Science in the Elementary School: Evaluating Student Progress

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Classroom evaluation, or the act "of finding out how far you have progressed towards where you want to go"[1] has been described by a sage as the "Vietnam of education".[2] While it is unfortunately true that this important responsibility of teachers tends to be inconclusive, the recent emergence of a number of "new" experimental science programs at the elementary level has focused attention on the problem and is currently providing some solutions.

This article will attempt to describe essential steps in the evaluation process and to present examples of evaluation instruments that reflect modern approaches. The writer is concerned here with describing the evaluation of a child's progress with respect to the elementary science program in which he is receiving instruction, *not* with a comparative group evaluation involving other science programs at the same level.

The beginning step in the evaluation of a child's science progress is to list the program objectives. For some programs[3,4] these are given; for others they need to be identified and defined by the teacher— a task for which she may well need help. Because only behavior that is observable can be measured, objectives need to be performance oriented, that is, they must be stated in terms of what the student is expected to "do" when he satisfactorily demonstrates behavior reflecting a specified objective. An attempt must even be made to translate into "action words" such verbs as "understand" and "think". Young[5], for example, has suggested that a demonstration of "understanding" would require the child "to show an *identifiable*, perhaps explicit, intellectual contribution of his own to the subject matter in which he is to demonstrate understanding."

The second step is to devise instruments for assessing progress towards the achievement of the stated objectives. Of the four elementary science programs referred to in this article, only two (6, 7) incorporate this capability.

For the others, and for most "hard-cover" textbook series, the teacher must construct her own evaluation devices. Karplus and Thier[8] point out that complex and varied objectives require more than paper-pencil tests and that much ingenuity must be employed to develop instruments "that will provide valid and reliable evidence of the achievement of *all* objectives". Not only cognitive, but affective behavior as well must be measured with devices which are "practical to use in the classroom setting."

The modern trend is to report progress on the stated objectives over a period of time (say, one year), in order to emphasize the child's longitudinal growth. This contrasts with the traditional method of reporting performance on a scale in relationship to a peer group. In other words, "the emphasis is on the learning activities of individual pupils"[9]. "Normative" or group data are not unimportant; they are merely subordinate to individual data. Such individual, longitudinal evaluation provides most useful information both to the teacher and to the child.

Instead of having the children answer abstract questions about science, their behavior, indicative of growth in abilities and attitudes, can be observed directly by an alert classroom teacher during a normal class session. According to Thier[10], "Such observing

FIGURE 1.—SECTION A

1. Can assemble a bulb, battery, and wire in several different ways in order to light the bulb.
2. Can generalize those features of circuits in which the bulb lights.
3. Can construct and demonstrate the use of a simple electrical circuit tester.
4. Can group a variety of solids and liquids into (a) conductors, (b) non-conductors, of electricity using a simple circuit tester.
5. Can assemble a circuit from:
   (a) a pictorial representation
   (b) a symbolic representation
   of that circuit.
6. Can predict whether a bulb in a given circuit (pictorial or symbolic) will light.
7. Can convert pictorial circuits into those using electrical symbols.
8. a. Can make observations on hidden wiring patterns using a circuit tester.
   b. Can use these observations to make inferences about the hidden wiring.
   c. Can draw several possible equally valid inferred wiring patterns to demonstrate an understanding of the fact that the inferred wiring pattern may, or may not, be the actual wiring pattern.
9. Can make generalizations about the effect of placing certain wires in an electrical circuit.
10. Can predict the effect of introducing an additional wire into a circuit.
11. Has constructed an original or improved design of simple electrical circuit equipment (e.g. a new bulb holder) for use in this course.
12. Can demonstrate the meaning of the terms:
    (a) short circuit
    (b) complete circuit
    (c) open circuit

FIGURE 1.—SECTION B

1. Bring questions and/or activities to class.
2. Can work in a group.
3. Can work independently
4. Persists with an area of interest.
5. Can say "I don't know"
6. Displays initiative
7. Displays skill
8. Asks for help when needed.
9. Refuses help when appropriate
10. Asks relevant questions.
11. Suggests a way of solving a problem
12. Challenges ideas, that is, is skeptical.
13. Contributes a fact.
14. Contributes an explanation
15. Works steadily
16. Gets excited about science

and listening which takes place primarily when the children are actively involved working with materials, should be thought of as an integral part of the evaluation..... endeavor. It is through such activity on your part that you can obtain information as to what the children do and do not understand about the materials being studied. Such evidence should be one of the major factors determining your instructional planning within the context of the adopted science program." An evaluation, to be meaningful, must be based on *consistent* behavior, several instances of each behavior are needed in order to demonstrate a trend.

A format, tapping both cognitive and affective behaviors, and designed for the ESS unit Batteries and Bulbs (11), is shown in Figure 1.

