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ing science, we have common problems and we seek common results. To quote from the "Joint Report . . ." which was derived from the meetings, " . . . we agree that: (1) we are not in sympathy with certain present procedures of mass production applied to education. We wish to progress toward an efficient, practical kind of teaching which will be attentive to the needs of the individual. (2) we recognize certain common objectives of teaching."

To the "Joint Report . . ." the Junior College science instructors added a special report from which the following is taken: " . . . we should like to emphasize that the success of any teaching program depends upon the nature of the learners, which is extremely variable and difficult to predict. It is therefore necessary that teachers continually analyze their work, and that they be ready at all times to adjust both content and methods in order to attain maximum results." The implication here is that the curriculum may be less at fault than the teaching methods by which it is applied.

The traditional sequence of courses and their content are due for close analysis. What is it that we are really trying to do? And then what is it that we actually achieve? Can we obtain a measure of the actual functional scientific knowledge of our high school graduates by some objective means? We have examinations which measure recall of facts and verbal statements of principle. Can we develop comprehensive examinations of the essay and problem-situation type which will be less a test of memory and more a test of application of principles?

In our traditional sequence, what inherent faults are there that prevent students from developing functional knowledge? There may be several. Is the sequence illogical to the student mind and its content too unrelated? Are we guilty of stressing subject matter coverage at the expense of mastery of principles? Is the entire content of our courses essential, or is much of it irrelevant detail? Since many students learn so little of what we attempt to teach, can we improve by doing less and doing it more thoroughly?

That there is much good in the present work of science education cannot be denied. Let us retain the good; and by constant intelligent analysis and research, let us realize more and more of it.

SOME ISSUES IN TEACHING SCIENCE IN THE POST-WAR PERIOD

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I shall attempt in the short time available to present a number of issues in the development of a science program designed to lead

to increased effectiveness in the post-war period. These issues are chiefly drawn from a symposium published in *Science Education* dealing with the problem: How can science education make its greatest contribution in the post-war period?* It should be understood at the outset that the answers given to this question are based on judgments of science teachers and educators in anticipating post-war educational problems and in formulating plans for their solution. It is recognized that freedom of thought and its expression are not in themselves sufficient for the scientist, who wants to find out first and talk afterwards. In many of the issues it is doubtful if we have or can secure sufficient and necessary data for final decisions. There is an urgent need, however, for all science educators to examine critically the facilities of schools to meet the country's need for the scientific training of youth for participation in the post-war world as citizens, as well as in regard to the training of greatly increased numbers of research workers and other scientifically trained personnel that will be required after the war. We must, however, get beyond the authoritative and argumentative stages in the attacks upon problems if science education is to be kept dynamic and in living contact with the society it claims to serve. Perhaps all we can expect to achieve in the near future is to keep our educational framework malleable so as to stimulate creative forces by encouraging experiments originating in the needs of the transition period. We should be continuously attentive to the possibility, however, that changes designed to meet exigencies should not preclude more significant changes or developments which further research may deem necessary.

It is assumed in presenting the following issues growing out of the Symposium that discussion of various points of view on similar subjects can become valuable in broadening the views of science teachers and educators. The subjects brought forward are so varied that I shall attempt to bring to a focus the outcome of the various opinions. When teachers have been following their own line of thought and development it is likely a wholesome thing to hear and consider the opinions of other teachers of the same field as their own. It is hoped that at least this report will stimulate those who are here to exchange ideas and widen their own view of their work. Perhaps this may serve to supply a good foundation for designing the nature and extent of future investigational programs for this section of the Academy. Were such a program put in operation it is likely that genuine additions could be made to our understanding of science education. Or perhaps more accurately such a program would lead to the discovery of ever newer, deeper, and more

* Palmer O. Johnson, Coordinator, Symposium: "How Can Science Education Make Its Greatest Contribution in the Post-War Period?" Science Education **28**: 231–239; 282–288, 1944.

general problems and to the testing of temporary answers again and again and each time more vigorously.

The issues raised by the contributors may be placed in four main groups:

1. The objectives of science education
2. The content and organization of the educational program
3. The permanent contributions of the war-time program in science.
4. The selection and preparation of teachers of science.

THE OBJECTIVES OF SCIENCE EDUCATION

There are first the fundamental questions as to the aims and purposes of science education and the extent to which previously formulated objectives still hold or need to be modified to meet better the new needs and the new times. Under this category such issues are discussed as the need for more mastery of knowledge on the part of the students, renewed emphasis upon understanding the scientific method and developing skill in problem solving, the inculcation of scientific attitudes, and increased attention to the role of science in general education. The need of shortening the lag between scientific knowledge and social wisdom is stressed. The prosecution of science as a cultural and intellectual interest as well as in its application in raising the standard of living is emphasized. In other words, the social responsibilities of the science teacher come to the fore in developing abilities in students to use knowledge of science as a tool of personal and civic competence. Intensive work in health organized around the personal health (mental, emotional, and physical) needs and problems of boys and girls should be a major aim. Also the scientific basis should be laid for a wise use of natural resources. This extensive list of objectives is a powerful demonstration that we cannot wisely tolerate stagnation in any area, and that we must seek to promote advance along the whole front so as to maintain a proper balance.

