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

HAROLD PRATT

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National Science Teachers Association

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ABOUT THE AUTHOR

Harold Pratt, a career district science coordinator and a former NSTA president, is a consultant working in all areas of science education. He was a senior program officer at the National Research Council during the development of the *National Science Education Standards.* He is the recipient of NSTA's Robert H. Carlton Award and the coauthor of a number of science textbooks and articles.

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PREFACE

NSTA fully supports the *Next Generation Science Standards (NGSS)* and believes the *NGSS* offers an extraordinary opportunity to move science education forward in the 21st century. NSTA is committed to supporting the science education community and offers many tools that promote better understanding of the *NGSS*, including *The NSTA Reader's Guide for the Next Generation Science Standards,* an essential companion to the *Next Generation Science Standards* as states, districts, and schools prepare to adopt and implement the new standards. One of NSTA's strategic goals is to advocate for the central role of science education to benefit students and society. To that end, NSTA provides high-quality products and services—print and electronic publications, e-newsletters, online and face-to-face professional development (including institutes and web seminars), conferences, and symposia that focus on the *NGSS*—to guide science educators along the continuum from awareness to adoption to implementation. Lean on our library of resources as you develop instructional and assessment strategies that address the *NGSS*. NSTA continues to develop exemplary training manuals and materials to support professional development efforts. This *Reader's Guide* is a requisite piece in these efforts.

—Karen L. Ostlund
2012–2013 NSTA President

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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.

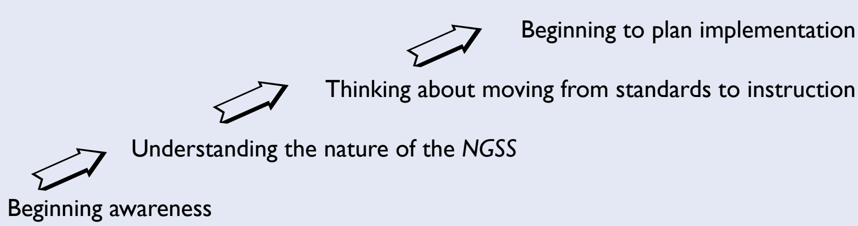
FIGURE I.1. *NGSS* table of contents of the total *NGSS* document

NGSS Front Matter
NGSS Structure
Appendices to the *NGSS*
- A. Conceptual Shifts
- B. Responses to May Public Feedback
- C. College and Career Readiness (coming soon)
- D. All Standards, All Students (coming soon)
- E. Disciplinary Core Idea Progressions
- F. Science and Engineering Practices
- G. Crosscutting Concepts
- H. Nature of Science (coming soon)
- I. Engineering Design in the *NGSS*
- J. Science, Technology, Society, and the Environment
- K. Model Course Mapping in Middle and High School (coming soon)
- L. Connections to CCSS-Mathematics (coming soon)
- M. Connections to CCSS-ELA Literacy (coming soon)

Commonly Used Abbreviations
Why Standards Matter
Public Attitudes Toward Science Standards

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*



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By the time you finish all six chapters, you will be on your way to a deep understanding of the *NGSS* and the promise it holds for science education. It's an important journey to navigate, holding the potential for your own professional growth and for a better education for your students. Future NSTA publications will pick up where this guide leaves off with many more details about using and implementing the *NGSS*.

Not everyone interested in studying the *NGSS* will want or need, at least immediately, to proceed the entire length of the path in Figure I.2. Your depth of learning and engagement will depend on your interest or role. If you are responsible for coordination and supervision at the state, regional, or district level, this guide may be a useful starting point in your understanding and planning before moving on to more comprehensive resources.

If you are a classroom teacher, the first four chapters may be the focus of your early reading. Chapter 4 will help you better understand how the *NGSS* can be used to plan instruction or instructional materials. This guide is not a comprehensive how-to manual, but rather a framework to provide what we might call an operational understanding of the *NGSS*. Rather than just read the standards, use this guide to stimulate in-depth thinking about how to use the *NGSS* for instructional purposes. In doing so, you will develop a better understanding of the components of the standards and how they can be used.

Although it sometimes occurs, teachers should never be handed standards, including the *NGSS*, and then be expected to translate them into classroom practice on their own. Teachers are certainly capable of doing so, but the time and effort required of such a task is beyond the scope of the normal teaching assignment and the time and resources allocated for the job. This guide will help the entire science education team in a district or state understand the extent of the tasks—outlined in chapters 4, 5, and 6—that need to be accomplished. The actual work involved calls for a significant team effort and adequate resources.

The information and messages in this *Reader's Guide* are in many ways the product of an NSTA team that has worked together for three years to review the *Framework* and then several drafts of the *NGSS*. Cindy Workosky coordinated the process of reviewing and providing feedback to the National Research Council (NRC) during the development of *A Framework for K–12 Science Education* (NRC 2012) and to Achieve Inc. during the review of the five *NGSS* drafts. Shortly after the *Framework* was released, Ted Willard joined the NSTA staff, leaving the American Association for the Advancement of Science (AAAS) after twelve years of work on the *Benchmarks for Science Literacy* and *Atlas of Science Literacy*, to help lead the review and feedback process of the *NGSS* drafts. More recently, as the work progressed to engaging NSTA membership in professional development, Zipporah Miller has lent her time and experience to this effort.

