INTRODUCING TEACHERS + ADMINISTRATORS TO THE NGSS

A PROFESSIONAL DEVELOPMENT FACILITATOR'S GUIDE

Eric Brunsell
Deb M. Kneser
Kevin J. Niemi

NSTApress
National Science Teachers Association

INTRODUCING TEACHERS + ADMINISTRATORS TO THE NGSS

A PROFESSIONAL DEVELOPMENT FACILITATOR'S GUIDE

INTRODUCING TEACHERS + ADMINISTRATORS TO THE NGSS

A PROFESSIONAL DEVELOPMENT FACILITATOR'S GUIDE

Eric Brunsell

Deb M. Kneser

Kevin J. Niemi

NSTApress
National Science Teachers Association
Arlington, Virginia

NSTA press®
National Science Teachers Association

Claire Reinburg, Director
Wendy Rubin, Managing Editor
Andrew Cooke, Senior Editor
Amanda O'Brien, Associate Editor
Amy America, Book Acquisitions Coordinator

Art and Design
Will Thomas Jr., Director
Joe Butera, Senior Graphic Designer, cover and interior design

Printing and Production
Catherine Lorrain, Director

National Science Teachers Association
David L. Evans, Executive Director
David Beacom, Publisher

1840 Wilson Blvd., Arlington, VA 22201
www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

17 16 15 14 4 3 2 1

NSTA is committed to publishing material that promotes the best in inquiry-based science education. However, conditions of actual use may vary, and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors do not warrant or represent that the procedures and practices in this book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book, including any of the recommendations, instructions, or materials contained therein.

Library of Congress Cataloging-in-Publication Data.
Brunsell, Eric, author.
Introducing teachers and administrators to the NGSS : a professional development facilitator's guide / Eric Brunsell, Deb M. Kneser, Kevin J. Niemi.
pages cm
Includes bibliographical references.
ISBN 978-1-938946-18-9 -- ISBN 978-1-938946-60-8 (e-book) 1. Science--Study and teaching--Standards--United States. 2. Educational accountability--United States. I. Kneser, Deb M., 1955- author. II. Niemi, Kevin J., 1956- author. III. Title.
Q183.3.A1B78 2014
507.1'273--dc23
2014010659
Cataloging-in-Publication Data for the e-book are available from the Library of Congress.

CONTENTS

CONTENTS

CONTENTS

ABOUT THE AUTHORS

ERIC BRUNSELL is an associate professor of science education in the Department of Curriculum and Instruction and coordinator of the Center for Excellence in Teaching and Learning at the University of Wisconsin-Oshkosh in Oshkosh, Wisconsin. Eric earned his EdD in Curriculum and Instruction with an emphasis in Science Education from Montana State University. He is a former high school science teacher and has served as NSTA District 12 Director. Eric has provided professional development sessions and presentations throughout the United States and internationally.

DEB M. KNESER is an assistant professor in the School of Education and the chair of the Institute of Professional Development at Marian University, Fond du Lac, Wisconsin. Deb earned her Ph.D. in curriculum leadership from Marian University. She was previously with the Cooperative Educational Service Agency 6 in Oshkosh, Wisconsin, serving as an educational consultant in curriculum, assessment, and instruction. Deb is a former elementary classroom teacher with a National Board Certification. Deb has extensive experience with providing professional development sessions and presentations on topics ranging from curriculum mapping to teacher effectiveness.

KEVIN J. NIEMI is director of the outreach group in the Institute for Biology Education at the University of Wisconsin-Madison. Kevin received his Ph.D. in plant physiology from the University of Minnesota, taught in the biology department at Grinnell College, and served as the first education coordinator for Olbrich Botanical Gardens in Madison, Wisconsin. Kevin has provided professional development sessions and presentations in science education in Wisconsin and Thailand.

CONTRIBUTORS

The following educators contributed to the development of many activities in this book. We would like to thank them for their help, and we consider them coauthors of the activities they assisted with (indicated in the table of contents).

Mark Bazata
Instructional support teacher, high school,
Oshkosh Area School District, Oshkosh, Wisconsin

Reynee Kachur
Department of Biology and Microbiology,
University of Wisconsin-Oshkosh, Oshkosh, Wisconsin

Emily Miller
NGSS Writing Team
Elementary bilingual resource teacher,
Madison Metropolitan School District, Madison, Wisconsin

Chad Janowski
Chair, Science Department, high school,
Shawano School District, Shawano, Wisconsin

Amy Parrott
Mathematics Department,
University of Wisconsin-Oshkosh, Oshkosh, Wisconsin

Stacey N. Skoning
Chair, Department of Special Education,
University of Wisconsin-Oshkosh, Oshkosh, Wisconsin

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 real-world 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.

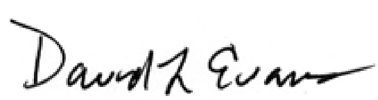
Start by visiting the NGSS@NSTA Hub at *www.nsta.org/ngss*, the gateway to the full spectrum of NSTA's *NGSS*-related products and services. Here you'll find a user-friendly presentation of the *NGSS* performance expectations with related practices, crosscutting concepts, and core ideas. View the full 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 L. Evans
NSTA Executive Director

5

INTRODUCING THE *NGSS*

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

Knowledge 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.

ACTIVITY 1
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 over grade levels?	**How are higher-order thinking skills integrated into these standards?**	
Is it clear what students are expected to know and be able to do?	**What excites you about these standards?**	**What concerns or "wonderings" do you have about these standards?**

ACTIVITY 2

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 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.

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.

ACTIVITY 3

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 grade-level 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).

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.*

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.

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.

ACTIVITY 3

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?

ACTIVITY 4

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 best-remembered 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 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.

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 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.*

INTRODUCING TEACHERS + ADMINISTRATORS TO THE NGSS

A PROFESSIONAL DEVELOPMENT FACILITATOR'S GUIDE

"Realizing the vision of *A Framework for K–12 Science Education* and the *NGSS* will require professional development of an unprecedented scale. Our hope is that this collection of activities will be helpful as you lead educators through the implementation process."

— FROM THE INTRODUCTION TO *INTRODUCING TEACHERS AND ADMINISTRATORS TO THE* NGSS

If you're charged with helping educators achieve the vision of the new science standards, this is the professional development resource you need. This book is chock-full of activities and useful advice for guiding teachers and administrators as they put the standards into practice in the classroom.

Written by three experts in professional development for science teachers, *Introducing Teachers and Administrators to the* NGSS

- introduces the vocabulary, structure, and conceptual shifts of the *NGSS;*
- explores the three dimensions of the *Framework*—science and engineering practices, crosscutting concepts, and disciplinary core ideas—and how they are integrated in the *NGSS;*
- provides classroom case studies of instructional approaches for students challenged by traditional science teaching;
- covers curricular decisions involving course mapping, designing essential questions and performance assessments, and using the *NGSS* to plan units of instruction;
- examines the connections between the *NGSS* and the *Common Core State Standards;* and
- offers advice for getting past common professional development sticking points and finding further resources.

Given the widespread changes in today's education landscape, teachers and administrators may feel overwhelmed by the prospect of putting the new standards into practice. If you are a science specialist, curriculum coordinator, or instructional coach who provides professional development, you will find this collection immensely helpful for heading off "initiative fatigue," whether in an individual school or throughout a district.

Grades K–12

NSTA press
National Science Teachers Association

PB350X
ISBN: 978-1-938946-18-9

9 781938 946189