

TO

THE

NGSS

Eric Brunsell Deb M. Kneser Kevin J. Niemi

PROFESSIONAL DEVELOPMENT FACILITATOR'S GUIDE

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NGSS

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CONTENTS

About	the Authors		İX
Contrik	outors		Xİ
A Lette	er From Davi	d L. Evans, NSTA Executive Director	Xiii
1	Introductio	n	1
2	Facilitating Professional Development Using This Book		3
3	Sticking Pa	pints	15
4	Tips for Administrators		19
5	Introducing the NGSS		23
	ACTIVITY 1	Examining the Standards	24
	ACTIVITY 2	NGSS Vocabulary	28
	ACTIVITY 3	The Structure of NGSS	32
	ACTIVITY 4	NGSS Conceptual Shifts With Chad Janowski	36
6	Exploring the Practices and Crosscutting Concepts		43
	ACTIVITY 5	Integrating the Three Dimensions	44
	ACTIVITY 6	Science Inquiry and the Practices of Science and Engineering	50

CONTENTS

	ACTIVITY 7	Engineering Design and the Practices of Science and Engineering With Reynee Kachur	58
	ACTIVITY 8	Science and Engineering Practices Self-Assessment	66
	ACTIVITY 9	Exploring Crosscutting Concepts With Emily Miller	81
	ACTIVITY 10	Integrating the Nature of Science	85
7	Supporting	Science Learning for All Students	89
	ACTIVITY 11	All Standards, All Students: Integrating Content, Practices, and Crosscutting Concepts	90
	ACTIVITY 12	All Standards, All Students and Universal Design for Learning With Stacey N. Skoning	96
	ACTIVITY 13	All Standards, All Students: A Strategy Matrix With Stacey N. Skoning	103
8	Fostering D	iscussion About Curricular Decisions	109
	ACTIVITY 14	Visioning and Values	110
	ACTIVITY 15	Course Mapping at the Elementary Level	112
	ACTIVITY 16	Plus, Minus, Delta (Grades 6–12)	119
	ACTIVITY 17	Course Mapping for Middle and High School	122
	ACTIVITY 18	Essential Questions and Crosscutting Concepts	140

CONTENTS

	ACTIVITY 19	Developing Performance Assessments	145
	ACTIVITY 20	From Standards to Units	153
9	Connecting State Stand	NGSS and the Common Core lards	167
	ACTIVITY 21	NGSS and the CCSS Mathematics With Amy Parrott	168
	ACTIVITY 22	Connecting NGSS and CCSS ELA With Mark Bazata	181
	ACTIVITY 23	NGSS and CCSS ELA: Connecting Through the Practices With Mark Bazata	185
	ACTIVITY 24	NGSS and CCSS ELA: Disciplinary Literacy With Mark Bazata	189
Refer	rences		197
APPENDIX	1: Resources		201
APPENDIX	2: Model Activi	ty (K-5)	203
APPENDIX	3: Model Activi	ty (6–12)	209
	4: Model Activi	ty for the Nature of Science	224
APPENDIX	5: Model Scien	ce and Math Activity (K–5)	230
APPENDIX	6: Model Scien	ce and Math Activity (6–12)	237
Index			245

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A Letter From David L. Evans, NSTA Executive Director

Pick up a newspaper and you'll see stories related to legalizing marijuana, internet privacy concerns, the gluten-free diet, and hydraulic fracturing (or "fracking"). Strike that. Who reads an actual *paper* anymore? Now we get our news reports in the palms of our hands with pocket-sized devices that also enable us to call friends, get weather and traffic reports, take pictures, listen to music, turn off the lights at home, and so on.

Every day, we make decisions that require a fairly high level of scientific literacy. *Should I buy antibacterial soap? Should I vaccinate my children? Should I buy organic fruits and vegetables?* Everywhere you turn, you see further evidence that we live in an increasingly technological world, a world supported by jobs and industries we couldn't imagine even two decades ago. *App developer? Bitcoin?*

We need to prepare our children not just to live but to thrive in a world we can't foresee. They *all* need high-quality science instruction. They need to understand how to think and behave like scientists and engineers. The *Next Generation Science Standards (NGSS)* outline an approach to science education that helps students understand important concepts within the context of realworld skills and applications, that helps them draw connections between and among science, engineering, math, and English language arts (ELA). These standards are based on decades of sound research, as summarized in *A Framework for K–12 Science Education*.

NSTA was a partner in the development of the *NGSS* and is committed to helping administrators and teachers better understand and implement the standards in their schools and classrooms. The shift in instruction and thinking can be overwhelming. NSTA encourages a thoughtful approach to implementation—with collaboration with colleagues being key—and NSTA offers an ever-growing collection of resources to help educators every step of the way.

Start by visiting the NGSS@NSTA Hub at *www. nsta.org/ngss,* the gateway to the full spectrum of NSTA's *NGSS*-related products and services. Here you'll find a user-friendly presentation of the *NGSS* performance expectations with related practices, crosscutting concepts, and core ideas. View the full standard page or isolate specific performance expectations with their corresponding dimensions. In addition, you'll find resources vetted by a group of NSTA curators and tagged to particular performance expectations. Other tools include streamlined charts of the dimensions, as well as of the relationships among science, math, and ELA practices. These resources are particularly useful when leading a team of teachers through a training workshop.

The NGSS@NSTA Hub will continue to evolve, as we add functionality and new content. However, it will always be NSTA's central spot for information and resources around the standards, including the latest news on adoption and assessment. And it's where we'll showcase upcoming events and opportunities such as special conference sessions and professional development institutes, virtual conferences, and online short courses.

In addition, administrators will appreciate NSTA's NGSS publications—especially *The NSTA Reader's Guide to A Framework for K–12 Science Education* and *The NSTA Reader's Guide to the Next Generation Science Standards*. Taken together, these slim and practical volumes will help you introduce teams of teachers to the three dimensions and new standards, then help you coach them through the planning and implementation phases. Both books are available in print or digital formats. In addition to this book, another valuable publication is Rodger Bybee's *Translating the* NGSS *for Classroom Instruction*, which helps bridge the gap between standards and practice, and the elementary-level *Science for the Next Generation* (Banko et al.), which approaches the new standards via the popular and effective 5E Model. In addition, browse the NSTA Learning Center for NSTA's full collection of journal articles, including several special series on the *NGSS*, as these pieces provide excellent foundations for working group discussions.

NSTA has also developed an archive of free web seminars covering each of the science and engineering practices, disciplinary core ideas, and crosscutting concepts in detail. Share these with colleagues, and encourage your teachers to gain familiarity and confidence with the idea of using the practices to teach the content. Future web seminars will delve into grade-specific standards.

During this extraordinary time in science education, the challenges and stakes are great, but so are the opportunities. NSTA's goal continues to be to support excellent and innovative science instruction for *all* students. To achieve that goal, we are committed to helping science teachers and administrators by developing the tools you need to successfully understand and implement the *Next Generation Science Standards*.

David & Evan

David L. Evans NSTA Executive Director



INTRODUCING THE NGSS

"Facts are not science—as the dictionary is not literature." —Martin H. Fischer (1944)

nowledge of science and engineering is important for all. An opening statement in *A Framework for K*–12 *Science Education (Framework;* NRC 2012) explains,

By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. They should come to appreciate that science and the current scientific understanding of the world are the result of many hundreds of years of creative human endeavor. It is especially important to note that the above goals are for all students, not just those who pursue careers in science, engineering, or technology or those who continue on to higher education. (p. 9)

In the 15 years since the National Research Council and the American Association for the Advancement of Science released the *National Science Education Standards*, there have been many changes in the world of science. In addition, there has been extensive research released on how students learn science. These pieces have been a driving force behind the writing of the *Framework* and the *Next Generation Science Standards* (*NGSS*; NGSS Lead States 2013).

