

Efforts to Strengthen Education in the Sciences

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It is my privilege to be serving for a year and a half as consultant in education in the sciences to the National Science Foundation and, on a part-time basis, to the Fund for the Advancement of Education as well. The purpose of this article is to sketch in broad outlines the programs of this government agency and this private foundation as these programs bear on science education.

National Science Foundation

The National Science Foundation was established by Act of the Congress in 1950 as an independent agency in the executive branch of the Federal Government. In describing the functions of the Foundation, the act begins with the following charge. "The Foundation is authorized and directed to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." (In the following discussion "the sciences" means "mathematics and the sciences.")

The most extensive activities of the Foundation, whether measured in terms of dollars expended or public awareness, are its program of grants for projects in basic research and its program of graduate fellowships. The fellowship program contributes to the support of education in the sciences in an obvious way. The announcement in March of awards to nearly 800 fellows for the academic year 1955-56 brings to a total of more than 2700 the number of man-years of graduate studies for prospective scientists that the Foundation has supported in the first 4 years of this program. Less obvious, perhaps, is the contribution to education of the Foundation's program of grants for projects in basic research. Yet hundreds of graduate students, taken into such projects as research assistants, have through such

work received firsthand training and experience in basic research.

The programs of research grants and fellowships, together with certain other activities that need not concern us here, are specifically authorized and described in the National Science Foundation Act. The Congress was less explicit about what other things the Foundation might do in order to meet fully its responsibility for strengthening education in the sciences. These things the Foundation is seeking constantly to discover, with the help and advice of research scientists and teachers, professional scientific societies, and groups of educators and laymen. Proceeding with caution in an area where criteria are neither clear nor generally agreed upon, it has chosen some things, rejected some, and in the case of others has decided to suspend judgment pending further study.

The emerging program, called simply "education in the sciences," includes three categories of activities aimed, respectively, at (i) encouragement and strengthening of present high-school and college teachers of science; (ii) improvement of the science curriculum, including the training of new teachers; and (iii) increased attention to identification, motivation, and counseling of able high-school students. Let me first describe things already undertaken by the Foundation, then things in prospect.

In the first of the three categories just described—activities aimed at strengthening present teachers—the major effort of the Foundation has gone into "summer institutes" designed to help high-school and college teachers of science increase their competence—primarily their subject-matter competence. These institutes have differed from both the typical academic summer session and the typical summer workshop. In them, teachers from high schools and the smaller liberal arts colleges and universities—especially those remote from centers of research—have gathered together to learn, from persons noted for both scholarship and skill in exposition, some of the more important and recent concepts and methods of inquiry in their fields. It has

been the hope that these teachers, armed with new information and insights and enthusiasms, will return to their colleagues and students and think anew with them about teaching materials, methods, and objectives in the light of modern scientific research. The enthusiasm with which this activity has been received by teachers has led the Foundation to increase the number of summer institutes it has supported from two in 1953 and four in 1954 to nine in 1955 [*Science* 121, 414 (1955)]. Still further increases are contemplated for 1956.

The Foundation is lending support experimentally to two further activities in the same category. The first, an alternative to the summer institute, is based on the suggestion that some teachers might profit more, insofar as teaching competence is concerned, from certain summer research experiences than from summer instruction. Under a grant to one university, for example, 10 college teachers devoted several weeks in the summer of 1954 to fieldwork at a biology station. The second of these experimental activities is designed to supplement the summer institutes by sending lecturers to the teachers rather than bringing teachers to the lecturers. Specifically, the Mathematical Association of America, under a grant from the Foundation, has scheduled visits of 3 to 5 days' duration to smaller colleges and universities by several mathematicians—again, persons noted for both scholarship and skill in exposition. It has been the expectation that in the course of his visit the lecturer will be able to bring his ideas and stimulation to bear not on just one member of a given staff but on all members of the staff and on some of the students as well. The Foundation hopes in the future to enlarge this program of "visiting scientists," both by including other sciences and by extending the program to high schools.

In the category of activities aimed at improving the science curriculum are conferences of two kinds to which the Foundation has tried lending support. In conferences of a first kind, outstanding scientists and teachers have met to discuss recent developments in science with a view to determining what place, if any, they ought to occupy in the science curriculum. Conferences of the second kind, bringing together scientists, teachers at all levels, and state and local commissioners and superintendents of education, have undertaken to study and propose changes in the teaching of a particular science in one or another region of the country. The Foundation hopes in the future to increase its support of conferences of these and similar kinds.

Finally, in the category of activities aimed at increased motivation of able

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students, the Foundation has for several years provided modest funds to enable Science Service to extend to new communities its program of science clubs, science fairs, and related activities.

The extent to which new activities can be undertaken by the Foundation in the future—and old activities expanded—depends on many factors, including availability of both adequate funds and meritorious proposals. At the risk of counting chickens not only before they are hatched but before the eggs are laid and in the nest, I should like to describe briefly a few things the Foundation thinks it should seek to do.

