The NSTA Reader's Guide to THE NEXT GENERATION SCIENCE STANDARDS

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CONTENTS

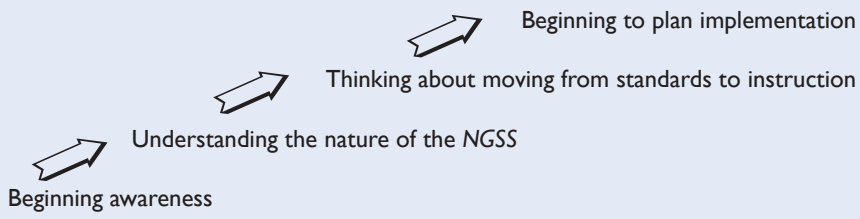
INTRODUCTION

The *Next Generation Science Standards (NGSS)* comprises many parts with many purposes, as evidenced by the contents of the *NGSS* website listed in Figure I.1. This *Reader's Guide* is designed to help you navigate and understand this array of parts, interpret the standards, and take the first steps toward putting the standards into practice.

FIGURE I.1. *NGSS* table of contents of the total *NGSS* document

Although there are many ways to navigate and make sense of the *NGSS,* this guide suggests a process that should be most helpful to you. By following the sequence of chapters in the guide, you will come to understand the various pieces listed in Figure I.1 in a logical and cohesive manner. The *Reader's Guide* is designed to help you move along the path in Figure I.2 from the beginning stages of awareness and understanding the nature of the *NGSS*, to the next stage of exploring how the *NGSS* translates to instruction, and finally to the stage of early planning for implementation.

FIGURE I.2. The path of progress in learning to use the *NGSS*



CHAPTER 1
GETTING STARTED

Welcome to the *Next Generation Science Standards (NGSS)*!

The new standards promote a vision that the instruction and the learning your students experience should change significantly. An early piece of front matter in the *NGSS* that lists the conceptual shifts called for in the *NGSS* provides a brief overview of the changes:

- K–12 science education should reflect the real-world interconnections in science.
- The *Next Generation Science Standards* are student outcomes and are explicitly NOT curriculum.
- Science concepts build coherently across K–12.
- The *NGSS* focuses on deeper understanding and application of content.
- Science and engineering are integrated in science education from K–12.
- Science standards coordinate with *Common Core State Standards* in English language arts and mathematics.

You may be reading this guide shortly after the new standards are released or picking it up many months later with the intention of getting better acquainted with the *NGSS* and the changes that should occur. In any case, this guide is designed to assist you and your team in gaining a deep understanding of the new standards and will supplement the many front matter documents and appendices provided with the *NGSS* itself. These documents should be carefully read as you progress through this guide and its many suggestions for action.

The *Reader's Guide* contains a series of suggested recommendations for action, starting with a plan to intensely study the *NGSS*—first by becoming familiar with the architecture of the document, then by thinking about the development of instructional strategies and the corresponding materials as a way of gaining a deeper and more "operational" understanding of the standards and how they should be used. These suggestions give you latitude to adjust them for your needs and rate of progress. This guide has been created as a part of an array of resources from NSTA to support you and your colleagues. These resources are listed at the end of this chapter.

Getting Started

A Checklist

The following checklist of activities will help you and your team carry out the process of first gaining an understanding of the *NGSS* and then developing a plan for putting the standards into practice. The checklist is followed by a few details and suggestions for each item with references to chapters in this *Reader's Guide*.

- Determine your state's or district's plan for implementation and timeline.
- Form a team or study group.
- Collect resource materials from NSTA and other sources.

- Follow a plan to study the *NGSS* using the suggestions in this guide.
- Create a plan for putting the *NGSS* into practice.
- Use the *NGSS* in limited trial situations.

More Details

Determine Your State or District's Plan for Adoption and Implementation Decisions and Timeline

Although the release of the *NGSS* in the spring of 2013 may appear to be the starting point for planning the adoption and implementation of the new standards in your state or school district, in many cases, an adoption decision may not yet have been made or work toward adoption might already have begun. In any event, your first important step is to determine if, how, and when adoption decisions are made in your school, district, or state. (If this is done at the state level, make your inquiries to the appropriate person such as the science coordinator or commissioner of education.) Even if an adoption date is known, it will most likely be several years before significant implementation is required in your school, district, or state. So, determining these dates is a critical first step for you.

