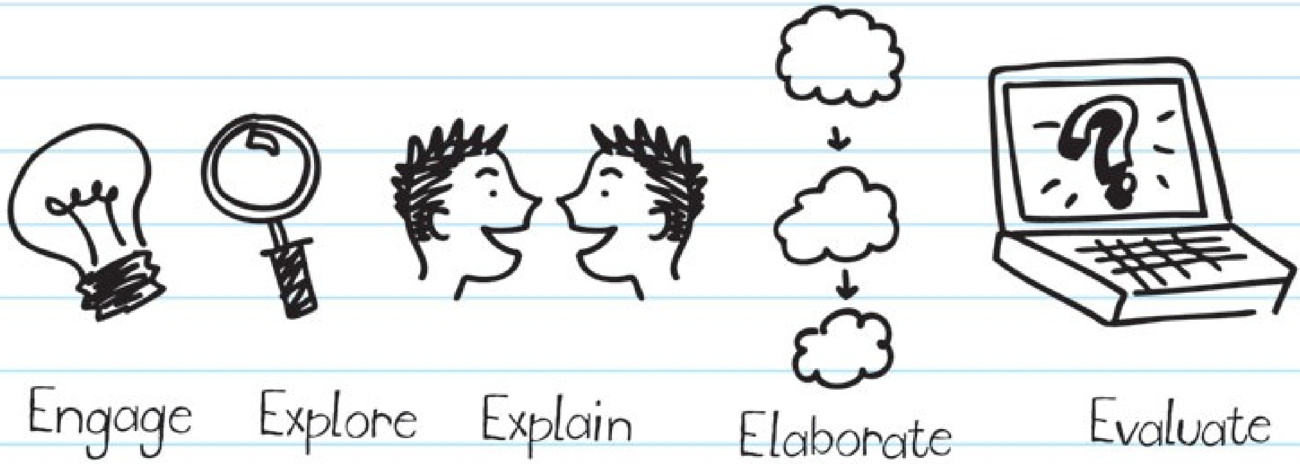
Shell Education

The 5Es of Inquiry-Based Science



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ISBN 978-1-4258-0689-7

The 5Es of Inquiry-Based SCiENCE

Chapter 1

An Overview of the 5E Instructional Model

"Science is a way of thinking much more than it is a body of knowledge"

—Carl Sagan (1986)

Today's science teachers face many challenges. Some challenges, such as poor student attitudes, are time-honored favorites. Other challenges, such as shifts in "the best" content and delivery methods, are recycled dilemmas, renewed and refreshed for the 21st century. Yet other challenges, such as high-stakes tests and society's need for a highly specialized workforce, challenge today's teachers like no other time in the history of education. As times continue to change, classroom teachers must focus their instructional delivery methods to meet the demands of challenging curriculum (content standards) and learning expectations (critical thinking and problem solving); compete against students' lax attitudes, disruptive behavior, and fixation with technology; and maintain their own professional development to meet the demands that a 21st century classroom places on its educators. The ideas in this chapter set the stage for a rationale regarding the implementation of the 5E instructional model for teaching science as it relates to each of these components:

- curriculum and instruction
- classroom environment
- professional development

Challenges Facing Today's Science Teachers

- challenging curriculum
- numerous content standards
- Common Core State Standards expectations for reading and writing in science
- accountability through course exams
- student disinterest and apathy
- competing with electronic devices and online gaming
- limited highly effective instructional programs, material resources, or equipment
- the need for continuous professional development

Scientific Literacy

Together, curriculum and instructional methods are the “what” and “how” of teaching. Science is an adventure in learning facts, figures, and information about the world around us. In addition to scientific discovery and factual learning, students must also understand scientific processes and be able to identify how science plays a critical role in their everyday lives. Collectively, all the facts and information, along with the understanding of the nature of science, the scientific enterprise, and the role of science in society and personal life, make up the definition of *scientific literacy* (National Science Education Standards 1996). To be literate in science, students need to know facts, but they must also be able to experiment, observe, problem-solve, work collaboratively, and think critically. In other words, students must “do” science.

