THE BSCS 5E INSTRUCTIONAL MODEL

CREATING TEACHABLE MOMENTS

RODGER W. BYBEE

NSTA press
National Science Teachers Association

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For Nan.
You helped create the 5E Instructional Model and supported its use throughout your career at BSCS.
This dedication is with my deepest appreciation.

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PREFACE

Since the BSCS 5E Instructional Model was developed in the late 1980s, it has been widely implemented in places such as state frameworks and frequently used in articles in professional publications about teaching. This widespread dissemination and use of the model has been, to say the least, amazing. I have often wondered about the extensive application of the model. I have asked questions such as, "What accounts for the model's popularity?" and "Why do teachers embrace the model?" In addition, I have asked whether the BSCS 5E Instructional Model is appropriate for contemporary teaching and learning.

Lest the reader be too surprised, I think the 5E Model's widespread application can be explained by several observations. The first may be the most obvious: The model addresses every teacher's concern—how to be more effective in the classroom. Second, the model has a "common sense" value; it presents a natural process of learning. Finally, the 5 Es are understandable, usable, and manageable by both curriculum developers and classroom teachers.

To my second question about contemporary use, I do believe the BSCS 5E Instructional Model is appropriate for contemporary innovations such as *A Framework for K–12 Science Education*, the *Next Generation Science Standards* (*NGSS;* NGSS Lead States 2013), STEM education, and 21st-century skills.

A Framework for K–12 Science Education, for example, sets forth policies that require integrating three dimensions—science and engineering practices, disciplinary core ideas, and crosscutting concepts. Is it possible to use the 5E Model to meet the challenge of implementing three-dimensional teaching and learning? The *Framework* and *NGSS* require innovations such as constructing explanations, designing solutions, and engaging in argument from evidence. Can practices such as these be addressed within the BSCS model? What about the use of contemporary technologies? Yes, the BSCS 5E Instructional Model can accommodate these contemporary innovations. I used the 5E Model for examples in *Translating the* NGSS *for Classroom Instruction* (Bybee 2013) and will include further discussions later in this book.

I must mention the book's subtitle and theme—creating teachable moments. As a classroom teacher, I experienced times when students were totally engaged. They were caught by phenomena, events, or situations that brought forth a need to know and increased motivation to learn. I am sure most, if not all, classroom teachers have had similar experiences.

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When these experiences occur, classroom teachers capture the potential of these teachable moments. Teachers are pleased when this occurs. The common conception of a teachable moment is that it is random and unplanned, that it just occurs from a current event or in the context of a classroom activity, student question, school problem, or other opportunity.

What if you could provide more opportunities for teachable moments? What if teachable moments were not totally random and unplanned, and the probability of an occurrence could be increased through the structuring and sequencing of your lessons? The BSCS 5E Instructional Model described in this book provides classroom teachers with an approach to teaching that changes the emphasis within lessons and provides a sequence that increases the probability of teachable moments.

Here is some context on developing the 5E Model. In the mid-1980s, I assumed the position of associate director of the Biological Sciences Curriculum Study (BSCS). In that position, I helped create the BSCS 5E Instructional Model. At the time, a team of colleagues and I were developing a new program for elementary schools. We needed an instructional model that enhanced student learning and was understood by classroom teachers. Although the instructional model had a basis in learning theory, we avoided the psychological terms and chose to use everyday language to identify the phases of instruction as *engage*, *explore*, *explain*, *elaborate*, and *evaluate*.

When we created the 5E Model, the team and I only had a proposed BSCS program in mind. We had no idea that the instructional model would be widely applied in the decades that followed, commonly modified, and frequently used without reference to or recognition of its origins.

With the experiences of several decades, I made the connection between teachable moments and the BSCS 5E Instructional Model. While I recognized the connection and need for an in-depth discussion of the model, other professional obligations did not allow time to realize the potential in the form of a book. Now, almost three decades later, I have time, and the National Science Teachers Association (NSTA) has given me the opportunity to reflect on the BSCS 5E Instructional Model and consider its origins, history, and contemporary applications.

