Patricia Blanton, Column Editor
Department of Physics and Astronomy, Appalachian State University, Boone, NC 28608; blantonp@appstate.

Learning Cycle Model of a Science Lesson

Jim and Jane Nelson, 4345 NW 36th Drive, Gainesville, FL 32605-6015; nelsonjh@ix.netcom.com

Editor's note: *One of the goals of AAPT is to provide support and encouragement to those new to teaching physics by sharing ideas that experienced physics teachers have found helpful. I hope you will look to this column throughout the year to find help with lesson planning, ideas for classroom management, and opportunities for professional growth. This month's contributing authors, Jane and Jim Nelson, are award-winning physics teachers with years of experience in the classroom, conducting PTRA workshops, and serving as leaders for local, state, and national AAPT organizations. Their contributions to physics teaching are much too numerous to list here, but their joy in sharing ideas with you is typical of the support you will find from AAPT.*

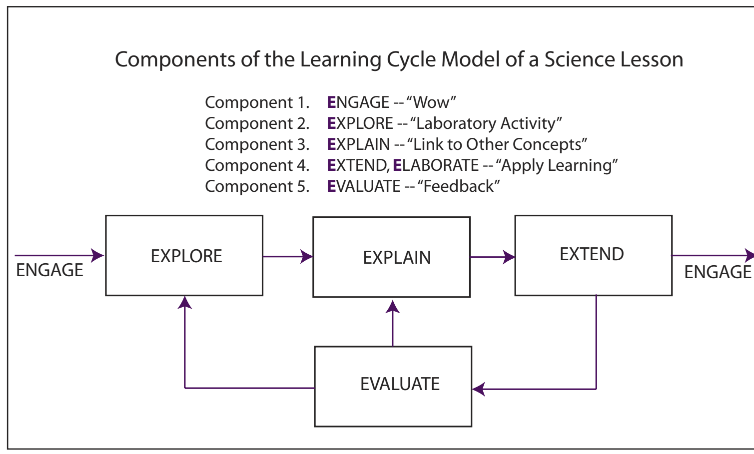

Fig. 1. Learning Cycle Model of a Science Lesson.

One model of science learning is called the "The Learning Cycle" or alternatively "The Five E's" model. Robert Karplus wrote the first reference to this as part of the Science Curriculum Improvement Study (SCIS) in the 1960s.

As scientists and science teachers, we often deal with models of physical systems. We understand that each model has strengths and weaknesses, and may change over time. We would like you to think of the following model of a science lesson in the same open way you might think of the Ideal Gas Law. Thus, we present this model realizing that it is neither perfect nor static.

1. ENGAGE is the component during which the teacher gets the attention and interest of the students. Often this can be done with a demonstration of a discrepant event. For example, fill a few identical glass bottles with varying amounts of water and label them A, B, C, D, etc. with the amount of water in the bottles increasing.

If you blow across the mouth of the bottles from A to B and so on, the pitch gets higher. If you hit the bottles in the same order, the pitch gets lower. For many, this is counter-intuitive and thus a discrepant event. The goal of the demonstration is not to explain; rather it is to engage the students' interest.

2. EXPLORE is the second component and is often a laboratory activity performed by a team of students. For example, measure the depth of the water and the pitch electronically and look for a mathematical relationship. The teacher acts as a guide but permits students to explore and find answers to questions that have been raised. To accomplish this, the teacher often selects among three strategies:

A. answering the student's question,
B. pointing the student in a particular direction, or
C. asking the right question(s) to help the student decide how to proceed.

As young teachers, we delighted in providing the answer. It was years before we realized that this was great for our ego but often clipped the learning wing of our students. Eventually we were able to support our ego just as well by realizing we were better teachers when we encouraged the students to seek their own answers.

Elsewhere we have listed characteristics of a laboratory activity.[1]

DOI: 10.1119/1.2336154

3. EXPLAIN is the component during which the teacher leads the students toward connecting the results of the activity and/or topic to other topics already understood (i.e., making sense of the activity). Here the lecture/discussion format plays a role in order to take advantage of the teacher's knowledge and experience. This is the time when teachers share their insights with the students by asking probing questions that allow students to move toward personal understanding and scientifically accepted explanations. In the quest for "hands-on" science, it is a temptation to omit this component, but science lessons must also be "minds-on."

Here is a delightful 128-year-old quote from DeGraff's *School-Room Guide*:[2]

> Definitions should be very sparingly introduced, and never in the first stages of a subject. If given at all, they should sum up knowledge already attained. . . . In every stage of the lessons, with the exception of a few indispensable definitions, the language used by the pupil should be entirely his own, and all set forms of words should be carefully avoided.

The emphasis here is to let the definitions and other concepts arise out of the experience rather than from textbook or lecture. Although everything cannot be learned in this manner, a science lesson is an excellent vehicle for students to gain experience at constructing their own understanding. Such efforts also help students evaluate what they learn from indirect experiences such as reading.

Our interpretation of "set forms of words" is standard or book definitions as opposed to definitions fabricated by the students.

4. EXTEND is the component during which students find applications of the knowledge gained. During this component students could invent a musical instrument, devise a method of predicting the amount of water in a glass container by measuring the pitch, or derive a mathematical relationship between variables. We developed the concept of the "*Extra*" for many of the laboratory activities we do (see Ref. 1). The expectation is that the students develop the question, the experimental procedure, and find the answer. To be sure, we often have to make suggestions to some students. When students visit us after graduation, this was an aspect of the course that seems to be important and memorable for them.

5. EVALUATE is not only an ongoing component of the lesson but also an important component during which the student reflects upon the topic at the end of a cycle. As young teachers, we thought of evaluation only as an end-of-unit pencil-and-paper test. It was a long time before we realized that assessment should be ongoing and involves many aspects (e.g., homework assignments, in-class assignments, in class discussions, model development, oral laboratory reports, pencil & paper, poster presentations, projects, public presentations, written laboratory reports, etc.). We now understand that evaluation involves continuous feedback loops.

In the best scenario, the evaluation component of one cycle will lead to a new topic and a new ENGAGE, thus the phrase "Learning Cycle" (see Fig. 1).

Clearly, this model is not appropriate for every science lesson, and every lesson does not have all five components. Often one or more of the components is missing; nevertheless, this model does give reasonable, realistic, and usually reachable characteristics of a science lesson, and it is a useful model for teachers to consider.

Regardless of the age of the students, the ENGAGE component provides motivation. An interesting and engaging start for the lesson helps to keep the students moving forward through the remaining components. In a sense, the ENGAGE component provides the inertia to keep going.

For students in grades K-5 (and perhaps grades 6-8) it may be appropriate to simplify the EXPLAIN component. This component requires connecting the present lesson's concepts to previous lessons and/or concepts held by the student. However, younger students many not have the experiences or maturity to deal with a thorough EXPLAIN component in an abstract way. Simple, concrete, but **not incorrect,** explanations of empirical rules may be enough at an early age.

On the other hand, for graduate students, the ENGAGE component may be self-imposed as they set themselves on a path of study based on interest and a future goal. For these students the EXPLAIN and EXTEND components become paramount. They have learned a great deal and connecting and extending concepts together is of primary importance.

Although EVALUATION is listed as the final component, it should be blended into all the other components. Thus, it is shown as underlying the entire model in Fig. 1. EVALUATION should be thought of as an all-pervasive and constant process.

1. J&J Nelson, *Role of the Laboratory in Introductory Physics* (American Association of Physics Teachers, 1995).
2. Esmond DeGraff, *School-Room Guide* (Davis, Bardeen & Co., Syracuse, NY, 1878), p. 324.