If your state or district does not adopt the *NGSS* or at least has no plans to do so, you should still encourage your school to use the best practices of the *NGSS*. The content in the *Framework* and the *NGSS* represents current research and best practices and thinking in science education and will provide significant insights about improving science teaching and learning.

Form a Team or Study Group

In almost all circumstances, planning and implementing the standards will require a team effort. (Please also note the importance of a team effort discussed in the Introduction.) To share the myriad tasks suggested in this *Reader's Guide,* you should involve teachers and educators at all levels and in all science content areas. See Chapter 5 in this guide for a discussion of how many team members provide the maximum coverage for dealing with the entire *NGSS* document.

Collect Resources From NSTA and Other Sources

See the list of NSTA resources at the end of this chapter. Collecting resources is easy and can start early in your learning process. As additional resources become available, continue to collect what you need while also working through the other steps in your process.

Follow a Plan to Study the *NGSS*

Based on suggestions later in this section, develop a tentative plan for an intensive study of the *NGSS* with dates, responsibilities, and a budget. Seek and attain approval as required. However, don't overplan at this point. Get started and continue to plan as you proceed. Unless you are required to submit a complete long-range plan, a dynamic planning process for such a new effort is advisable. Plan, get started, review and evaluate progress, revise the plan, and continue to work. This cycle will allow you to get started with early results as you continue the planning process.

The place to start in understanding and using the *NGSS* is the *Framework for K–12 Science Education*. The *Framework* provides a vision for K–12 science education and detailed information for the science and engineering practices, disciplinary core ideas, and crosscutting

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CHAPTER 3
INTRODUCTION TO THE *NGSS*

The Anatomy of a Standard

The *Next Generation Science Standards (NGSS)* consists of a series of standards for grades kindergarten through 12 such as the example standard for grade 2 that is shown in Figure 3.1 (p. 12). The standard page (in the higher grade levels there will be as many as three pages) consists of a title and code, performance expectation, foundation box, and connection box. The document does not, however, precisely define what components of the page constitute the "standard." The reason is, each state that adopts the *NGSS* will need flexibility to assemble the components in a way that meets the needs of that state. The identification of the components is detailed in Figure 3.2 (p. 14), but a short overview is a helpful place to start.

Title and Code

The top of the page contains a code and title that describe the content of the standard. The grade level is designated by the first number—"2" in the example in Figure 3.1—followed by a code—"PS1"—which stands for the first set of ideas in Physical Science. For middle and high school, you will find MS and HS rather than a number representing grade level.

Performance Expectations

The performance expectations describe what a student is expected to be able to do at the completion of instruction. The statement of performance includes a phrase for each of the three "dimensions"—a practice, a disciplinary core idea, and a crosscutting concept—that the *Framework* specifies must be integrated in the performance expectation. These are identified by the color that corresponds to the appropriate dimension in the foundation box below it. Performance expectations are intended to guide the development of assessments, but they are not the assessment as such. They are not instructional strategies or instructional objectives, but they should influence and guide instruction. The listed order of performance expectations does not imply a preferred order for instruction. Note that most of the performance expectations also contain a clarification statement and an assessment boundary statement to provide clarity to the performance expectations and guidance to the scope of the expectations, respectively.

Foundation Box

The foundation box, which follows next on the page and actually comprises three colored columns, contains the learning goals that students should achieve and that will be assessed using the performance expectations. The three parts of the foundation box are

1. science and engineering practices (blue),
2. disciplinary core ideas (orange), and
3. crosscutting concepts (green).

The material contained in the foundation box is taken directly from the respective chapters in the *Framework*. The foundation box also contains learning goals identified as

- What are some commonly held student ideas (both troublesome and helpful) about this topic? How could instruction build on the helpful ones and address the troublesome ones?
- What prior ideas or concepts do students need to learn to understand this core idea? What level of abstraction is expected of students?
- What are some phenomena and experiences that could provide observational or experimental evidence that that targeted core idea is an accurate description of the natural world?
- What representations or media would be helpful for students to use in making sense of core ideas?