All science teachers should agree on the ideas supporting the concept of scientific literacy. The National Science Education Standards define this as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (1996, 22). The characteristics of a scientifically literate citizen include but are not limited to the following:

- Asks and answers questions that have been born out of sheer curiosity about everyday events
- Describes, explains, and predicts naturally occurring events
- Reads and understands articles about scientific topics
- Competently participates in social conversations about scientific results
- Justifies his or her position related to scientific issues that affect society on a local, national, and global level
- Argues scientific conclusions based on evidence
- Uses appropriate terminology

The National Science Education Standards remind us, too, that scientific literacy has varying degrees and forms. Most students come to school with natural curiosity. Teachers discuss and teach about concepts to satisfy students’ curiosity and to develop their scientific literacy. However, many students graduate not having completely solidified their scientific literacy. Just as avid readers continue to develop their breadth and depth of reading skills, many people continue to expand and deepen their understanding of science continuously over time. And with the emphasis on STEM (Science, Technology, Engineering, and Mathematics) careers as one option for students’ future accomplishments (National Science Board 2007), many will likely graduate from school only to continue on their quest for answers in the workforce.

What Is the 5E Model of Instruction?

The 5E model of science instruction provides the structure for teachers to meet the demands of today’s science standards (both quantitative and qualitative). It engages students’ thinking, then allows for explorative discovery and factual learning to deepen students’ understanding of content matter. Students learn that one scientific question leads to another, which may lead to several more. Students have the opportunity to become critical thinkers and continue their learning of topics of interest as time passes.

The 5E model is a method of teaching science to produce scientifically literate students. Because it is a pedagogical approach to teaching science, it provides a framework for teachers around which to develop students' understanding of scientific ideas and concepts (content). However, the 5E model of instruction does not support any one program or any one set of material resources. Nor does it define scientific inquiry. This method is flexible and can be used with many different types of instructional resources, programs, and materials that teachers may already have. The 5Es are as follows:

1. Engage
2. Explore
3. Explain
4. Elaborate or Extend
5. Evaluate

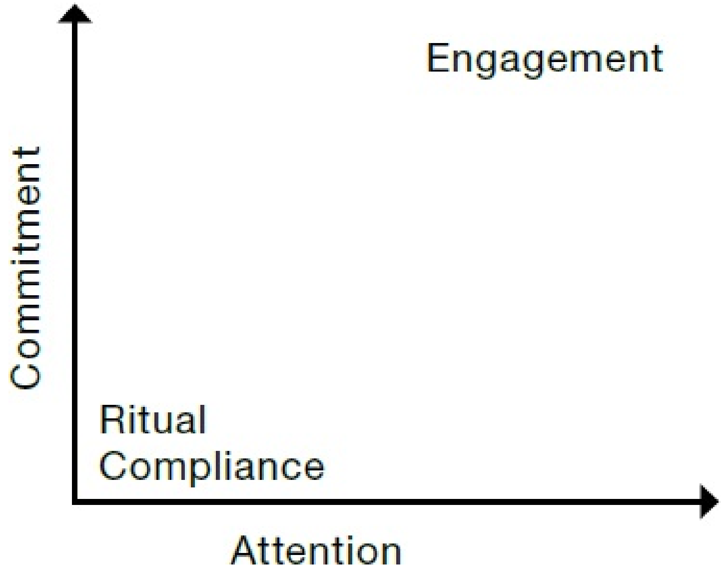
As previously discussed, curriculum and instruction refer to the "what" and "how" of teaching. The standards concretely provide educators with the "what." The 5E model structures the "how."

The 5Es Promote an Engaging Classroom Environment

Classrooms are filled with students who find science boring, unengaging, or otherwise useless. Disruptive behavior, poor attitudes, and downright apathy are not new challenges facing today's teachers. However, today's teachers must accomplish more with seemingly less in the same amount of time as their yesteryear counterparts.

In many science classrooms, lectures and textbooks have historically been part of the instructional approach of many teachers. Unfortunately, when used exclusively, these approaches lead to ritually compliant students, students who sit quietly listening to what may seem to be an endless barrage of uninteresting facts, information, and unknown scientific terms. Students have little commitment to the topic or task, and they devote little attention to what they should know and be able to do. Although lecture certainly has its place in the classroom, today's students deserve to be active learners, engaged and involved in the topic presented to them. An engaging classroom is one where students are both committed and attentive to the task. They value the work they are doing, and they find meaning in the outcome (Schlechty Center 2009). Figure 1.1 illustrates this point. The 5E instructional model allows teachers to assign tasks with both meaning and value to students. Yet, for those who hold their lectures and textbook learning at the heart of their instructional delivery, the 5E model allows room for this, too. It is a win-win for students and teachers.