The activities in this chapter provide an introduction to the *NGSS*. Activities 2, 3, and 4 represent three different ways to introduce the terminology and structure of the standards to educators. We do not intend that you do all three of these activities with the same group of teachers. Instead, choose the activity that best fits your presentation style.

Educators explore the progressions of NGSS to begin understanding the structure of NGSS.

ACTIVITY 2

Educators participate in a lecture and then discuss the development and structure of NGSS to begin developing a working knowledge of NGSS.

ACTIVITY 3

Educators use inquiry to develop their working definitions of NGSS vocabulary and the structure of NGSS.

ACTIVITY 4

Educators examine six conceptual shifts in NGSS that demonstrate how NGSS is different from previous standards documents.

ACTIVITY 1

Examining the Standards

Approximate Length

30-40 minutes

Objectives

During this activity, participants will

- explore one strand of the standards from early elementary through high school,
- describe how the standards' expectations progress as the grade level increases, and
- summarize their discussions on chart paper.

Vocabulary

- progressions
- NGSS standards page
- performance expectations
- foundation boxes

Evidence of Learning

- Group summary on chart paper
- Graphic organizer "Examining the Standards"

At a Glance

In this activity, participants explore one strand (organized by either topic or disciplinary core idea) of the standards from early elementary through high school. This activity works well for helping educators get a general feel for the *NGSS* and develop an understanding that the content in the standards builds developmentally over the course of a student's education.

When we design professional development, we try to use a learning cycle approach whenever possible. This often means that we use an "ABC" or "activity before content" format to give participants the chance to engage and explore concepts before we explicitly introduce the content of the session. When time permits, we follow the introduction of content with an opportunity for participants to apply that content. We have found that this activity works well for introducing NGSS before we dig in to the development and structure of the standards. Participants only need a limited understanding of how to read an NGSS standards page. This is not a stand-alone activity. It should be followed by an activity that introduces the purpose and structure of NGSS (e.g., Activity 2, 3, or 4 in this book).

Facilitator's Notes

Since this is an exploration activity, do not focus on providing a comprehensive overview of the *NGSS* or how to read a standards page. Participants quickly notice that the content at each grade level builds on the previous level and introduces increased complexity without being redundant. Most participants are excited by the clarity of the verbs used in the performance expectations (the science and engineering practices) and note that students are expected to be able to "do things with the content they are learning."

Materials

- Copies of the handout "Examining the Standards" (p. 27)
- Chart paper and markers (per group of three to four)
- Standards progression (per group of three to four). Identify one set of related standards that includes standards in grades K-2, 3-5, 6-8, and 9-12. For example, we have used a "waves progression" (organization by topic) that included the following pages: 1. Waves: Light and Sound; 4. Waves: Waves and Information; MS. Waves and Electromagnetic Radiation; HS. Waves and Electromagnetic Radiation.

Procedure

Set-up: Participants should be organized into small groups prior to starting this activity. If possible, place participants in mixed grade-level groups.

Introduction (5 minutes): After giving participants a copy of the handout and standards progression, provide a very brief introduction to reading an *NGSS* standards page. Explain that both the standards page title and performance expectation code (e.g., 1-PS4-1) identify the grade level. Also state that the foundation boxes in the middle of the page provide more depth as to what students should know and be able to do at each grade level. You do not need to provide a comprehensive overview of the standards page at this time.

Group Work (20 minutes): Charge the participants to explore the standards that you have given them. They should pay particular attention to how expectations progress as the grade

level increases. Participants should complete the organizer on the handout. With five minutes remaining in this stage, instruct participants to summarize their discussions on a chart paper. The summary should include questions that they have about the standards. At the end of this stage, each group should post their summary so that it is visible for the entire group.

Debrief (5–10 minutes): Ask a few of the groups to present their summary to the whole group. Foster cross talk between groups by asking participants to describe differences between their summary and previous presentations.

Wrap-up (5 minutes): Conduct a gallery walk by giving participants a chance to look at the group posters. Participants should place a check next to questions on the summaries that resonate with them.

Next Steps

If this is your participants' initial exposure to *NGSS*, consider following this activity with Activity 2, 3, or 4 to introduce the background and structure of the standards. You should also make note of the questions on the group summary posters. Many of these questions can be answered by using the activities in this book. However, to answer questions related to state or district policy, you will need additional resources.





ACTIVITY 1 Examining the Standards

Examine a *progression* of standards from *NGSS*. As you examine it, think about the questions below. It may be useful to compare the *NGSS* to your existing standards.

How does the content build o levels?	ver grade	er-order thinking skills o these standards?
Is it clear what students are expected to know and be able to do?	What excites y these standard	What concerns or "wonderings" do you have about these standards?

NGSS Vocabulary

Approximate Length

45 minutes

Objectives

During this activity, participants will

- learn the structure of NGSS,
- read a standards page, and
- explore the standards for their grade level or grade band.

Vocabulary

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS)
- A Framework for K–12 Science Education
- science and engineering practices
- crosscutting concepts
- disciplinary core ideas
- performance expectations
- assessment boundaries
- clarification statements
- foundation boxes
- connection boxes

Evidence of Learning

• Lists of generated questions

At a Glance

This activity is a straightforward presentation about the development and structure of the *NGSS*. The presentation ends by providing an overview of a standards page. "*NGSS* Vocabulary" is one of three introductory presentations included in this book.

Facilitator's Notes

The following narrative provides the background information needed for this activity. Facilitators should feel free to determine the best way to present this information. For example, you might present it as a PowerPoint presentation, a lecture, or a jigsaw reading.

Then and Now

Much has happened since the *National Science Education Standards* (*NSES*) were released by the National Research Council in 1996. Putting the previous standards in context can be helpful for understanding why new standards are needed.

Science and Technology

When the *NSES* were released, "soccer mom" was the word of the year, and "dot" (as in dot-com) was selected as the most useful word of the year. We had to worry about rewinding VHS tapes before returning them to the rental store and had trouble jogging without our compact disc players skipping. Hitachi released a camcorder that could take both still and moving digital pictures. For \$2,000, your camera could store 20 minutes of video or 3,000 pictures, with a stunning 0.3 megapixel resolution. Shortly after the *NSES* were released, the first personal digital music player hit the market: The \$400 MPMAN by SaeHan

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could store six of your favorite songs. Dolly the sheep had not yet been cloned (that happened July 5th, 1996). We only had 111 elements (now we have 118). Mars Pathfinder was waiting for launch (it began its journey December 4, 1996). And the human genome had not been mapped.

Science Education

We have also learned a lot about teaching and learning in science. The journals *Science Education*, the *Journal of Research in Science Teaching*, and the *International Journal of Science Education* alone have published more than 2,500 peer-reviewed research articles. Achieve Inc. has published the *International Science Standards Benchmarking Report* and the National Research Council (NRC) has published multiple reports on effective science education, including the following:

- How Students Learn History, Science, and Mathematics in the Classroom
- America's Lab Report
- Taking Science to School
- Ready, Set, Science!
- Successful STEM Schools

Perhaps it is time to update our standards.

Development

This activity is not intended to go in depth about the development process for the *NGSS*. However, it may be important to provide a few highlights of the process.

