School Science in an Age of Science

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A major study sponsored by the National Science Foundation says most science education is characterized by traditional teaching of the contents of textbooks.

During the post-Sputnik years, the 1960s, public attention was focused on advancements in space science and on the whole of science education. Teachers, school leaders, learning theorists, philosophers, and most important, practicing scientists took a look at how young people were learning about science. Becoming involved in everything from curriculum development to teacher training, they set new directions and established many firsts. Now, more than a decade later, the National Science Foundation studies[1] have produced new information about science education.

Curriculum. The stated goals of the science program include understanding self, appreciating technology, preparing for college, advancing today's culture, and understanding local issues. There is little evidence, however, that the big ideas or stated goals of science education are ever translated into curriculum and classroom practice (Denny, p. 90).

Although the goals for science in the elementary school tend to be stable, it is apparent that the goals for secondary science are in a period of significant transition (Helgeson, p. 190). This has resulted in new offerings that emphasize environmental concerns, societal issues, world problems, decision making, and interdisciplinary efforts (Helgeson, p. 21). Identifying, verbalizing, and advancing such new goals is easier than implementing them in science classrooms.

Science in the school program can be characterized by one word—textbooks (Denny, p. 42). The science curriculum exists as the facts and concepts that are traditionally packaged in textbooks. The textbook not only determines the content, but the order, the examples, and the application of that content (Stake, p. 13-5). The influence of teachers occurs in the choice of a textbook—apparently the most important decision in establishing the curriculum or curriculum component identified by a given course (Stake, p. 19-2). Teachers appear to have "faith" in the textbook; they lament "if only the right one could be found" (Stake, p. 13-2). The science

[1] For more information about the studies, see: Ron Brandt and others. "Thanks, We Needed That." *Educational Leadership* 36(5):354-55; February 1979.

* The material in this report is based upon work supported by the National Science Foundation under Purchase Order No. 78-SP-1131. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation.

curriculum, then, is a set of knowledges and skills rooted in the various disciplines of science and packaged in textbooks (Stake, p. 19-4).

Little real curriculum planning or school articulation of science materials has occurred (Helgeson, p. 190). The textbook determines the science curriculum, and a limited number of titles are widely used. For example, 40 percent of all schools use Holt's *Modern Biology*, with another 40 percent using the BSCS Green and Yellow Versions in about equal numbers (Helgeson, p. 26). This probably means that the biology program in 80 percent of the classrooms is drawn from these three textbooks. Approximately 50 percent of all schools use Holt's *Modern Chemistry* and 40 percent use Holt's *Modern Physics* (Sanders, p. 27). More than half of the teachers and classes in secondary science use one basic textbook (Weiss, p. 89). Eighty percent of the primary and 90 percent of the intermediate grade teachers base their instruction in science upon a single textbook (Helgeson, p. 17).

Interaction with teachers suggests that reliance upon guides and books and the emphasis upon "given" science content is a way of avoiding the untidy reality of science (Hill-Burnett, p. 26). Following the book is safe and comfortable—but it prevents dealing with the stated and verbalized "bigger" objectives. Science instruction focuses on content because it is there. There is often the feeling that the content (that is, the textbook) *might* be needed someday. There is rarely a teacher reference to consumer needs or current student needs (Hoke, p. 25). There is little enthusiasm for emphasizing science as inquiry or considering inquiry skills as a form of content (Denny, p. 42).

After expenditures in excess of $100 million on science curriculum materials following Sputnik, it is appropriate to question the impact of the NSF-supported national programs. About a third of the schools use or have used one of the several NSF programs for the elementary schools (Helgeson, p. 16). About the same fraction of students experienced the CHEM chemistry and PSSC physics courses while over 40 percent experienced one of the basic biology versions (Helgeson, pp. 26 and 28). Teachers who tried one or more of the new (NSF) curricula seem to be returning to the old courses and text series (Stake, p. 15-5).

