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## ALTERNATIVES IN SCIENCE EDUCATION<sup>1</sup>

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In the spring of 1972 the theme of the annual convention of the National Science Teachers' Association was *Alternatives in Science or Alternatives to Science*. The topic obviously was chosen for its shock value. Science teachers were being told they must be imaginative and bold in developing more relevant and more attractive science curricula or they would find students increasingly leaving their courses to elect other subjects and society in general turning even more to such alternatives as the occult. The title has haunted me ever since.

At that time, after a period of decline in financial support for research, and while many young people were blaming science and technology for the ills of the world (especially pollution and war's destructiveness), inner city residents were rejecting science and technology for another reason. I have seen a literal turning away from science, elementary school children in the inner city deliberately turning their backs to a television set during the launching of one of the later Apollo missions, refusing to watch. The children were not bored. They were angrily disapproving, reflecting the feeling of many of their elders that the money might better have been spent in another way.

Things have changed, however, in two years, with the official end of the war, the cooling of the campus revolts, and the completion of the Apollo program. A survey of public attitudes toward science and technology, issued in the fall of 1973 by the National Science Board of the NSF reported what *Science News* interpreted as "strong public approval about past achievements in these disciplines and even stronger confidence for the future." Among other questions, the American people were asked in that survey whether they felt science and technology had changed their lives for the better or for the worse. Seventy per cent said for the better, eight per cent worse, eleven per cent said some of both, probably the truest answer, with the remainder seeing no effect or having no opinion. The same study showed that, as professionals, scientists share a prestige second only to that of physicians, with ministers ranking third and engineers fourth.

It seems that the greater disenchantment is now, as it has often been in the past, with education rather than with science. Federal money poured into the schools for a decade while America tried to meet the challenge of Sputnik, and then when we began to concentrate on opportunities for the disadvantaged. The space program was a success, but results in ghetto schools and with the three "R's" everywhere were less dramatic and often discouraging. The schools now stand accused by some of their critics of being repressive institutions which perpetuate the status quo and hold down the children of the poor. Some of these critics would abolish schools as we know them. The term "alternative school" is being applied to projects in which there is an attempt to abandon practically all authority and operate without any prescribed curriculum. This paper, however, is confined to less radical alternatives.

<sup>1</sup>Presidential address delivered at the Eighty-third Annual Meeting of The Ohio Academy of Science at the College of Wooster, Wooster, Ohio, on April 26, 1974.

Let us see what has really happened recently to science in the schools. The curriculum projects of the '60's, while they had some real strengths, generated problems, too. The NSF-sponsored programs, such as PSSC physics, CHEM Study, and BSCS biology, were developed to emphasize the structure of particular disciplines as known to research scientists, and to give insight into the way in which theories are developed in these disciplines. The designers of the programs were concerned with educating future scientists but even more in developing a citizenry which would understand and support the scientific enterprise. The courses and the summer institutes designed to help implement them did result in greatly improved instruction for many students. The courses also "turned off" large numbers of students. I see two chief reasons for their alienation. First, nearly all technology was excluded, and so were the applications of science in personal life, and most of its implications for society. Second, great numbers of students rejected science because science seemed to be rejecting them. Those were the ones for whom the work was proving too difficult, not just in detail but also in the sophistication of concepts. The range of intellectual interests, abilities and study skills among high school students is comparable to the range among adults in their communities; but the programs of the '60's, designed as they were for an orderly, sequential unfolding of important ideas, tended to be quite inflexible.

So, as we look for alternatives *in* science education, one of the most obvious needs is to adapt programs to the less able students. The Biological Sciences Curriculum Study (BSCS) Committee was already aware of the problem before the mid-'60's, and tried to solve it by developing a Special Materials course (1966). The course was quite similar to the three original versions of BSCS, except that it was greatly simplified. It was a forward step. Its major limitation was that it took for granted a basic motivation toward academic achievement that simply does not exist for students from some home and community backgrounds.

Then came Harry Wong, an extraordinarily dynamic classroom teacher who took seriously the problem of motivation. In his biology and physical science programs (Wong and Dalmatz, 1971; Dalmatz and Wong, 1971) he presented some of the most basic concepts of those disciplines but also made the content relevant to the "educationally uninvolved," as he calls them. He programmed the courses so that success could come in easy steps and would be reinforced. He injected humor generously into the printed materials, not to entertain but to teach while relieving the apprehension and depression resulting from past failures. He lectured across the country, talking with teachers unabashedly about love and its importance in establishing a good student-teacher relationship that would provide a climate for learning. Many potential drop-outs improved their attitudes toward school and learned some science, too.