Before a detailed discussion of this book and the BSCS 5E Instructional Model, a few words of background seem appropriate. In developing the instructional model, we did take several issues into consideration. First, to the degree that it was possible, we wanted to begin with an instructional model that was research based. Hence, we began with the Science Curriculum Improvement Study (SCIS) Learning Cycle because it had substantial evidence supporting the phases and sequence. The additions and modifications we made to the Learning Cycle also had a basis in research.

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Second, we realized that the constructivist view of learning requires experiences to challenge students' current conceptions (i.e., misconceptions) and ample time and activities that facilitate the reconstruction of ideas and abilities.

Third, we wanted to provide a perspective for teachers that was grounded in research and had an orientation and purpose for individual lessons. What perspective should teachers have for a particular unit, lesson, or activity? Common terms such as *engage* and *explore* indicated an instructional perspective for teachers. In addition, we wanted to express coherence for lessons within an instructional sequence. How does one lesson contribute to the next, and what was the purpose of the sequence of lessons?

Finally, we tried to describe the model in a manner that would be understandable, usable, memorable, and manageable. All of these considerations contributed to the development of the 5E Instructional Model.

Not surprisingly, I structured this book using the 5E Model. Chapter 1 introduces the engaging theme (I hope) of teachable moments and, very briefly, the BSCS 5E Instructional Model. Chapter 2 explores the historical idea of what can be considered an instructional model. Chapter 3 is an in-depth explanation of the BSCS 5E Instructional Model. Chapter 4 reviews education research supporting instructional models, including the 5Es. Chapters 5, 6, and 7 elaborate on the model's application to *NGSS*, STEM education, 21st-century skills, and implementation in the classroom, respectively. Chapters 8, 9, and 10 present evaluations in the form of questions about the BSCS 5E Model and concluding reflections.

The audience for this book includes curriculum developers, classroom teachers, and those responsible for the professional development of teachers. I have tried to maintain a conversational tone and weave a narrative of education research, the psychology of learning, and the reality of classroom practice.

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NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

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When I began writing this book, I contacted Pamela Van Scotter, then acting director of BSCS. After telling her of my intention and asking about the use of BSCS reports and materials, she immediately and unconditionally gave permission. I thank her and acknowledge her long and deep support of BSCS and my work.

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Rodger W. Bybee
Golden, Colorado
October 2014

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ABOUT THE AUTHOR

Rodger W. Bybee, PhD, was most recently the executive director of the Biological Sciences Curriculum Study (BSCS), a nonprofit organization that develops curriculum materials, provides professional development, and conducts research and evaluation for the education community. He retired from BSCS in 2007.

Prior to joining BSCS, Dr. Bybee was executive director of the National Research Council's (NRC) Center for Science, Mathematics, and Engineering Education (CSMEE), in Washington, D.C. From 1986 to 1995, he was associate director of BSCS, where he was principal investigator for four new National Science Foundation (NSF) programs: an elementary school program called *Science for Life and Living: Integrating Science, Technology, and Health*; a middle school program called *Middle School Science & Technology*; a high school program called *Biological Science: A Human Approach*; and a college program called *Biological Perspectives*. He also served as principal investigator for programs to develop curriculum frameworks for teaching about the history and nature of science and technology for biology education at high schools, community colleges, and four-year colleges, as well as curriculum reform based on national standards.

Dr. Bybee participated in the development of the *National Science Education Standards*, and from 1993 to 1995 he chaired the content working group of that NRC project. From 1990 to 1992, Dr. Bybee chaired the curriculum and instruction study panel for the National Center for Improving Science Education (NCISE). From 1972 to 1985, he was professor of education at Carleton College in Northfield, Minnesota. He has been active in education for more than 40 years and has taught at the elementary through college levels.

