Guest Editorial

The BSCS 5E Instructional Model: Personal Reflections and Contemporary Implications

By Rodger W. Bybee

More than 25 years ago, a team of colleagues and I created the BSCS 5Es instructional model.[1] At the time, we were developing a new program for elementary science and health and needed an instructional model. With an awareness of the long history of instructional models, the BSCS team adapted the learning cycle described by J. Myron Atkin and Robert Karplus (1962). Their model was used in the elementary school program Science Curriculum Improvement Study (SCIS) developed at the Lawrence Hall of Science in Berkeley, California.

At the time, we only had the proposed BSCS program in mind. We had no idea that in the decades that followed, the instructional model would be widely applied, commonly modified, and frequently used without reference or recognition of its origins. So, almost three decades later, I appreciate this opportunity to reflect on the instructional model and describe some contemporary implications, particularly in the era of *Next Generation Science Standards (NGSS)*.

Before a detailed discussion of the instructional model, a few words of background and context seem appropriate. In developing the instructional model, we did take several things into consideration. First, to the degree possible, we wanted to begin with an instructional model that was research-based. Hence, we began with the SCIS Learning Cycle because it had substantial evidence supporting the phases and sequence. The BSCS additions and modifications to the Learning Cycle also had a research base. For example, we integrated cooperative learning (Johnson and Johnson 1987) as a complement to the original model for the SCIS program.

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

Third, we wanted to provide perspective for teachers that was grounded in research and had an orientation for individual lessons. We asked—what perspective should teachers have for a particular lesson or activity? Common terms such as engage, explore, explain, elaborate, and evaluate signaled the perspectives. In addition, we wanted to express a coherence for lessons within an instructional sequence. How does one lesson contribute to the next, and what was the point of the sequence of lessons?

Finally, we tried to describe the model in a manner that would be understandable, usable, and memorable for teachers. This was the origin of 5Es for the different phases of the model.

This editorial continues with a brief review of the five phases and some personal reflections about each phase. This summary is followed with a broader discussion of the model and its contemporary implications.

The BSCS 5Es Instructional Model

Engaging Learners

The goal of this phase is to capture the students' attention and interest. Get the students focused on a situation, event, demonstration, or problem that involves the content and abilities that are the aims of instruction. From a teaching point of view, asking a question, posing a problem, or presenting a discrepant event are all examples of strategies to engage learners. If students look puzzled, expressing "How did that happen?" or "I have wondered about that," and "I want to know more about that," they likely are engaged in a learning situation. Students have some ideas, but the expression of concepts and use of their

[1] The BSCS team included: Nancy Landes, Jim Ellis, Janet Carlson, Deborah Muscella, William Robertson, Susan Wooley, Stephen Cowdrey, and Gail Foster.

abilities may not be scientifically accurate and productive.

Over the decades, I have come to realize two things about this phase. The engagement need not be a full lesson, but usually it is because of the need to surface and assess students' prior knowledge.. It might be as brief as a question or a short demonstration. Teachers might, for example, provide a brief description of natural phenomenon and ask students how they would explain the situation. The main point is that the students are puzzled and thinking about content related to the learning outcomes of the instructional sequence. The second point about this phase is that it presents opportunities for teachers to informally determine misconceptions expressed by the students. I emphasize the informal nature of these observations. The engage phase is not a preassessment.

Exploring Phenomena

In the exploration phase, students have activities with time and opportunities to resolve the disequilibrium of the engagement experience. The exploration lesson or lessons provide concrete, hands-on experiences where students express their current conceptions and demonstrate their abilities as they try to clarify puzzling elements of the engage phase.

Exploration experiences should be designed for later introduction and description of the concepts, practices, and skills of the instructional sequence. Students should have experiences and the occasion to formulate explanations, investigate phenomena, observe patterns, and develop their cognitive and physical abilities.

The teacher's role in the exploration phase is to initiate the activity, describe appropriate background, provide adequate materials and equipment, and to counter any misconceptions. After this, the teacher steps back and becomes a coach with the tasks of listening, observing, and guiding students as they clarify their understanding and begin reconstructing scientific concepts and developing their abilities.

Explaining Phenomena

The scientific explanation for phenomena is prominent in this phase. The concepts, practices, and abilities with which students were originally engaged and subsequently explored, now are made clear and comprehensible. The teacher directs students' attention to key aspects of the prior phases and first asks students for their explanations.

Using students' explanations and experiences, the teacher introduces scientific or technological concepts briefly and explicitly. Here, using an *NGSS* example, the disciplinary core ideas including vocabulary, science or engineering practice, and crosscutting concept are presented, clearly and simply. Prior experiences should be used as contexts of the explanation.

I would make the point that verbal explanations are common in this phase. However, use of video, the web, or software also may provide excellent explanations.

Elaborating Scientific Concepts and Abilities

The students are involved in learning experiences that extend, expand, and enrich the concepts and abilities developed in the prior phases. The intention is to facilitate the transfer of concepts and abilities to related, but new situations. A key point for this phase—use activities that are a challenge but achievable by the students.

In the elaboration phase, the teacher challenges students with a new situation and encourages interactions among students and with other sources such as written material, databases, simulations, and web-based searches.

Evaluating Learners

At some point, students should receive feedback on the adequacy of their explanations and abilities. Clearly, informal, formative evaluations will occur from the initial phase of the instructional sequence. But, as a practical matter, teachers must assess and report on educational outcomes; hence, the evaluate phase that addresses the issue of assessment.

