

CHAPTER 4

From NGSS to Classroom Instruction

This chapter provides a context for translating standards into something understandable, manageable, and usable for those with the real task of teaching science. I assume you have reviewed *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2012). Although for different audiences and at different points in the development of NGSS, “The Next Generation of Science Standards and the Life Sciences” (Bybee 2013), “The Next Generation of Science Standards: Implications in Biology Education” (Bybee 2012) and *The NSTA Reader’s Guide to the Next Generation Science Standards* (Pratt 2013) would be helpful background and resources. Prior chapters in this book also provide background related to discussions in this chapter.

The process of answering questions about the effects of NGSS on education systems must address both classroom instruction and the larger curricular perspective of how science concepts and practices that are the basis for the discussion also accommodate a learning progression across the K–12 curriculum.

In the first sections, the chapter progresses from a brief discussion of the disciplinary core idea used in the next three chapters (i.e., Chapters 5–7), analysis of a standard, description of an integrated instruction sequence (i.e., 5E Instructional Model), and a brief overview of the learning progression that is the basis for classroom instruction described in Chapters 5–7.

The second part of the chapter summarizes insights, lessons, and recommendations learned in the process of translating the NGSS to the classroom examples described in Chapters 5–7.

A BASIS FOR STANDARDS

This chapter centers on the core idea Biological Evolution: Unity and Diversity. By introducing Biological Evolution in this chapter, I set the stage for developing a learning progression in the examples described in the following chapters. Classroom instruction in grade spans K–2 and 3–5 should establish a foundation of concepts and practices on which middle and high school science teachers can build. Figure 4.1 (p. 50) is an overview of the core ideas and component topics for Biological Evolution in NGSS.

FIGURE 4.1. BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

<p>LS4.A: Evidence of Common Ancestry and Diversity</p> <hr/> <ul style="list-style-type: none"> Fossils provide evidence about the types of organisms (both visible and microscopic) that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences.
<p>LS4.B: Natural Selection</p> <hr/> <ul style="list-style-type: none"> Genetic variation in a species results in individuals with a range of traits. When there are environmental changes, there is a natural selection for individuals with particular traits so those individuals are more likely to survive and reproduce. This process of natural selection results over time in a predominance of certain inherited traits in a population.
<p>LS4.C: Adaptation</p> <hr/> <ul style="list-style-type: none"> Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.
<p>LS4.D: Biodiversity and Humans</p> <hr/> <ul style="list-style-type: none"> Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their environments.

The NRC *Framework* also presented science and engineering practices and cross-cutting concepts. These will be evident in the following discussion of standards and were described in Chapter 2.

THE ANATOMY OF A STANDARD

We will begin by briefly reviewing a standard. Table 4.1 presents the standard. The standard is the box at the top of the framework. This is one perspective for a standard. Due to states' requirements, what is defined as a standard is ambiguous in NGSS. I have found it most helpful to focus on the performance expectations, as they define the competencies that serve as the learning outcomes for instruction and assessments. Notice the standard is headed by Heredity: Inheritance and Variation of Traits. The subhead is "Students who demonstrate understanding can:" This is

TABLE 4.1. HEREDITY: INHERITANCE AND VARIATION OF TRAITS

1-LS3 Heredity: Inheritance and Variation of Traits		
1-LS3 Heredity: Inheritance and Variation of Traits Students who demonstrate understanding can: 1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.] [Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.] The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> .		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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. <ul style="list-style-type: none"> Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-LS3-1) 	LS3.A: Inheritance of Traits <ul style="list-style-type: none"> Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents. (1-LS3-1) LS3.B: Variation of Traits <ul style="list-style-type: none"> Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1) 	Patterns <ul style="list-style-type: none"> Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS3-1)
<i>Connections to other DCIs in first grade:</i> N/A <i>Articulation of DCIs across grade-levels:</i> 3.LS3.A (1-LS3-1); 3.LS3.B (1-LS3-1) <i>Common Core State Standards Connections:</i> ELA/Literacy – RI.1.1 Ask and answer questions about key details in a text. (1-LS3-1) W.1.7 Participate in shared research and writing projects (e.g., explore a number of “how-to” books on a given topic and use them to write a sequence of instructions). (1-LS3-1) W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (1-LS3-1) Mathematics – MP.2 Reason abstractly and quantitatively. (1-LS3-1) MP.5 Use appropriate tools strategically. (1-LS3-1) 1.MD.A.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object. (1-LS3-1)		

followed by a statement identified with the number and letters: 1-LS3. Statement 1-LS3-1 describes a performance expectation.

