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

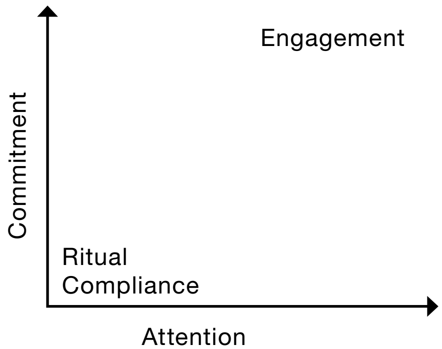
As previously discussed, curriculum and instruction refer to the "what" and "how" of teaching. The standards concretely provide educators with the "what." The 5E model structures the "how."

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

Chapter 2

Phase 1: Engage

How would Sir Isaac Newton answer the age-old question, "Why did the chicken cross the road?"

During the Engage phase of the 5E instructional model, teachers introduce content to students. This involves gaining students' attention and getting them to commit to the topic. Think of this like a television commercial. If it is too short, our curiosity may be unsatisfied—too long, and we may lose interest. The Engage phase serves as a "commercial" for students' minds. It must be interesting enough to grab their attention in just a short amount of time.

Effective Engage activities:

- are short in duration
- pique students' interest
- personally involve students
- tap into and assess students' prior knowledge

There is no one right or wrong way to conduct an Engage activity, as long as it accomplishes what its name implies: engage. In particular, time limitations vary from class to class and situation to situation. For example, teachers who take their students on an observation walk to look for evidence of the reflection and refraction of light will likely need more time to conduct this Engage activity than teachers who give their students a magnet and ask them to find three things it is attracted to. Both these examples are engaging activities, but walks typically require more than just a few minutes of class time.

A Rationale for Engaging Student Thinking

Continuing with the commercial metaphor, think about your favorite commercial. What compels you to watch it? Perhaps something unexpected happens. Perhaps it challenges your own moral compass. Perhaps it includes cute and cuddly animals or even disgusting blobs of mold. Perhaps it is about a popular topic. Perhaps it is just strange. Regardless, it is a favorite and captures your attention each time. Engage activities in the science classroom are like popular commercials on television. They grab students' attention and leave them asking questions, wondering about what is to come, and simply wanting more. Once students are engaged and attentive, they are more likely to commit to the topic, thus elevating their engagement of the entire learning process.

Madeline Hunter, one of the first leaders in instructional best practices, identifies the need to begin every lesson by engaging student thinking (1982). She calls this the *anticipatory set*. Experienced teachers likely wrote many lesson plans as college students that followed Hunter's lesson plan model. Each lesson should begin with this simple step. As evidenced in this chapter, there are many ways to engage student thinking.

As discussed in Chapter 1, Robert Marzano and Debra Pickering (2011) have identified four essential criteria that must be in place for students to be fully engaged: their emotional investment in the topic, their

Review Time!
According to Marzano and Pickering (2011), students ask themselves four questions to determine whether they will engage in a topic:

1. How do I feel?
2. Am I interested?
3. Is this important?
4. Can I do this?

interest in the topic, whether the topic is important to them, and whether their skills leave them capable of learning the information or performing a learning task.

Regarding difficulty and the level of complexity, engaging student thinking sounds very easy. However, in practice, asking one simple question (a useful Engage activity) can lead to a time-consuming discussion, leaving little time to move on to the remaining 5E phases. Consider this example:

> Mrs. Smith asked a class of fifth-graders, "Should the United States government require all of its citizens to get a flu shot?" She was excited to discover that this seemingly simple question led to a 40 minute debate about the imposing presence of the government in the personal lives of its citizens versus the responsibility of the government to ensure the safety and welfare of all of its citizens.

Mrs. Smith's time restrictions did not meet the intended brevity of the Engage activity. But because the Engage question spurred emotional responses from students and required them to justify their positions, she let the debate run its course and modified the activity that followed. Mrs. Smith wanted students to explore their personal viewpoints. She justified this instructional decision by remembering the purpose of an Engage activity: to jump-start student thinking and hook them into wanting to learn more. This question definitely accomplished its objective.

Time-Saving Tips

Teachers should set the expectation that their students will discuss a new topic. To learn, students need to interact with each other. As illustrated by Mrs. Smith's class discussion, paired, small-group, or class discussions can sometimes last longer than anticipated. To save time, teachers can have students discuss only one question. They can set time limits (30–90 seconds) for responses and rebuttals. In order to address additional questions that may arise during the discussion, teachers can have a "Parking Lot" chart where students write their questions on sticky notes and post them on the chart for later consideration. Some teachers may feel inclined to answer every question or have a class discussion about everything students want to discuss. This is just not feasible. Teachers should get in the habit of saying, "That's a really great question. Please post it on the 'Parking Lot' chart so we remember to go back to it."

Not all Engage questions need to be answered wholly. When students ask questions, they are sharing their interest in the topic. But one way to maintain their interest is to leave them hanging. Teachers can set students to the task of finding out more about the topic themselves. This way, students begin to answer their own questions. Teachers can reserve class time for students to share their research. A student who is interested enough to independently seek out answers is well on the way to becoming a self-motivated, lifelong learner.

Tech Tip!
Instead of physically posting questions to a "Parking Lot" chart, students can virtually post them to a classroom blog or wiki. Setting up a blog or wiki is easy. Visit http://www.blogger.com or http://www.wikispaces.com to get started.

Allowing respectful discussion among students before committing answers to the class requires all students to engage in conversation. Known as the Think-Pair-Share strategy, students first think to themselves and then turn to a partner to discuss their ideas. Then, students share their conversations with the whole class. According to Echevarría, Vogt, and Short (2008), this strategy is especially supportive of struggling students and English language learners (ELLs). The more opportunities a teacher provides for students to listen to and use oral language in a nonthreatening environment, the more confident they will be in their abilities to act as contributing members of the class.

The subsequent sections of this chapter will help teachers develop effective Engage strategies for their classrooms. The strategies are divided into three categories:

1. strategies to gain students' attention

2. strategies to personally involve students

3. strategies to activate prior knowledge

In practice, any one strategy can fit into any one or more categories. For example, teachers can gain students' attention *and* engage them personally by involving them in a class discussion. Regardless of the task, teachers should keep the purpose of the Engage activity in mind: to jump-start student thinking and to get students interested in the learning that is yet to come.

Strategies to Gain Students' Attention

Generally speaking, anything unexpected, cognitively challenging, emotionally pleasing (or displeasing), or of high interest to students will grab their attention. The following strategies can be used to gain students' attention:

- teacher demonstrations
- pictures and media files
- jokes, facts, and realia
- songs
- stunning vocabulary
- news articles and current events

Teacher Demonstrations

The element of surprise is always a big hit in the classroom. A lot of science phenomena can seem like "magic" to students, particularly when they see something for the first time. These unexpected incidences have the "Wow!" factor many teachers use to hook students both cognitively and emotionally. Choruses of "Wow!," "Did you see that?," and, "How'd you do that?" are music