# *Answers to Teachers' Questions About the*

# Next Generation Science Standards

*Cindy Workosky and Ted Willard*

K–12 teachers of science have been digging into the *Next Generation Science Standards (NGSS)* (NGSS Lead States 2013) to begin creating plans and processes for translating them for classroom instruction. As teachers learn about the *NGSS,* they have asked about the general structure of the standards document and how to read and use it. This article, part of a series about different aspects of the standards, answers some of the most common questions about the architecture of the *NGSS,* from deciphering the codes to understanding the boxes.

**Q. What are the major components of the standards?**

A. Generally speaking, there are four major components on every standards page (Figure 1):

1. A code and title that describe the content of the standard;
2. A varying number of performance expectations that describe what students should be able to know and do at the end of instruction;
3. A foundation box that describes in more detail each of the three dimensions of the performance expectation; and
4. A connection box that includes connections to the standard from other disciplinary core ideas at the grade level and across grade levels and to the *Common Core State Standards* (*CCSS*) (NGAC and CCSSO 2010) in mathematics and English language arts and literacy.

**Q. What exactly are performance expectations?**

A. The standards include performance expectations that describe what students should be able to know and do at the end of instruction. This is very different from previous national and state standards that had separate inquiry and content goals. The performance expectations combine three key dimensions:

1. Science and engineering practices (how science is conducted in the real world—such as through planning and carrying out investigations);
2. Disciplinary core ideas (the content—for example, biology); and
3. Crosscutting concepts (ideas—such as cause and effect—that permeate all the sciences).

Performance expectations describe what is to be assessed at the *end* of instruction and guide the development of assessments. Teachers should not use the performance expectations as a curriculum. Instead, they should use their own professional judgment about how learning should take place in the classroom, keeping in mind what students should be able to do by the end of instruction, as described by the performance expectation.

**Q. How does the foundation box support the performance expectations? What do I do with this content?**

A. The foundation box provides a more complete description of the performance expectations. It describes the science and engineering practices, disciplinary core ideas, and crosscutting concepts used to make up a particular set of performance expectations. These are the "raw materials" that teachers can use to construct learning experiences for students.

**Q. What do the colors represent?**

A. The foundation box has three separate areas that are color coded. The blue area represents science and engineering practices; the orange area is for disciplinary core ideas; and the green area is for crosscutting concepts. Sometimes, the text of performance expectations is color coded to indicate what part of the foundation box the text is based on.

**Q: What is considered "the standard"? Is it the performance expectations or does it include the boxes below?**

A. Different states have different legal definitions for what they consider a "standard." Some states, for example, consider a single performance expectation to be a standard. Other states may refer to an entire set of performance expectations (a topic) to be a standard. Still others may consider a set of performance expectations and the corresponding foundation box to be a standard. NSTA considers the content of the foundation boxes to be just as important as the performance expectations in planning curriculum, instruction, and assessment, so we consider the "standard" to be the performance expectations plus the material in the foundation box.

**FIGURE 1** A typical standards page

## MS.Weather and Climate

**MS.Weather and Climate**

Students who demonstrate understanding can:

**MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.** [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]

**MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.** [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]

**MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

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

**Asking Questions and Defining Problems**

Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, clarify arguments and models.

- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

**Developing and Using Models**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-ESS2-6)

**Planning and Carrying Out Investigations**

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)

### Disciplinary Core Ideas

**ESS2.C: The Roles of Water in Earth's Surface Processes**

- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5)
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6)

**ESS2.D: Weather and Climate**

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)
- Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)

**ESS3.D: Global Climate Change**

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)

### Crosscutting Concepts

**Cause and Effect**

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

**Systems and System Models**

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. (MS-ESS2-6)

**Stability and Change**

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Connections to other DCIs in this grade-band: **MS.PS1.A** (MS-ESS2-5); **MS.PS2.A** (MS-ESS2-5),(MS-ESS2-6); **MS.PS3.A** (MS-ESS2-5),(MS-ESS3-5); **MS.PS3.B** (MS-ESS2-5),(MS-ESS2-6); **MS.PS4.B** (MS-ESS2-6)

Articulation of DCIs across grade-bands: **3.PS2.A** (MS-ESS2-6); **3.ESS2.D** (MS-ESS2-5),(MS-ESS2-6); **5.ESS2.A** (MS-ESS2-5),(MS-ESS2-6); **HS.PS2.B** (MS-ESS2-6); **HS.PS3.B** (MS-ESS2-6),(MS-ESS3-5); **HS.PS4.B** (MS-ESS3-5); **HS.ESS1.B** (MS-ESS2-6); **HS.ESS2.A** (MS-ESS2-6),(MS-ESS3-5); **HS.ESS2.C** (MS-ESS2-5); **HS.ESS2.D** (MS-ESS2-5),(MS-ESS2-6),(MS-ESS3-5); **HS.ESS3.C** (MS-ESS3-5); **HS.ESS3.D** (MS-ESS3-5)

Common Core State Standards Connections: will be available on or before April 26, 2013.