It is important to note that performance expectations specify a set of learning outcomes—that is, they illustrate the competencies students should develop as a result of classroom instruction. At this point, I will also note that the performance expectations are specifications for assessments with implications for curriculum and instruction, but they are not instructional units, teaching lessons, or actual tests.

Performance expectations embody science and engineering practices, disciplinary core ideas, and crosscutting concepts. The three columns beneath the performance expectation(s) are statements from *A Framework for K–12 Science Education* (NRC 2012) and provide detailed *content* for the three elements in the performance expectation(s).

To further understand standards, we can dissect the performance expectation. Look at performance expectation 1 in Table 4.1: “Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.” *Making observations to construct an explanation* is the practice. Look in the foundation box on the left for Constructing Explanations and Designing Solutions and find the bullet statement: “Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.” Details for the Disciplinary Core Ideas are in the center of foundation columns and the Crosscutting

Concept (Patterns) is described in the right column. All three descriptions are keyed to the performance expectation as indicated by 1-LS3-1 in parentheses.

The box beneath the three content columns provides connections to *Common Core State Standards* for English language arts and mathematics and the articulation of this standard to other topics at the grade level and across grade levels.

THINKING BEYOND A LESSON TO AN INTEGRATED INSTRUCTIONAL SEQUENCE

Expanding conceptions about instruction from “the lesson” to an integrated instructional sequence will be helpful when translating NGSS to classroom instruction. Here is a metaphor that clarifies this suggestion. Life sciences recognize the cell as the basic unit of life. There also are levels at which cells are organized—tissues, organs, organ systems, organisms, and so on. While the lesson remains the basic unit of instruction, when translating NGSS to classroom instruction, it is essential to expand one’s perception of science teaching to other levels of organization such as a coherent, integrated sequence of instructional activities. By analogy, think about organ systems, not just cells. Although the idea of instructional units has a long history, a recent analysis of research on laboratory experience in school science programs brings a new emphasis to the idea. Researchers have investigated sequences of instruction, including the role of laboratory experiences, as these sequences enhance student achievement of learning goals. Based on a synthesis of this research, an NRC committee proposed the phrase *integrated instructional units*:

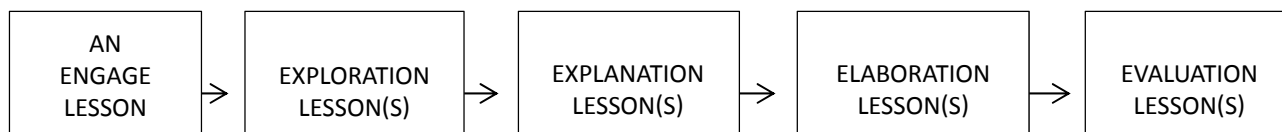
Integrated instructional units interweave laboratory experiences with other types of science learning activities, including lectures, reading, and discussion. Students are engaged in forming research questions, designing and executing experiments, gathering and analyzing data, and constructing arguments and conclusions as they carry out investigations. Diagnostic, formative assessments are embedded into the instructional sequence and can be used to gauge the students’ developing understanding and to promote their self-reflection of their thinking. (NRC 2006, p. 82)

Integrated instructional units have two key features: First, laboratory and other experiences are carefully designed or selected on the basis of what students should learn. Second, the experiences are explicitly linked to and integrated with other learning activities in the unit.