Science and Engineering Practices

Framework Chapter 3 provides essays for each science and engineering practice and a discussion of progression along the grade levels, but no specific endpoints other than grade 12. The practices in the foundation box were developed by the *NGSS* writers for each grade level or band.

- The practice in the performance expectation is the one to be used in the assessment process. Many other practices from the full set of eight will need to be included in the instructional sequence. Which ones and in what order will you use them?
- How will each practice be used to develop an understanding of the disciplinary core idea?
- What practices could students engage in to explore phenomena and/or representations?

Crosscutting Concepts

The same format is available for the crosscutting concepts in Chapter 4 of the *Framework*. As with the practices, the *NGSS* writers created the endpoints for each practice for grades 2, 5, 8, and 12 that appear in the foundation box. As you create the instructional sequence consider the following questions:

- How will the crosscutting concepts indicated in the performance expectation support the understanding of the core idea?
- Are there other crosscutting concepts that could also support learning the core idea?

Before leaving the overview of the material in the standard, locate the last connection box at the bottom of the page and consider what connections to the *Common Core State Standards (CCSS)* in mathematics and English language arts could be emphasized as students engage in the instructional sequence. More on these connections in the next chapter.

Putting It All Together

The above review of the three dimensions coupled with the embedded questions and comments should provide the ingredients from which the activities in the instructional sequence can be created. The next task is the use of an integrated instructional model to actually create the sequence. One of the most widely used, well-described, and researched models for designing an instructional sequence is the BSCS 5E Model developed by Rodger Bybee. Bybee uses this model to develop an instructional sequence starting with the standards in the *NGSS* in a forthcoming

NSTA publication, *Translating the NGSS for Classroom Instruction*. This would be an excellent resource for guidance in using the 5E Model to develop the integrated instructional sequence.

Creating an Assessment

The last step, which is also included in the 5E Model, is a return to the first step, where a description of the desired results was created. The summative assessment is a refinement, if necessary, of the previous assessment constructed as an early step in the backward design process. While refining, consider the following questions:

- Is the assessment procedure or task aligned and consistent with the performance expectation?
- Are all three dimensions assessed?
- What intermediate or formative assessment can be created to check student progress and modify instruction during the instructional sequence?

Conclusion

This simplified process is only the beginning of a more elaborate and often reiterative process of writing, reviewing, piloting, and rewriting that goes into the development of instructional sequences and quality instructional materials. Nevertheless, it can be a starting point for interpreting a portion of a standard and clarifying the fundamental nature of how to use the various components of the standards in the process. The next chapter provides more details on how to organize a group to review the entire *NGSS* and think more deeply about designing instruction, developing the total K–12 curriculum, and resolving professional development issues.

The entire process of developing an instructional sequence based on a standard is summarized with the sequence of activities in Figure 4.1.

FIGURE 4.1. A summary of the process for moving from the *NGSS* to instruction

1. Select a performance expectation.
2. Read the performance expectation, clarification statement, and assessment boundary.
3. Read the applicable disciplinary core idea in the foundation box.
4. Read material in the *Framework* for the disciplinary core idea cited.
5. Read the science and engineering practices in the foundation box related to the performance expectation.
6. Read the material in the *Framework* for these practices.
7. Read the crosscutting concept in the foundation box associated with the performance expectation.
8. Read the material in the *Framework* for this crosscutting concept.
9. Create one or more descriptions of the desired results or learning goals for the instruction integrating the three dimensions in the foundation box.
10. Determine the acceptable evidence for the assessment of the desired results. Draft the summative assessment process for the learning goal.
11. Create the learning sequence using the BSCS 5E Model.
12. Create the summative assessment and check its alignment with the performance expectation.