I have had the privilege of working with this team from the beginning and gaining from their knowledge, expertise, and experience as we considered the many issues and processes shared in this *Reader's Guide*. I am grateful for what I have learned from their collegial sharing and insights. This is their work as well as mine.

—Harold Pratt

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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

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FIGURE 3.1. A sample standard from the *NGSS* for grade 2

2-PS1 Matter and its Interactions

2-PS1 Matter and its Interactions

Students who demonstrate understanding can:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [Assessment Boundary: Assessment of quantitative measurements is limited to length.]

2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. [Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.]

2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS1-1) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. ▪ Analyze data from tests of an object or tool to determine if it works as intended. (2-PS1-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. ▪ Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3) **Engaging in Argument from Evidence** Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). ▪ Construct an argument with evidence to support a claim. (2-PS1-4) -- ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ▪ Science searches for cause and effect relationships to explain natural events. (2-PS1-4)	**PS1.A: Structure and Properties of Matter** ▪ Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1-1) ▪ Different properties are suited to different purposes. (2-PS1-2),(2-PS1-3) ▪ A great variety of objects can be built up from a small set of pieces. (2-PS1-3) **PS1.B: Chemical Reactions** ▪ Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)	**Patterns** ▪ Patterns in the natural and human designed world can be observed. (2-PS1-1) **Cause and Effect** ▪ Events have causes that generate observable patterns. (2-PS1-4) ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2) **Energy and Matter** ▪ Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3) -- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science, on Society and the Natural World** ▪ Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. (2-PS1-2)

Connections to other DCIs in this grade-level: will be available on or before April 26, 2013.

Articulation of DCIs across grade-levels: will be available on or before April 26, 2013.

Common Core State Standards Connections: will be available on or before April 26, 2013.
ELA/Literacy –
Mathematics –

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

Source: Achieve. 2013. *Next generation science standards. www.nextgenscience.org/next-generation-science-standards.*

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1. connections to engineering, technology, and applications of science (found in the green crosscutting area); and
2. connections to the nature of science (found in the practices area in this example but also can be found in the crosscutting concepts).

These supplemental goals are related to the other material in the foundation box and are intended to guide instruction, but the outcomes are not included in the performance expectations.

Appendix H, Nature of Science, and Appendix J, Science, Technology, Society, and the Environment, in the *NGSS* document contain more useful information about this material.

> Although the *NGSS* does not define a standard, NSTA considers a standard to be the performance expectations and foundation box associated with a core idea at a given grade level or band.

Connection Box

To support instruction and development of instructional material, a connection box appears immediately below the foundation box. This box

1. identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard (it contains the code for standards in other core ideas);
2. identifies the articulation of disciplinary core ideas across grade levels (it contains the codes of other standards in both prior and subsequent grade levels); and
3. identifies connections to the *Common Core State Standards (CCSS)* in mathematics and in English language arts and literacy that align to this standard (note that each *CCSS* standard is followed by a reference to a performance expectation).

What Are Standards?

Although the above information describes the anatomy or contents of a standard and its supporting connection box, it is important to have a more fundamental idea—independent of the *NGSS*—as to what standards are and how they relate to instruction, curriculum, and assessment. This understanding is important so that the role and purpose of the *NGSS* is understood and misconceptions do not arise during its use.

- Standards shed only partial light on how instruction should be conducted to meet the goals in the standards. The front matter of the *NGSS* discusses instruction but does not specify the exact nature of it for any given standard. The practices specified in a performance expectation may suggest a type of activity or behavior, but the practices do not define the type or nature of instruction.
- Standards are for all students. They can be considered an achievement level that all students should attain but not an average level of attainment. Performance for any given student or group of students may be higher as a result of instruction and expectations

