Teacher Behaviors and Student Inquiry in Biology

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Much emphasis has recently been placed on inquiry as an outcome of instruction in biology. Problem-solving, the nature of science, and processes of science are also given frequently as desirable outcomes. Schwab (1963, p. 40) says the essence of teaching science as inquiry is to show conclusions in the framework of the way they arise and are tested. Anderson (1968), in a discussion of teaching the nature of science, also emphasizes the aims and methods employed by the scientist. Gagne (1963, p. 145) makes this statement about various authors writing about inquiry: "I judge them to mean, that what it *is* is a set of activities characterized by a problem-solving approach, in which each newly encountered phenomenon becomes a challenge for thinking." It would appear that, however it is being phrased, inquiry is being seen as a desirable outcome of science instruction because of the productive mental processes and favorable affective conditions involved. Some would say also that this concern is justified because of the potential of scientific thinking in arriving at decisions in various nonscience areas of life.

Many classroom techniques have been devised to promote inquiry learning. Laboratory experiments, "lab blocks," "invitations to inquiry," and the "case study" approach are a few examples. Often these approaches are quite structured: problems are stated, sequence is prescribed, and numerous and detailed questions are asked. Laboratory experiments used by BSCS, for example, give considerable information about the topic and frequently prescribe quite specifically the design of the experiment and the format of the data. Unstructured activities, on the other hand, are generally seen as those in which the teacher presents the problem and aids the student in the design and execution of an experiment by means of questions that are spaced and sequenced according to student needs. Schwab (1966, p. 55) has described three levels of openness and permissiveness in laboratory inquiry based on whether problems and methods for finding answers are given or left open.

In the remainder of this paper, attention is given to the role of teacher behaviors in promoting student inquiry. The two major aspects discussed concern the *degree* of attention given to inquiry and the *nature* of that attention.

Teacher Behaviors

Inquiry requires an initial incompleteness of knowledge and the mental participation of the individual learner. Since the teacher generally determines content and student participation in activities, the effectiveness and, indeed, the very nature of the learning experience must be dependent on the decisions and behaviors of the teacher. For example, the teacher may provide learning experiences about an event through verbal symbols or he may provide for direct experiences. The nature of the student experiences in the two cases is likely to differ greatly.

Evans (1968; 1969) and Balzer (1968; 1969) categorized virtually all of the verbal and nonverbal behaviors, on the part of biology teachers, that influenced the teaching-learning situation in 40 class periods. All types of classroom activities, including laboratory sessions, were incorporated as encountered, with the exception of long examinations and films. BSCS teachers and non-BSCS teachers were equally represented. Of all the teacher behaviors encoded, 47.08% were teacher-centered content development and 2.78% were student-centered content development, for a total of 49.86% pertaining to the development of content. The other 50.14% of the teacher behaviors did not pertain to content development or inquiry, and need not concern us here. Of the 49.86% pertaining to development of content, 12.48% (or 6.16% of the total) were scientific-process behaviors. This 12.48% was made up of a total of 738 scientific-process behaviors, where each behavior represented a 10-second interval of time. Of the 738 scientific-process behaviors, 21 were student-centered. Thus, the teachers spent an average of about 5 seconds per class period on student-centered scientific-process behaviors.

A major proportion of the 738 scientific process behaviors pertained to data interpretation, prediction of results, formation of conclusions, and specific questions that posed problems. Also present, though much less prominent, were questions on experimental design. Behaviors requiring student identification of problems and formulations of hypotheses were virtually nonexistent.

Observations of teachers, student teachers, and students enrolled in biological-education courses, as well as my personal experience in teaching for inquiry, seem also to warrant the following comments:

1. When presenting a structured inquiry activity there is a tendency to present such a detailed sequence of questions that student attention is directed to guessing and fumbling for the sought-after answer, thus actually diverting student attention away from inquiry into the nature of the event under consideration. These questions are often "what do you think" questions that actually require prior knowledge of the answer for an "acceptable" response. When used in this way, such questions cannot be expected to promote inquiry into anything except the teacher's expectations.

2. Even when presenting an unstructured inquiry activity, teachers tend to present substantial background information and a statement of the problem, thus denying the student the opportunity to observe natural phenomena critically, detect conflicts in evidence, and formulate problems and hypotheses.

Discussion

The data and observations presented above suggest that the teacher may often be functioning as a distractor from student inquiry. It is clear that comparatively little time is spent by some teachers on the processes involved in inquiry. Even when attention is given, student participation is often severely limited by the continued central role of the teacher. And the teacher may place a severe restriction on processes in which the student is allowed to participate.