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CHAPTER 5
A GUIDE FOR LEADING A STUDY GROUP ON THE TOTAL CURRICULUM

Chapter 4 provided a procedure to acquaint you with the substance and structure of a portion of a single standard in the *Next Generation Science Standards (NGSS)* by taking you through an exercise of translating a performance expectation and the associated content in the foundation box into a limited instructional sequence. It was not an exhaustive process of developing a "ready to use" learning sequence but rather a means to help you understand how the components of a standard interact and can be used to create an instructional sequence of activities. It could be completed as an individual or a team with each member using a different performance expectation and comparing results at the conclusion of the work.

The procedure outlined in this chapter is the next step in understanding the full array of what is in the *NGSS* and will prepare your team for the more comprehensive step of examining what is in the entire document, considering the learning progressions, and beginning the development of a multiyear (K–12, K–5, 6–8, or 9–12) curriculum. The questions in this chapter are meant to assist you in thinking about how standards or parts of standards are grouped together and sequenced and where they are located in the curriculum. The questions help you continue to think about the instructional strategies and assessments that you need. The process requires a team because it is a comprehensive study of the entire *NGSS* or any subset of the document that a team selects.

Using a group to study the *NGSS* and plan its use or implementation has a number of advantages. The *NGSS* is a large and complex document that spans 13 grade levels and four major content domains, requiring a leadership team with a wide variety of experience and expertise. The task of developing instructional materials and providing professional development requires a team of several individuals in most school or district situations.

During the development of the *NGSS*, NSTA created a guide to help educators plan and facilitate a group study of the various draft standards. That guide has been modified here to foster understanding and interpretation of the *NGSS* by a team of people working together as a study group. This group work is an important part of the process of using the standards to guide the development of instructional materials and professional development.

Organizing a Group

Your first steps in organizing a team are determining the scope of study and the number of participants. There needs to be a match between the scope of the study and the group size.

In some cases, the membership of the group is already predetermined and the group leader must set the scope of the study. For example, a group of four high school biology teachers may have decided to work together to study the standards. Since the membership of this group is predetermined, they would then use that information to decide on scope, which would likely be to focus on the life science standards in high school. In other cases, the scope of study may be predetermined and the group leader then needs to decide the membership of the group. For example, a district curriculum coordinator has been asked to form a team to review the standards and develop an implementation plan for grades K–8. Because the scope of task has

Practices as assessed outcomes and instructional methodology. Many teachers already include inquiry strategies in their instruction but rarely are they considered to be outcomes that are assessed. For these teachers, the shift means making sure the complete set of science and engineering practices are included in their overall instruction and developing means to assess a student's ability to carry out the practices independently. This will, in most cases, require new instructional strategies and materials. Review the information in Appendix F, Science and Engineering Practices, in the *NGSS*. This topic is discussed further later in the chapter.

To better understand the shift required for teachers already using inquiry as defined in the *NSES*, consider the similarities between inquiry "abilities," as they were called in the *NSES,* and the new practices described in the *NGSS,* as illustrated in Figure 6.1.

FIGURE 6.1. A comparison of Abilities of Inquiry from the *NSES* with science and engineering practices from the *NGSS* (The order has been changed in the Abilities of Inquiry to correspond to the most relevant practice.)

Science and Engineering Practices ***NGSS***	**Inquiry** *(Abilities)* ***NSES Grades 5–8***
Asking questions and defining problems	Identify questions and concepts that guide scientific investigations
Developing and using models	Develop descriptions, scientific explanations, and models using evidence
Planning and carrying our investigations	Design and conduct scientific investigations
Analyzing and interpreting data	Use appropriate tools to gather, analyze, and interpret data
Using mathematics and computational thinking	Use mathematics in all aspects of inquiry
Constructing explanations and designing solutions	Recognize and analyze alternative explanations and predictions
Engaging in arguments from evidence	Think critically and logically to make relationships between explanations and evidence
Obtaining, evaluating, and communicating information	Communicate a scientific procedure and explanations

Integrating crosscutting concepts. The crosscutting concepts will require modification of instruction and instructional materials for many teachers. Although the idea of common themes (AAAS 1993) or unifying concepts and principles (NRC 1996) have been present for many years, it has been rarely emphasized or assessed. The similarities and differences in com-

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