THE CONTENT AND ORGANIZATION OF THE EDUCATIONAL PROGRAM

The proposals for the instructional program as the means of fostering growth toward achieving the aims of science instruction include recommendations for a type of program organized around problems of contemporary life, a specific plan for a continuous program in science throughout the elementary and secondary schools, the design of four one-year courses in secondary school science, and the differentiation of the science curriculum into pre-professional science courses and courses for general education. These are not new issues, of course, but they are becoming more and more pressing. The movement for the twelve or fourteen year program of science seems likely to receive increased emphasis in the post-war

period. If this becomes a common practice, there is evidently a need for a complete change in the present program. Proponents of this program, point out, among other things that instruction in science should begin in the first grade because if postponed until as late as the junior high-school, the students are already inculcated with unscientific attitudes and beliefs, and possess unscientific habits of thinking and behavior. This development would hasten the breaking down of barriers between science subjects thus stressing the unity of science. The contention, long held by a number of science educators, is indicated or implied among the issues, viz., that while the classical organization of scientific knowledge into the respective subject matter field has been highly effective and useful to scholars, the same type of organization is not necessarily the most efficient for instructional purposes. The incorporation of the 12 or 14 year program in the schools would also introduce new aspects into the problem of high school science as a preparation for college. The old issues arise in a new setting: Can a single high school science program serve every one's needs at this level; or are differentiated programs needed for those who terminate their formal training upon leaving high school and for those preparing to enter college? If differentiation is necessary, are dual programs possible in all schools, particularly in the small high school? If not, what differentiation can be made? If the junior-colleges continue to increase, as seems to be the case, what articulation can be made between the college preparatory aspects of their program and the senior college program? Further issues arise concerning the place of science in the vocational programs now tending toward allocation to the thirteenth and fourteenth years. Other issues arise in the specification of criteria and principles for the selection of content and activities, in the methods of organization and presentation, in laboratory and demonstration work, in visual and auditory aids, and in evaluation procedures.

Time does not permit further elaboration, but the suggested plan of one contributor may serve as an illustration of a science program of the future. He proposes a continuous science program in grades one to six, a general science program in grades seven and eight, elementary biology in grade nine, and physical science in grade ten. This will be a common program for all pupils, but it is not necessary that all pupils complete it in the same allotted time. A differentiated program will be offered in grades eleven and twelve built on the needs of the community and the size of the school. Intensive and thorough courses in physics and chemistry will be offered in grades eleven and twelve respectively, or vice versa, dependent upon local conditions. Students completing successfully the intensive course in physics may take advanced work in mechanics, aviation (including meteorology and navigation), and radio and electronics. Special courses in optics and photography, heat engineering,

and air conditioning may also be made available. It is also intended that all these specialized courses, while more practical than vocational, should provide a thorough understanding and background basic to some vocational choice on the part of the pupil. Advanced courses might also be presented in household chemistry, nutrition, sex education and heredity, or in still other fields. It is contended that these intensive courses would be good college preparatory courses, just as good, if not better, than the present academic courses. For those pupils not interested or qualified to take the advanced courses in grades eleven and twelve, the contributor proposes a year's course in science built around problems somewhat social in character and having their origins in scientific discoveries and inventions.

THE PERMANENT CONTRIBUTIONS OF THE WAR-TIME PROGRAM IN SCIENCE

The emphasis of the educational program during war-time upon making education functional by providing experiences that prepared directly for participation in the war, by developing health and physical fitness programs, by providing pre-induction and other practical courses, and by modifying the conventional courses in physics, chemistry, biology, and mathematics to include special war-time and industrial applications will likely produce some values which will carry over into the post-war program. Rightly to identify these values would be an important contribution to science education.

Among the predictions made were that certain of the new subjects introduced into the war-time program will be continued, that accelerated programs in science as in other fields will need to be provided at the high school and college levels, and that there will be compulsory military training for young men of college age, which will require a background in science and will include additional training in special fields of applied science.

Additional problems of great importance will be the provision of educational programs for the returning veterans who take advantage of the government's provision for free education and living expenses. This group will be heterogeneous with respect to previous training, experiences, and occupational preferences. Some will enter college or institutes of special design for the first time, others will resume their interrupted programs. In addition, there will be the recent high school graduate entering college. There will likely be need for further training and retraining of civilian war workers. In many of these programs, training in science will play an important role. What modifications in existing programs and what new programs need to be developed?

THE SELECTION AND PREPARATION OF TEACHERS OF SCIENCE

Finally, prominent attention is given to the highly significant problem of the selection and preparation of prospective teachers of science who are capable of meeting the great challenge of science in the new education. This is the challenge to explore more fully, more patiently, more resolutely, and more imaginatively, the problems in the many areas where knowledge is still lacking and thus contribute significantly to the evolution of the new forces in education which are required to serve the needs of tomorrow.

Institutions engaged in the education of teachers play a significant role in the development of any modern program of youth education. Specialization, the main emphasis in the traditional program, is not sufficient. The competent teacher of science of the future will be required to see and to teach the relationships of his field to education as a whole and to the whole of life.

In conclusion, it may be pointed out that the answers given to the questions raised here will in the long run determine the content, scope, and effectiveness of science education of the future.