In the area of improvement of science curriculums there is the need for new teaching materials at both high-school and college levels. Although it has been deemed inadvisable on a number of grounds for the Foundation, a federal agency, to support the writing of this or that particular textbook as against some other, it has seemed to me that the Foundation could quite properly support the preparation of syllabuses by writing groups appointed by national associations. By "syllabuses" I have in mind not textbooks, but outlines of topics and alternative ways of presenting them, together with copious new problem material. Such syllabuses, distributed widely to teachers throughout the country, would stimulate the usual competitive writing by the teachers themselves of new and modern textbooks adapted to local needs.

Another need is for reexamination of the curriculums under which prospective science teachers are trained. Until rather recently our foremost scientists seem to have preferred to devote their full time and energy to research and to leave to others the preparation of teachers. There are now signs, however, of a growing awareness on their part that they have a responsibility here and that their contributions would be both helpful and welcome. Support of conferences at which scientists and educators can discuss this common problem will soon be in order, as will support of some of the experimental programs that will presumably emerge from such conferences.

It seems fairly certain that in spite of our best efforts to produce more and better science teachers, the supply will fall far short of the demand in the years ahead. This being the case, new and improved ways of using the teachers that will be available should be investigated while there is still time to do so with care and deliberation instead of under emergency conditions. The development and use of television and films and the training and use of teachers' aides are examples of promising leads in this respect.

In the area of identification, motiva-

tion, and counseling of able students there is much that needs to be done. Various studies concur in the estimate that of the totality of students who graduate from high school and are competent to do college work, only about half in fact enter college, and of that half only about three-fifths graduate. At the high-school level, support of such activities as the establishment of student science journals (for example, *The Mathematics Student Journal*), summer science experiences for students, and rotating science libraries might be helpful supplements to the already popular science clubs and fairs. And at both high-school and college levels new and improved counseling materials, for teachers and parents as well as for students, might be prepared. Finally, we need more knowledge than is now available about intellectual and emotional factors characteristic of scientific ability, about motivation and counseling, and about career choices in science and science teaching. Support of studies designed to secure more adequate knowledge of such matters could contribute significantly to the strengthening of education in the sciences.

Fund for the Advancement of Education

The Fund for the Advancement of Education was established in 1951 by the Ford Foundation as an independent corporation, with its own board of directors. Although science teachers and teaching have, of course, received their proportionate share of attention, it must be kept in mind in what follows that the Fund seeks to serve not just science education but education generally.

Of the Fund's several major areas of concern, two are of particular interest to us here: (i) improvement of teaching, including the strengthening of present teachers, the preparation and recruitment of new teachers, and better utilization of both; and (ii) improvements in curriculums.

The Fund's fellowship programs for high-school and college teachers constitute major efforts to be of service to those who seek to improve their competence as teachers. Specifically, these programs are designed to provide recipients with a year of study and reflection, free of usual duties, in which to acquire further knowledge in their fields or in related fields, to observe at first-hand new developments in education, and to exchange ideas and experiences with colleagues in other parts of the country. Both programs are administered by national committees of educators appointed for the purpose. In the first 3 years of the high-school program, awards

have been made to more than 750 teachers; in the first 4 years of the college program, to nearly 1000.

As a supplement to the fellowship programs, the Fund has supported a number of summer institutes for high-school and college teachers together. In several instances the Fund made provisions for an institute for high-school teachers in conjunction with an institute for college teachers supported by the National Science Foundation; in other instances the Fund itself supported the joint institutes. Although the aims of this program are similar in many respects to those of the Foundation's program of summer institutes, the Fund has been particularly interested in increasing communication between high-school and college teachers for the sake of improved mutual understanding and improved articulation of curriculums.

In the area of preparation of teachers, the Fund is supporting three experimental programs. One, a program of internships in college teaching, is designed to bridge the discontinuity that usually occurs in the prospective college teacher's career as he moves from full-time graduate research to full-time teaching. Under grants from the Fund to a number of colleges and universities, interns have been given the opportunity, under the supervision of experienced teachers, to observe good teaching, assume certain teaching responsibilities, and explore in seminars some of the problems of curriculum, courses, and teaching that every college teacher must inevitably meet and solve.

Two other programs of the Fund in the area of preparation of teachers are designed to alleviate the present and prospective shortage of elementary- and secondary-school teachers and to improve their quality. Both are concerned with recruitment and special training of graduates of liberal arts colleges who did not as undergraduates prepare for a teaching career, the one with recent graduates and the other with older persons such as women with lessened home responsibilities. A dozen or more experimental plans, differing widely in details but directed toward these general ends, are now being administered under grants from the Fund by colleges and universities working in close collaboration with state or local school systems.