Figure 1.1 A Relationship of Attention to Engagement



According to Robert Marzano and Debra Pickering (2011), students process several ideas when they are deciding whether they will commit to a topic. First, they consider their emotional investment in the topic. They unknowingly ask themselves, "How do I feel about this?" Second, students consider their interest in the topic. For obvious reasons, if students are uninterested, they are likely to be less engaged. They also decide whether a topic is important to them. The more often a teacher can demonstrate to students that their learning has value to their own personal lives, the greater importance a topic has to students, and the greater their engagement with the learning process. Finally, students consider whether their own skills leave them capable of learning the information or performing a learning task. Students who feel empowered and confident are likely compelled to learn new information. Students who feel incompetent or who lack confidence are likely to disengage from a task. When teachers follow the 5E instructional model—Engage, Explore, Explain, Elaborate or Extend, Evaluate—to teach students about scientific concepts, they can consciously attend to each aspect of the students' perceptions identified by Marzano and Pickering.

The first phase of the 5Es is Engage. When a teacher kicks off a lesson with an activity that boosts the level of classroom energy, students' emotions are heightened, and they become enthused and interested in the topic. By continuing with hands-on activities throughout the rest of the Es, students maintain their level of interest and feel successful and accomplished. Teachers can pull in relevant current events at any phase of the 5E learning cycle, leading students to appreciate the importance of what it is they are learning. Engaging instructional techniques, such as games, controversy, cognitively complex tasks, unusual information, and effective questioning strategies, are elaborated upon in later chapters. Suffice it to say, implementing the 5E instructional model is inherently engaging for students.

When a teacher follows the 5E model, students are free to become active participants in their learning experiences. This is done by way of the careful fluidity of each phase of the instructional model when the teacher is activating prior knowledge, providing time for the exploration of concepts, integrating reading and writing through the explanation of ideas, extending current learning experiences, and evaluating students to provide evidence of learning. These actions collectively formulate critical thinkers in the classroom. Each phase helps students become immersed in science content. This immersion creates exposure to content through varied learning experiences that address all student learning styles and support a variety of teaching styles.

An increased level of engagement leads to other positive classroom environment changes. The use of the 5E model fosters an environment that promotes a positive culture about inquiry. This helps students become problem-solving individuals. Teachers and students become sources of information in the science classroom. The National Science Education Standards (1996) remind us that "[i]nquiry into authentic questions generated from student experiences is the central strategy for teaching science" (31). Through the 5Es, students are able to interact in investigative tasks about concepts and contribute in their classroom environment. This can give students increased feelings of satisfaction and worthiness within the culture and climate of their class, leading to fewer negative outbursts and more productive work. In addition, this model helps students see themselves as scientists rather than spectators in the classroom. In the 5E model, students actively experience learning with an investigative approach as well as a teacher-directed approach. Students' perceptions of science and their role as learners are positively affected. They are allowed and even encouraged to explore, question, and investigate the world around them, which is a natural-born instinct.

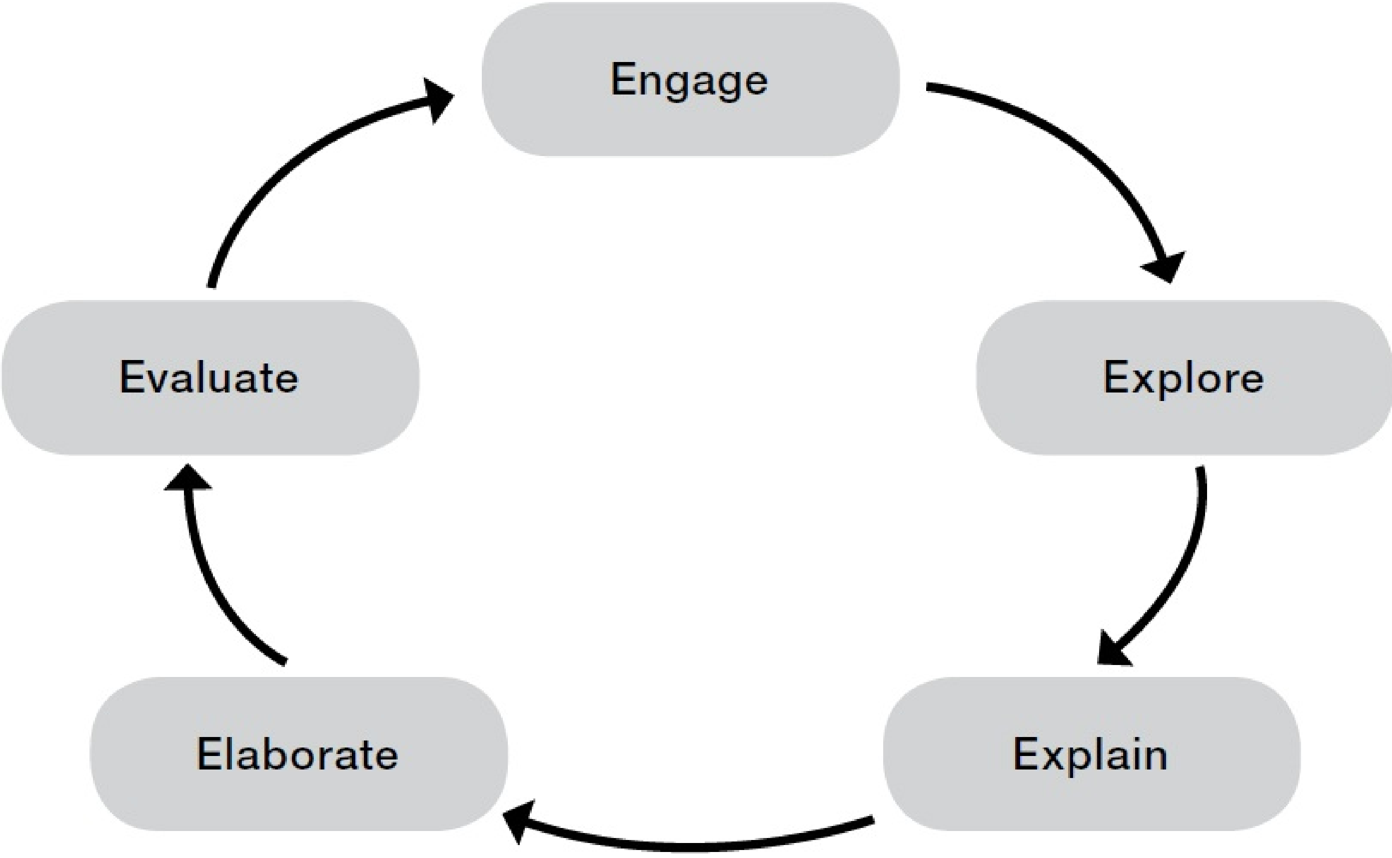
The 5Es Grounded in Constructivist Theory