For purposes of curriculum development and classroom teaching, the features of integrated instructional units can be interpreted as a sequence of lessons such as the BSCS 5E Instructional Model—*engage, explore, explain, elaborate, and evaluate* (Bybee et al. 2006; Wilson, Taylor, Kowalski, and Carlson 2010). Stated another way, the BSCS model is a specific example of the general architecture for integrated instructional

units. According to the NRC committee's report, integrated instructional units connect laboratory experience with other types of learning activities including reading, discussions, and lectures (see Figure 4.2).

FIGURE 4.2. INTEGRATED INSTRUCTIONAL SEQUENCE



Chapters 5–7 use the 5E Instructional Model as the basis for examples of classroom instruction based on performance expectations.

CLASSROOM INSTRUCTION IS PART OF A SCIENCE CURRICULUM.

This section presents a brief reminder that there is a school curriculum. For *NGSS*, the science curriculum consists of learning progressions for the disciplines. In Chapters 5–7, *Biological Evolution: Unity and Diversity* describe a learning progression (see Table 4.2, p. 54).

In recent years, the idea of learning progressions has gained interest in the education community. This is especially the case in science education. With publication of *Taking Science to School* (NRC 2007), the idea of learning progressions—empirically-grounded, testable hypotheses about how students' understanding of and ability to use core scientific concepts and explanations and related scientific practices grew and became more sophisticated over time, with appropriate instruction—has influenced *A Framework for K–12 Science Education* (NRC 2012) and the *Next Generation Science Standards* (Achieve 2013).

In the past, most groups designing standards or developing curricula certainly had at least an initial understanding of learning progressions. Children in third grade do not have the same science concepts and inquiry abilities as students in high school. Examination of the *National Science Education Standards* (NRC 1996) or the *Benchmarks for Science Literacy* (AAAS 1993) supports this observation. But recent lines of research have certainly deepened our understanding of learning progressions for core concepts and fundamental practices. The publication *Learning Progressions in Science: An Evidence-Based Approach to Reform* (Corcoran, Masher, and Rogat 2009) presents a major synthesis of research on learning progressions.

Learning progressions have clear and direct implications for standards, curriculum, instruction, and assessment. In developing the *Framework* and *NGSS*, teams paid attention to the learning progressions for disciplinary core ideas and implied progressions for practices and crosscutting concepts. In Chapters 5–7, I recognize the research of others as described in *Tracking a Prospective Learning Progression for*

TABLE 4.2. PROPOSED LEARNING PROGRESSION FOR CONCEPTUAL UNDERSTANDING OF BIOLOGICAL EVOLUTION
INCREASING SOPHISTICATION OF LEARNING OUTCOMES

Performance Expectation	Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
LS4 Evidence of Common Ancestry and Diversity	Some living organisms resemble organisms that once lived on Earth.	Fossils provide evidence about the types of organisms and environments that existed long ago.	The fossil record documents the existence, diversity, extinction and change of many life forms and their environments through Earth’s history and enables the inference of lines of evolutionary descent.	The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.
LS4 Natural Selection	There are differences in characteristics between organisms of the same species.	Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing.	Natural or artificial selections result in genetic variations that give some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.	Natural selection occurs only if there is variation in the genetic information between organisms in a population and trait variation.
LS4 Adaptation	Particular organisms can only survive in particular environments.	Particular organisms can only survive in particular environments. Change in an organism’s environment is sometimes beneficial and sometimes harmful.	Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	Natural selection results from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population—as well as species expansion, emergence, or extinction—can change when environmental conditions change.
LS4 Biodiversity and Humans	A range of different organisms live in different places.	All organisms obtain living and nonliving resources from their environment.	Biodiversity is the range of existing life forms on Earth and includes genetic variation within a species and species variation in different habitats and ecosystem types. Changes in biodiversity can influence humans’ resources and ecosystem services.	Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it, including the potential of major extinctions that may be harmful to humans and other organisms. Sustaining biodiversity is essential to supporting life on Earth.

Source: Achieve 2013.

Developing Understanding of Evolution (Catley, Lehrer, and Reiser 2005) and the additional work published as *Implications of Research on Children's Learning for Standards and Assessment: A Proposed Learning Progression for Matter and the Atomic-Molecular Theory* (Smith, Wiser, Anderson, and Krajick 2006).