Dr. Bybee received his BA and MA from the University of Northern Colorado and his PhD from New York University. Dr. Bybee has written about topics in both education and psychology. He has received awards as a Leader of American Education and an Outstanding Educator in America, and in 1979 he was named Outstanding Science Educator of the Year. In 1989, he was recognized as one of 100 outstanding alumni in the history of the University of Northern Colorado. In April 1998, the National Science Teachers Association (NSTA) presented Dr. Bybee with NSTA's Distinguished Service to Science Education Award. Dr. Bybee chaired the Science Forum and Science Expert Group (2006) for the Programme for International Student Assessment of the OECD (PISA). In 2007, he received the Robert H. Carleton Award, NSTA's highest honor for national leadership in the field of science education.

Although he has retired from BSCS, Dr. Bybee continues to work as a consultant.

CHAPTER 5

Using the 5E Model to Implement the *Next Generation Science Standards*

This chapter provides recommendations for translating standards into instructional materials that are usable for those with the real task of teaching. The discussion provides an affirmative answer to the question, How can the BSCS 5E Instructional Model be used to implement the *Next Generation Science Standards* (*NGSS*)? I recommend beginning with a review of *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2012) and becoming familiar with the *Next Generation Science Standards: For States, by States* (NGSS Lead States 2013). *A Reader's Guide to the* Next Generation Science Standards (Pratt 2013) would also provide helpful background and resources.

The BSCS 5E Instructional Model can be used as the basis for instructional materials that align with the aims of *NGSS*. In fact, the instructional model proves to be quite helpful as an organizer for the instructional sequences required to accommodate the three dimensions of performance expectations in *NGSS*. I have described this process in significant detail in *Translating the* NGSS *for Classroom Instruction* (Bybee 2013) and recommend that book for those deeply involved in the task of developing or adapting instructional materials based on *NGSS*. This chapter draws on insights I gained during my work on both the *National Science Education Standards* (NRC 1996) and the *NGSS* (NGSS Lead States 2013); the process of writing the book on translating the *NGSS* for classroom instruction required developing examples of classroom instruction that may be of interest.

ENGAGING IN *NGSS* AND CLASSROOM INSTRUCTION

How would you apply the 5E Model to *NGSS*? What would you consider as central to the process? Think about how you would answer these questions in the contexts of your classroom and your students.

EXPLORING *NGSS*

The Anatomy of a Standard

Let's begin by briefly reviewing a standard. Figure 5.1 (p. 64) is a standard for first-grade life science. I selected this example because it is simple and presents elements that clarify the anatomy of a standard.

One can view the standard as 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 followed by a statement identified with the number and letters "1-LS-3." Statement 1 describes a performance expectation. In the case of this standard, the performance expectation is, "Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents."

Very important, 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, it is important to note that the performance expectations are specifications for assessments with implications for curriculum and instruction, but they are neither instructional units or teaching lessons, nor actual classroom tests.

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

Figure 5.1. Heredity: Inheritance and Variation of Traits Standard From *NGSS*

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 *A Framework for K-12 Science Education*:

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. ▪ Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-LS3-1)	**LS3.A: Inheritance of Traits** ▪ 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** ▪ Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)	**Patterns** ▪ Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS3-1)

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: NGSS Lead States 2013.

To further understand standards, we can dissect the performance expectation. Look at performance expectation 1 in Figure 5.1: 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 idea are in the center of the foundation column under Inheritance of Traits and Variation of Traits. Finally, 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.

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.

With this brief introduction to *NGSS* and the competencies, we can move to the translation from the standard—the performance expectation—to the instructional model.

EXPLAINING A PROCESS FOR APPLYING THE 5E MODEL TO *NGSS*

Thinking Beyond a Lesson to an Integrated Instructional Sequence

Expanding conceptions about instruction from a daily lesson to an integrated instructional sequence will be helpful when translating *NGSS* to classroom instruction. Here is a metaphor that clarifies my 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, and organisms. While the lesson remains the basic unit of instruction, in translating the *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 (NRC 2006) presents a perspective of integrated instructional units that connect laboratory experience with other types of learning activities, including reading, discussions, and lectures. The BSCS 5E Instructional Model is a helpful way to think about an integrated instructional unit (see Figure 5.2, p. 66). The 5E Model provides the general framework for the translation of *NGSS* to classroom instruction.

