Inquiry, the Learning Cycle, & the 5E Instructional Model

From the Guidelines for Lesson Planning from the Electronic Journal of Science Education:

The National Science Education Standards (NSES,1996) define inquiry as:

> Inquiry is a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories. Inquiry is a critical component of a science program at all grade levels and in every domain of science, and designers of curricula and programs must be sure that the approach to content, as well as the teaching and assessment strategies, reflect the acquisition of scientific understanding through inquiry. Students then will learn science in a way that reflects how science actually works (p 214).

Inquiry & the Learning Cycle:

The Learning Cycle originally credited to Karplus & Thier (1967), who published it in the *Science Teacher,* has been used in science education from its conception. Probably one of the earliest and foremost supporters of the Learning Cycle was the SCIS (Science Curriculum Improvement Study) program which adapted it and included it in its science curriculum. Although there are several "E" versions (e.g. 3E, 4 E, 5E, and other modifications) the basic premise is that children have an experience with the phenomena in the learning of the concept / topic. In other words, the Learning Cycle applied the inquiry approach to teaching into a series of planning strategies. Versions of the Learning Cycle are present in the major science curricula today (FOSS, STC, BSCS, etc.) As well as introduced and used as a science lesson planning strategy in most current Science Methods texts. The BSCS approach to the Learning Cycle is credited to Roger Bybee who developed the 5 E model.

How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning?
From National Institutes of Health (NIH) Website: Doing Science: The Process of Scientific Inquiry
http://science.education.nih.gov

Because learning does not occur by way of passive absorption, the lessons in this module promote active learning. Students are involved in more than listening and reading. They are developing skills, analyzing and evaluating evidence, experiencing and discussing, and talking to their peers about their own understanding. Students work collaboratively with others to solve problems and plan investigations. Many students find that they learn better when they work with others in a collaborative environment than when they work alone in a competitive environment. When active, collaborative learning is directed toward scientific inquiry, students succeed in making their own discoveries. They ask questions, observe, analyze, explain, draw conclusions, and ask new questions. These inquiry-based experiences include both those that involve students in direct experimentation and those in which students develop explanations through critical and logical thinking.

The viewpoint that students are active thinkers who construct their own understanding from interactions with phenomena, the environment, and other individuals is based on the theory of constructivism. A constructivist view of learning recognizes that students need time to

- express their current thinking;
- interact with objects, organisms, substances, and equipment to develop a range of experiences on which to base their thinking;
- reflect on their thinking by writing and expressing themselves and comparing what they think with what others think; and
- make connections between their learning experiences and the real world.

This module provides a built-in structure for creating a constructivist classroom: the 5E Instructional Model. The 5E model sequences learning experiences so that students have the opportunity to construct their understanding of a concept over time. The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engage, Explore, Explain, Elaborate, and Evaluate. The following paragraphs illustrate how the five Es are implemented across the lessons in this module.

Engage

Students come to learning situations with prior knowledge. This knowledge may or may not be congruent with the concepts presented in this module. The Engage lesson provides the opportunity for teachers to find out what students already know or think they know about the topic and concepts to be developed. It also gives each learner the opportunity to consider what his or her current ideas and thoughts about the topic are. The Engage phase should also capture students' interest and make them curious about the topic and concepts.

Students come to learning situations with prior knowledge. This knowledge may or may not be congruent with the concepts presented in this module. The Engage lesson provides the opportunity for teachers to find out what students already know, or think they know, about the topic and concepts to be covered. The Engage lesson in this module, Lesson 1, *Inquiring Minds*, is designed to

- pique students' curiosity and generate interest,
- determine students' current understanding about scientific inquiry,
- invite students to raise their own questions about the process of scientific inquiry,
- encourage students to compare their ideas with those of others, and
- enable teachers to assess what students do or do not understand about the stated outcomes of the lesson.

Explore

In the Explore phase of the module, Lesson 2, *Working with Questions*, students investigate the nature of scientifically testable questions. Students engage in short readings and generate their own set of testable questions. This lesson provides a common set of experiences within which students can begin to construct their understanding. Students

- interact with materials and ideas through classroom and small-group discussions;
- consider different ways to solve a problem or frame a question;
- acquire a common set of experiences so that they can compare results and ideas with their classmates;
- observe, describe, record, compare, and share their ideas and experiences; and
- express their developing understanding of testable questions and scientific inquiry.

Explain

The Explain lesson (Lesson 3, *Conducting a Scientific Investigation*) provides opportunities for students to connect their previous experiences with current learning and to make conceptual sense of the main ideas of the module. This stage also allows for the introduction of formal language, scientific terms, and content information that might make students' previous experiences easier to describe. The Explain lesson encourages students to

- explain concepts and ideas (in their own words) about a potential health problem;
- listen to and compare the explanations of others with their own;
- become involved in student-to-student discourse in which they explain their thinking to others and debate their ideas;
- revise their ideas;
- record their ideas and current understanding;
- use labels, terminology, and formal language; and
- compare their current thinking with what they previously thought.

Elaborate

In Elaborate lessons, students apply or extend previously introduced concepts and experiences to new situations. In the Elaborate lesson in this module, Lesson 3, *Conducting a Scientific Investigation*, students

- make conceptual connections between new and former experiences, connecting aspects of their health department investigation with their concepts of scientific inquiry;
- connect ideas, solve problems, and apply their understanding to a new situation;
- use scientific terms and descriptions;
- draw reasonable conclusions from evidence and data;
- deepen their understanding of concepts and processes; and
- communicate their understanding to others.