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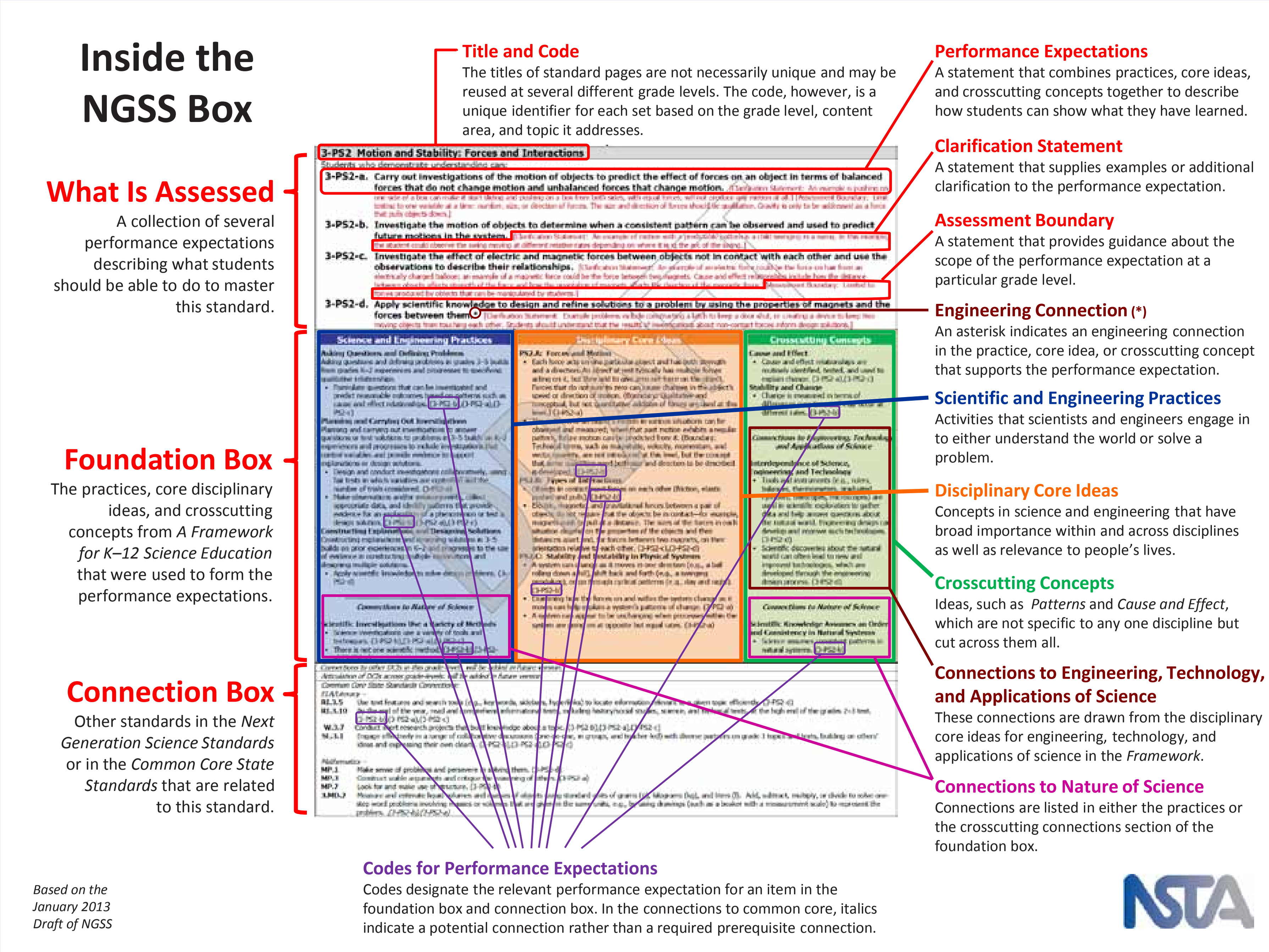
FIGURE 3.2. Inside the *NGSS* Box, a key to the various elements of a page in the *NGSS*



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designed to reach these higher goals. See a discussion of this topic in Appendix D, All Standards, All Students, in the *NGSS* document.

- Standards are not a plan for curriculum or a curriculum framework. Individual standards may specify learning goals for a given grade or grade band, but the order or arrangement of instruction and the learning goals within a grade level or band is not specified.
- Standards have strong implications for the professional preparation of teachers at the preservice level and the ongoing professional development of practicing teachers, but they do not specify the nature or extent of the preparation.

In rather straightforward terms, the *NGSS* has only two specific purposes beyond its broad vision for science education, namely (1) to describe the essential learning goals, and (2) to describe how those goals will be assessed at each grade level or band. The rest—instruction, instructional materials, assessments, curriculum, professional development, and the university preparation of teachers—is up to the science education community.

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Not since the 2011 release of *A Framework for K–12 Science Education* has a document held such promise and significance for the science education community as does the *Next Generation Science Standards (NGSS)*.

The *NGSS* aims to better prepare U.S. students for the rigor of career and college-level scientific study by stressing the importance and integration of the three dimensions: science and engineering practices, disciplinary core ideas, and crosscutting concepts. The *NGSS* will provide for a more integrated and cohesive approach to science instruction, leading to a more scientifically literate citizenry.

However, the *NGSS* also marks a change in how we think about science instruction, and the task at hand—the adoption of these new standards and their incorporation into instruction—will require a significant amount of support.

The key to unlocking the full potential of the *NGSS* is a deep understanding of the interrelationship of its core ideas, scientific and engineering practices, and crosscutting concepts. This brief and easy-to-use *Reader's Guide* offers teachers, principals, district and state administrators—anyone with a vested interest in improving the quality of science education—the tools they need to fully absorb the new standards and begin to implement them, effectively, into classroom practices.

Grades K–12

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