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Developments in Science Education

Several studies are assessing the impact of science upon education.

SOMEONE has said that after the first Sputnik many persons also went into orbit and began "beep-beeping" about science teaching in the schools. There is no doubt that public concern about the improvement of science teaching was stepped up greatly by Sputnik and more recently by the orbiting of Cosmonauts Gagarin and Titov.

But the origin of our present national concern about better science teaching predates the Sputniks by a number of years. The urgency of federal support for scientific research and development was clearly and forcefully reported to the President of the United States in 1945 by Vannevar Bush,[1] who at the time was Director of the Office of Scientific Research and Development. In 1947 a report by John R. Steelman, Chairman of the President's Scientific Research Board,[2] dealt more specifically with such topics as: the crisis of science in the United States; background of the crisis; the need for training more scientists; and science education in schools and colleges. After five years of deliberation over various bills designed to implement the national concern about science, Congress passed the National Science Foundation Bill in 1950. Since that time the Foundation has expended millions of dollars of federal funds to improve science teaching in the schools. This has been done primarily through financial support of institutes for science teachers and of projects to develop new high school science courses.

Concern about scientific manpower in America has been shared by many private and public agencies. Over the past ten years, industry and a number of private foundations have contributed generously to support a variety of projects designed to improve science teaching. For the most part, these projects have been designed to up-date and up-grade teachers in science, to prepare supplementary teaching materials, and to develop student interest in scientific careers.

Across the country, local school and

[1] Vannevar Bush. *Science: The Endless Frontier*. Washington, D.C.: Government Printing Office, 1945.

[2] John R. Steelman. *Manpower for Research*. Volume Four of *Science and Public Policy*. Washington, D.C.: Government Printing Office, 1947.

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state department personnel have been evaluating and revising their courses of study. It would seem that for the first time many schools have become concerned about sequential K-12 science programs, although a developmental sequence in science through the high school and into the colleges has been supported in theory[3] for more than 30 years. To a large extent the lag between theory and practice is accounted for by the three-layered stratification of our schools.

Constructive Efforts

Stratification has brought about administrative specialization in elementary education, secondary education, and higher education. At the teaching level the problem of closing the gap has been complicated further by the tendency for teachers in the upper levels to specialize in one of the sciences, whereas teachers in the elementary and junior high school are expected to be generalists. For these reasons, both administrators and teachers find that effective communication from one level to the other is difficult. As will be pointed out later, some of the recently developed courses in secondary school science are complicating even further the problem of effective communication on the part of those who are responsible for curriculum planning.

Since 1932, several major efforts have been made to redirect and improve science teaching in the secondary schools. These efforts were advanced by a relatively few forward-looking educators in a more passive scientific climate than exists today.[4] Those who are restless for change may be discouraged with the small extent to which former efforts to redirect science teaching have made an impact on practice. However, this would appear to be true. Most of these efforts were based upon the assumption that science teaching should make a difference in the personal-social life of the learner. In practice, this meant that learners should have experiences with the methods of science, and that through these experiences they should become more predisposed to think critically about problems. In addition, the problems should be related to ways in which science is used, or should be used, to improve our personal and social well-being.

Science Projects

At present we are experiencing a good deal of reaction to this point of view by scientists who have recently become concerned about science teaching in the schools. They hold that science courses which emphasize the applications of science to problems of living leave the learner with misconceptions regarding the nature of science. They further contend that such emphasis upon technology results in superficial, descriptive treatments, because of the complex nature of the science involved in technology. They have not only proposed a redirection for science teaching but some groups have become actively involved in the process of bringing this about at the secondary school level.

[3] S. Ralph Powers. "The Plan of the Public Schools and the Program of Science Teaching." *A Program for Teaching Science*, Chapter 1. Thirty-first Yearbook of the National Society for the Study of Education; Part I. Bloomington, Illinois: Public School Publishing Company, 1932.

[4] Samuel R. Powers. "The Work of the Bureau of Educational Research in Science." *School Science and Mathematics* 41:7-9; January 1941.

Wilford M. Aikin. *The Story of the Eight-Year Study*. New York: Harper and Brothers, 1942.

The efforts which have gained greatest attention are those sponsored by the National Science Foundation. The first of these, the Physical Science Study Committee, came into being in 1956 at the Massachusetts Institute of Technology. Its primary purpose was to improve the teaching of physics in secondary schools. Over the past five years those scientists and high school teachers associated with the project have developed an entirely new physics course and prepared such materials as: textbook, laboratory manual, teachers' guide, films and supplementary reading references. Through additional grants from the National Science Foundation, indoctrination institutes for physics teachers have been conducted over the past several years.

Two major projects in secondary school chemistry are currently under way. One project is known as the Chemical Bond Approach; the other as the Chemical Education Materials Study. Both are financed by the National Science Foundation. The objective of each project was to conduct a thorough investigation of secondary school chemistry leading to a newly designed course, rather than patching up present ones. In the first project, the chemistry content is organized around one theme, the "Chemical Bond." In the second project, an effort has been made to identify the "irreducible minimum of basic fundamentals" that can and should be taught as a first course in chemistry. In each of these projects teaching materials, including textbook, laboratory manual, audio-visual aids and teachers' guides are being developed. As in the PSSC project, these materials are prepared cooperatively by scientists and high school teachers. They are tried out in selected schools and revised in light of the tryout experience.