To increase numbers of teachers is, of course, only one way of alleviating the shortage; another is to make better use of the teachers we have. For example, the Fund has made grants in support of projects that seek to explore recruitment, training, and use of teachers' aides. In one community the use of such aides to relieve experienced teachers of sub-professional duties, and so to enable them to teach many more students than

usual, has been greeted with enthusiasm by all concerned—aides, teachers, students, and parents. The fact that the experience has stimulated a number of the aides to undertake professional teacher training has obvious implications for recruitment of regular teachers. The Fund has also supported some experimental efforts to develop and use closed-circuit television and kinescopes, so that outstanding instruction can be brought to many times the number of students who now benefit from it. Still other means to better utilization of teachers should be explored more fully: the use of older students as tutors, the encouragement of more and earlier independent study, and the adoption of simpler curriculums.

In the area of curricular improvement, the Fund has directed its attention primarily to the work of the secondary-school and college years with a view to enabling the student—especially the abler student—to move through these years at a rate commensurate with his ability and maturity and to provide him with the best possible education along the way. Three major projects supported by the Fund have these ends in common but are distinguishable in the means they use to approach these ends.

In one of these projects three preparatory schools and three colleges attended by many graduates of the three schools undertook a joint study of their respective programs. Conceiving of the last 2 years of secondary school and the first 2 years of college as an integrated whole, the joint committee found the current educational pattern wasteful of student time and interest. In recommending a new pattern the committee was led to the conclusion that better students should be able to complete the traditional 8 years in 7, either by going directly from 11th grade to freshman year or directly from 12th grade to sophomore year.

Acceleration by entrance to college before graduation from school characterizes a second of the three projects. In this project a dozen colleges have been exploring the desirability of admitting students under 17 years of age who appear to be ready in terms of intellectual

and personal growth to undertake regular college work.

In contrast, acceleration by admission to college with advanced standing characterizes the third project. As a result of joint exploratory studies by certain secondary-school and college teachers and administrators, a dozen colleges have agreed to consider for advanced credit those graduates of some 40 schools who in their final school years have completed especially designed college-level courses.

These attempts to reduce the number of years spent in formal education by able students have important implications for science. If, for example, ways could be found by which science-bound students could complete requirements for the Ph.D. degree a year earlier than they now do, and without sacrifice of quality of training, consider what the year so saved might mean in terms of the nation's total scientific output. Of particular significance is the fact that the extra year made available for independent research would come at the beginning of what for most scientists is their period of maximum productivity.

Concluding Remarks

It should be clear from what has been said that in both the Foundation's program of education in the sciences and the Fund's program at large, top priority has been assigned to teachers: to the strengthening of present ones, the preparation of new ones, and the better utilization of both. This policy can be justified, it seems to me, on several grounds.

We are being told with increasing frequency and forcefulness that, in order to safeguard both the national security and the national economy, it is imperative that we increase the supply and improve the quality of scientists and engineers.

Consider first the question of supply. In my more optimistic moments I like to think that the problems of numbers of scientists and engineers may be met in a natural fashion by the fact that both the population as a whole and the percentage of college-age youngsters who

go to college are increasing. In any case, it is hard enough to estimate what today's demands for scientific and engineering manpower are and many times harder to estimate what the demands 15 or 20 years hence will be.

By contrast, estimating future needs for teachers seems simple and safe. Although the ideas and techniques that will be of first importance to the nation 15 or 20 years from now may not yet be born, the children of the nation have been born. We know how many there are and where they will be in school or college during the next 15 or 20 years, and we can compute with fair accuracy the numbers of teachers that will be needed to teach them under this or that assumption concerning optimal class size. We are faced on the one hand with a swelling population of school and college students and on the other with a shrinking population of college graduates prepared to teach. The shortage promises to be especially acute in the case of teachers of science and mathematics, where competition from industry for college graduates trained in these fields is most heavily felt.

Consider next the question of quality. Just as a shortage of teachers can be alleviated in part by making better use of those we have, so a shortage of scientific and engineering manpower can be alleviated in part by increasing the quality of the scientists and engineers we have. Moreover, whereas some doubt our ability to make use of greatly increased numbers of scientists and engineers in the future, few if any would express similar doubts concerning improved quality. Here the role of the teacher is of undisputed importance. For in the last analysis it is the teacher who constructs the curriculum. And it is the teacher who instructs and inspires the students destined to become the scientists and teachers of the future.

Surely, such considerations as these warrant the increasing attention now being accorded to teachers and teaching by government agencies, private foundations, industrial concerns, and the public at large in support of efforts to strengthen education in the sciences.

The science teacher should always teach that science has made two fundamental contributions to modern life: it has given man the choice between want and abundance; and it has freed him from irrational fear. Man has not quite conquered fear, but through science he has freed himself from the tyranny of ancient superstition and is gradually coming to understand his own inner fears. The scientific conception of the nature of the world and of man can free man's mind just as the scientific control of matter and energy has freed his hands.—ROBERT J. HAVIGHURST, *Sch. Sci. and Math.* 44, 120 (1944).