

Science Literacy: Its Meaning for American Schools

School people and public have come to realize that it is through the programs of the schools that science will be advanced and the ideals of a free world will be perpetuated.

WITH nuclear fission came the atomic age. Before America realized its significance, the transistor introduced the electronic age which in turn fathered automation. With a roar and a whistle the jet made "supersonic" a common term—and the world became smaller. Ballistic missiles circle the earth, a space age is born, and the size of our universe is diminished. The control of thermo-nuclear reactions will soon introduce a new power age.

Plastics and pesticides, biotics and detergents, silicones and synthetic elements have introduced the modern world of chemistry. Half of the chemicals in common use today were unknown 10 years ago. Tranquilizing drugs provide a research tool for studying the human mind; "tagged" molecules supply information about living cells, and developments in virus vaccines give promise of a disease-free world. Biophysics and biochemistry are bringing us closer and closer to understanding the nature of life.

These are the achievements of man about which thousands of valedictorians will orate at graduation, and rightly they should, because these events are the events of their lifetime. They will talk about discoveries in science and how

man has increased his control over his physical and biological environment. They will discuss automation and the increase in leisure time, better health and a longer life. These are the words we hear from the first graduating classes of the "space age."

Even the casual observer recognizes that science with its applications in technology has become the most characteristic feature of modern society. Attempts to define human values, to understand the social, economic and political problems of our times, or to validate educational objectives without a consideration of modern science are unrealistic. More than a casual acquaintance with scientific forces and phenomena is essential for effective citizenship today. Science instruction can no longer be regarded as an intellectual luxury for the select few. If education is regarded as a sharing of the experiences of the culture, then science must have a significant place in the modern curriculum from the first through the twelfth grade.

What Kind of Education?

The American people, sparked by a Sputnik, and almost as a single voice, have inquired whether their children are

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receiving the kind of education that will enable them to cope with a society of expanding scientific and technological developments. There is a concern about the next generation's ability to continue the accelerated momentum of science. The question has been raised whether high school graduates even know the meaning of science.

We are approaching a period in history that will be distinguished by a great discontinuity in scientific and social development. The challenges to be faced will be more numerous than ever before. Will curriculum workers be able to devise the educational program necessary to maintain the delicate balance of scientific, social and economic forces that will be found in this period? Will it be possible to evolve the kind of education essential for continued scientific advancement within the framework of a free society? Can a philosophy of education be developed and a curriculum invented that will prepare young people for the approaching era of world industrialization?

In this period there will be a demand for intensive specialized training for an increasingly larger fraction of the population. Already the creative and the technical manpower shortages are problems of serious proportions. Can science education be modernized fast enough to meet these challenges without destroying the balance of educational experiences? These are the questions that satellites, rockets and missiles have focused in the American mind and these are the problems that educators are asked to help solve.

The crisis in education has both an immediate and a future aspect. The im-

mediate problem is one of closing the gap between the wealth of scientific achievement and the poverty of scientific literacy in America. There is also the problem of developing a program of education suitable for the probabilities of the future. This requires an educational plan that prepares young people to expect change and to meet change without shock, fear and anxieties. Progress in science and technology has reached the place where their future is dependent upon an education that is appropriate for meeting the challenges of an emerging scientific revolution.

The problems facing American education are complex and urgent. They will not be solved by any simple process of "patching" or "retreading" the existing curriculum. The need is for a perspective of education compatible with the forces of science that are now shaping the ways of men. Furthermore, these forces are increasing both in tempo and magnitude. Breakthroughs in science lead to new horizons, and establish new areas for intellectual conquest which in turn demand a plan of education to sustain the cycle of achievement. An education of this nature must have built into it some of the dynamic qualities that have given us the "scientific age."

Public Interest in Schools

Schools find themselves in an unusual position today. The public has suddenly taken an overwhelming interest in education even to the point of demanding curriculum changes. The situation has been commented upon by the President and debated in Congress. While most of the attention has been directed toward improving science teaching, it is apparent that there is a strong movement for a "new look" at all American education.

Science has been a dominant factor in determining the beliefs of educated

men for the past 200 years, and the measure of human progress for the past century; it is the most distinguishing characteristic of modern society, and represents the best investment for the future of mankind. However, it is seldom possible to find any time consistently assigned for teaching science in the elementary school; few junior high schools offer a full program of science; and in the majority of high schools students are able to graduate with only a year's work in science. How does one explain why the greatest intellectual achievements of our time and the major forces which have shaped our culture shall have no more than incidental treatment in general education?

The demand to "do something" about science teaching in schools has resulted in considerable action. More than 50 national committees are actively engaged in efforts to improve the quality of the curriculum and instruction. Hundreds of scientists are giving help by suggesting experiences of greater potential significance for the development of scientific literacy in the young people of America—a professional responsibility they have too long neglected. One group of scientists has developed a new physics course for high schools. Others are working on the improvement of chemistry and biology laboratory experiments. The National Science Foundation has established thousands of fellowships to enable secondary teachers to broaden their background and to contemporize their knowledge of science. There are plans to extend these opportunities to elementary and junior high school teachers. Many professional organizations for scientists have reactivated their educational committees and have begun to encourage high school teachers to participate in their meetings.