Constructivism is a learning strategy that builds on students' prior knowledge, ideas, and skill sets. Educators who follow constructivist theory do so following the work of Jerome Bruner. His work was influenced by other theorists, including Lev Vygotsky and Jean Piaget. According to constructivist theory, students formulate new ideas by bridging prior knowledge with new information. Thus, scaffolding takes place. According to Bransford, Brown, and Cocking (2000), scaffolding involves several activities and tasks, such as the following:

- Creating student interest in the task
- Analyzing student needs for current academic task and managing components of the process
- Maintaining the overall objective of the task for the duration of the task
- Evaluating student assessments and products to determine content mastery
- Controlling frustration levels and risk in problem solving
- Providing exemplars/rubrics for student expectations

Clearly, the 5E instructional model abides by constructivist theory. Teachers who utilize the 5E approach in the science classroom tap into students' prior knowledge during the Engage phase. They generate thoughtful inquiry through problem solving, scientific investigations, simulations, or other hands-on activities during the Explore phase. Students' exploration is monitored and guided through inquiry, which allows the teacher to steer students in the right direction without giving them the answer. This way, students synthesize their own learning through problem solving and critical thinking. Information provided during the Explain phase supports students' developing understanding of scientific facts, concepts, and ideas. Students are then offered additional opportunities to build their understanding through Elaboration. Through thoughtful assessment strategies (Evaluation), teachers can help students realize what they have learned and what they have yet to learn, looping back to the Engage phase, when necessary. Ideally, students begin to see learning as a continuous process. The cyclical nature of the 5E model is illustrated in Figure 1.2.

Figure 1.2 5E Instructional Model for Science



During the Engage and Explore phases, students participate in hands-on or critical-thinking experiences and activities before delving into the scientific content that is introduced during the Explain phase. This is sometimes referred to as the Activity-Before-Content Model, or the ABC Model, which is grounded in constructivist theory. Because of this, the 5E model is inherently based on the constructivist theory of learning, too. Teachers who follow constructivist theory believe that students build, or construct, new learning on top of ideas they already have. Oftentimes, hands-on activities are the mainstay of a constructivist classroom. Generally, these constructivist teachers help students make connections between facts in order to foster new understanding of concepts. These teachers organize learning experiences that require students to analyze, interpret, and predict information. This is sometimes accomplished through open-ended questions, and students are encouraged to engage in dialogue with each other to process their ideas. Constructivist theory is not restricted to any one age group, which allows the 5E model to be successful across many grade levels.