The *NGSS* are not part of the *CCSS* initiative. *CCSS* should only be used to refer to the *CCSS*, in English language arts (ELA) and mathematics. The *CCSS ELA* does include an appendix of literacy standards for science and technical fields. These standards guide disciplinary literacy standards for science teachers in grades 6–12 but do not include science content standards.

The development of *NGSS* included a partnership between the National Science Teachers Association, the National Research Center, the American Association for the Advancement of Science, and Achieve Inc. *NGSS* is not an initiative of the U.S. Department of Education or any other federal agency. The Carnegie Foundation funded the development.

The first step of the development process culminated in the publication of the *Framework* by NRC. The *Framework* was the guiding document for the *NGSS* writing team, which was managed by Achieve Inc. This writing team was composed of classroom teachers, scientists, and science education researchers. The development process included a comprehensive review process with teams from multiple states and several public review periods.

For more information on the review process, visit the *NGSS* website at *www.nextgenscience.org/ development-overview*.

Framework

The NRC's *Framework* provides a vision for what science should look like in the United States. The *Framework* defined the following three dimensions: science and engineering practices, crosscutting concepts, and disciplinary core ideas.

Science and Engineering Practices

The *Framework* identified eight science and engineering practices. These are intentionally called practices (instead of skills) to acknowledge that in

order to engage in the process of science and engineering, students need to have specific knowledge. The eight science and engineering practices build developmentally from kindergarten all the way through high school. The practices are as follows: asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations and designing solutions; engaging in arguments from evidence; and obtaining, evaluating, and communicating information. It is important to note that the final three practices are very well aligned and complementary to the CCSS for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects.

Crosscutting Concepts

The *Framework* identifies seven crosscutting concepts. Crosscutting concepts are the concepts or ideas that stretch across all disciplines of science. The benefit of focusing on crosscutting concepts is that it helps provide students with an organizational structure for understanding the world. The crosscutting concepts build from kindergarten through twelfth grade and include patterns; cause and effect; scale, proportions, and quantity; systems and system models; energy and matter in systems; structure and function; and finally, stability and change in systems.

Disciplinary Core Ideas and Component Ideas

The *Framework* outlines a series of 13 disciplinary core ideas. These core ideas are foundational to science. There are four core ideas each in physical science and life science. There are three core ideas in the Earth and space sciences and two

engineering core ideas. Component ideas provide additional detail for each core idea.

One of the goals of the *Framework* was to identify a coherent scope and sequence of a few ideas that are central to science and build on them throughout a student's K–12 education career.

Performance Expectations

The standards are written as learning progressions that integrate disciplinary core ideas, science and engineering practices, and crosscutting concepts. Performance expectations serve as guidelines for assessment, not instructional tasks or curriculum mandates. Many performance expectations also include assessment boundaries and clarification statements to further define appropriate depth at that grade level or grade band.

Reading a Standards Page

An initial look at a standards page from NGSS can be quite overwhelming. However, as educators gain comfort with NGSS, they can begin to see how the different pieces of a page work together. A cluster of performance expectations related to a specific topic or core idea sits at the top of the page. The three foundations boxes are found directly beneath the performance expectations. These three foundations boxes contain statements, many directly from the Framework, that further define student learning expectations for each of the three dimensions. A series of connections boxes can be found at the bottom of the page. Connections boxes illustrate how the performance expectations on that page are related to other performance expectations within NGSS and provide connections to the CCSS. These connections are included as a starting point to determine how mathematics and literacy concepts

and skills can be integrated or reinforced during science instruction.

Materials

• Each participant should have access to at least one standards page. You should decide in advance if you will be using the *NGSS* organized by topics or by disciplinary core ideas.

Procedure

Introduction (5–10 minutes): Begin this activity by activating prior knowledge. Ask participants to reflect on the question, "What is the purpose of curriculum standards?" Provide an opportunity for participants to briefly discuss this question in small groups. End the introduction by doing a round robin, in which each group suggests one idea related to the question.

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Presentation (20 minutes): Use the Facilitator's Notes to provide participants with an overview of the development and structure of the *NGSS*.

Explore (10 minutes): During this step, participants should be given time to explore the standards for their own grade level or band. As they explore the standards, encourage them to generate and record questions.

Debrief (10 minutes): Close this activity with a question and answer session. You may be able to address some of these questions directly; other questions may be answered by using activities in this book. Finally, some questions that are asked may be specific to state or district policy decisions. If you do not know how to answer these questions, make sure that you do not speculate.

The Structure of NGSS

Approximate Length

55 minutes

Objectives

During this activity, participants will

- define the different structural parts of *NGSS*,
- learn the structure of *NGSS*,
- read a standards page, and
- explore the standards for their grade level or grade band.

Vocabulary

- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS)
- A Framework for K–12 Science Education
- science and engineering practices
- crosscutting concepts
- disciplinary core ideas
- performance expectations
- assessment boundaries
- clarification statements
- foundation boxes
- connections boxes

Evidence of Learning

- Graphic organizer describing the components of *NGSS*, "The Structure of *NGSS*"
- List of generated questions

At a Glance

This is one of three activities in this book that can be used to introduce educators to the structure of the *NGSS*. Instead of providing the structure through a lecture (as in Activity 2), participants use one of the introductory sections of *NGSS* to determine their own definitions for important elements of the *NGSS* structure (performance expectations, disciplinary core ideas, foundation boxes, connections boxes).

Facilitator's Notes

See the Facilitator's Notes on pages 28–31 in Activity 2 for the background information necessary to facilitate this activity.

Materials

- Each participant should have a copy of the "NGSS Structure" document from the front matter of the NGSS. (This document can be found at *www.nextgenscience.org/ next-generation-science-standards.*)
- Copies of the handout "The Structure of *NGSS*" (p. 35)
- Access to at least one *NGSS* standards page

Procedure

Before beginning this activity you should be comfortable with the background information on the development and structure of *NGSS* provided in the Facilitator's Notes of Activity 2 (pp. 28–31).

Set-up: If you are going to use small groups, create them prior to beginning this activity. This activity works best if you put participants into pairs or groups of three. Groups can be either mixed or gradelevel teams.

Introduction (5–10 minutes): Begin this exercise by activating prior knowledge. Ask participants to reflect on the question, "What is the purpose of curriculum standards?" Provide an opportunity for participants to briefly discuss this question in small groups. End the introduction by doing a round robin during which each group suggests one idea related to the question. (*Note*: This introduction is the same as that in Activity 2, p. 31).

Group Work (20 minutes):

Place participants into pairs or small groups and distribute materials. Explain to the participants that they will be using the "*NGSS* Structure" section of the *NGSS* to define concepts that are important to understanding the standards. *Optional*: You may want to begin this activity by providing context from the Facilitator's Notes in Activity 2 (pp. 28–31). Participants should use the next 15 minutes to read the "*NGSS* Structure" document and come to a consensus on how to answer the questions in the handout.

FIGURE 5.1

Model presentation figure

THE STANDARD

Title:

Performance expectations describe what students should know and be able to do at the end of instruction. Performance expectations guide summative and formative assessment.

The foundation boxes provide the context for performance expectations.				
Science and engineering practices	Diciplinary core ideas	Crosscutting concepts		

The connection boxes provide guidance for connecting the standard to others in NGSS or the CCSS.

Note: Disciplinary Core Ideas form the main concepts that are essential to the major science disciplines. These 39 ideas are drawn from A Framework for K–12 Science Education and span kindergarten through grade 12.

> **Report Out (10 minutes):** Ask groups to report out how they have answered the questions on the handout. Stimulate cross talk between groups by encouraging them to share how their answers are similar and different from each other. Clarify definitions for performance expectations, disciplinary core ideas, the components of the foundations boxes, and the connections boxes as needed. Display Figure 5.1 as a summary of the *NGSS* structure.

