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Table of Contents

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Selected Procedures for Improving the Science Curriculum. ERIC/SMEAC Science Education Digest No. 2.

A 1989 ERIC/SMEAC Digest dealt with the impact of educational reform on science education. Its message was that some positive changes had occurred in response to calls for science education reform, but that much work remains to be done. This digest has been prepared to provide some information about activities aimed at improving the science curriculum, a task that is neither easy nor simple.

WHAT ARE SOME CURRENT SCIENCE CURRICULUM EMPHASES?

Currently there are several identifiable emphases within science curriculum materials. One, inquiry teaching, advocated as part of the science curriculum reform movement after Sputnik, is still in use. The rationale for this emphasis is that students will develop better understandings of the nature of science and will be more interested in science if they are involved (actively) in "doing" science. Student investigations are the backbone of the inquiry curriculum, and the focus of student investigations is on the use and development of science inquiry and process skills. Science content and science thinking skills are both important, interrelated parts of science, with content knowledge acquisition secondary to the development of thinking skills. The nature and development of conceptual understanding is less emphasized than process skills development. The assumption appears to be that conceptual understanding is a product of scientific thinking processes.

A second emphasis is that of science, technology, and society. In this emphasis, the purpose of school science is not to create future scientists. It is to create citizens who understand science in ways that will enable them to participate intelligently in critical thinking, problem solving, and decision making about how science and technology are used to change society. The science curriculum is human and society focused, problem centered, and responsive to local issues. Problems to be investigated are selected for their relevance to students' lives and are multidisciplinary in nature. Because the focus is on skill development in problem solving and decision making, it appears that process goals are emphasized over content goals. The role of the science teacher is a complex one. Science teachers have to help their students see how science and technology can both cause problems and help solve problems.

A third emphasis is that of conceptual change. The rationale for this emphasis is that scientific knowledge is meaningful to learners only when it is useful in making sense of the world they encounter. The primary goal of science education is to help students develop meaningful conceptual understandings of science and its ways of describing, predicting, explaining, and controlling natural phenomena. The central goal of science education is to develop scientific literacy for all students. The science curriculum is focused on investigations and activities designed to help students CHANGE their intuitive, everyday ways of explaining the world around them--to incorporate scientific concepts and ways of thinking into their personal frameworks. Instruction is designed to integrate science processes and conceptual knowledge. The science processes are used within a conceptual framework, and the focus is on the power of conceptual understanding. Content is important as it contributes to conceptual understanding. However, the emphasis is on the acquisition of understanding, not on rote memorization, terminology, etc. The conceptual change emphasis has its basis in knowledge resulting from research on how children learn (Roth, 1989: 46-48).

A fourth emphasis that is still developing is thematic science teaching. The concepts that compose the science curriculum are built upon a structure of major ideas that connect the science disciplines. This is illustrated in PROJECT 2061: SCIENCE FOR ALL AMERICANS sponsored by the American Association for the Advancement of Science (AAAS) (1989). Project 2061 is aimed at identifying, developing curriculum models for, and implementing the understandings and habits of mind essential for all citizens in a scientifically literate society. (This project is discussed in more detail in Science Education Digest #3, 1990.) Six themes pervade science, mathematics, and technology and unify the various disciplines (1989: 123-131): systems, models, stability, patterns of change, evolution, and scale.

This thematic approach may be used to provide the unifying strands for the science curriculum to be taught as part of the National Science Teachers Association's (NSTA) project on Scope, Sequence, and Coordination of the Science Curriculum. (See Science Digest #3, 1990.) The NSTA project proposes a major change in the structure of the science curriculum. As is true with Project 2061, the aim of the NSTA project is to educate all students, not just the science-prone. The Scope, Sequence and Coordination project advocates eliminating the current single-year courses in secondary school science and having students study all sciences, taught in some developmentally appropriate fashion, every year in grades 7-12 or 9-12. The Scope, Sequence and Coordination project of NSTA (Aldridge, 1989) is considered as a fifth emphasis.