Millions of dollars are being contrib-

uted by business and industry to provide scholarships and work opportunities for science students, and fellowships and summer jobs for science teachers. Some business-industry associations have taken the leadership in developing curriculum and guidance materials that are frequently superior to those ordinarily available to classroom teachers. Within the past two years nearly 200 colleges and universities have developed within their science departments special courses for the education of teachers. Over 125 bills have been introduced into Congress to improve the teaching of science in some manner. The entire situation is unique in educational history. Never has so much effort been expended to modify the content and teaching procedures of one phase of the curriculum.

The problems encountered in organizing a new program for the "space age" are not easy to resolve. There is a tremendous volume of scientific knowledge and concepts from which it is necessary to choose a small per cent to form the content of courses. Moreover, this fund of knowledge is increasing so rapidly that even the specialist becomes relatively more ignorant with each passing week. Authors of textbooks have sometimes endeavored to solve this problem by adding pages to the text or by touching lightly on more topics. As a result, the science curriculum has been spread so thin over so many topics that students acquire only dribbles and dabbles of assorted information. There is also the problem of building into the science curriculum some depth and quality of understanding. It is essential to select learning materials that are the most fertile in providing opportunities for using the methods of science. Further efforts are required to choose learning experiences that have a particular value for the development of an appreciation of

science as an intellectual achievement, as a procedure for exploration and discovery, and which illustrate the spirit of scientific endeavor. It will be most difficult to discard those sections in our courses which have been taught for so many years that they appear to be forever fundamental.

Frontiers of Discovery

Science courses need to be taught somewhere near the frontiers of discovery. Students should have opportunities to look through the doors of science and to be tantalized by the unknowns. How can a student develop the curiosity and the imaginative qualities of a researcher if he is never introduced to the probabilities of a trip to the moon, controlled thermonuclear reactions, mining the seas, artificial photosynthesis, psycho-chemotherapy, and the many other problems that challenge the minds of scientists today? These are areas in which students can visualize a future. The science curriculum must advance with the achievements of science and with some projections into the future.

Modernizing the courses does not mean that the history of science is to be neglected, but that it should be presented in its more significant aspect as a major intellectual accomplishment of mankind. It is common to find the history of technology taught, but rarely in the perspective of scientific investigation. One of the reasons students have little appreciation of the work of scientists is that they have never really heard much about it. The growth of scientific ideas and theories and their contribution to the intellectual climate of man are the history of science, and as such have an important place in the modern curriculum.

Understanding science means know-

ing something about the procedures of theoretical inquiry and recognizing these procedures as the means by which the imagination of man and the laws of nature are focused upon unsolved problems. Research is not simply a rigid procedure of collecting and organizing data in terms of a problem followed by logical deductions. When taught in this manner, it is little wonder that many of the better students fail to find satisfaction in science courses. Ways of teaching are needed that give students a chance to feel some of the joys and sorrows of a research effort, to experience the excitement of discovery, and to appreciate the beauty of a well executed "play" in a scientific endeavor. A laboratory experience should leave the student with the feeling that he has in some small way been a scientist for a day.

Today most aspects of human welfare and social progress are in some manner influenced by scientific and technological innovations. In turn scientific knowledge establishes new perspectives for reflection upon social problems. The ramifications of science are such that they can no longer be considered apart from the humanities and the social studies. Modern education has the task of developing an approach to the problems of mankind that considers science, the humanities, and the social studies in a manner so that each discipline will complement the other. Scientists are as much concerned as the humanists with what man ought to do and why. Modern science teaching must at many points consider questions related to the processes of social change. This is not a responsibility most scientists would seek but one which must be assumed as science continues to influence more and more directly the life of every person

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look for, perhaps what to watch out for. Such reports would certainly have more body than would generalized "answers" to research problems. And the series, with its emphasis on real situations, should be an interesting contrast to the kind of column we conducted last year on what most needs to be studied.

Thus, the succeeding columns will report what on-going research looks like from the inside to those who are doing it.

Miriam Goldberg and Harry Passow of New York will analyze their procedures in studying the underachieving gifted. From Kansas, Robert Ridgway will tell what a group of teachers encountered as they developed a program for the mentally retarded.

Several Florida teachers will work with Glenn Thomas in reporting their experi-

ences with individualized reading. Grady Parker and Elmer Ellis will analyze a Texas study on the achievement and personal adjustment of underage first-graders. A Wisconsin study in color perception of elementary school pupils will be reviewed by Arthur Adkins.

In these accounts, we hope to give others help in getting a better picture of what research looks like while it is being undertaken. We hope to offer something of practical value in helping you find better research answers to some of the questions you may have in mind.

We hope you will find what we do useful.

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on the earth. The development of atomic power and man-made satellites has served to intensify the necessity of examining their effect on the lives of men. Both science and social studies teachers must intensify their efforts to help young people to understand our culture as it is influenced by scientific discovery.

It took a ballistic missile to wake up the American people to a realization that the most underprivileged and undereducated group of students in America is the gifted and the talented. Educators are being asked to explain why the majority of students are put into the same courses, taught in about the same way, using the same textbooks, doing the same experiments, and spending the same number of hours per week and of months per year in a course. Parents

want to know what is really being done for the "bright" youngster. They are not happy with the "special opportunities" provided for the rapid learner which frequently consist of simply doing more of the standard activities. Schools are now charged with the responsibility for devising new curricula and teaching methods that will give the academically gifted educational opportunities at least comparable with those of other students.

What have satellites, rockets and missiles contributed to American education? They have created an awareness of the importance of science and technology to social progress and economic security. The public realizes more clearly than heretofore that it is through the program of schools that science will be advanced and the ideals of a free world perpetuated.

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