Explore (10 minutes): During this step, participants should be given time to explore the standards for their grade level or band. As they explore the standards, encourage participants to generate and record questions.

Debrief (10 minutes): Close this activity with a question and answer session. You may be able to

address some of these questions directly; other questions may be answered by using activities in this book. Finally, some questions that are asked may be specific to state or district policy decisions. If you do not know how to answer these questions, make sure you do not speculate.

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The Structure of NGSS

How would you describe an NGSS performance expectation to a colleague?

What is a disciplinary core idea?

What is the purpose of the foundation boxes?

What are the connections boxes?

NGSS Conceptual Shifts

With Chad Janowski

Approximate Length

55 minutes

Objectives

During this activity, participants will

- come to understand the rationale for the conceptual shifts in *NGSS*,
- reflect on how these shifts benefit student learning, and
- reflect on how these shifts positively impact their instructional planning.

Vocabulary

- conceptual shift
- three dimensions
- progressions
- Next Generation Science Standards (NGSS)
- Common Core State Standards (CCSS)
- A Framework for K-12 Science Education
- science and engineering practices
- crosscutting concepts
- disciplinary core ideas
- performance expectations

- assessment boundaries
- clarification statements
- foundation boxes
- connections boxes

Evidence of Learning

• Responses to handout "Conceptual Shifts in the *NGSS*"

At a Glance

This is one of three activities that can be used to introduce the development and structure of the *NGSS* to educators. This activity focuses on the six conceptual shifts that demonstrate how *NGSS* is different from previous standards documents. This activity serves three purposes:

- To provide a rationale for the importance of the conceptual shifts
- To give teachers a chance to discuss the impact of the conceptual shifts
- To illustrate how these shifts are reflected on a standards page as a way to help participants learn how to read the *NGSS*

Facilitator's Notes

Educators and education researchers have learned a lot about designing effective standards since the release of the *National Science Education Standards* more than 15 years ago. As a result, the *NGSS* writing team made a series of six conceptual shifts. Understanding those shifts, and how they are reflected in the structure of the standards, is important to understanding the vision of the *Framework* and the standards.

The first and fifth conceptual shifts reflect how science and engineering are done in the real world by integrating content, practices, and crosscutting concepts while raising the profile of engineering in science education. The National Research Council's America's Lab Report (2005) is a synthesis of research related to the efficacy of science laboratory activities. One major finding was that integrated learning experiences increase student understanding and transfer of that understanding to different situations. We also know that context and the integration of content, practices, and crosscutting concepts supports the learning of students from nondominant groups and helps English language learners develop language skills (see Chapter 7).

From work in neuroscience, we also know that

experiential learning that stimulates multiple senses in students, such as hands-on science activities, is not only the most engaging but also the most likely to be stored as long-term memories. ... The bestremembered information is learned through multiple and varied exposures followed by authentic use of the knowledge. (Willis 2006, p. 6)

These two shifts will positively impact how students experience and learn science in our classrooms.

The third and fourth shifts focus on the need for coherency and a focus on depth of understanding of core ideas. One common criticism of U.S. science education is that we try to cover large amounts of content without providing time to develop an understanding of concepts; we give our students fat textbooks and race to cover them during the school year. Phil Sadler and colleagues (Tai, Sadler, and Mintzes 2006) found that high school students who study a topic in depth for one month are much more successful during introductory university science courses when compared with students in courses characterized by covering many more topics.

Wiggins and McTighe (2011) also point to research that shows that deeper understanding is important. They say

research on expertise suggests that superficial coverage of many topics in the domain may be a poor way to help students develop the competencies that will prepare them for future learning and work. Curricula that emphasize breadth of knowledge may prevent effective organization of knowledge because not enough time is provided to learn anything in depth. Curricula that are 'a mile wide and an inch deep' risk developing disconnected rather than connected knowledge. (p. 5)

The first and sixth shifts are related to the use of performance expectations and the inclusion of connections to the *CCSS*. Performance expectations highlight the importance of integrating the dimensions and call for an emphasis on performance assessments. Wiggins and McTighe (2011) state,

Many assessments measure only recently taught knowledge and never ask for authentic performance (conditional knowledge and skills)—whether students know when, where, and why to use what they have learned in the past. This approach leads to surprisingly poor test results, because students do not recognize prior learning in unfamiliar-looking test questions—especially when the test has no context clues and hints (as occurs when teachers immediately quiz students on recent material). (p. 5)

Additionally, strong connections to the *CCSS* will help teachers of science better align instruction with what we know about disciplinary

literacy and how to reinforce mathematical concepts and skills.

Materials

- Copies of the handout "Conceptual Shifts in NGSS" (pp. 39–42)
- Each participant will also need access to the *NGSS*

Procedure

Before beginning this activity, review the background information provided in the Activity 2 Facilitator's Notes (pp. 28–31) and read *NGSS* Appendix A, "Conceptual Shifts in the *Next Generation Science Standards.*"

Introduction (5–10 minutes): Begin this activity by activating prior knowledge. Ask participants to reflect on the question, "What is the purpose of curriculum standards?" Provide an opportunity for participants to briefly discuss this question in small groups. End the introduction by doing a round robin in which each group suggests one idea related to the question. (*Note*: This introduction is the same as in Activity 2.)

Presentation (35 minutes): You may want to begin by using the Activity 2 Facilitator's Notes to provide context for why the *NGSS* are important.

Provide each participant with the handout "Conceptual Shifts in the *NGSS*."

Use the Facilitator's Notes from this activity to provide participants with background on the conceptual shifts and structure of *NGSS*. In this activity, we clustered the conceptual shifts into three pairs. After you discuss each pair, pause to give participants time to answer the associated question. You may want to use a Think-Pair-Share strategy at this point. After the question has been answered, you can continue the presentation by showing participants how the conceptual shift is reflected in the *NGSS* structure and on an *NGSS* standards page.

Explore (10 minutes): During this step, participants should be given time to explore the standards for their grade level or band. As they explore the standards, encourage participants to generate and record questions.

Debrief (10 minutes): Close this activity with a question and answer session. You may be able to address some of these questions directly; other questions may be answered by using activities in this book. Finally, some questions that are asked may be specific to state or district policy decisions. If you do not know how to answer these questions, make sure you do not speculate.

ACTIVITY 4 Conceptual Shifts in the NGSS

See NGSS Appendix A for more details on the conceptual shifts. The shift descriptions in this activity are from the article "NGSS Conceptual Shifts" by Karen L. Ostlund. NSTA Reports, February 28, 2013. www.nsta.org/publications/news/story. aspx?id=59853.

Pair 1

Shift 1: The NGSS reflect how science is done in the real world by intertwining three dimensions: scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Scientists ask and answer questions to further our understanding of the world around us. Engineers define problems and design solutions to solve problems. The intent of NGSS is to weave the three dimensions together to reflect the work of scientists and engineers. For example, students are expected to use scientific and engineering practices and apply crosscutting concepts to develop an understanding of disciplinary core ideas. This is a conceptual shift from most state and district standards, which separate these dimensions in curriculum, instruction, and assessment. Curriculum often initially focuses on the science process skills of inquiry without emphasizing science content. To prepare students for the competitive global economy, we must equip them with the skills and information to develop a sense of contextual understanding of scientific knowledge: how scientists acquire it, how engineers apply it, and how it is connected through crosscutting concepts. These understandings can be achieved by interlocking the three dimensions. Therefore, each NGSS performance expectation integrates scientific and engineering practices to understand disciplinary core ideas and connect ideas across disciplines by applying crosscutting concepts.