Although the idea of research-based learning progressions has appeal and did influence the chain of activities and assessments in Chapters 5–7, the reader should recognize that translations from the idea of learning progressions to standards and eventually to curriculum, instruction, and assessments does have trade-offs and omissions.

The next sections of this chapter present several insights and lessons learned as a result of translating NGSS performance expectations for elementary, middle, and high school classrooms.

The process of actually translating standards to classroom practices was, for me, a very informative experience. To say the least, the process is more complex than I realized. The discussion sets the stage for the next three chapters by providing background information that will help those who engage in the process of adapting instructional materials based on the NGSS.

IDENTIFY A COHERENT SET OF PERFORMANCE EXPECTATIONS.

In prior examples, I focused on a single performance expectation (PE). I did this for simplicity and clarity. Here, I move to discussion of a “coherent set” of performance expectations (i.e., a cluster or bundle) and caution against identifying single PEs with single lessons. The process of translating PEs is much more efficient if one considers a coherent set of PEs that make scientific and educational sense.

Begin by examining a standard with the aim of identifying a cluster of performance expectations that form a topic of study. Components of the disciplinary core ideas, major themes, topics, and conceptual themes represent ways of identifying a coherent set of performance expectations. Topics common to science programs may help identify a theme for an instructional sequence. The primary recommendation is to move beyond thinking about each performance expectation as a lesson—try to identify a theme that would be the basis for a unit of study that incorporates several performance expectations. This is a very reasonable way to begin thinking about translating standards to school programs and classroom practices.

With this recommendation stated, in some cases you may find that a single performance expectation does require a lesson or sequence of lessons or that all of the PEs in a standard can be accommodated in a single unit of instruction.

DISTINGUISH BETWEEN LEARNING OUTCOMES AND INSTRUCTIONAL STRATEGIES.

The scientific and engineering practices may be both teaching strategies and learning outcomes. Of particular note is the realization that the scientific and engineering

practices as learning outcomes also represent both knowledge and ability. When identifying learning outcomes, one wants students to develop the abilities and knowledge of these practices that are basic to science and engineering.

As you begin redesigning instructional materials, try to recognize instructional strategies students can use: actively ask questions, define problems, develop models, carry out investigations, analyze data, use mathematics, construct explanations, engage in arguments, and communicate information—and understand that each practice is a learning outcome. As a curriculum developer and teacher, you should distinguish between the teaching strategies and learning outcomes for the student.

CONSIDER HOW TO INTEGRATE THREE LEARNING OUTCOMES—PRACTICES, CROSSCUTTING CONCEPTS, AND DISCIPLINARY CORE IDEAS.

Recognize that a performance expectation describes a set of three learning outcomes and criteria for assessments. This recommendation begins by considering—thinking about, reflecting on, pondering—how the three dimensions might be integrated in a carefully designed sequence of activities. Taken together, the learning experiences should contribute to students’ development of the scientific or engineering practices, crosscutting concepts, and disciplinary core ideas.

Beginning with *A Framework for K–12 Science Education* (NRC 2012), continuing to the *Next Generation Science Standards* (NGSS; Achieve 2013), and now translating those standards to curriculum and instruction, one of the most significant challenges has been that of integration. It is easy to recommend (or even require) that the three dimensions be integrated, but much more complex to actually realize this integration in classroom instruction. The teams developing standards solved the problem in the statements of performance expectations. Now the challenge moves to curriculum and instruction.

At this point, I will mention several fundamentals of integrating a science curriculum. These lessons are paraphrased from a study (BSCS 2000) and article that colleagues and I completed (Van Scotter, Bybee, and Dougherty 2000).

First, do not worry about what you call the integrated curriculum; consider what students are supposed to learn. Second, regardless of what you integrate, coherence must be the essential quality of the curriculum, instruction, and assessments. Third, the fundamental goal of any science curriculum, including an integrated one, should be to increase students’ understanding of science concepts (both core and crosscutting), science and engineering practices, and their ability to apply those concepts and practices.