A sixth emphasis is that of interactive science learning. Rather than using competition in the science classroom, students are encouraged to converse and collaborate about an idea or event. The use of cooperative learning is particularly evident in several of the elementary school science projects (discussed in Science Digest #3, 1990). In some projects, such as the National Geographic Society's Kids Network, grade 4-6 students are involved nationwide in collecting, analyzing, and sharing scientific data through extensive use of telecommunications.

However, the science curriculum does not exist in isolation. It is implemented by teachers who are influenced by the students with whom they work as well as by the materials and facilities with which they work.

HOW DO OTHER, RELATED FACTORS

INFLUENCE THE SCIENCE CURRICULUM?

Teacher Preparation. It does not matter how well designed a science curriculum is if the teacher assigned to teach it is not prepared for the job. A widely-held assumption is that teachers with a lot of subject matter background will do a more effective job than those with less preparation. However, research has not yet documented a strong relationship between teachers' course-taking in science and student achievement (Weiss, 1988:6). Certification requirements vary among the states: 42 states offer a broad-field science certification, with requirements ranging from 18 to 60 credit hours of science. Many science teacher education programs prepare teachers to teach a particular science. However, many schools do not have sufficient enrollment to enable a science teacher to teach only one science discipline. Data from a study conducted by NSTA revealed that most science teachers are assigned to teach courses in at least two, and often three or more, sciences (Weiss, 1988: 11-12).
When a teacher teaches a subject not listed on his/her certificate, this situation is known as teaching-out-of-field. Blank emphasizes that the composition of the state, primarily urban vs. primarily rural, is an important factor to be considered. In Physics, for example, 25 of 27 states surveyed have more high schools than teachers assigned to Physics, and 12 states have less than two-thirds of the high schools with a teacher assigned to Physics (Blank, 1990: 11). Such data certainly have implications for improving the science curriculum.

Teacher supply and demand are also related to teacher preparation. Although some science education reports predict a severe shortage of science teachers, data from a national survey by Weiss do not support this. According to Weiss (1988: 12), the average age of science teachers is about 40, with about 17 percent age 30 and younger and 15 percent age 50 and older. However, Weiss also found that sizable proportions of science teachers had not taken a course for college credit in their subject in the last 10 years (1987: 84). And, Blank reported that the majority of new hires in teaching come from a reserve pool composed of teachers who left teaching and then, later, decided to return as openings increased (1990:3). It would appear that in-service is needed to help science teachers keep up-to-date with developments in the sciences.

Textbooks. Teachers frequently rely on revised editions of science textbooks to identify changes in the content they are teaching. Data from the 1985-86 National Survey of Science and Mathematics Education (Weiss, 1987: 31-32) indicate that, for grades 4 and higher, roughly 90 percent of the science classes at each grade level use published textbooks/programs. Two publishers (Merrill and Holt, Rinehart and Winston) account for more than half of the textbook usage in secondary school science. Also, a sizable proportion of science teachers are using textbooks that are six years old.

Textbooks have been criticized by many science educators as being too encyclopedic, of perpetuating misconceptions, and of not reflecting current knowledge both about science and about how children learn. The one middle school and seven elementary school "triad" partnerships made up of publishers, scientists and science educators, and schools, discussed in Science Digest #3, 1990, reflect current knowledge about how children learn and construct their own knowledge, about the benefits of using science activities that foster cooperative learning, as well as integrating science with other subjects.

WHAT REMAINS TO BE DONE?

To improve the science curriculum, we need to change some of our traditional practices. We need to become more focused on helping students think scientifically rather than memorize facts. We need to take into account the way different ethnic and minority groups learn science. We need to become more sensitive to gender issues so that females are encouraged to continue to study science. We need to involve intervention activities to encourage women and minorities to choose the proper courses in mathematics so they are able to continue to study science in high school and college, and succeed. We need to make different curricular and instructional decisions as we develop courses of study or use instructional materials so that we can have a science curriculum that is for all students.

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