The Biological Science Curriculum Study is also financed by the National Science Foundation. Its purpose is to redesign secondary school biology. The pattern whereby scientists and high school teachers work together also holds for this study. However, the study differs from PSSC in that three different biology courses have been developed. One has ecology as its central theme of organization; another has evolution; and the third emphasizes the biochemical approach. Materials developed by the various scientist-teacher teams are also tested in selected schools. Feed-back from the test schools is used in revising the materials. As is true of the other projects, NSF-financed institutes have been used to indoctrinate selected biology teachers in the new courses.

So far, nothing comparable to these major projects has been undertaken at the elementary and junior high school levels. In part, this reflects the manner in which curriculum study has been stratified in the past. It is also partly accounted for by the fact that the participation of scientists in rethinking science courses in the schools has been restricted to their special fields of competence, physics, chemistry or biology. The general science approach which characterizes the elementary and junior high school has seemed, to such a specialist, to be unmanageable. However, as some of these specialists gain experience in course preparation for the high school, they appear to become less timid about moving into junior high school and elementary school science.

Based upon findings of an investigation which it conducted during 1959-60,[5] the Curriculum Committee of the Na-

[5] Donald G. Decker. "NSTA Committee Report on the K-12 Science Program." *The Science Teacher* 28:15, 17; October 1961.

tional Science Teachers Association has developed a comprehensive plan for a K-12 science curriculum study. One of the basic assumptions underlying the NSTA plan is that any effort to develop a sequential K-12 science should begin at the elementary school level. For this reason, attention in the earlier phases of the study will be focused upon elementary school science. The plan calls for a critical examination of science teaching in the elementary schools as well as the present status of science learning at various grade levels. It proposes an analysis of what is known about the learning process as it relates to science and a synthesis of guidelines for the development of learning materials. The plan reveals a concern about clearer delineation of the process-concept goals of science teaching and suggests that scientist, science educator and teacher work cooperatively to define these goals. Finally, the plan proposes that new teaching materials be prepared, be tested in selected schools, and then be made available as resource materials for local and state curriculum workers. To carry out the elementary science phase of the NSTA plan in ways that will have an impact upon the schools will require funds amounting to about 20 million dollars. This may sound like a great deal of money. However, it is reported that the cost of producing the PSSC physics course was nearly 5 million dollars.

During 1960 the American Association for the Advancement of Science obtained a grant from the National Science Foundation to conduct a series of three conferences of selected teachers and scientists. Object of the meetings was to determine what should be done to improve science instruction in the elementary and junior high school. The conferences reached three rather obvious conclusions: science should be a regular part of the curriculum in the elementary and junior high school; a major effort to improve science teaching in elementary and junior high school should be undertaken; and this effort should be directed toward improving both course materials and teaching. It was proposed that the program for development of course materials should be under the direction of a national advisory or steering committee; also, that there should be three centers in the United States for the development of these materials. There is some indication that the American Association for the Advancement of Science intends to initiate action toward the implementation of the recommendations of its conferees.

It would appear that the strong motivation to re-examine and reorganize science courses on such a large scale at the high school level has come from scientists. Furthermore, suggestions as to how the courses should be organized have also come largely from scientists. But the scientist has not terminated his curriculum services at the stage of helping to decide what should be taught and how it should be organized; he has also considered ways in which it should be taught. The "new" secondary school science courses are largely process oriented within the context of the basic sciences. This is to say that they are to be taught in ways that get the student actively involved in thinking his way to the science concepts. For this reason the courses are designed to cover less ground and provide for experiences that probe more deeply into selected areas of the basic sciences.

The new high school science courses are quite different from the college courses which high school science teachers took as a part of their preservice training. For this reason, most high school science teachers have not been equipped to teach the new courses. They have been retooled primarily through in-service institutes. These institutes have had two major functions: to develop a better understanding of the "new" science; and to develop facility in the techniques of teaching it.

While the scientist had his doubts about the competence of the educator to prepare courses of study in secondary school science, the educator, in turn, had strong misgivings about the dominant role which scientists appear to have assumed in designing new courses. However, in most instances where scientist-educator teams have worked on problems of common interest, such suspicions have been dispelled. A quotation from the final paragraph of the report of the AAAS conferences on elementary and junior high school science, illustrates this adjustment:

> A most encouraging aspect of the three conferences was the ease and satisfaction with which scientists representing all of the major scientific disciplines, and educators representing teacher education, administration, and the classroom, were able to reach agreement about needs for improvement of early science education and ways of bringing about that improvement.[a]

Comments

So far in this paper I have attempted to assume the role of a reporter on recent developments in science education. In conclusion, I feel compelled to make editorial comments.

In our concern about increasing science manpower supply; in our determination to purge science curriculums of technology; in our desire to make science a truly satisfactory intellectual adventure, we, as science educators, must not lose sight of three pertinent facts and implications.

A relatively small proportion of the school population are potential candidates for the science manpower pool, therefore in our zeal to "fire up" the minority we must be careful lest we "burn out" the majority.

The present excitement about space dramatizes the fact that the major impact of science upon our lives today is through technology. In our eagerness to keep science "pure," we must move with caution lest we divorce it from the culture which it is reconstructing.

A satisfactory intellectual experience is one out of which the learner comes to understand at his own experience level. In our passion for intellectualism we must not run the risk of confusing either mere verbalism or "trained performance," with understanding.

[a] "Science Teaching in Elementary and Junior High Schools," *Science* 133:2019-24; January 1941.

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