Here is a consideration that will help with curricular integration. Begin with an understanding that concepts and practices will be integrated across an instructional sequence, then proceed by identifying scientific investigations or engineering problems, and the rest will fall into place. “Why?” you ask. In the process of going from

scientific questions to explanations or engineering problems to solutions, one must use the practices and address core and crosscutting concepts.

USE AN INTEGRATED INSTRUCTIONAL SEQUENCE SUCH AS THE BSCS 5E INSTRUCTIONAL MODEL.

Use an integrated instructional sequence as the basis for a curriculum unit. While lessons serve as daily activities, design the sequence of lessons using a variety of experiences (e.g., web searches, group investigations, reading, discussion, computer simulations, videos, direct instruction) that contribute to the learning outcomes described in the performance expectations.

The idea of using integrated instructional sequences is based on *America's Lab Report: Investigations in High School Science* (NRC 2006). For the translation of PEs to curriculum and instruction, sequences of investigations and laboratory experiences combined with other forms of instruction show this approach is effective for achieving three goals: improving mastery of subject matter, developing scientific reasoning, and cultivating interest in science. Furthermore, and very important, integrated instructional units appear to be effective in helping diverse groups of students make progress toward achieving these goals.

The three key dimensions of the NGSS complement major conclusions from *America's Lab Report* (NRC 2006). Here are the four principles of instructional design that contribute to attaining learning goals as stated in NGSS. First, instructional materials are designed with clear performance expectations in mind. Second, learning experiences are thoughtfully sequenced into the flow of classroom science instruction. Third, the learning experiences are designed to integrate learning of science concepts (i.e., both disciplinary core ideas and crosscutting concepts) with learning about the practices of science and engineering. Finally, students have opportunities for ongoing reflection, discussion, discourse, and argumentation.

The BSCS 5E Instructional Model serves as an understandable and manageable application of an integrated instructional sequence. I have discussed the origin and use of the 5E model elsewhere (Bybee 1997). In addition, colleagues and I completed a review of research on the BSCS 5E Instructional Model (Bybee et al. 2006). See Figure 4.3 (p. 58) for a summary of the five phases of the model.

In *How People Learn*, the authors synthesized key ideas about learning based on an exhaustive review of the related research and identified parallel implications for classroom instruction (NRC 2000). This synthesis of research from the National Research Council (NRC) recommended an instructional sequence very close to the 5Es Instructional Model. In *How People Learn* (1999), Bransford, Brown, and Cocking explained:

An alternative to simply progressing through a series of exercises that derive from a scope and sequence chart is to expose students to the major

features of a subject domain as they arise naturally in problem situations. Activities can be structured so that students are able to *explore, explain, extend, and evaluate* their progress. *Ideas are best introduced when students see a need or a reason for their use*—this helps them see relevant uses of knowledge to make sense of what they are learning. (p. 127, italics added)

This summary, based on research, supports an integrated instructional sequence similar to the model described in Figure 4.3.

FIGURE 4.3. THE BSCS 5E INSTRUCTIONAL MODEL

<p>Engage</p> <p>The engage lessons initiate the instructional sequence. An engaging activity should (1) activate prior knowledge and make connections between the students’ past and present learning experiences, and (2) anticipate activities and focus students’ thinking on the topics and learning outcomes in the forthcoming lessons. The learner should become mentally engaged with the science ideas, concepts, and practices of the instructional unit.</p>
<p>Exploration</p> <p>The exploration should provide students with a common base of experiences within which they identify and begin developing science ideas, concepts, and practices. Students actively explore the contextual situation through investigations, reading, web searches, and discourse with peers.</p>
<p>Explanation</p> <p>These lessons develop an explanation for the concepts and practices students have been exploring. The students verbalize their conceptual understanding and demonstrate their scientific and engineering practices. Teachers introduce formal labels, definitions, and explanations for concepts, practices, skills, or abilities.</p>
<p>Elaboration</p> <p>The elaboration lessons extend students’ conceptual understanding through opportunities to apply knowledge, skills, and abilities. Through new experiences, the learners transfer what they have learned and develop broader and deeper understanding of concepts about the contextual situation and refine their skills and abilities.</p>
<p>Evaluation</p> <p>This segment of the instructional sequence is based on the performance expectations and emphasizes students assessing their ideas, concepts, and practices. The evaluation also includes embedded assessments that provide feedback about the degree to which students have attained the competencies described in the performance expectations.</p>

USE BACKWARD DESIGN.