Figure 5.2. Integrated Instructional Sequence

An *Engage* Lesson → *Explore* Lesson(s) → *Explain* Lesson(s) → *Elaborate* Lesson(s) → *Evaluate* Lesson(s)

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 insightful experience. To say the least, the process is more complex than I realized. But my familiarity with the 5E Model was a great help in figuring out how to design classroom instruction based on *NGSS.*

Identify a Coherent Set of Performance Expectations

The examples in Figure 5.2 focused on a single performance expectation. I did this for simplicity and clarity. Here, I move to a discussion of a coherent set of performance expectations (i.e., a cluster or bundle) and recommend not identifying single performance expectations with single lessons. The process of translating performance expectations is much more efficient if one considers a coherent set of performance expectations 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 that may be appropriate for a two- to three-week unit. Components of the disciplinary core ideas, major themes, topics, and conceptual ideas represent ways to identify 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 reasonable way to begin thinking about translating standards to school programs and classroom practices. In the prior example, Figure 5.2, the unit might be Heredity and Variation of Traits.

With this recommendation stated, in some cases you may find that one performance expectation does require a single lesson sequence or that all of the performance expectations 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 viewed *both* as 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 abilities for the instructional sequence. As learning outcomes, one wants students to develop the abilities and knowledge that these practices are basic to science and engineering.

As you begin applying the instructional model, bear in mind that students can, in using instructional strategies, 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 of these science and engineering practices is a learning outcome. In applying the 5E Model, you should distinguish between the teaching strategies and learning outcomes—for the student. Using the practices as teaching strategies does not necessarily mean students will learn the practices.

Consider How to Integrate Three Learning Outcomes—Science and Engineering 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, and 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 Lead States 2013) and now translating those standards to using the 5E Instructional Model, 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.

Several fundamentals of integrating a science curriculum may help. 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 instructional sequence; instead, consider what students will learn. Second, regardless of what you integrate, coherence must be the essential quality of the instruction and assessment. 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), and science and engineering practices and their ability to apply those concepts and practices. Begin with an understanding that concepts and practices will be integrated across an instructional sequence, then proceed by identifying activities, investigations, or engineering problems that may be used as the basis for instructional sequence.

Apply the BSCS 5E Instructional Model

Use the 5E Model 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, readings, discussions, computer simulations, videos, direct instruction) that contribute to the learning outcomes described in the performance expectations.

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 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.