Shift 5: The *NGSS* integrate science, technology, and engineering throughout grades K–12. The *NGSS* integrate applications of science, technology, and engineering into the disciplinary core ideas along with life, Earth, space, and physical science. This conceptual shift also raises engineering design to the same level

Conceptual Shifts in the NGSS

as scientific inquiry. This requires the development of curriculum, instruction, and assessments—as well as teacher preparation—to integrate engineering and technology into the structure of science education. Science and engineering are needed to address challenges we face in our ever-changing world, such as an adequate food supply, clean water, renewable energy, and disease control. Hopefully, students will be motivated to pursue careers rooted in science, technology, engineering, and mathematics as a result of early opportunities to apply their scientific knowledge to develop solutions to similar challenges. Integrating science, technology, and engineering into curriculum and instruction empowers students to apply what they learn to their everyday lives beginning in kindergarten, throughout their academic careers, and beyond.

How will these shifts benefit student learning in your classroom?

Pair 2

Shift 3: The *NGSS* build coherently from grades K through 12. The *NGSS* concentrate on a limited number of essential disciplinary core ideas that build student understanding progressively from grades K through 12. The conceptual shift is the movement away from learning disjointed and isolated facts and toward opportunities to learn more complex ideas as students progress through grade levels and bands. The disciplinary core ideas identified in *NGSS* form a coherent progression of knowledge leading to more complexity of student understanding by the end of high school. The goal is to help students achieve scientific literacy by focusing on fundamental content that builds as they progress. The *NGSS* progressions are based on the assumption that students have learned previous content and can build on their understandings. Therefore, it is critical that students master the content designated for each grade level or band. The omission of any content in a grade level or band can negatively impact student understanding of increasingly more complex core ideas as students advance through grades K–12.

Conceptual Shifts in the NGSS

Shift 4: The *NGSS* focus on deeper understanding of content and applications of content. The *NGSS* focus on disciplinary core ideas rather than the myriad of facts associated with each core idea. Although the facts support the core ideas, they should not be the focus of curriculum, instruction, and assessment. The conceptual shift places more emphasis on the core ideas and less on facts to provide an organizational structure that delivers the scaffolding students need when acquiring new knowledge. Research indicates experts understand core principles and theoretical constructs of their field and use them to make sense of new information or to apply their understandings to solve problems. Novices hold disconnected and even contradictory pieces of knowledge as isolated facts and have difficulty organizing and integrating the pieces. Therefore, the intent of the *NGSS* is to engage students in scientific and engineering practices to gain a deeper understanding of disciplinary core ideas and connect those ideas with crosscutting concepts to help them develop from novices into experts.

How will these shifts benefit student learning in your district?

Pair 3

Shift 2: The *NGSS* **are student performance expectations.** Student performance expectations clarify what students should know and be able to do at the end of a grade level or band. This conceptual shift recognizes the *NGSS* are *not* curriculum, instruction, or assessment; the *NGSS* are student performance expectations that elucidate the intent of assessments. The *NGSS* will guide curriculum developers as they develop coherent instructional programs designed to ensure students attain the performance expectations. The three dimensions are integrated in each performance expectation and are intended to enhance instruction and curriculum, not limit it. The scientific and engineering practices and crosscutting concepts should be used throughout the curriculum and instruction so students have many opportunities to become proficient at using the practices to deepen their understanding

Conceptual Shifts in the NGSS

of disciplinary core concepts by connecting them with crosscutting concepts. Backward curriculum design will be required to analyze each performance expectation and develop an instructional sequence that will help students achieve the outcomes delineated in the *NGSS*.

Shift 6: The NGSS correlate to the CCSS in English language arts (ELA) and mathematics. The NGSS are the vehicle for mastering the CCSS in ELA and mathematics. Science and engineering provide a content area for applying ELA and mathematics skills. The conceptual shift is away from viewing ELA and mathematics as content areas to the perception that they are skills to be practiced and mastered in the science and engineering curriculum. A synergy is created when ELA, mathematics, science, and engineering standards reinforce the acquisition of the skills and knowledge in all of these areas of the school curriculum.

How will these shifts positively impact your instructional planning?

INDEX

Page numbers printed in **boldface** type refer to tables or figures.

Α

A Framework for K-12 Science Education, xiii, 1, 2, 23, 29, 66 supporting science learning for all students. 89 three dimensions of, 29-30, 43 crosscutting concepts, 30, 81-84, 140 disciplinary core ideas, 30 integration of, 37, 39, 43, 44-49, 90-95 science and engineering practices, 29-30, 50-51, 68 Accountability systems, 2, 16 Achieve, Inc., 29 Achievement gap, 89 Active learning, 5, 7 Activities for professional development, 2, 6-8. See also specific activities becoming familiar with, 7 sample uses of. 6 selection of, 6 summaries of. 8-13 Activity before content (ABC) format, 25 Administrators and NGSS implementation, 19-21 building a library of resources, 20 continuity of focus, 20-21 embracing collaboration, 21 importance of leadership, 21 making relevance clear, 20 providing time for teachers to grow and learn, 20 support in district or school, 19 view of professional development as a process, 19-20 visibility and participation in process, 20 Advanced Placement courses, 18 All standards, all students: a strategy matrix (Activity 13), 103-107 activity at a glance, 103 evidence of learning for, 103 facilitator's notes for, 103 handout for, 104, 105-107 length of, 103 materials for, 104 next steps after, 104 objectives of, 103 procedure for, 104 summary of, 11 vocabulary for, 103 All standards, all students: integrating content, practices, and crosscutting concepts (Activity 11), 90-95

activity at a glance, 90-91 evidence of learning for, 90 facilitator's notes for, 91 handouts for, 91, 94-95 length of, 90 materials for, 91 next steps after, 93 objectives of, 90 procedure for, 92-93 summary of, 10 vocabulary for. 90 All standards, all students and Universal Design for Learning (Activity 12), 96-102 activity at a glance, 96 evidence of learning for, 96 facilitator's notes for. 96 handouts for, 97, 99-102 length of, 96 materials for. 97 next steps after, 98 objectives of, 96 procedure for, 97 summary of, 11 vocabulary for, 96 American Association for the Advancement of Science, 23, 29 America's Lab Report, 29, 37 Annotated Unit Planner Template. 159-161 Antarctic penguin communities: model activity (6-12), 46, 209-223 Argumentation Modeling, Evidence, Explanations, and Argumentation, 69 Using Evidence to Support an Argument, 188 Assessments, 4, 13, 16, 37. See also Performance expectations developing performance assessments (Activity 19), 145-152 science and engineering practices self-assessment (Activity 8), 9,66-80