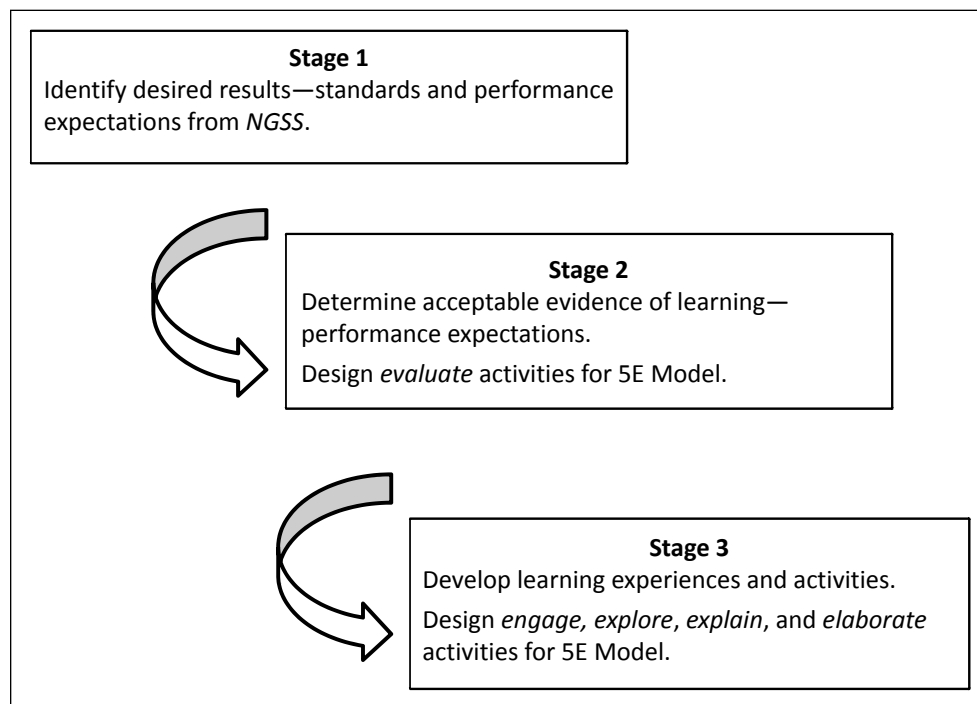
Because performance expectations and foundation boxes in the NGSS describe learning outcomes, they are the basis for using backward design for the development or adaptation of curriculum and instruction. Simply stated, the performance expectation can and should be the starting point of backward design.

Understanding by Design (Wiggins and McTighe 2005) describes a process that will enhance science teachers' abilities to attain higher levels of student learning. The process is called *backward design*. Conceptually, the process is simple. Begin by identifying your desired learning outcomes, such as the performance expectations from the NGSS. Then determine what would count as acceptable evidence of student learning and actually design assessments that will provide evidence that students have learned the competencies described in the performance expectations. Then, and only then, begin developing the activities that will provide students opportunities to learn the concepts and practices described in the three dimensions of the performance expectations.

The BSCS 5E Instructional Model and the NGSS provide practical ways to apply the backward design process. Say you identified a unit and performance expectations for Life Cycles of Organisms. One would review concepts and practices to determine the acceptable evidence of learning. For instance, students would need to use evidence to construct an explanation clarifying life cycles of plants and animals, identify aspects of the cycle (e.g., being born, growing to adults, reproducing, and dying), and describe the patterns of different plants and animals. You might expect students to recognize that offspring closely resemble their parents and that some characteristics are inherited from parents while others result from interactions with the environment. Using the 5E Instructional Model, one could first design an *evaluate* activity—for example, growing Fast Plants under different environmental conditions—and design a rubric with the aforementioned criteria. Then, one would proceed to design the *engage*, *explore*, *explain*, and *elaborate* experiences. As necessary, the process would be iterative between the *evaluate* phase and other activities as the development process progresses. Figure 4.4 (p. 60) presents the backward design process and the 5E Instructional Model.

