Teaching a Biology Concept Using the Learning Cycle Approach

Jean McGregor Cate
Eileen Bross Grzybowski

Jean McGregor Cate is director of Curriculum Development: Computer Literacy, Business Education and Drug Education for the Norman Public Schools, Norman, OK 73069. She earned a B.S. in Zoology, an M.S. in Science Education and administrative certification from the Univ. of Oklahoma, Norman. Cate was a biology teacher for five years, and has taught a variety of science courses in grades 6-12. She also has served as codirector of curriculum development writing projects in biology and middle school science. **Eileen Bross Grzybowski** has taught biology, physiology-anatomy and chemistry at Normal High School, Norman, OK 73069 for 11 years. She obtained her B.S. in Biology at St. Bonaventure Univ., NY, and her M.S. in Botany at Ohio Univ., Athens. A current doctoral candidate in science education at the Univ. of Oklahoma, Norman, Grzybowski's dissertation research is a qualitative study of concrete and formal science teaching in secondary biology and chemistry classrooms. Other current projects involve biology curriculum development and the relationship between intellectual development and middle school science concept understandings. Recently she was awarded the Outstanding Research Presentation, Univ. of Oklahoma Graduate College and the Outstanding Student Research Award.

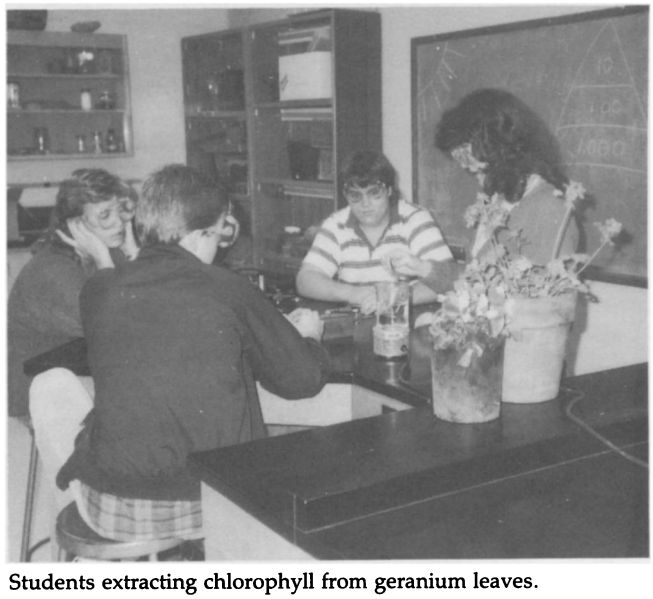
At first glance, a Norman, Oklahoma high school biology class may not appear different from a class anywhere else. However, a closer examination would reveal an application of Jean Piaget's developmental learning model (Piaget 1963).

Our students study the role of plants in the food chain by growing two sets of plants: bean plants from seeds and *Coleus* plants from cuttings. The leaves of the young bean plant are covered with strips of aluminum foil. After several days, the students extract the chlorophyll from the leaves and perform starch tests. Data from this controlled experiment are recorded on a table similar to Table 1. Using the same experimental technique, the students extract the chlorophyll from variegated *Coleus* leaves. Again, the students record the data from this controlled experiment on a table similar to Table 1.

Throughout these experiments, the teacher provides guidelines for using the equipment, interacts with the students and listens as the students discuss the experiment. The teacher might ask the following questions:

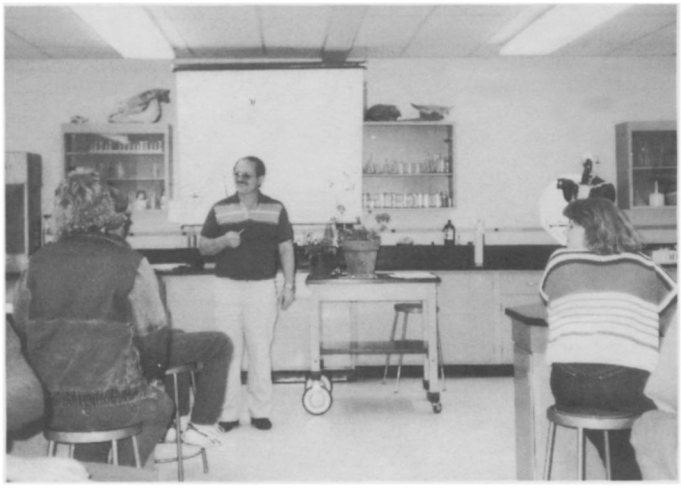
- What differences do you observe in the leaf before and after boiling?
- What differences do you observe in the leaf before and after the starch test?
- In which portion of the leaf do you get a positive starch test?

As the students complete the controlled experiments with the bean and *Coleus*, these data are posted on a class data chart similar to Table 2. The chart is displayed on an overhead projector or reproduced on the chalkboard. At this point, the students begin to question the meanings of the experimental results. During a class discussion, the teacher directs the students' attention to their data. The summary of the class data is examined as the teacher asks questions similar to the following:



Students extracting chlorophyll from geranium leaves.