В

Basic Elements of a Unit Planner, 155
Berra, Yogi, 109
Big ideas, 4, **12**, 47, 82, 83, 93. See also Crosscutting concepts
Brainstorming Topics and Crosscutting Concepts, 116
Bransford, J. D., 140
Brown, A. L., 140
Bybee, Rodger, xiv С Cheeks, 193 Climate Change from Pole to Pole: Biological Investigations, 46 Cocking, R. R., 140 Coherent instruction, 30, 37, 40, 41, 109, 112, 169, 172, 173 Collaboration, 21 Common Core State Standards in English language arts (CCSS ELA), 1-2, 13, 15, 16, 29, 30, 37-38, 42, 89, 167 connecting NGSS and CCSS ELA (Activity 22), 181-184 NGSS and CCSS ELA: connecting through the practices (Activity 23), 185-188 NGSS and CCSS ELA: disciplinary literacy (Activity 24), 189-196 Common Core State Standards in mathematics (CCSS Mathematics), 1-2, 13, 15, 29, 37-38, 42, 89, 167 conceptual shifts in, 169 model activity connections in, 170-172 NGSS and the CCSS Mathematics (Activity 21), 168-180 reading of, 170, 170 standards for math practice, 169-170 Communication, 3 Completed Unit Planner Template, 162-164 Conceptual shifts, 9, 36-42 Conceptual Shifts in the NGSS, 39-42 Connecting NGSS and CCSS ELA (Activity 22), 181-184 activity at a glance, 181 evidence of learning for, 181 facilitator's notes for, 181-182 handout for, 182, 184 length of, 181 materials for, 182 next steps after, 182-183 objectives of, 181 procedure for, 182 summary of, 13 vocabulary for, 181 Connecting NGSS and CCSS ELA Feedback, 196 Connecting NGSS and CCSS Mathematics Feedback, 180 Connections boxes, 30, 33 Course mapping at the elementary level (Activity 15), 112-118 activity at a glance, 112

Index

evidence of learning for, 112 facilitator's notes for, 112-113 handouts for, 113, 115-118 length of, 112 next step after. 114 objectives of, 112 procedure for, 113 summary of, 11 vocabulary for. 112 Course Mapping Feedback, 139 Course mapping for middle and high school (Activity 17), 122-139 activity at a glance, 122 evidence of learning for, 122 facilitator's notes for, 122-123 handout for, 124, 139 length of. 122 materials for, 123-124 next steps after, 124 objectives of, 122 procedure for, 124 summary of, 12 vocabulary for. 122 Crosscutting concepts, xiii-xiv, 2, 4, 12, 30, 43, 109, 112 Brainstorming Topics and Crosscutting Concepts, 116 essential questions and, 140-144 exploring. 10. 81-84 importance of teaching, 82-83 Integrating Crosscutting Concepts, 48 integration of, 44-48 Topics and Crosscutting Concepts, 115 Curricular decisions, 2, 4 for advanced courses, 17-18 alignment with NGSS, 17 course mapping at the elementary level (Activity 15), 112-118 course mapping for middle and high school (Activity 17), 122-139 developing performance assessments (Activity 19), 145-152 essential questions and crosscutting concepts (Activity 18), 140-144 fostering discussion about, 109 importance of depth over breadth, 17, 37, 41 plus, minus, delta (grades 6-12) (Activity 16), 119-121 from standards to units (Activity 20), 153-165 visioning and values (Activity 14), 110-111

Curriculum Mapping Feedback, 117

D

Developing performance assessments (Activity 19), 145–152 activity at a glance, 145 evidence of learning for, 145 facilitator's notes for, 145-146 handouts for, 146, 148-152 length of, 145 materials for. 146 next steps after, 147 objectives of, 145 procedure for, 146-147 summary of, 13 vocabulary for, 145 Disciplinary core idea cards. 123-124 Disciplinary core ideas, xiii-xiv, 2, 4, 30, 37, 41, 43, 109, 112 integration of, 44-49 in the NGSS final release, 125-138 science and engineering practices and. 66 Disciplinary literacy, 2, 13, 15, 16, 29, 185-186, 189-192. See also English language arts connections Disciplinary Literacy and Science, 192 Diverse student populations, 89-91 all standards, all students: a strategy matrix (Activity 13), 103-107 all standards, all students: integrating content, practices, and crosscutting concepts (Activity 11), 90-95 all standards, all students and Universal Design for Learning (Activity 12), 96-102 English language learners, 37, 82, 83, 104 nondominant groups, 11, 37, 47, 82, 89, 90, 91-95, 103-107

Е

Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric, 17 Elementary and Secondary Education Act, 16 Engineering design, 2, **9**, 17, 39, 44, 66 components of, 58–59 vs. science investigations, 64 videos of, 60 work of engineers in the three spheres, **60**, 65 Engineering design and the practices of science and engineering (Activity 7), 58-65 activity at a glance, 58 evidence of learning for. 58 facilitator's notes for, 58-59 handouts for, 59-60, 62-65 length of, 58 materials for, 59-60, 60 model activities for. 60 next steps after, 61 objectives of, 58 procedure for, 61 summary of, 9 vocabulary for, 58 English language arts (ELA) connections. xiii. xiv. 2. 15. 16. 30-31, 37-38, 42, 167 connecting NGSS and CCSS ELA (Activity 22), 181-184 NGSS and CCSS ELA: connecting through the practices (Activity 23), 185-188 NGSS and CCSS ELA: disciplinary literacy, 189-196 English language learners, 37, 82, 83, 104 Erickson, H. L., 140 Essential Questions: Opening Doors to Student Understanding, 140 Essential questions and crosscutting concepts (Activity 18), 140-144 activity at a glance, 140 evidence of learning for, 140 facilitator's notes for, 140-141 handout for, 141, 143-144 length of, 140 materials for, 141 next steps after, 142 objectives of, 140 procedure for, 141-142 summary of, 12 vocabulary for, 140 Evidence-based argumentation Modeling, Evidence, Explanations, and Argumentation, 69 Using Evidence to Support an Argument, 188 Examining the Standards, 27 Examining the standards (Activity 1), 24-27 activity at a glance, 24-25 evidence of learning for, 24 facilitator's notes for, 25 handout for, 25, 27

NATIONAL SCIENCE TEACHERS ASSOCIATION

Index

length of, 24 materials for, 25 next steps after, 26 objectives of, 24 procedure for. 25-26 summary of, 8 vocabulary for, 24 Example Performance Assessment Tasks. 148-149 Exploring crosscutting concepts (Activity 9), 81-84 activity at a glance, 81 evidence of learning for, 81 facilitator's notes for, 81-83 lenath of. 81 materials for, 83 next steps after. 84 objectives of, 81 procedure for, 83 summary of, 10 vocabulary for. 81 Exploring the practices and crosscutting concepts. 43-44 engineering design and the practices of science and engineering (Activity 7), 9, 58-65 exploring crosscutting concepts (Activity 9), 10, 81-84 integrating the nature of science (Activity 10), 10, 85-88 integrating the three dimensions (Activity 5), 9, 44-49 science and engineering practices self-assessment (Activity 8), 9,66-80 science inquiry and the practices of science and engineering

F

Features of Performance Assessment Tasks, 150 Feedback on Unit Planning, 165 Fischer, Martin H., 23 5E Instructional Model, xiv Fogarty, R., 5 Forces and motion: model activity (K–5), 46, 203–208 Foundation boxes, 30, **33** From standards to units (Activity 20), 153–165 activity at a glance, 153 evidence of learning for, 153 facilitator's notes for, 153–154 handouts for, 154, 155–165

(Activity 6), 9, 50-57

length of, 153 materials for, 154 next steps after, 154 objectives for, 153 procedure for, 154 summary of, **13** vocabulary for, 153