Standards in the NGSS include the performance expectations. The standards describe the competencies or learning goals and are best placed in the first stage when applying backward design. The performance expectations and the content described in foundation boxes beneath the performance expectations represent acceptable evidence of learning and a second stage in the application of backward design. One caution should be noted. Sometimes use of the scientific and engineering practices combined with the crosscutting concepts and disciplinary core ideas are interpreted as learning activities that would be included in Stage 3. The caution is to include them in Stage 2 as learning outcomes. Stage 3 involves development or adaptation of activities that will help students attain the learning outcomes.

FIGURE 4.4. BACKWARD DESIGN PROCESS AND THE 5E INSTRUCTIONAL MODEL



Source: Adapted from *Understanding by Design* (Wiggins and McTighe 2005).

RECOGNIZE OPPORTUNITIES TO EMPHASIZE DIFFERENT LEARNING OUTCOMES.

Be aware of opportunities to emphasize science or engineering practices, crosscutting concepts, and disciplinary core ideas within the instructional sequence. This is an issue of recognizing when one of the three dimensions can be explicitly or directly emphasized—move it from the background (i.e., not directly emphasized) of instruction to the foreground (i.e., directly emphasized). Think of a picture. Usually there is something in the foreground (e.g., a person) and other features in the background. The foreground is what the photographer emphasizes and the background provides context (e.g., location of the picture). You can apply the idea of foreground and background to curriculum and instruction. For curriculum materials of instructional practices, what is emphasized (foreground) and what is the context (background)? Furthermore, as one progresses through an instructional sequence, different aspects of performance expectations can be in the foreground or background. This curricular emphasis is indicated in Table 4.3 by the words *foreground* and *background* in the framework's cells.

TABLE 4.3. A FRAMEWORK FOR CURRICULUM UNITS

Instructional Lessons	Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engage	Foreground Background	Foreground Background	Foreground Background
Explore	Foreground Background	Foreground Background	Foreground Background
Explain	Foreground Background	Foreground Background	Foreground Background
Elaborate	Foreground Background	Foreground Background	Foreground Background
Evaluate	Foreground Background	Foreground Background	Foreground Background

I must clarify this recommendation. Although the three dimensions are integrated, the intention is that students learn all three. The probability, for example, of students learning a practice that is in the background and used as an instructional strategy is lower than the probability of using the same practice for instruction and making it explicit and directly letting students know that this is a scientific or engineering practice.

In Chapters 5–7, I use a framework near the end of each chapter to summarize the three dimensions and their emphases within the lessons. Table 4.3 presents a variation of that framework. Note that the 5E Model and three dimensions of the standards are the defining features of the framework.

Completing a framework such as the one displayed in Table 4.3 provides an analysis of the three dimensions and can serve as feedback about the balance of the dimensions within the curriculum unit and the need for greater or lesser emphasis on particular dimensions. The terms *foreground* and *background* in the cells of the framework suggest the need to clarify whether the dimension is emphasized (i.e., in the foreground) or not (i.e., in the background) in that particular phase of instruction (e.g., *explore*).

REMEMBER TO INCLUDE ENGINEERING AND THE NATURE OF SCIENCE.

Performance expectations emphasizing engineering and the nature of science are included in the NGSS. It is important to identify these (note that they are identified in the scientific and engineering practices and crosscutting concepts columns of the foundation boxes). Because they are described as practices or crosscutting concepts,

they should be integrated along with the disciplinary core ideas. Their recognition calls for a different emphasis in curriculum and instruction.

CONCLUSION

Based on lessons I learned while preparing Chapters 5–7, this chapter provides helpful insights for those tasked with translating standards into curriculum and instruction. Additionally, the chapter sets the stage for Chapter 8, which provides details and processes for adapting or developing curriculum materials based on the NGSS.

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