The following is an example of a classroom situation where constructivism was the center of the learning process:

Greg	*Why aren't all science concepts called* laws?
Teacher	*There are three words commonly misused or misunderstood in science:* hypothesis, theory, *and* law. (The teacher writes these words on the board.) *Talk with a partner about these three terms. Between the two of you, decide if you know the differences between these words and if you can explain them*. (The teacher lets students discuss these three terms with partners.)
Jeremy	*I know a* hypothesis *is an educated guess. We make these when we do experiments in class*.
Teacher	*Right. Are they only used during experiments?*
Emma	*I think so. Marie Curie probably made* hypotheses *about the experiments she did*.
Jamal	*Maybe, but she had* theories *about what she was doing, too. So, is a* theory *like a* hypothesis?
Tyler	*You can't have a* theory *without proof*.
Gigi	*But you can get the proof when you do the experiments*.

A class discussion continued in this fashion. When needed, the teacher provided a guiding question to steer the conversation back to the main point to define and explain the differences among a *hypothesis*, a *theory*, and a *law*. Eventually, the teacher moved instruction forward and challenged students to find out the difference among these three ideas at home. The teacher promised they would continue to work toward a common understanding of these terms throughout the week.

What does the previous scenario have to do with constructivism and the 5Es? First, a student, not the teacher, posed a question that had meaning to him. Both his interest and commitment levels were high, so he was definitely Engaged with the topic. Secondly, the teacher did not provide a direct response. Instead, the teacher posed a different question, one that allowed students to make connections to and think critically about what they already knew. Students were allowed to collaborate together and build on their prior knowledge to construct new ideas and justify their ideas with partners. There was no "hands-on" activity, per se, but students were encouraged to Explore more information on their own time, and the teacher promised to devote additional class time to this topic. Hopefully, this scenario illustrated how a constructivist classroom compares to a traditional one. As for the 5Es, the teacher had limited time to devote to an organized, structured 5E lesson plan about scientific laws. However, the teacher masterfully engaged students with a rebuttal question and student-led conversation. The discussion left off having students explore the ideas independently. Once they brought back definitions and examples, students could then begin to construct and Explain the meanings of these terms using the information they found. Then, the teacher could have students Elaborate by asking them to define subsequent ideas as they encounter them in science. For example, in order to engage students when learning about the conservation of energy, the teacher might ask, “What do scientists mean when they say that energy cannot be created or destroyed? Would you categorize this idea as a hypothesis, theory, or law? Why?” Since students initiated this learning, they could, after a suitable amount of time, reflect on their own ideas to ensure a true and complete understanding of these three terms.

Understanding the 5E Instructional Model

Rather than directly profess the nature of the 5E instructional model, this chapter will walk you through each phase—Engage, Explore, Explain, Elaborate or Extend, Evaluate—by asking you to actively experience each phase of the 5Es by participating in activities that mirror each respective phase. The goal is to develop a deeper understanding of the 5E instructional model and its benefits for both teachers and students. So before delving into the “meat” of the content, let us first Engage our thinking. Once the mind is engaged, we can Explore the content, Explain its specific phases or steps, Elaborate or Extend our knowledge, and then Evaluate our own learning.

Phase 1: Engage

> What adjectives describe the most highly effective science classrooms? Create a list of as many as you can think of.

Before learning about the 5E model, we want to ready our minds for the content. In this instance, a question was posed for thoughtful reflection, which is one strategy for increasing student commitment and attention, the mere definition of engagement (Schlechty Center 2009). Requiring students to respond to questions allows them to make personal connections to the content, pull from their prior experiences, or otherwise take a stand on one side of an issue or another. If all readers of this book were part of a learning community, defined for our purposes as a group of teachers reading and discussing this book collectively or participating in a virtual book study, we could compare our descriptions of an effective classroom and discuss each person’s adjectives. As a group, we could then identify the most common descriptions and work to develop our own working idea of an effective science classroom. Although clearly not possible, this type of discussion and analysis of responses would be the ideal scenario. This first phase in becoming fluent in the 5E model marks a starting point along our journey, one we all now have in common, and one which sets a collaborative and collective goal for both the group and each individual participant.

This particular question has no right or wrong answer, although some educators might challenge others’ responses. As long as the learning environment remains supportive and respectful, polite banter is welcome in a 5E classroom. When students question each other, teachers know students are thinking critically (without being critical). Other questions to engage include asking philosophical questions *(Are renewable resources the answer to our energy needs?)*, opinion questions *(Should Pluto be readmitted as a planet?)*, or investigative questions *(What happens when cold and warm air masses meet?)*. In all cases, these questions elicit responses that require some thought. They require students to pull from their own personal experiences or background knowledge in order to assert their own ideas or to make reasonable predictions.

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