Both evaluation blanks described to date are completed by the teacher. An alternative approach for upper elementary grades is to ask the child to evaluate himself. One possible Self-Evaluation Inventory is to list all program objectives, and to provide for each a numerical scale 1 through 9. The child is asked to rate his present mastery of an objective by circling the appropriate numeral. If the self-ratings are consistently low, the child may feel compelled to remedy the situation. A second advantage of this procedure is that, because the child has diagnosed himself, any interview with the parents will tend to prove more effective.

An extension and refinement of this idea of self-evaluation has been developed at the University of Hawaii Laboratory School where the principal contributor has been Dr. Edna Demanche[12]. Although designed for Junior High School level, the idea is just as useful for upper elementary grades. The instrument consists of:

1. A Student Progress Record which lists the skills and concepts for the year and which, upon completion, becomes the official school and parental record. For each skill, achievement levels 1, 2, or 3 are entered by the child, and increasing competence should be shown in successive quarters.
2. A Class Progress Record which lists names, and level of achievement for each skill in a limited section of the year's work. This record is open for inspection and can be posted on the class bulletin board for the purpose of encouraging successful students to help the less-successful.

This instrument is intended to emphasize:

FIGURE 2.—STUDENT PROGRESS RECORD

Levels of Achievement:

Column left blank. Skill or concept not yet introduced.
Level 1. Starting.
Level 2. Usually Successful.
Level 3. Proficient.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
SKILLS FOR PHYSICAL SCIENCE AND ECOLOGY				
1. Can estimate distance, volume and mass in metric units				
2. Can measure distance accurately using appropriate metric units				
3. Can measure volume accurately using appropriate metric units				
4. Can measure mass accurately using appropriate metric units				
5. Can measure temperature accurately using appropriate units				
6. Takes care of laboratory equipment (balances, glassware, etc.)				
7. Has facility in laboratory procedures (Following flow diagrams, handling equipment, glassware, etc.)				
8. Makes pertinent observations in laboratory and field work				
9. Can identify, organize, and record data				
10. Can interpret and utilize data				
11. Can make appropriate graphs				
12. Can read and interpret graphs				
13. Can make clear and concise reports of laboratory investigations				
14. Participates in scientific discussion				
15. Can organize and write a concise scientific journal report				
16. Has carried out an individual student science project				
17.				
18.				
19.				
20.				
PHYSICAL SCIENCE PROGRESS RECORD				
1. Can identify elements necessary to explain buoyancy				
2. Can determine density from mass and volume measurements				
3. Can relate density changes to thermal expansion				
4. Can generalize about compressibility and attenuation				
5. Can determine and relate pressure to density and buoyancy				
6. Can relate temperature changes to state changes of matter				
7. Can identify pure substances and mixtures by physical properties				
8. Can generalize about temperature and heat				
9. Can predict and interpret thermal phenomena with a model of heat				
10. Can analyze and synthesize chemical compounds				
11. Can identify elements by chemical and physical properties				
12. Can identify gases				
13. Can generalize about atomic structure				
14. Can explain heat phenomena in terms of molecular motion				
15.				
16.				
17.				

FIGURE 2.—STUDENT PROGRESS RECORD

ECOLOGY PROGRESS RECORD

Levels of Achievement:

Column left blank. Unit is not yet initiated.

Level 0. Unit has been initiated but evaluation is not yet possible.

Level 1. The student has carried through the basic instructions given in the notebook.

Level 2. The student has worked through the unit skillfully with little or no assistance.

Level 3. The student has invented and reported on additional significant tests or techniques in the unit.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Has scarified and germinated seeds and graphed results				
2. Has reported on growth of a weed from seed to maturity				
3. Has shared in mapping the school science plot				
4. Has carried through a field trip assignment				
5. Has investigated local rainfall patterns				
6. Has investigated absorption and percolation phenomena				
7. Has investigated runoff				
8. Has investigated evaporation rates				
9. Has investigated transpiration				
10. Has made observations on humidity				
11. Has engaged in some air pollution studies				
12.				
13.				
14.				

a. Achievement rather than failure. Every child learns something, i.e., the Progress Record is not punitive.

b. Where the child has been rather than where he is heading.

c. A lack of concern with performance in a competitive sense.

Furthermore, the entries on the Progress Record Sheets are not translatable into letter grades.

The last evaluational procedure to be described, and probably the most productive, is the Piaget-type interview in which children are questioned individually. A child, confronted with an appropriate experiment, can be asked to observe, describe, and explain what is happening. He can be asked to make predictions, to hypothesize, to design experiments, to manipulate variables, and to make inferences; also he can be asked to comment on a set of obtained data. Such a procedure provides valuable information on what the child knows and, more importantly, on what he does not know, including his misconceptions. This time-consuming method requires careful planning, and some experience with the procedure on the part of the teacher, but much of the information that it provides is available in no other way.

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