G

Guskey, T. R., 19

н

Handouts Brainstorming Topics and Crosscutting Concepts, 116 Conceptual Shifts in the NGSS. 39-42 Course Mapping Feedback, 139 Curriculum Mapping Feedback, 117 Disciplinary Core Ideas in the NGSS Final Release, 125-138 Examining the Standards, 27 Example Performance Assessment Tasks, 148-149 Features of Performance Assessment Tasks, 150 Inquiry Frayer Model, 54 Integrating Crosscutting Concepts, 48 Integrating the Science and **Engineering Practices**, 49 Integrating the Three Dimensions, 94 Jigsaw Summary, 95 Modeling, Evidence, Explanations, and Argumentation, 69 The Nature of Science, 88 NGSS Mapping, Grades K-5, 118 Science and Engineering Practices Self-Assessments 3-5, 72-74 Science and Engineering Practices Self-Assessments 6-8, 75-77 Science and Engineering Practices Self-Assessments 9-12, 78-80 Science and Engineering Practices Self-Assessments K-2. 70-71 Science Investigations Versus Engineering Design, 64 The Spheres of Science and Engineering Activity, 55-56, 62-63 Strategy Matrix, 105-107 The Structure of NGSS, 35 Topics and Crosscutting Concepts, 115

Turning Performance Expectations Into Performance Tasks/ Assessments (Blank), 151 **Turning Performance Expectations** Into Performance Tasks/ Assessments (Scripted), 152 UDL Strategy Matrix, 102 Universal Design for Learning Essay, 99-101 What Do We Teach?, 121 What Do We Want to Learn? Essential Questions, 143-144 The Work of Engineers in the Three Spheres, 65 The Work of Scientists in the Three Spheres, 57 Heat exchange in air. water. and soil: model science and math activity (6-12), 237-244 How People Learn: Brain, Mind, Experience, and School, 140 How Students Learn History, Science, and Mathematics in the Classroom, 29 Hunzicker, J., 5-6

L

Implementation of NGSS assessment of. 4. 13. 16 curricular decisions for, 4, 17-18 pedagogical development for, 4-5 professional development activities for, 2, 3-8, 8-13 (See also specific activities) responsibility for, 16-17 sticking points for, 15-18 timelines for, 16, 19-20 tips for administrators, 19-21 Inquiring Scientists, Inquiring Readers, 46 Inquiry Frayer Model, 54 Integrating Crosscutting Concepts, 48 Integrating the nature of science (Activity 10), 85-88 activity at a glance, 85 facilitator's notes for, 85-86, 86 handout for, 86, 88 length of, 85 materials for, 86 model activity for, 86, 224-229, 225-229 next steps after, 87 objectives of, 85 procedure for, 86-87 summary of, 10

Index

vocabulary for, 85 Integrating the Science and Engineering Practices. 49 Integrating the Three Dimensions, 94 Integrating the three dimensions (Activity 5), 44-49. See also All standards, all students; integrating content, practices, and crosscutting concepts (Activity 11) activity at a glance, 45 evidence of learning for, 45 facilitator's notes for, 45 handouts for, 45, 48-49 length of. 44 materials for, 45-46 model activities for. 46 grades 6-12, 209-223, 210-213 grades K-5, 203-208, 205, 206 next steps after, 47 objectives of, 44 procedure for, 46-47 summary of. 9 vocabulary for, 44 International Journal of Science Education. 29 International Science Standards Benchmarking Report, 29 Introducing the NGSS examining the standards (Activity 1), 8, 24-27 NGSS conceptual shifts (Activity 4), 9, 36-40 NGSS vocabulary (Activity 2), 8, 28-31 structure of NGSS (Activity 3), 8, 32-35

J

Jigsaw groups, **10**, 90–93, 97, 104, 210, 228 Jigsaw Summary, 95 *Journal of Research in Science Teaching*, 29

L

Leadership, 21

М

Magnet properties: model science and math activity (K–5), 230–235 Mathematics connections, xiii, xiv, 2, 15, 30–31, 37–38, 42, 167 model science and math activity (6–12): heat exchange in air, water, and soil, 237–244

model science and math activity (K-5): properties of magnets, 230-235 NGSS and the CCSS Mathematics (Activity 21), 168-180 McTighe, J., 37, 140-141 The Method of Eratosthenes, 194 Model activity (6–12): Antarctic penguin communities, 46, 209-223 activity at a glance, 209 introduction to. 209 materials for, 211 modifications of, 213-214 overview of, 210-211 performance rubric for assessment of, 213, 213 prior knowledge for. 211 procedure for, 211-213, 212 student pages for, 216-223 warming climate, waning sea ice, 209–210, 210, 211 Model activity (K-5): forces and motion, 46.203-208 explore phase of, 204-208 changing direction, 204-205, 205 changing force I, 205–208, 206 materials for, 204 scientific background information for, 203-204 Model activity for the nature of science, 86, 224-229, 225-229 Model science and math activity (6-12): heat exchange in air, water, and soil, 237-244 connecting to standards, 237-238 materials for, 237 objectives of, 238 overview of, 237 procedures for, 238-241 processes/skills for, 237 recommended for, 237 safety considerations for, 238 sample rubric for, 240 time required for, 237 Model science and math activity (K-5): properties of magnets, 230-235 activity sheet for, 235-236, 243-244 assessment of, 241 connections to standards, 230-231 discussion questions for, 233-234, 241 materials for, 230 objectives of, 231 options and extensions of, 241 overview of, 230

procedures for, 231–233, **232** processes/skills for, 230 recommended for, 230 safety considerations for, 231 sample rubric for, **233** time required for, 230 Modeling, Evidence, Explanations, and Argumentation, 69

Ν

National Research Council (NRC), 23, 28.29.37 National Science Education Standards (NSES), 4, 23, 28, 36 National Science Teachers Association (NSTA) NGSS-related products and services. xiii–xiv. 20 role in development of NGSS, xiii, 29 2013 NSTA National Conference on Science Education. 1 Nature of science, 10, 85-88 The Nature of Science, 88 Newton, Isaac, 224 Next Generation Science Standards (NGSS), xiii, 1–2 Appendix A (Conceptual Shifts in the NGSS), 17, 38, 39 Appendix D (All Standards, All Students), 2, 10, 47, 89, 90-92, 96-97, 103-105 Appendix E (DCI Progressions Matrix), 46 Appendix F (Science and Engineering Practices Matrix), 46, 52, 59, 60,67 Appendix G (Crosscutting Concepts Matrix), 46, 81, 82, 83 Appendix H (Nature of Science Matrix), 85, 86, 87, 88, 164 Appendix I (Engineering Design), 58, 59 Appendix K (Model Course Mapping in Middle and High School), 122, 123, 124 Appendix L (Connections to the Common Core State Standards for Mathematics), 167, 172, 173, 202 Appendix M, 167, 181 assessments and, 4, 13, 16 conceptual shifts in, 9, 36-42 connecting with Common Core State Standards, 15, 29, 42, 167–196

NATIONAL SCIENCE TEACHERS ASSOCIATION

development and review of, 1, 23, 29 examination of, 8, 24-27 integrating three dimensions of, 9, 37, 39, 43, 44-49 (See also Crosscutting concepts; Disciplinary core ideas; Science and engineering practices) introducing, 23-42 nature of science statements in, 85-86.86 NSTA products and services related to, xiii-xiv performance expectations in, xiii, 4, 16, 30, 37, 41–42, 66, 109, 112.145-146 professional development activities for implementation of, 2, 3-8, 8-13 (See also specific activities) reading a page from, 5-6 relationship to curriculum, 17, 109, 112 release of. 1 structure of, 8, 32-35 supporting science learning for all students, 89 timelines for implementation of, 16, 19-20 tips for administrators. 19-21 vocabulary of, 8, 28-31 NGSS and CCSS ELA: connecting through the practices (Activity 23), 185-188 activity at a glance, 185 evidence of learning for, 185 facilitator's notes for, 185–186 handout for, 186, 188 length of, 185 materials for, 186 next steps after, 187 objectives of, 185 procedure for, 186-187 summary of, 13 vocabulary for, 185 NGSS and CCSS ELA: disciplinary literacy (Activity 24), 189-196 activity at a glance, 189 evidence of learning for, 189 facilitator's notes for, 189–190 handouts for, 190, 192-196 length of, 189 materials for, 190 next steps after, 191 objectives of, 189 procedure for, 190-191