- What experiment did you perform?
- How did you test for starch?
- What observations did you make?
- Which portion of the leaf (bean or *Coleus*) contained starch?
- What conclusions can you draw from the results of the starch test on the bean leaf?
- What conclusions can you draw from the starch test on the *Coleus* leaf?
- What similarities do you observe between the areas which gave a positive starch test and the original leaf?



The teacher leads the class in the conceptual invention discussion.

Students performing starch tests on different food samples.

What do these experiments indicate about the presence of starch in the leaf?
What things have you observed that are needed by plants to produce starch?
What idea do the data allow you to state about the production of starch in plants?

The students observe that starch is indicated only in the area of the bean leaf exposed to the light and in the green portion of the variegated *Coleus* leaf. Throughout the class discussion the teacher uses student responses to develop the concept. The teacher helps the students organize the data in such a way as to guide the students in the construction of the concept: Green plants use light to make their own food and are known as producers. The language is added to the concept, that is, the name photosynthesis is given to the process of starch production in green plants. The students next test a variety of animal and plant food samples for the presence or absence of starch. Again the class results are displayed on a class data chart similar to Table 3. From a discussion of these data, the teacher guides the students to include common plant foods as a source of starch, an expansion of the concept. The teacher then leads the class discussion by continuing to use the language of the concept. Questions that you might hear the teacher asking are:

What experiments did you perform?
What observations do you make?
Which substances tested contained starch?
Which substances tested do not contain starch?
How would you classify the food samples from the organisms that contain starch?
How would you classify the food samples from the organisms that do not contain starch?
How does the role of plants differ from the role of animals?
What do these data suggest to you about starch production in organisms?

Table 1. Report Form for Exploration Activities

	Before Boiling	*After Boiling*	*After Lugol's*
Leaf Drawing and Color of Leaf			

At this time, a reading is presented that applies the role of green plants to an imaginary environmental situation.

The teaching of this concept reflects Jean Piaget's model of mental functioning (Piaget 1963). Piaget proposed that learning occurs through experience with the materials and data of a concept, that is, during assimilation. From these experiences, a state of disequilibrium occurs until the new experiences are processed and put in accord with previous experiences during the phases of accommodation and organization. This model of teaching is known as the learning cycle (Atkin & Karplus 1962; Karplus & Their 1967) and is a three phase teaching approach:

Figure 1: The Relationship Between the Developmental Learning Model of Jean Piaget and the Learning Cycle Model

Piaget's Learning Model	Assimilation	Accommodation	Organization
Learning Cycle	Exploration	Conceptual Invention	Expansion of the Concept
Producers	Controlled experiments on leaves	Green plants that produce their own food are known as producers	Starch tests on a variety of foods/ Reading

Table 2. Data Summary Form for Conceptual Invention Discussion

Plants Placed in the Light:

	Group	*Covered Area*	*Uncovered Area*	*Green Area*	*Non-Green Area*
Starch was Present in the leaf (Check, if yes)					

In cooperation with the University of Oklahoma Science Education Center, the biology teachers of the Norman Public Schools have written a full year high school biology program based upon the learning theories of Jean Piaget. Our rationale incorporates the intellectual development level of the learner and the concepts and activities that we believe are most appropriate for the students at this level. Consider the concept of the foregoing learning cycle. We feel that this learning cycle reflects the intellectual level of the typical tenth grade biology student. Research (Lawson & Renner 1975; Purser & Renner 1983; Schneider & Renner 1980) shows that the majority of high school biology students operate on the concrete reasoning level (Inhelder & Piaget 1958). These students require first-hand experience with real objects, events or happenings. In each investigation, we attempt to match the science process skills required of the student with the curriculum analysis taxonomies found in *Towards a Science of Science Teaching* (Shayer & Adey 1981). For these reasons, the chemical equation for the reaction of photosynthesis, and its light and dark phases are omitted. Our experiences have shown that the concrete operational students cannot construct their own knowledge of the aforementioned chemical equations because they cannot manipulate these late formal operational concepts.

The Piagetian learning models have been incorporated in the chemistry and physics programs at Norman High School, and these programs have experienced a 100 percent and a 150 percent increase, respectively, in enrollment after the incorporation of the learning cycle model of learning and teaching.

If you are interested in our materials please write to: Laboratory Investigations in the Natural Sciences: Biology, Science Education Center, Physical Science Building, Room 323, University of Oklahoma, Norman, OK 73019.

References

Atkin, J.M. & Karplus, R. (1962). Discovery or invention? *Science Teacher, 29,* 45-51.

Table 3. Student Report Form for Expansion Activity

Substance Tested	*Results*	
	Positive	*Negative*
Water		
Starch Solution		
bean		
fish		
chicken		
rock		
carrot		
potato		
cereal grain		

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