In the evaluate phase, the teacher should involve students in experiences that are understandable and consistent with those of prior phases and congruent with the explanations. The teacher should determine the evidence for student learning and means of obtaining that evidence, as part of the evaluate phase. Figure 1 summarizes the BSCS 5Es instructional model.

Questions, Recommendations, and Implications

Across the years, I have seen and been asked many questions about the BSCS 5Es instructional model. This section addresses some of the issues raised by curriculum developers and classroom teachers applying the 5Es model to materials and instruction. The 5Es model is based on the psychology of learning (NRC 1999a) and the observation that students need time and opportunities to formulate or reconstruct concepts and abilities. These two factors justify the perspective for each phase and the sequence of 5Es.

What Is the Appropriate Use of the Instructional Model?

More specifically, should the instructional model be the basis for one lesson? A unit of study? An entire program? My experience suggests that the optimal use of the model is a unit of two to three weeks where each phase is used as

the basis for one or more lessons (with the exception of the engage phase, which should be less than a lesson). In this recommendation, I assume some cycling of lessons within a phase; for example, there might be two lessons in the explore phase and three lessons in the elaborate phase.

Using the 5Es model as the basis for a single lesson decreases the effectiveness of the individual phases due to shortening the time and opportunities for challenging and restructuring of concepts and abilities—for learning. On the other hand, using the model for an entire program so increases the time and experience of the individual phases that the perspective for the phase loses its effectiveness. For example, teachers may have too much exploration time allotted, or multiple explanations may be concentrated.

Can a Phase Be Omitted?

My recommendation: Do not omit a phase. Earlier research on the SCIS Learning Cycle found a decreased effectiveness when phases were omitted or their position shifted (Lawson, Abraham, and Renner 1989). From a contemporary understanding of how students learn, there is integrity to each phase and the sum of the phases, as originally designed (Taylor, Van Scotter, and Coulson 2007). This question is often based on prior ideas about teaching that would omit engage or exploration and go immediately to explain. Alternatively, some suggest omitting elaborate. Here the important point centers on the transfer of learning combined with the application of knowledge.

Can the Sequence of Phases Be Shifted?

My response is similar to the prior one on omitting a phase. What would be shifted? Would one have explain precede explore? The original sequence was designed to enhance students' learning and subsequently supported by research (NRC 1999a and 1999b; Bybee et al. 2006; and Wilson et al. 2010). There also is earlier research on the learning cycle that specifically investigated the question about changing the sequence (Renner, Abraham, and Bernie 1988; Marek and Cavallo 1997). That research indicated reduced effectiveness when the sequence was changed. So, I do not recommend shifting the phases' order.

Can a Phase or Phases Be Added?

My colleague, Arthur Eisenkraft, added two phases by splitting engage to elicit and engage and adding an extend after evaluate, in order to underscore the importance of knowledge transfer (Eisenkraft 2003). In principle, I do not have a problem with adding a phase (or two) if the justification is grounded in research on learning, which was the case for Eisenkraft's modification.

Although there is no research support, I believe there is

FIGURE 1.

Summary of the BSCS 5Es instructional model.

Engagement
The teacher or a curriculum task helps students become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.

Exploration
Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions, and design and conduct an investigation.

Explanation
The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. In this phase teachers directly introduce a concept, process, or skill. An explanation from the teacher or other resources may guide learners toward a deeper understanding, which is a critical part of this phase.

Elaboration
Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept and abilities by conducting additional activities.

Evaluation
The evaluation phase encourages students to assess their understanding and abilities and allows teachers to evaluate student progress toward achieving the learning outcomes.

the practical issue of recalling titles, establishing criteria, and differentiating strategies for more phases. I have found three to five to be the optimum number of total phases.

Can Phases Be Repeated?

Yes, it is sometimes necessary to repeat a phase. This change should be based on the curriculum developer or teachers' judgement relative to students' need for time and experiences to learn a concept or develop an ability. To be clear, an example of repeating a phase would be engage, explore, explore … not necessarily placing an explore before the evaluate.

Shouldn't Evaluation Be Continuous?

Effective teachers continuously evaluate their students' understanding. In the instructional model, the evaluate phase is intended as a summative assessment conducted at the end of a unit. Certainly, some evaluation ought to be informal and continuous. But, there also is need for an evaluation at the end of the unit.

What If I Need to Explain an Idea Before (or After) the Explanation Phase?

This may be necessary as some ideas are prerequisites to students understanding the primary concepts of a unit. Teachers will have to make a judgement about the priority and prerequisite nature of the concepts. One should maintain an emphasis on the primary or major concepts and abilities of the unit and not digress with less-than-essential explanations.

Can the 5Es Be Used for NGSS *and the Integration of Multidimensions?*

Yes. I have actually found the 5Es to help solve the challenge of incorporating the multidimensions of *NGSS* in the classroom. The phases of instruction certainly can include activities that afford opportunities for students to experience the science and engineering practices, disciplinary core ideas, and crosscutting concepts. In *Translating the* NGSS *for Classroom Instruction* (Bybee 2013), I used the 5Es for examples of the integration of multidimensions of *NGSS*.

Conclusion

My early association with the BSCS 5Es instructional model was to design an instructional sequence that would help teachers approach instruction in a meaningful way, one that enhanced student learning. I still hold this goal. At the time of its origin, I had no idea of the potential wide use. Many within the science education community have recognized the model's practical value and incorporated it into school programs, state frameworks, and national guidelines. There is something to the model that has held the community's interest during the decades, and this has touched me deeply.

To conclude, I encourage the continued use of the model with the full recognition that classroom teachers will bring appropriate adaptations based on the unique circumstances of their students. ■

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