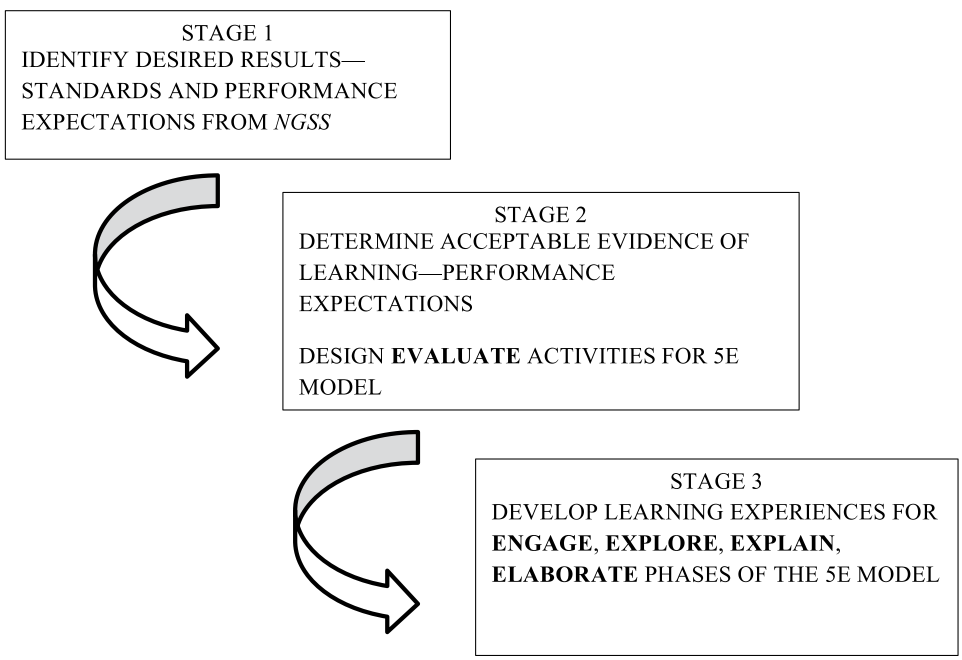
Use Backward Design

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—for example, the performance expectations from *NGSS*. Then determine what would count as acceptable evidence of student learning. You should formulate strategies that set forth what counts as evidence of learning for the instructional sequence. This should be followed by actually designing assessments that will provide the 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 dimensions of scientific and engineering practices, crosscutting concepts, and disciplinary core ideas as described in the *A Framework for K–12 Science Education* (NRC 2012) and the performance expectations and foundation boxes in the *NGSS* (NGSS Lead States 2013) describe learning outcomes. They are the basis for using backward design for the development or adaptation of curriculum and instruction. Performance expectations also are the basis for assessments. Simply stated, the performance expectation can and should be the starting point for backward design.

The BSCS 5E Instruction Model and the *NGSS* provide practical ways to apply the backward design process. Let us say you identified a unit and performance expectations for Life Cycles of Organisms. One would describe concepts and practices to determine the acceptable evidence of learning. For instance, students would need to use evidence to construct an explanation that clarifies life cycles of plants and animals, identify aspects of the cycle (e.g., being born, growing to adulthood, 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 BSCS 5E Instructional Model, one could first design an *evaluate* activity, such as growing Fast Plants under different environmental conditions and designing 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 5.3 presents the backward design process and the 5E Instructional Model.

Figure 5.3. Backward Design Process and the 5E Instructional Model



Source: Adapted from Wiggins and McTighe 2005.

Remember to Include Engineering and the Nature of Science

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 is interpreted as a learning activity that would be included in Stage 3. The caution is to include the activity in Stage 2—as a learning outcome.

Stage 3 involves development or adaptation of activities that will help students attain the learning outcomes.

In *NGSS*, some performance expectations emphasizing engineering and the nature of science are included. It is important to identify these (*Note:* 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 the instructional sequence.

Recognize Opportunities to Emphasize Different Learning Outcomes

As you begin adapting activities or developing materials, be aware of opportunities to emphasize science or engineering practices, crosscutting concepts, and disciplinary core ideas within the 5E 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 or explicitly emphasized) of instruction to the foreground (i.e., clearly and directly emphasized). To understand my use of foreground and background, think of a picture. Usually there is something (e.g., a person) in the foreground and other features in the background. The foreground is what the photographer emphasized, and the background provides context (e.g., the 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 the 5E instructional sequence, different aspects of performance expectations can be in the foreground or background. This curricular emphasis is indicated in Table 5.1 by the words *foreground* and *background* in the framework's cells.

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

Completing a framework such as the one displayed in Table 5.1 provides an analysis of the three dimensions and can serve as feedback about the balance and emphasis of the three dimensions within the 5E instructional sequence and, subsequently, the need for greater or lesser emphasis on particular dimensions.