The newer national programs were increasing in use until 1970; since then adoptions and student use of the materials have declined. Stated reasons for the decline include: (a) no room for teacher and student spontaneity; (b) overemphasis on pure content; and (c) material too difficult (abstract) for most students (Helgeson, p. 181). All of these courses could be characterized as being organized around the structure of the discipline(s) of science. The programs deemphasized "practical science" and emphasized basic concepts and processes (Helgeson, p. 21).

Instructional Strategies. Classical didactic teaching seems to characterize most classrooms.

Since 1955 there have appeared more and more materials calling for student-centered and hands-on instruction. Even when these materials are in use in a given school, however, it is rare for large numbers of students to be involved with them (Helgeson, p. 190). Less than half of the teachers report use of any inquiry approaches (Weiss, p. 148). This raises many interesting questions regarding the effectiveness of the national programs of the 1960s—all of which approached science as inquiry and called for it being taught as a "narrative of inquiry."

Although attention to individual differences is frequently the subject of discussion, there is little evidence that it is receiving attention in the form of classroom practice. In most instances, science is taught to an entire class with the teacher as the central figure. It is rare to find students engaged in individual activities either in or out of the classroom. The entire class "does" an activity or is involved with the teacher in a discussion. Recent research establishes that certain instructional modes are more effective with certain students (Helgeson, p. 36). However, this finding has resulted in few individualized programs and/or approaches in science. Where such materials are utilized, they appear as supplements to a course and are not central to it (Stake, p. 16-55).

Examples of effective science teaching approaching modern goals in the elementary school are rare. Teaching science in the junior high school is primarily by recitation (Stake, p. 19-6). When laboratories are used, they tend to be demonstrations of information already presented or exercises merely used to break the monotony. Almost all questions arise from information in the textbook, and most center on terminology and definition (Stake, p. 19-6).

More than 80 percent of the science teachers use audiovisual material, with 15 percent of the secondary teachers using both films and filmstrips on an average of once per week (Weiss, p. 112). Where massive use of media was tried, it was found to be unsuccessful (Sanders and Stufflebeam, p. 13). Most audiovisual materials are used to supplement textbooks and add to the information base. Most provide more basic content for the existing course structure. Less than 10 percent of the schools utilize TV or CAI (Weiss, p. 112).

Teachers say that they want advice on pedagogy. They seem openminded when it comes to teaching style (Stake, p. 18-112). They frequently talk of the lack of classtime, less financial support for inservice work, new demands on their nonclasstime, and other barriers to change. What a given teacher believes, knows, and does along with what he/she doesn't believe, know, and do represent what science education will be for a given child (Stake, p. 19-1). Instructional materials and curriculum design are not the critical factors (Stake, p. 15-2).

Teachers express great concern for student attitude. Yet they continue to be imprisoned by the textbook, existing courses, and traditional instructional strategies. Observers speculate that some teachers may be unable to conceptualize both the dynamics of curriculum and of student understanding (Stake, p. 15-2).

Organization/Support. Providing strong science programs in schools is not considered as high a priority as it was ten years ago. Surprisingly, many people do not consider it "basic" at a time of cultural, environmental, and resource crisis. High school science teachers, rather than changing their courses to address the problems of our time, tend instead to lament enrollment decreases and guard their advanced courses tenaciously (Stake, p. 12-1). They talk and use the ditto machine increasingly (Hill-Burnett, p. 23). Many have curriculum outlines, including objectives, articulation plans, and sequence charts. In practice, however, these bear little resemblance to actual content in textbooks or the strategies employed (Stake, p. 19-7).

On the average, state guidelines call for 16 minutes per day of science instruction in kindergarten to 34 minutes per day in grade six (Weiss, p. 22). Teachers report actually spending 17 minutes pe day in K-3 and 28 minutes in grades 4-6 (Weiss, p. 51). Most elementary science is taught in self-contained classrooms with the first departmentalization occurring in grades 6-8 (Helgeson, p. 13). Science classes (segregated by ability) in the junior high pave the way for advanced science sequence at the senior high level (Stake, p. 12-1). Often an accelerated junior high program for the gifted enables the science-prone to complete several advanced courses in the various disciplines in the senior high school.

