WHITE PAPER

The 5E Instructional Model
Engage Explore Explain Evaluate EXTEND

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Introduction

An instructional model, or learning cycle, is a sequence of stages teachers may go through to help students develop a full understanding of a lesson concept. Instructional models are a form of scaffolding, a technique a teacher uses that enables a student to go beyond what he or she could do independently. A scaffold is a temporary structure that is established for support but can be removed once the task is complete. An example of an instructional model is how effective caregivers use familiar scaffolding techniques, such as those listed below, to teach even young children (Wood, Bruner and Ross 1976):

- interest the child in the task
- simplify the task so that the child can manage it
- motivate the child to keep trying
- gently identify differences between what the child has produced and the ideal solution
- control frustration and risk
- demonstrate the process

An instructional model is a scaffold that is planned and developed prior to instruction to provide an effective and efficient learning experience. Some instructional models are designed for a particular learning theory, such as behaviorism, cognitivism, or constructivism. Some combine aspects of different learning theories. The 5E instructional model, developed by Rodger W. Bybee in the 1980s, was designed specifically to provide a model that promotes a constructivist approach to science education while incorporating aspects of behaviorism and cognitivism. The model has been widely adopted by science educators and is useful in other subject areas as well.

This white paper summarizes the research behind the 5E instructional model and contrasts it with other types of instruction.

LEARNING THEORIES AND INSTRUCTIONAL MODELS

A learning theory is an attempt to describe how people learn. If educators understand how children learn, they can provide instruction that supports increased learning through more effective, engaging, and efficient educational experiences. There are three basic learning theories that have been proposed by educators and psychologists: behaviorism, cognitivism, and constructivism. Instructional models have been developed in response to each learning theory.

BEHAVIORISM

Behaviorism is a theory that has been identified most widely with psychologist B.F. Skinner. Behaviorism considers learning to be a process of forming connections between stimuli and responses, with motivation to learn driven by rewards and punishments (Bransford, Brown and Cocking 2000). Behaviorism inspired the writing of behavioral lesson objectives—the lesson objectives that attempt to explain what behaviors a student should be able to demonstrate as a result of a lesson. Many state standards are written with behavioral objectives, describing what the student should be able to do if the standard is met.

Curriculum-based measurement and direct instruction (the explicit, systematic teaching of a skill-set using lectures or demonstrations, as opposed to exploratory or discovery learning models) are developed from the theory of behaviorism. Some behaviorist instructional materials use scripted teacher materials: the goal of this type of instruction is to ensure that teachers complete a specified sequence of steps and also to ensure adequate responses from the students. These techniques have proven to be highly effective, particularly in teaching skills such as phonics or basic math facts to mastery.

Robert Gagne was an American educational psychologist considered to be the foremost researcher and contributor to a systematic behaviorist approach to training. His nine events of instruction (Gagne 1977), which constitute a behaviorist instructional model, include:

1. Gaining attention
2. Expectancy: Informing the learner of the objective

3. Memory retrieval: Stimulating recall of prerequisite learning
4. Presenting stimulus materials
5. Providing learning guidance
6. Eliciting performance
7. Providing feedback
8. Assessing performance
9. Enhancing retention and transfer to the job

Another well-known instructional model is the Madeline Hunter instructional model (Herr 2007), which was widely promoted during the 1980s. The hallmarks of instructional materials based on this model are:

- Anticipatory set (a short activity to focus student attention)
- Objectives and purpose (explanation of the importance of the lesson and the objective)
- Input (vocabulary, skills, and concepts to be learned)
- Modeling (teacher demonstration)
- Guided practice (teacher leads students through steps)
- Check for understanding (questioning to determine student understanding)
- Independent practice (students practice on their own)
- Closure (teacher wraps up lesson)

The Madeline Hunter model was never meant to be prescriptive and yet it was prescribed widely. Eventually it came to be seen by many educators as too inflexible and not providing for teacher innovation or student spontaneity.

Behaviorism has its limitations. Because it focuses on observable behaviors, it is difficult to study student understanding, reasoning, and thinking—all of which are critical to education.

COGNITIVISM

Cognitivism was a response to behaviorism. The premise of cognitism is that people are thinking beings that need active participation in order to learn. The cognitive learning theory looks beyond overt behavior to explain learning. It promotes the idea that prior knowledge is a critical component of learning and that human memory is an organizer of information. In this theory the mind is seen as a computer, with information coming in, being processed, and leading to certain outcomes. Learning models related to cognitivism focus on activating prior knowledge and address the concern of concept load, recognizing that lessons should be limited so as not to overwhelm children (Mayer 2001). How to process information is key in cognitive learning theory.

