The BSCS 5E Instructional Model: Creating Teachable Moments

Rodger W. Bybee

National Science Teachers Association
Arlington, Virginia

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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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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.
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.
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.

REFERENCES


I acknowledge and express my gratitude to a team of colleagues that helped create the BSCS 5E Instructional Model. That team included Nancy Landes, Jim Ellis, Janet Carlson Powell, Deborah Muscella, Bill Robertson, Susan Wooley, Steve Cowdrey, and Gail Foster.

The BSCS team who helped prepare *The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications* (Bybee et al. 2006) included Joseph Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, and Nancy Landes. In addition, other BSCS staff contributed by assisting with the research: Samuel Spiegel, Molly McGarrigle Stuhlsatz, Amy Ellis, Barbara Resch, Heather Thomas, Mark Bloom, Renee Moran, Steve Getty, and Nicole Knapp.

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.

BSCS staff provided support for this work. I especially acknowledge Joe Taylor for providing articles and information on research supporting the 5E Model. Stacey Luce, the production coordinator, was most helpful with permissions and art for this book. I appreciate her contribution.

Appreciation must be expressed for my editors at NSTA Press. Claire Reinburg has consistently supported the publication of my works, and Wendy Rubin has improved on every draft manuscript. And just for Wendy—go Rockies! Maybe next year.

A special acknowledgment goes to Linda Froschauer, editor of *Science and Children*. Late in 2013, Linda asked me to prepare a guest editorial on the BSCS 5E Instructional Model. Linda’s request and the preparation of the editorial initiated the long-overdue work on this book.

Reviewers for this manuscript included Pamela Van Scotter, Harold Pratt, Nancy Landes, Karen Ansberry, and Nicole Jacquay.

I express my sincere and deep gratitude to Nancy Landes. Nancy was on the BSCS team that created the BSCS 5E Instructional Model, incorporated the model in numerous BSCS programs she developed, and completed a thorough review of an early draft of this book. As an expression of my appreciation, I have dedicated this book to Nancy.
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Byllee Simon has been my assistant for five years. She and I have worked closely on five books. My debt to Byllee is broad and deep.

Finally, Kathryn Bess read the manuscript. Her comments continually reminded me that teachers will use the 5E Model, and her recommendations brought sensitivity and a personal touch to the book. Kathryn has long supported my work. I am indebted to her and extend my appreciation and gratitude.

Rodger W. Bybee
Golden, Colorado
October 2014

REFERENCE

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.
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.

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

**1-LS3 Heredity: Inheritance and Variation of Traits**

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
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<tbody>
<tr>
<td><strong>Science and Engineering Practices</strong></td>
<td><strong>Disciplinary Core Ideas</strong></td>
<td><strong>Crosscutting Concepts</strong></td>
</tr>
<tr>
<td>Constructing Explanations and Designing Solutions</td>
<td>LS3.A: Inheritance of Traits</td>
<td>Patterns</td>
</tr>
<tr>
<td>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.</td>
<td>• 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)</td>
<td>• Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS3-1)</td>
</tr>
<tr>
<td>• Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-LS3-1)</td>
<td>LS3.B: Variation of Traits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)</td>
<td></td>
</tr>
</tbody>
</table>

Connections to other DCS in this grade-level will be available on or before April 26, 2013.
Articulation of DCS 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.
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
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**

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

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

<table>
<thead>
<tr>
<th>INSTRUCTIONAL SEQUENCE</th>
<th>SCIENCE AND ENGINEERING PRACTICES</th>
<th>DISCIPLINARY CORE IDEAS</th>
<th>CROSSCUTTING CONCEPTS</th>
</tr>
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<tbody>
<tr>
<td>Engage</td>
<td>Foreground Background</td>
<td>Foreground Background</td>
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<tr>
<td>Explore</td>
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<td>Explain</td>
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<td>Elaborate</td>
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<td>Evaluate</td>
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</table>

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

<table>
<thead>
<tr>
<th>THE BSCS 5E INSTRUCTIONAL MODEL</th>
<th>WHAT THE TEACHER DOES</th>
<th>WHAT THE STUDENT DOES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engagement:</strong> 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</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exploration:</strong> 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Explanation:</strong> 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Elaboration:</strong> 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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation:</strong> 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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>QUESTIONS FOR THE ANALYSIS</th>
<th>YOUR ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identification of scientific and engineering practices</td>
<td>• Do topics of the instructional sequence match the three dimensions of NGSS?</td>
<td></td>
</tr>
<tr>
<td>• Crosscutting concepts</td>
<td>• Are standards explicitly represented in the sequence?</td>
<td></td>
</tr>
<tr>
<td>• Disciplinary core and component ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Explicit connections among practices, crosscutting concepts, and disciplinary core and component ideas</td>
<td>• Do activities include the practices, crosscutting concepts, and disciplinary core ideas of the standards?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Do activities include all the component ideas?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Are connections made with other topics, concepts, and practices?</td>
<td></td>
</tr>
<tr>
<td>• Time and opportunities to learn</td>
<td>• Does instruction include several experiences on a dimension?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Do students experience concepts before vocabulary is introduced?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Do students apply concepts and practices in different contexts?</td>
<td></td>
</tr>
<tr>
<td>• Appropriate and varied instruction</td>
<td>• Are different methods of instruction used?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Are students engaged in activities that emphasize all three dimensions?</td>
<td></td>
</tr>
<tr>
<td>• Appropriate and varied assessment</td>
<td>• Do you first identify what students know and do?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Are assessment strategies consistent with the performance expectations?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Are assessments comprehensive, coherent, and focused on the integration of core and component ideas, crosscutting concepts, and science and engineering practices?</td>
<td></td>
</tr>
<tr>
<td>• Potential connections to Common Core State Standards for English language arts and mathematics</td>
<td>• Where does the instructional sequence present opportunities to make connections to the Common Core State Standards?</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5

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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With this book, you can stop wishing you could engage your students more fully and start engaging. Magic moments no longer have to be random. The BSCS 5E Instructional Model can help you create more teachable moments in your classroom.

Created in the late 1980s by a team led by author Rodger Bybee, the popular BSCS 5E Instructional Model includes five phases: engage, explore, explain, elaborate, and evaluate. Bybee wrote this book to be just as well organized and practical as the model itself. Much of it is devoted to an in-depth explanation of how to put the model to work in the classroom, but the book also

• explores the historical idea of what can be considered instructional models and education research that supports such models;
• explains how to connect the model to the Next Generation Science Standards, STEM education, 21st-century skills, and implementation in your classroom; and
• weaves a narrative that encompasses education research, the psychology of learning, and the reality of classroom practice.

Firmly rooted in research but brought to life in a conversational tone, The BSCS 5E Instructional Model addresses every teacher’s concern: how to become more effective in the classroom—and enjoy more of those teachable moments.