One contributing factor may be that some biology teachers are still reluctant to accept inquiry as a major goal in teaching. Also, there may be a low level of understanding of what inquiry means. A third factor may be the problem of not knowing just how to transfer initiative to the students—even though, given the individual nature of inquiry, it is essential to do so. Specific nonverbal and verbal behaviors of the teacher would appear to lie at the core of the solution to this problem. A fourth factor may be that the teacher does not know how to introduce natural phenomena and objects for study in a way that provides direction without unnecessary structure and limitation of student behavior.

Although adequate solutions do not appear to be available at the present time, some suggestions can be made. Perhaps research will provide more adequate and authoritative guidelines.

Introduction of the Activity

1. It is not always necessary or even desirable to provide a verbal orientation to the activity. This tends to *present* the problem and thus to decrease the need to observe phenomena or objects critically.

2. In some activities (such as field trips) it is possible to have students take the initiative in selecting phenomena and identifying problems for inquiry. An alternative method is for the teacher to call attention to a phenomenon or object (on a field trip, as a demonstration, or as something set up by students) and ask students to record anything observed that they do not understand. Suchman (1966, p. 16) suggests student observation of "discrepant" events. Such techniques promote focusing of inquiry without verbal presentation of a problem.

3. Student attention should be continuously focused on the phenomenon or object being studied, *not* on the teacher. This means that the teacher must use a minimum of nonessential verbal behavior; otherwise he will divert attention to himself. Second, the nonverbal behaviors of the teacher are now extremely important. The teacher's attention must be focused on the phenomenon or object being studied, thus continuously directing student attention away from himself. In other words, the teacher should stand back (physically) and observe with the students.

4. Inquiry is now student-centered. To keep it that way, the teacher must resist the temptation to take charge again. Students are likely to be surprised at individual responsibility for critical observation and problem-formulation. The teacher's refusal to give a verbal answer or prolific hints on "what he wants" is essential. More appropriate are silence and continued attention to the object or phenomenon under consideration.

Teacher Influence during the Activity

1. If a discussion in which students compile observations is planned, some leadership by the teacher may be essential. For example, once problems have been identified the teacher may find it necessary to limit discussion to one problem at a time. Attempts to involve students in mental processes

basic to inquiry need not lead to classroom chaos. Schwab (1966, pp. 65-72) has described the roles of discussion in promoting inquiry in considerable detail.

2. As questions and problems arise the teacher must use care in the release of information. At some points, voicing of a fact known by the teacher may permit the class to proceed to further questions and the design of experiments; in other cases, release of information may resolve the matter and make continued inquiry impossible. The teacher's awareness of the consequences of such specific behaviors appears to be essential to effective inquiry teaching. It may be that the judgments and behaviors called for here are similar to Suchman's request (1966, p. 21) for use of the "teachable moment."

3. If inquiry is being honored, the teacher must insure that his behaviors are consistent with this aim. All relevant observations and questions should be honored and data should be accepted. Nonverbal implications (such as grimacing) and the verbal insistence that certain problems or data are the "wrong" ones are clearly inconsistent with the objective of open inquiry. Restricting attention to a certain problem after various items have been suggested is better accomplished by discussion and explanation than by arbitrary rejection of the direction of inquiry by certain students.

Summary

Although many factors are operative in the promotion of inquiry, the essential and pivotal role of specific teacher behaviors in facilitating inquiry is clear. The teacher can prevent inquiry by failing to give opportunities for inquiry or by providing information prematurely. He can decrease the involvement and enthusiasm of students by positioning himself as the center of attention, thus diverting attention away from the events under consideration. He can convert the curiosity associated with independent inquiry into attempts to meet the specific expectations of the teacher. He may unknowingly force students to function at an artificially abstract level in a teacher-centered "inquiry" discussion when *direct* experience with the event or object is available within the immediate learning situation.

It is hoped that the suggestions contained herein will help teachers interested in teaching for inquiry to avoid such pitfalls as these. Very often, success or failure may be determined by the specific nonverbal and verbal behaviors of the teacher.

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COMPUTERIZED LOBSTER

Ever heard of a colony of lobsters living, breeding, dying, and getting caught for the dinner table—all within the confines of an electronic computer? It is happening in the coastal town of Kingston, R.I.—by simulation with an IBM System/360. The project, conducted by the University of Rhode Island, is testing the effects of man's and nature's laws on a typical lobster population and is turning up clues to the crustaceans' habits, instincts, and behavior patterns. It has shown, for example, that laws protecting large lobsters actually reduce the total catch without effectively increasing the lobster population. Laws protecting egg-bearing females, however, substantially increase the birthrate of a lobster colony. Other studies performed through the use of the computer have revealed that lobsters are not wanderers, although egg-bearing females can be moved to other areas in order to start new colonies.

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