One type of cognitivist instructional model is the Self-Regulated Strategy Development Model. The model espouses learning strategies that become habitual, flexible, and automatic. Here, the focus is on learning to think rather than content knowledge (Harris and Graham 1999). Learning is best accomplished through six stages:

Stage 1: Develop and activate background knowledge, including skills and knowledge.

Stage 2: Discuss the strategy, to promote active involvement and ownership of the strategy.

Stage 3: Model the strategy, to demonstrate how to learn and to illustrate the thought process of a skilled learner.

Stage 4: Memorize the strategy, so that students know and understand what is involved with each step in the process

Stage 5: Support the strategy, using scaffolding to promote a transfer of strategy performance from teacher to student.

Stage 6: Observe independent performance, to demonstrate use of the strategy for improved academic performance.

Educators have long complained that the focus of Cognitivism on information processing does not take into account how people build understanding and knowledge.

CONSTRUCTIVISM

Constructivism promotes the idea that people construct knowledge and meaning from experiences. It has its roots in the work of Jean Piaget. Paiget proposed that, through a process of accommodation and assimilation, people incorporate new ideas by changing or accommodating their understanding to fit the new information. Educational movements, such as inquiry-based learning, active learning, experiential learning, discovery learning, and knowledge building, are variations of constructivism. In a constructivist model the teacher acts as a facilitator rather than as the source of knowledge. Lev Vygotsky gave us one of the key principles of constructivism: He promoted the idea of a "zone of proximal development" (Vygotsky 1978). This zone is the distance between the actual developmental level that an individual is capable of and the potential the individual has under adult guidance or with the help of capable peers.

THE ORIGINAL 5E INSTRUCTION MODEL

The 5E instructional model that has been used since the late 1980s is based upon one used in the creation of the BSCS curriculum materials. It falls within the theories of constructivist teaching model (Bybee 2006). Every element of the five "Es" is carefully crafted to promote student construction of knowledge.

1. **Engagement**—Access prior knowledge and engage the new concept through short activities that promote curiosity.
2. **Exploration**—Provide a common base of activities in which current concepts are identified and conceptual change is facilitated.
3. **Explanation**—Focus on a particular aspect of engagement to provide opportunities to demonstrate conceptual understanding, process skills, or behaviors. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.
4. **Elaboration**—Challenge conceptual understanding and skills through new experiences to develop deeper and broader understanding and application.
5. **Evaluation**—Students assess their understanding and teacher evaluates student progress toward educational objectives.

Constructivism, in general, has been criticized for not promoting a foundation of knowledge, but the 5E model incorporates aspects of the behaviorist and cognitivism models, as well.

THE RESEARCH BEHIND THE 5E INSTRUCTIONAL MODEL IN *iSCIENCE*

The 5E Instructional Model has its roots in the ideas of Johann Herbart, John Dewey, and Jean Piaget. The concept behind the model is to begin with students' current knowledge, make connections between current knowledge and new knowledge, provide direct instruction of ideas the students would not be able to discover on their own, and provide opportunities to demonstrate understanding (Bybee 2006). The 5E Model has been used since the 1980s in elementary, middle, and high school science curricula.

Tests of the 5E instructional model against other forms of science instruction demonstrate evidence of increased mastery of subject matter, development of more sophisticated scientific reasoning, and increased interest in science. After working with students during the Evaluate step (formative assessment), a teacher can then use the results to make instructional decisions: differentiating instruction by challenging students who are ready for more, or intervening for students who need a different approach or a modified presentation of the content.

Each phase of the 5E Instructional Model used in *iScience* is supported by research.

ENGAGE

The Engagement phase of the 5E Model is the attempt to activate prior knowledge to discover student preconceptions. Preconceptions, misconceptions or naïve conceptions are prevalent in our society and are often immune to traditional instruction. Many people, for example, attribute the change of seasons to Earth periodically moving closer and farther in distance from the sun, rather than to the changing tilt of Earth on its axis. Prior knowledge has been shown to be a major factor in comprehension in any subject. Effective instruction must take into account the knowledge that students already have. In science, when students reveal their prior knowledge, any naïve conceptions are exposed. Recent work in using prior knowledge at the base of an analogy for a lesson's science concept helps to build understanding throughout the lesson and has been shown to be highly effective in developing science expertise. (Clement and Stephens 2008).

There are many ways to activate prior knowledge including:

- Brainstorming (listing information solicited from students).
- Asking specific questions and noting responses.
- Engaging students in a problem, activity, or scenario to elicit what they know.

iSCIENCE Engage students with "What do you think?" anticipation guide found at the beginning of each Chapter or in the inquiry-based discussions related to images. See examples of these in Integrated iScience (Owl), Vol. 1, Chapter 1 pp. 84 and 86. You may also want to look at the Engagement Toolbox, such as the one found on p. 97 of Integrated iScience (Owl), Vol. 1, Chapter 3, Lesson 1, for videos, demos, and more visuals and activities to foster student engagement.