summary of, 13 vocabulary for, 189 NGSS and CCSS ELA Connections. 184 NGSS and CCSS Mathematics-Elementary, 175-176 NGSS and CCSS Mathematics-Middle and High School, 177-178 NGSS and the CCSS Mathematics (Activity 21), 168–180 activity at a glance, 169 evidence of learning for. 169 facilitator's notes for, 169-172 handouts for, 172, 175-180 length of, 168 materials for, 172 next steps after, 174 objectives of. 168 procedure for elementary school, 172-173 procedure for middle and high school, 173–174 summary of, 13 vocabulary for. 168 NGSS conceptual shifts (Activity 4), 36-42 activity at a glance, 36 evidence of learning for, 36 facilitator's notes for, 36-38 handout for. 38. 39-42 length of, 36 objectives of, 36 summary of, 9 vocabulary for, 36 NGSS Mapping, Grades K-5, 118 NGSS vocabulary (Activity 2), 28-31 activity at a glance, 28 evidence of learning for, 28 facilitator's notes for, 28-31 length of, 28 materials for, 31 objectives of, 28 procedure for, 31 summary of, 8 vocabulary for, 28 NGSS@NSTA Hub, xiii-xiv, 20 No Child Left Behind Act, 16 Nondominant groups, 11, 37, 47, 82, 89, 90, 91-95, 103-107. See also Diverse student populations Now You "Sea" Ice, Now You Don't: model activity (6-12), 46, 209-223 The NSTA Reader's Guide to A Framework for K-12 Science Education, xiv

The NSTA Reader's Guide to the Next Generation Science Standards, xiv

0

Ostlund, Karen L., 39

Ρ

Partnership for Assessment of Readiness for College and Careers (PARCC), 16 Pedagogical development, 4-5 Penguin communities on Antarctic Peninsula: model activity (6-12), 46.209-223 Performance assessments, 145-152 Performance expectations, xiii, 4, 16, 30, 37, 41-42, 66, 109, 112, 145-146 Turning Performance Expectations Into Performance Tasks/ Assessments (Blank), 151 Turning Performance Expectations Into Performance Tasks/ Assessments (Scripted), 152 Pete. B., 5 Plus, minus, delta (grades 6-12) (Activity 16), 119-121 activity at a glance, 119 evidence of learning for, 119 facilitator's notes for, 119 handout for. 119, 121 length of, 119 materials for, 119 next steps after, 120 objectives for, 119 procedure for, 119-120 summary of, 12 vocabulary for, 119 Professional development, 2, 3-8 activities for, 2, 6-8, 8-13 (See also specific activities) for curricular decisions, 2, 4, 109-110 effective, 5-6 guideposts for design of, 5, 6 for pedagogical development, 4-5 planning logistics of, 7-8 as a process, 19-20 tips for administrators, 19-21 using this book in planning for, 6-8

R

Ready, Set, Science!, 29 Relevance of NGSS, 20

S

Sadler, Phil, 37 Scaffolding, 11, 41, 100, 112, 113, 182, 190 Science and engineering practices, xiiixiv, 2, 4, **9, 10,** 29–30, 109, 112 current use and development of new strategies for, 17 disciplinary core ideas and, 66 engineering design and, 9, 58-65 Integrating the Science and Engineering Practices, 49 integration of, 39-40, 43, 44-47, 49 science inquiry and (Activity 6), 9, 40, 50-57 work of scientists in the three spheres. 51. 57 Science and engineering practices selfassessment (Activity 8), 66-80 activity at a glance, 66 evidence of learning for, 66 facilitator's notes for, 66 handouts for. 67. 69-80 length of, 66 materials for, 67 next steps after, 68 objectives of, 66 procedure for, 67-68 summary of. 9 vocabulary for, 66 Science and Engineering Practices Self-Assessments 3-5, 72-74 Science and Engineering Practices Self-Assessments 6-8, 75-77 Science and Engineering Practices Self-Assessments 9-12, 78-80 Science and Engineering Practices Self-Assessments K-2, 70-71 Science Education, 29 Science for the Next Generation, xiv Science inquiry, 2, 4, 44, 45, 47, 66, 230-231, 237-238 evaluating inquiry activity for classroom use, 56, 59, 63 Science inquiry and the practices of science and engineering (Activity 6), 50-57 activity at a glance, 50 evidence of learning for, 50 facilitator's notes for, 50-52, 51 handouts for, 52, 54-57 length of, 50 materials for, 52 objectives of, 50

procedures for, 52-53 summary of, 9 vocabulary for, 50 Science Investigations Versus Engineering Design, 64 Science learning for all students, 89-90 all standards, all students: a strategy matrix (Activity 13), 11, 103-107 all standards, all students: integrating content, practices, and crosscutting concepts (Activity 11), **10**, 90–95 all standards, all students and Universal Design for Learning (Activity 12), **11**, 96–102 English language learners, 37, 82, 83.104 nondominant groups, 11, 37, 47, 82, 89, 90, 91-95, 103-107 Science Texts. 195 Scientific literacy, xiii, 40, 43, 122, 186 Smarter Balance assessment consortia. 16 Spheres of Science and Engineering Activity, 50, 52, 55-56, 58, 59, 61, 62-63 The Spheres of Science and Engineering Activity, 55-56, 62-63 Sticking points for NGSS implementation, 15-18 Strategy Matrix, 105-107 The Structure of NGSS, 35 Structure of NGSS (Activity 3), 32-35 activity at a glance, 32 evidence of learning for, 32 facilitator's notes for, 32 handout for, 32, 35 length of, 32 materials for, 32 model presentation figure for, 33 objectives of, 32 procedure for, 32-34 summary of, 8 vocabulary for, 32 Successful STEM Schools, 29

Т

Taking Science to School, 29 Teacher certification, 16 Teacher evaluations, 2, 16 Teaching strategies for nondominant groups, **11**, 37, 47, 82, 89, 90, 91–95, 103–107. See also Science learning for all students Timelines for *NGSS* implementation, 16, 19–20 Topics and Crosscutting Concepts, 115 *Translating the NGSS for Classroom Instruction, xiv* Turning Performance Expectations Into Performance Tasks/ Assessments (Blank), 151 Turning Performance Tasks/ Assessments (Scripted), 152 Tyson, Neil deGrasse, 43

U

UDL Strategy Matrix, 102 Unit Planner Template (Blank), 156–158 Unit planning, **13**, 153–165 Universal Design for Learning (UDL), **11**, 90, 91, 93, 96–102, 103, 104 Universal Design for Learning Essay, 99–101 Using Evidence to Support an Argument, 188 Using the *NGSS* Connections Boxes for

CCSS Mathematics, 179

v

Visioning and values (Activity 14), 110–111 activity at a glance, 110 evidence of learning for, 110 facilitator's notes for, 111 length of, 110 materials for, 111 next steps after, 111 objectives of, 110 procedure for, 111 summary of, **11** vocabulary for, 110 Vocabulary of *NGSS*, **8**, 28–31

w

Web seminars, xiv What Do We Teach?, 121 What Do We Want to Learn? Essential Questions, 143–144 Wiggins, G., 37, 140–141 Willard, Ted, 18 The Work of Engineers in the Three Spheres, **60**, 65 The Work of Scientists in the Three Spheres, **51**, 57

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