Wong's programs, like the BSCS Special Materials and many others, depend on grouping in separate classes the students who need a modified program. For several decades, in the effort to adapt to individual differences, many schools have grouped students into honors classes, regular and slower classes. But the differences within a class are still too great for the most effective learning if all students must go through the same experiences at the same pace. Perhaps there was a time when most students would accept a degree of boredom while the teacher explained a point to those who had not yet grasped it. Now, a generation accustomed to professional entertainment at the flick of a button is less willing to be bored. Indeed, it could be argued that at one time people needed to become inured to boredom in order to survive as laborers in an industrial society, whereas now we are entering a post-industrial society in which very few will have assembly-line jobs, and adjustment to change will be by far the greater challenge. With so much to be learned today, we can no longer afford the inefficiency of a lockstep in education.

Present alternatives *in* science include a wide variety of attempts to break that

lockstep within the classroom. One of them, a junior high school laboratory-centered program referred to as ISCS (Intermediate Science Curriculum Study, 1970) is completely self-pacing. Explicit directions in the textbook enable a student to work at his own speed, whether faster or slower than would be the pace for the class as a unit. In this program flexibility is provided through optional exercises called excursions, some remedial and some for enrichment. There is little variety, however, in modes of instruction in this and many other pre-packaged programs.

A system called IGE (Individually Guided Education) has resulted from an attempt begun at the University of Wisconsin (Klausmeier, 1971) to provide at the elementary level a variety of instructional modes for different learning styles as well as to adapt to the child's present level and learning rate. By learning style we refer to the fact that some children require motor activities for nearly all of their learning while others can learn quickly through the spoken or the written word; that some need the security of quite detailed directions while others, not necessarily any more intelligent, are more independent and creative, developing more fully with open-ended assignments; that some children work better alone and some in groups. Observant teachers see many other differences. Efforts to meet so many kinds of differences require a great variety of activities and constant regrouping of children. Some teachers achieve a remarkable degree of individualization with their own groups of thirty or so children, but it is very difficult to do so. The kind of flexibility suggested here is greatly facilitated by team-planning, team-teaching, and extra adult help in the classroom. These features are characteristic of IGE, which is thus a very sophisticated alternative in education. Much work remains to be done, however, in developing curriculum in science which will make it possible to reap maximum benefits from the organizational patterns of IGE.

Along with these alternatives within the accepted subject area of science there have been some developments which have made me wonder whether we may have inadvertently chosen some alternatives *to* science and whether we can always tell the difference between alternatives *in* science education and alternatives *to* it. The problem faces us especially when we undertake the quest for relevance.

Whatever else science education is, the best current thinking is that in elementary and secondary schools it must be directed toward scientific literacy (NSTA, 1971). It must prepare people to handle new information in dealing with new problems related to science. The very term "literacy" implies that there shall be no pretense in school of presenting even a major part of the scientific information the student is going to need, but the school must help him build a conceptual structure along with process skills and attitudes that will enable him to interpret and apply new information. The goal is to prepare for a future very dimly seen, developing an understanding of concepts so pervasive in science that we can reasonably expect them to be useful in unforeseen circumstances. Scientific literacy must be part of the common education for citizenship in a society shaped in large measure by science and technology.

One type of current alternative which may help attain or may defeat that goal is the recent proliferation of elective courses in many high schools. Electives include not only semester courses but also minicourses of six or nine weeks, sometimes even shorter. This development is basically a healthy one, part of the effort to be more flexible in dealing with different needs and different interests. But should the science curriculum include a minicourse in photography, for example? Of course the answer depends upon how the course is developed. It may be an exciting alternative *in* science if basic principles of chemistry and physics are investigated, or if the central project is to communicate through photographs some important ideas in any branch of science. It may be an alternative *to* science if it is taught only as a how-to-do-it course.

There is now a group referred to as ISIS, for Individualized Science Instructional System (Burkman, 1973), that is developing about 125 two-to-three week minicourses for high school. These are complete learning packages ready for the student to use at his own pace at any time. In pilot schools the whole high school science curriculum will be replaced with such interest-centered topics as "Too Many People," "Home Electrical Repairs," and "The Psychology of Shopping and Selling." Interest and a peripheral relationship to science, however, are not sufficient criteria for establishing a course or enrolling a student. Designers of ISIS are defining unitary and cumulative objectives and developing a management scheme for guidance of each student so that cumulative objectives will be achieved. With such a comprehensive plan, if it continues to evolve, the goal of flexibility without confusion of purpose may well be achieved. Without some such over-all planning (and it requires capable leadership and a great investment of time) the minicourse idea could lead to triviality or chaos.