EXPLORE

The Exploration phase of the 5E model challenges student preconceptions.

"Creating an opportunity to challenge our students to call on their collective experiences (prior knowledge) is essential. Through this process we move students from memorizing information to meaningful learning and begin the journey of connecting learning events rather than remembering bits and pieces. Prior knowledge is an essential element in this quest for making meaning. " *(Christen and Murphy 1991)*

Four conditions need to be present in order for students to undergo a conceptual change (Mestre 1994):

1. Student dissatisfaction with an existing conception. (If an explanation makes sense to the student and is unchallenged, there is no motivation to change it.)
2. Students must have some minimal understanding of the concept or they will not appreciate its meaning.
3. Students must view the new concept as plausible or they will not give it serious consideration.
4. Students must see the new concept as useful for interpreting or predicting phenomena.

To create these conditions, teachers must do the following:

- Listen to student ideas to identify misconceptions.
- If misconceptions are identified, promote dissatisfaction by challenging students; they can do this by providing evidence that illustrates inconsistencies between student beliefs and scientific phenomena.
- Inspire debate about the evidence to help students appreciate the value of the scientific conception in terms of its consistency with other concepts and phenomena.
- Help students to reconstruct their knowledge.
- Through exploration—including discussion, demonstration, and hands-on activities—teachers can challenge student conceptions.

iSCIENCE You can explore, assess, and address misconceptions with Page Keeley's Science Probes at the beginning of each chapter.

EXPLAIN

The Explanation phase involves presenting information that students are unlikely to discover on their own and allows for students to demonstrate skills, knowledge, or behavior. This phase provides the teacher the opportunity to address concerns that students might miss the point of the lesson, may experience cognitive overload, or—without instruction—might even develop misconceptions.

"The past half-century of empirical research has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning." *(Krischner, Sweller and Clark 2006).*

Furthermore, a foundation of knowledge is critical to developing expertise (Bereiter and Scardamalia 1993). Without the explanation and relaying of content knowledge, many students—particularly weaker students—will not benefit from the lesson or activities, no matter how engaged they are.

iSCIENCE use Differentiated Instruction strategies to better explain main ideas and key concepts or check out the Teacher Toolbox for reading strategies and demonstration ideas. See examples of these in Integrated iScience (Owl), Vol. 1, Chapter 1, p. T89 or Chapter 3, Lesson 1 p. 89.

EVALUATE

Evaluation is a critical phase of any instructional model. The purpose of *formative* assessment during instruction is to provide information about student understanding and performance to enable the teacher to make course corrections as need be, based on sound, defensible decisions (Anderson 2003). A *summative* assessment following instruction provides for evaluation of performance, but can also inform the instructor about how to manage subsequent lessons.

A key factor in any assessment is that it is valid: that it enables the instructor to gauge if and how students are meeting the lesson objectives. Evaluations may take the form of quizzes, tests, observations of performance, writings, interviews, or some other form. Without a valid assessment neither instructors nor students can be confident that objectives are being addressed and met.

iSCIENCE See examples of the Teacher Toolbox, Intervention Planner, or Lesson Reviews for support in evaluating student progress. See Integrated iScience (Owl), Vol. 1, Chapter 3, Lesson 3 pp. 110-112.

EXTEND

Extending or elaborating on content is the next phase of the 5E Instructional Cycle. This phase reflects Elaboration Theory, which emerged from Cognitivism Learning Theory. The premise is that for the most effective learning to take place, instruction should be organized in increasing order of complexity. The idea is that students need to develop a meaningful context into which new learning can be connected. Background knowledge can be reinforced and naïve conceptions further challenged through revisiting and elaborating on the lesson concepts. This also allows more intricate concepts to be introduced (Reigeluth 1999). In this phase of the 5E Instructional Model, supporting content—including information, understandings, and skills that are directly relevant but have not been addressed—can be elaborated on.

iSCIENCE See examples in Integrated iScience (Owl), Vol. 1, Chapter 3 pp. 112-113 or Chapter 2 p. 93 for suggestions to extend student learning through an Inquiry Lab or Visual literacy activities.

