow." Literally, say, "Wow." So, there are a lot of positives from NGSS. The kids are doing science, as opposed to just reading, hearing, and learning about it. (Grade 8 teacher)*

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## Engaging All Students

*Students who are better at memorizing or traditional instruction, they're not as comfortable. Now they have to think and analyze and be creative — it levels the playing field. Students who feel they can't do science realize that they are in the same place as others. No one knows the answer. (Grade 3 teacher)*

*We have a high population of both English learners and special ed students. I had 10 English learners in my class this year. Then I had eight students with an IEP in my class, and only two were overlapping — English learners with IEPs. And then I integrated two students with autism spectrum disorder in science with me this year. That was my home room. . . . They're not writers, so pictures helped me understand what they understood. They can write one or two words. . . . I was surprised when one of my students who was going to a moderate-severe class next year was able to draw a picture — and I didn't prompt him at all — [showing] that the earth rotates around the sun. He drew it perfectly and I had an aha moment and went, "Wow, this is good for everyone!" (Grade 5 teacher)*

*I do think that NGSS have benefited EL [English learner] students, whereas the old standards didn't, and especially my special ed students where I can see they just have an ability to get engaged when*

*they couldn't get engaged before, because, now, everybody kind of understands at the same level. Nobody [initially] understands the phenomenon. We're all talking about data no one's seen before. . . . Most of them can engage in NGSS with the other kids and not feel like they're behind. (Grade 8 teacher)*

*I've noticed NGSS don't just close the gap, it allows ELs to go past the others. Sometimes EL students can come to a concept that is beyond what the other students would think. If you'd asked them to write, you couldn't understand. The idea that they can share their thoughts and thinking is okay because there is no right or wrong answer. (Grade 3 teacher)*

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## More High-Level Learning

*I believe that NGSS are impacting students' ELA [English language arts] abilities. They are able to think at a different level, to reflect. I'm not sure it will come through in test scores, but NGSS are exposing them to expository reading (informational text), more of a variety of texts, opportunities to see and enjoy the information. They can connect what they're learning to experiences they had. (Grade 3 teacher)*

*I have noticed that they are much more focused on finding evidence. I tell them, "If you tell me something, or want to be*

*persuasive, it's all about finding evidence." That's helped them with reading comprehension tests. Not just underlining but because you have to prove [your point]. They've had practice and it's now easier for them to go back and find evidence. (Grade 3 teacher)*

*We do these investigations, and then do a reading, so they can gather more information. They'll devour a piece of reading about science, so that they can understand what they were trying to figure out the day before. (Grade 6 teacher)*

# Glossary

**Conceptual Flow** — Tool developed by the K–12 Alliance for mapping the storyline of three-dimensional NGSS instruction. A conceptual flow can be constructed for a six- to eight-week instructional unit or a year-long program, depending on the complexity of the anchoring phenomenon and how many of the grade-level performance expectations are incorporated.

**Core Administrator** — Administrator member of the Core Leadership Team. Provides professional learning to teachers and/or other administrators in the district.

**Core Leadership Team (CLT)** — Group of 3–5 administrators and 5–8 teachers established at each district at the beginning of the Initiative. The CLT meets with their Project Director regularly during each school year to plan and lead all Early Implementers Initiative activities. They meet with their K–12 Alliance Regional Director for six Technical Assistance Days each school year.

**Core Teacher Leader** — Teacher member of the Core Leadership Team. Provides professional learning to Teacher Leaders, other teachers, and/or administrators in their district or at project-wide events such as the Summer Institute.

**Crosscutting Concepts (CCCs)** — A way of linking the different domains of science. They include patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change.<sup>24</sup>

**Disciplinary Core Ideas (DCIs)** — According to National Research Council’s Framework for K–12 Science Education, disciplinary core ideas are the important concepts in each of four domains: physical sciences; life sciences; Earth and space sciences; and engineering, technology, and applications of science.

**Expansion principal** — Principal of a school with at least one Teacher Leader. While they have not received extensive professional learning from the Initiative, many expansion principals have attended brief professional learning sessions provided for them during the annual Early Implementer summer institutes and during the school year through Principal Academy activities in their districts.

**Expansion teacher** — Teacher who has not directly received significant professional learning or support from the Initiative but who is benefiting through the shared expertise of those who have. In larger districts, expansion teachers are typically in schools with at least one Teacher Leader.

**Instructional Unit** — Three-dimensional (3D) NGSS phenomenon-based instruction lasting approximately six to eight weeks. Duration of an instructional unit can vary depending on the complexity of the anchoring phenomenon and the needs of the teachers involved in developing and teaching the unit. Often, instructional units are based on an anchoring phenomenon and, as such, would supply the framework for an entire conceptual flow.

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<sup>24</sup> For more information on crosscutting concepts, see this website developed by an Early Implementer leader (A’Hearn, 2013): <https://crosscutsymbols.weebly.com/>

### **K–8 NGSS Early Implementers Initiative** —

Six-year Initiative (summer 2014 to spring 2020) supporting implementation of the NGSS by eight public school districts and two charter management organizations in California. Developed by the K–12 Alliance at WestEd in collaboration with the California State Board of Education, California Department of Education, and Achieve, the Early Implementers Initiative builds capacity of participating local education agencies to fully implement the NGSS in grades K–8.

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

**Lesson** — Three-dimensional (3D) NGSS phenomenon-based instruction lasting for a single class period, typically 45 to 90 minutes, but potentially longer.

**Phenomena** — Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict.<sup>25</sup> There are two types of phenomena, anchoring and investigative.

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

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

**Project Director** — District person responsible for leading all Early Implementers Initiative activities

for the district and representing the district at monthly Initiative-wide planning meetings with Regional Directors.

**Regional Director** — Member of WestEd’s K–12 Alliance staff assigned to provide leadership and support to one or two Early Implementer districts and to meet at monthly Initiative-wide planning meetings with Project Directors.

### **Science and Engineering Practices (SEPs)** —

Behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. They include asking questions (for science) and defining problems (for engineering); developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations (for science) and designing solutions (for engineering); engaging in argument from evidence; and obtaining, evaluating, and communicating information.

**Teacher Leader (TL)** — One of 30–70 teachers in each district who joined the Early Implementers Initiative in Year 2, one year after the Core Teacher Leaders. Teacher Leaders attend annual Summer Institutes and participate in two TLCs each school year (one in the fall and one in the spring) and other district-level professional learning.

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

25 See: <https://www.nextgenscience.org/resources/phenomena>



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# Engaged and Learning Science

How Students Benefit from  
Next Generation Science Standards Teaching

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EVALUATION REPORT 6

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Ted Britton  
Ashley Iveland  
Kimberly Nguyen  
Jerry Hipps