Table 5.1. A Framework for Applying the BSCS 5E Instructional Model to *NGSS* Performance Expectations

INSTRUCTIONAL SEQUENCE	SCIENCE 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

EXPANDING YOUR UNDERSTANDING OF *NGSS* AND THE 5E MODEL

In this section, you actually extend your understanding by translating a performance expectation from the *NGSS* to a sequence of classroom instruction. For simplicity and convenience, you can begin with the first-grade life science performance expectation you explored in a prior section. That standard is displayed in Figure 5.1 (see p. 64).

Using this performance expectation and related information in the foundation boxes and connections, design an instructional sequence using the 5E Model. You should complete the framework in Table 5.2 (p. 72) by describing what the teacher does and what the students do.

I selected this *NGSS* standard because it presented less complexity from a practice, core idea, and crosscutting concept point of view. It also is the case that you had already explored the standard and gained some understanding of the performance expectation, foundational content, and connections.

Now that you have completed this process, you may wish to identify a set of performance expectations for a discipline and grade level of relevance to you. This activity would give a second elaboration, and one that should be more complex.

Table 5.2. Applying the BSCS 5E Instructional Model to *NGSS* Standards

THE BSCS 5E INSTRUCTIONAL MODEL	WHAT THE TEACHER DOES	WHAT THE STUDENT DOES
Engagement: This phase of the instructional model initiates the learning task. The activity should make connections between past and present learning experiences, surface any misconceptions, and anticipate activities that reveal students' thinking on the learning outcomes of current activities. The student should become mentally engaged in the concepts, practices, or skills to be explored		
Exploration: This phase of the teaching model provides students with a common base of experiences within which they identify and develop current concepts, practices, and skills. During this phase, students may use cooperative learning to explore their environment or manipulate materials.		
Explanation: This phase of the instructional model focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities for them to verbalize their conceptual understanding or demonstrate their skills or behaviors. This phase also provides opportunities for teachers to introduce a formal label or definition for a concept, practice, skill, or behavior.		
Elaboration: This phase of the teaching model challenges and extends students' conceptual understanding and allows further opportunity for students to practice desired skills and behaviors. Cooperative learning is appropriate for this stage. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills.		
Evaluation: This phase of the teaching model encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the performance expectation.		

EVALUATING YOUR INSTRUCTIONAL SEQUENCE

You can use a modification of criteria for adapting instructional materials for an evaluation of your understanding of the 5E model and *NGSS*. Table 5.3 describes the criteria, questions for evaluation, and your analysis.

Table 5.3. Evaluating Your Application of the BSCS 5E Instructional Model to *NGSS*

CRITERIA	QUESTIONS FOR THE ANALYSIS	YOUR ANALYSIS
• Identification of scientific and engineering practices • Crosscutting concepts • Disciplinary core and component ideas	• Do topics of the instructional sequence match the three dimensions of *NGSS?* • Are standards explicitly represented in the sequence?	
• Explicit connections among practices, crosscutting concepts, and disciplinary core and component ideas	• Do activities include the practices, crosscutting concepts, and disciplinary core ideas of the standards? • Do activities include all the component ideas? • Are connections made with other topics, concepts, and practices?	
• Time and opportunities to learn	• Does instruction include several experiences on a dimension? • Do students experience concepts before vocabulary is introduced? • Do students apply concepts and practices in different contexts?	
• Appropriate and varied instruction	• Are different methods of instruction used? • Are students engaged in activities that emphasize all three dimensions?	
• Appropriate and varied assessment	• Do you first identify what students know and do? • Are assessment strategies consistent with the performance expectations? • Are assessments comprehensive, coherent, and focused on the integration of core and component ideas, crosscutting concepts, and science and engineering practices?	
• Potential connections to *Common Core State Standards* for English language arts and mathematics	• Where does the instructional sequence present opportunities to make connections to the *Common Core State Standards?*	

CONCLUSION

Based on lessons I learned in translating *NGSS* to classroom instruction, this chapter provides helpful insights for those who have the task of applying the BSCS 5E Instructional Model. Additionally, the chapter modeled the 5E instructional sequence for addressing a performance expectation.

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