ELA/Literacy –

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|---|---|
| **RST.6-8.1** | Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5),(MS-ESS3-5) |
| **RST.6-8.9** | Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-5) |
| **WHST.6-8.8** | Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-ESS2-5) |
| **SL.8.5** | Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. (MS-ESS2-6) |

Mathematics –

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|---|---|
| **MP.2** | Reason abstractly and quantitatively. (MS-ESS2-5),(MS-ESS3-5) |
| **6.NS.C.5** | Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-ESS2-5) |
| **6.EE.B.6** | Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-5) |
| **7.EE.B.4** | Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-ESS3-5) |

**Q. Why are there two arrangements of the standards: one by disciplinary core idea and one by topic? Which arrangement is better for me to use?**

A. Both in print and on the web, the standards are shown in two different arrangements. One arrangement (by disciplinary core idea) matches the organizational structure used by the writers of *A Framework for K–12 Science Education* (NRC 2012), a publication from the National Academies of Science that guided development of the *NGSS*. The other arrangement (by topic) matches the arrangement that was used by the educators who wrote the standards. Teachers can use either arrangement or make their own arrangements. In the elementary grades (K–5), the performance expectations are presented grade by grade. In middle school and high school, they are presented by grade bands (6–8 and 9–12). Beyond that, the standards do not specify any particular order or organization for their teaching.

**Q. When designing instruction using a particular performance expectation, do I have to use the exact disciplinary core idea, practice, and crosscutting concept that make up the performance expectation?**

A. Absolutely not. The performance expectations are not meant to prescribe what to do during instruction. Teachers have the freedom and professional responsibility to decide what learning experiences will be most effective in helping students achieve the outcomes described in the performance expectations. Furthermore, research indicates that students will learn best if they engage in multiple practices as they develop their understanding of core ideas and crosscutting concepts. Each lesson should be three dimensional, meaning that it should integrate at least one practice, core idea, and crosscutting concept. Teachers should develop a logical sequence of activities during instruction that will provide students the proper motivation to develop and use the practices, core ideas, and crosscutting concepts they are to learn.

**Q. Some standards have a connection to the nature of science and to engineering, technology, and applications of science. How do those concepts get integrated into the standard?**

**A.** Just as the practices, core ideas, and crosscutting concepts should be integrated in a way that fits them together naturally, the same approach should be used for the connections to the nature of science and to engineering, technology, and applications of science. The writers of the standards have identified some places where connections may work naturally, but teachers should look for other opportunities as well.

NSTA is dedicated to helping all teachers of science and school leaders better understand the important instructional shifts in the *NGSS* and translate them into classroom instruction. Whether you're just beginning the process of exploring the *NGSS* or are already far along the path, NSTA has a growing number of tools and resources. Your starting place is the NGSS@NSTA Hub (*www.nsta.org/ngss*), where you will find our newest materials, including curated resources linked to the standards; a new interactive e-book called *Discover the* NGSS; NSTA Press books on topics such as *Science for All*; and videos to show you what *NGSS* instruction looks like in the classroom. Also, check out the official *NGSS* website (*www.nextgenscience.org*) that offers a detailed exploration of the *NGSS* architecture, the Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric, and other resources (*www.nextgenscience.org/resources*). Also see the NSTA position statement on the *NGSS* (*www.nsta.org/about/positions/ngss.aspx*).

As educator Harold Pratt noted in his *NSTA Reader's Guide to the* Next Generation Science Standards: "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."

There is much work ahead, but science teachers everywhere are embracing these exciting changes that are reinvigorating science education. Watch for future articles in this special series on the *NGSS*. ■

## References

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***Cindy Workosky*** *(cindy_w@nsta.org) is a communications specialist, and* ***Ted Willard*** *(twillard@nsta.org) is director of NGSS@NSTA, at the National Science Teachers Association in Arlington, Virginia.*