Related science in vocational programs is another alternative. Presently there is across the country a very strong thrust for vocational education. Related science is included in many vocational programs. A shop course designed for high school juniors and seniors and meeting requirements for state funding in Ohio consists of three hours daily of shop work and ninety minutes daily of related subjects, including some science and mathematics, all taught by one person who has been successful in the trade but not necessarily educated in science or as a teacher.

Vocational courses are designed primarily for immediate effectiveness, to provide entry level skills needed for employment in the business and industrial community. The rationale is that, because success begets success, preparing for success on the first job in the trade as it is today is the best preparation which can be made now for vocational adjustment in an unknown future. As we enter the post-industrial age, all jobs are changing rapidly, but success at a specific initial job is the goal of vocational education.

The view in these courses contrasts sharply with the goal of scientific literacy. It demands as much emphasis on specificity as scientific literacy does on universality; and the strong emphasis on individual performance contrasts with the goal of scientific literacy as a necessity for informed public opinion.

This related science could be an alternative *in* science if the specific information needed in the trade were used to introduce fundamental concepts and principles, helping the student to become more adaptable. On the other hand, if the only real concern here as in the shop is for a specific job, "related science" must be recognized as an alternative *to* science. Surely vocational education in high school is of great value to many students and to society; but related science courses, as presently conceived, must not be used to satisfy the minimum graduation requirement in science, a meager one year in Ohio.

Another very important type of alternative is represented by the environmental education movement. It is interdisciplinary, working not only through science but through social sciences, language, and the arts as well. In Toledo, as in many school systems, we offer an environmental education course for science credit in high school. There is reason to wonder whether a so-called science course that gets students deeply involved in social problems and social action may become an alternative *to* science. It may! It can become indoctrination, but that is neither good science nor good social studies. Or an excessive amount of time may be spent in social problems or repetitive service projects to the neglect of relevant science content.

However, if we accept the goal of scientific literacy as a part of the common education for citizenship, we cannot turn away from the challenge of environmental education. All our efforts to develop basic concepts, scientific attitudes and modes of thinking are of little consequence to the future citizen unless he can carry them over into questions of human concern, and then draw reasonable

tentative conclusions as a basis for action. Evidence must be accepted and evaluated regardless of the discipline to which it is related.

Perhaps we must ask a different question: not "Are our alternatives completely *in science*?" but "Do our alternatives meaningfully and adequately *involve science*?"

It is not just starry-eyed theorists in education or youngsters who cannot handle mathematics who are calling for relevant material.

Albert Baez, (1973), chairman of the AAAS Commission on Science Education, writing on educational goals for the '70's, said "Science and technology are at least in part responsible for the mess we are in. In this same breath, however, I have to say that we will not pull ourselves out of the mess without further applications of science and technology . . . their importance must be appreciated by all people of the future."

Jerome Bruner, (1971), leading theorist and spokesman for the strongly intellectual curriculum reform of the '60's, wrote in 1971 explaining how those reforms of a decade earlier met a need of the time. He went on to say, however, that, if he had his choice now, in terms of a curriculum project for the '70's, it would be to find a means of bringing society back to its sense of values and priorities. He would be satisfied, he said, to declare something of a de-emphasis on the structure of the disciplines. He would deal with that structure not so directly but rather in the context of the problems that face us. We are not falling away from Bruner's leadership, at least, when we give prime consideration to the human problems related to science.

There is much ferment now toward problem-centered curricula in which science, social studies and humanities will be integrated. In whatever ways and to what extent that may be worked out, and there are many problems which must be surmounted, clearly the immediate thing we must do is to deal in a compassionate and open-minded way in our science classes with the social concerns related to the science subjects we teach. If our teaching remains compartmentalized, we cannot expect the students to bridge the gap.

The necessity to bridge the gap between science and social studies must not be regarded as something extraneous, added to our responsibilities. We are human beings first, and scientists or science educators second. Our first question must be "What needs to be done?" and our second, "What is our special responsibility based on our competence and our positions?" We must see that the resources of science are applied compassionately to human concerns, and that, in education, our alternatives meaningfully and adequately involve science.

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