Evaluate

The Evaluate lesson (Lesson 4, *Pulling It All Together*) is the final stage of the instructional model, but it only provides a "snapshot" of what the students understand and how far they have come from where they began. In reality, the evaluation of students' conceptual understanding and ability to use skills begins with the Engage lesson and continues throughout each stage of the instructional model. When combined with the students' written work and performance of tasks throughout the module, however, the Evaluate lesson provides a summative assessment of what students know and can do.

The Evaluate lesson in this module, Lesson 4, *Pulling It All Together*, provides an opportunity for students to

- demonstrate what they understand about scientific inquiry and how well they can apply their knowledge to carry out their own scientific investigation and to evaluate an investigation carried out by a classmate;
- share their current thinking with others;
- assess their own progress by comparing their current understanding with their prior knowledge; and
- ask questions that take them deeper into a concept.

To review the relationship of the 5E Instructional Model to the concepts presented in the module, see the chart Science Content and Conceptual Flow of the Lessons.

When you use the 5E Instructional Model, you engage in practices that are different from those of a traditional teacher. In response, students learn in ways that are different from those they experience in a traditional classroom. The charts, What the Teacher Does and What the Students Do, outline these differences.

What the Teacher Does

Stage	That is *consistent* with the BSCS 5E Instructional Model	That is *inconsistent* with the BSCS 5E Instructional Model
Engage	Piques students' curiosity and generates interest Determines students' current understanding (prior knowledge) of a concept or idea Invites students to express what they think Invites students to raise their own questions	Introduces vocabulary Explains concepts Provides definitions and answers Provides closure Discourages students' ideas and questions
Explore	Encourages student-to-student interaction Observes and listens to the students as they interact Asks probing questions to help students make sense of their experiences Provides time for students	Provides answers Proceeds too rapidly for students to make sense of their experiences Provides closure Tells students that they are wrong Gives information and facts that solve the problem

	to puzzle through problems	Leads the students step-by-step to a solution
Explain	Encourages students to use their common experiences and data from the Engage and Explore lessons to develop explanations Asks questions that help students express understanding and explanations Requests justification (evidence) for students' explanations Provides time for students to compare their ideas with those of others and perhaps to revise their thinking Introduces terminology and alternative explanations after students express their ideas	Neglects to solicit students' explanations Ignores data and information students gathered from previous lessons Dismisses students' ideas Accepts explanations that are not supported by evidence Introduces unrelated concepts or skills
Elaborate	Focuses students' attention on conceptual connections between new and former experiences Encourages students to use what they have learned to explain a new event or idea Reinforces students' use of scientific terms and descriptions previously introduced Asks questions that help students draw reasonable conclusions from evidence and data	Neglects to help students connect new and former experiences Provides definitive answers Tells the students that they are wrong Leads students step-by-step to a solution
Evaluate	Observes and records as students demonstrate their understanding of the concepts and performance of skills Provides time for students to compare their ideas with those of others and perhaps to revise their thinking Interviews students as a means of assessing their developing understanding Encourages students to assess their own progress	Tests vocabulary words, terms, and isolated facts Introduces new ideas or concepts Creates ambiguity Promotes open-ended discussion unrelated to the concept or skill

What the Students Do

Stage	That is *consistent* with the BSCS 5E Instructional Model	That is *inconsistent* with the BSCS 5E Instructional Model
Engage	Become interested in and curious about the concept or topic Express current understanding of a concept or idea Raise questions such as, What do I already know about this? What do I want to know	Ask for the "right" answer Offer the "right" answer Insist on answers or explanations Seek closure

	about this? How could I find out?	
Explore	“Mess around” with materials and ideas Conduct investigations in which they observe, describe, and record data Try different ways to solve a problem or answer a question Acquire a common set of experiences so they can compare results and ideas Compare their ideas with those of others	Let others do the thinking and exploring (passive involvement) Work quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) Stop with one solution Demand or seek closure
Explain	Explain concepts and ideas in their own words Base their explanations on evidence acquired during previous investigations Record their ideas and current understanding Reflect on and perhaps revise their ideas Express their ideas using appropriate scientific language Compare their ideas with what scientists know and understand	Propose explanations from “thin air” with no relationship to previous experiences Bring up irrelevant experiences and examples Accept explanations without justification Ignore or dismiss other plausible explanations Propose explanations without evidence to support their ideas
Elaborate	Make conceptual connections between new and former experiences Use what they have learned to explain a new object, event, organism, or idea Use scientific terms and descriptions Draw reasonable conclusions from evidence and data Communicate their understanding to others	Ignore previous information or evidence Draw conclusions from “thin air” Use terminology inappropriately and without understanding
Evaluate	Demonstrate what they understand about the concept(s) and how well they can implement a skill Compare their current thinking with that of others and perhaps revise their ideas Assess their own progress by comparing their current understanding with their prior knowledge Ask new questions that take them deeper into a concept or topic area	Disregard evidence or previously accepted explanations in drawing conclusions Offer only yes-or-no answers or memorized definitions or explanations as answers Fail to express satisfactory explanations in their own words Introduce new, irrelevant topics