Total enrollments in science increased until 1973 with a leveling off since then. There has been no sharp decline (Helgeson, p. 190). A full 50 percent of all students never complete another science course beyond grade 10 (Helgeson, p. 191). Therefore, most science in the secondary school is taught in the junior high school, where teachers are least prepared and where the poorest facilities for instruction exist (Helgeson, p. 191).

There is a need for preservice and inservice education to be part of a continuous program (Helgeson, p. 192). Planned inservice programs are infrequent. Sixty-three percent of the districts have no science coordinator (Weiss, p. 36) while 45 percent of the states have no state science education specialist devoting at least 75 percent time to science (Weiss, p. 33). Science specialists (coordinators) are rated generally useful but progressively less so as grade level increases (Weiss, p. 153). Science teachers, however, want more help from consultants (Dawson, p. 18-112) and paraprofessionals (Weiss, p. 136).

Inservice programs are rated higher by elementary teachers than by secondary teachers (Weiss, p. 154). However, only 14 percent of all science teachers indicate they have had enough help with hands-on materials (Weiss, p. 148). As funds have tightened, support staff has decreased, and teachers and students miss it (Hill-Burnett, p. 3). Inservice efforts usually take the form of staff meetings, special inservice days, and enrollment in university courses. A decline in such programs is explained by (a) fewer inexperienced teachers; (b) less incentive for gaining credit and degrees; and (c) fewer dollars for resource persons (Stake, p. 16-48). Teachers continue to be interested in help from universities. They want:

(a) help with curriculum development (43 percent); (b) special inservice workshops made available (16 percent); and (c) courses specifically oriented to teachers' needs (12 percent) (Stake, p. 16-49).

Better articulation of the science program is considered a more serious problem by coordinators than by teachers (Weiss, p. 162). Teachers appear concerned with classroom problems, course issues, and their particular disciplines. These concerns result in little real articulation—either vertically with respect to science or with other disciplines (Stake, p. 19-7). The problems are likely to increase as the role of the science coordinator changes. Such persons are now spending more time interpreting and enforcing new regulations and preparing proposals for increased funding. Less time is thereby available for curriculum matters and for improvement of teaching strategies (Stake, p. 19-26).

Participation in NSF institutes represents a kind of support that was abundant during the 1960s, but nearly disappeared in 1976. Such institutes were generally rated as excellent vehicles for sharing new ideas and for maintaining content currency (Welch, p. 15). Teachers who participated in such programs tend to use more manipulative material than other teachers (Weiss, p. 107). Unfortunately, the majority of science teachers have not participated in NSF and/or OE institutes (Helgeson, p. 191). About 40 percent of the secondary science teachers have attended an NSF institute while 60 percent of the district and state supervisors of science have been involved (Dawson, p. 106 and Weiss, p. 69).

There have been real changes in schools during the past 20 years. These include: (a) appearance of paraprofessionals; (b) new instructional technologies; (c) varying levels of desegregation; (d) increased federal funding accompanied by federal control; (e) larger school districts; (f) more informal instructional arrangements; and (g) unionization of teachers (Stake, p. 17-24). School pressures have changed including greater teacher militancy, greater realization of the difficulties involved with "real" teaching, and disappearance of support systems (Welch, p. 14).

The NSF reports on the status of science education are not surprising to anyone who has studied past and current problems in education. The 1960s were boom years for science. Perhaps we were arrogant; perhaps we were too blind to see the obvious: for all the science learned, the teacher is the "enabler, the inspiration, and the constraint" (Stake, p. 19-1).

The NSF study provides a challenge for educational leaders—for curriculum directors and supervisors, for researchers and philosophers. Self-correction is a basic characteristic of the human endeavor we call science. It is a feature that we could well incorporate into the fabric of science education. It must occur if our "age of science" is not to be our *demise*.

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