CHALLENGES

Skills, Content, and Problem Solving To be well-educated, a person needs knowledge, skills, and problem-solving abilities. Attaining a vast command of factual knowledge, by itself, is not the goal of education. Likewise, being highly proficient in a skill— such as knowing basic math facts—is not an end in itself. Furthermore, if people have great problem solving or processing ability, but have limited knowledge or skill, many of their efforts will be fruitless. It is the combination of the three forms of knowledge that is effective. Some disciplines are more skill- than content-oriented at different stages. Reading and mathematics, for example, demand a mastery of skills at an early stage because those skills are necessary to effectively access knowledge and solve problems. Some disciplines, such as social studies and science, depend on a knowledge base. No discipline is strictly skills, strictly knowledge, or strictly problem solving. An effective instructional model must address all three. It should build skills, expand content knowledge, and develop problem-solving thinking abilities.

Teacher Expertise Instructional models are only effective if they are used by effective teachers. The instructor must be prepared to make decisions about each of the following:

Which activities will best engage students in a lesson?

What preconceptions do students have?

How can preconceptions be challenged?

What explanations do students need?

When and how can the lesson content be meaningfully elaborated?

How can student understanding be validly assessed?

Expert teachers have a firm understanding of their respective disciplines, knowledge of the conceptual barriers that students face in learning about the discipline, and knowledge of effective strategies for working with students. Teachers' knowledge of their disciplines provides a cognitive roadmap to guide their assignments to students, to gauge student progress, and to support the questions students ask. The teachers focus on understanding rather than memorization and routine procedures to follow, and they engage students in activities that help students reflect on their own learning and understanding. The interplay between content knowledge and pedagogical knowledge contradicts a commonly held misconception about teaching—that effective teaching consists of a set of general teaching strategies that apply to all content areas. This notion is erroneous, just as is the idea that expertise in a discipline is a general set of problem-solving skills that lack a content knowledge base to support them *(Bransford, Brown and Cocking 2000).*

An effective instructional model such as the 5E Instructional Model, along with effective instructional materials, is tools and resources for educators that can play a substantial role in providing quality instruction and education.

iSCIENCE Need more strategies? Go to *Blueprints for Success* as referenced in Integrated iScience (Owl), Vol. 1, Chapter 3 p. 115.

References

Anderson, Lorin W. Classroom Assessment: Enhancing the Quality of Teacher Decision Making. Mahwah, NJ: Lawrence Erlbaum Associates, 2003.

Bereiter, Carl, and Marlene Scardamalia. Surpassing Ourselves: An Inquiry into the Nature and Implications of Expertise. La Salle, IL: Open Court, 1993.

Bransford, John D., Ann L. Brown, and Rodney R. Cocking. How People Learn: Brain, Mind, Experience, and School. Washington, DC: National Academy Press, 2000.

Bybee, W. Rodger, Joseph A. Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, and nancy Landes. "The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications." Colorado Springs, CO: BSCS, 2006.

Christen, William L., and Thomas J. Murphy. Increasing Comprehension by Activating Prior Knowledge. ERIC DIGEST, 1991.

Clement, John J., and A. Lynn Stephens. "Anchoring Student Reasoning in Prior Knowledge: Characteristics of Anchoring Cases in a Curriculum." NARST (National Association of Research in Science Teaching) 2008 Annual Meeting, 2008.

Gagne, Robert M. The Conditions of Learning. New York, NY: Holt, Rinehart and Winston, 1977.

Harris, Karen R., and Steve Graham. Making the Writing Process Work. Brookline Books, 1999.

Herr, Norman. The Sourcebook for Teaching Science. San Francisco, CA: Jossey-Bass Publishers, 2007.

Krischner, Paul A., John Sweller, and Richard E. Clark. "Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-

Based,, Experiential, and Inquiry-Based Teaching." Educational Psychologist (Lawrence Erlbaum Associates, Inc.) 41, no. 2 (2006).

Mayer, Richard. Multimedia Learning. Cambridge, MS: Cambridge University Press, 2001.

Mestre, Jose P. "Cognitive Aspects of Learning and Teaching Science." In Teacher Enhancement for Elementary and Secondary Science and Mathematics: Status, Issues, and Problems, edited by S.J. Fitzsimmons and L.C. Kerplelman. Washington, DC: National Science Foundation, 1994.

Reigeluth, C.M. The Elaboration Theory: Guidance for Scope and Sequence Decisions. Vol. II, in Instructional-Design Theories and Models: A New Paradign of Instrucrtional Theory Volume II, edited by C.M. Reigeluth. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 1999.

Vygotsky, Lev S. Mind in Society: The development of higher mental processes. Cambridge, MA: Harvard University Press, 1978.

Wood, D., J.S. Bruner, and G. Ross. "The Role of Tutoring in Problem Sovling." *Journal of Child Psychiatry and Psychology* 17, no. 2 (1976).