

PHASES OF SCIENCE TEACHING IN SECONDARY SCHOOLS.¹

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That the position science holds in our democracy today leaves much to be desired is a fact well illustrated by recent happenings in Kentucky, Tennessee, and elsewhere. These happenings are, however, merely effects and, when we look deeper below the surface of conditions, we are likely to find that dogmatic antagonisms by special political and religious interests are not the only, nor the worst, difficulties we meet, important though they may be.

It is within the walls of our institutions of learning that we are most apt to encounter the causes of the troubled waters upon which the good ship of science is at present sailing. The very growth of science and the traditions of scientists can better explain our present situation than anything else. The science professors of our worth-while colleges and universities have been guided by the "itch to know" spirit in their work. They have blasted new trails into the wilderness of the unknown and have lit strange torches to show humanity the new roads that have been opened to travel. These professors have also done their best, through their writings and teachings, to inspire their students with that same spirit. This is only natural and it is just as natural that those of their students that aspired to become science teachers should strive to carry on that spirit in their work. This has been true of science teachers in secondary schools, as well as of those in higher institutions of learning; they have tried to do in miniature what they had learned in the colleges and universities. Such a procedure was perhaps both proper and wise in the days when our secondary schools were college preparatory institutions, with a small select student body that had ambitions for professional careers.

But the world has changed and, thanks to science, the common man has, in America and elsewhere, found a "place in the sun." The change has been felt in our school systems perhaps as much as anywhere, and, as a consequence, our secondary schools are not what they used to be. Within the past generation their population has changed from the select few to the great multitudes and, it seems, the interest in "knowledge for its own sake" has been correspondingly diluted. This may seem a regrettable defeat to science but, looked at from an educational standpoint, it really is the greatest possible victory. We have, for the first time in human history, conditions under which it is possible for practically a whole population to get a systematic, though usually very elementary, course in science. The resulting possibilities may prove to be the greatest asset humanity has ever had, or it may prove to be the last chance science will ever have to show its worth to the human race.

¹ The Practice of Teaching. Morrison, H. C. University of Chicago Press.

Whatever the results will be, only time can tell; but the fact is that the youth of our nation is facing us today with the question—can science prepare for life as well as for college?

This question places the science teachers in our secondary schools in peculiar but interesting and important situations. If the aims motivating the students which such teachers find under their care are not the same that motivated the teachers, then the teachers must turn face about and find out what these aims are, to do justice to their work. But a survey of the field of science in our secondary schools of today shows many other obstacles. Briefly we may describe the most important of these as follows: (1) A heterogeneous population of boys and girls, from bright to dull, curious to cynical, industrious to lazy, pupils with a good educational background and pupils with practically no such background, pupils from excellent homes and pupils from mere hang-outs. (2) Competition with outside influences, such as the movies, books and other printed matter, much of which passes as scientific but which one of our greatest scientists so strikingly characterizes as "The Underworld of Science."² (3) Textbook difficulties³ which mostly arise from the fact that such books are written from the specialist's point of view, though this is becoming less and less true. (4) Administrative difficulties, which make it necessary for many teachers to give instruction in science without adequate preparation while well prepared science teachers often must instruct in other subjects.⁴ These, and other factors of minor importance, as scanty financial support and size and composition of classes, over which the science teachers in these schools have little or no control, all form serious obstacles to effective science teaching in these schools. That reorganization of science courses is necessary under such conditions is self-evident, and while much good work has been done along those lines, much more must be done before all friction arising from these causes disappears.

Remembering that less than five per cent of our high school students ever go to college and that but a small percentage of those that do, go to become scientists, our question becomes, "What can science do for all the others?" In this connection it might be well for us to remember that those others will always constitute a voting majority in any democracy. To answer such a question is as far beyond the scope of this paper as it is beyond the power of the writer. There will be differences of opinions at every turn, but one thing seems certain, we must find the aims of our pupils and, whatever we find them to be, we must, to conscientiously fulfill our duty, make those the guiding lights in our work. In other words, when I teach botany in a secondary school, I must remember that I am not to train botanists, but I am to train boys and girls that are potential men and women, prospective citizens and parents. It is in the activities of those fields then, rather than in that of the professional botanist, that I must seek the goals toward which my efforts should be directed. Whatever my ideals in the field

² The Underworld of Science. D. S. Jordan. Science, October 9, 1925, p. 326.

³ A Comparative Analysis of High School Textbooks in Botany. Frederik C. N. Hedebol. Univ. of Chicago, School of Education, 1924. Unpublished Master's Thesis.

⁴ Northern California Conference on Science Teaching. Science, August 21, 1925.

of botany are, they must be subservient to the ideals in my field of work, the proper development and adjustment of my students.⁵

Can science prepare for life as well as for college? In our attempt to answer this question we science teachers in the secondary schools find that we must follow other roads than those we learned to cherish at the feet of our masters. We must renounce, remove, remodel, reorganize before we can fulfill our mission properly. What then are we to do? There are certain fundamental principles which, it seems to me, should diffuse through all our work if it is to be worthy the name of science. (1) An acquaintance with and an understanding of what science is, what the scientists are doing, and why they do it. This is quite essential for any individual that is to be properly adjusted to this scientific world of ours. It should not only prove interesting to everyday people but should create "the duty of trusting intelligence"⁶ which is so necessary if "the righteous shall not be forsaken and his seed begging bread." (2) Training in scientific methods of thought. This should be given to all that can profitably benefit from such training and it should be so directed that it will form a sound defense against propaganda and dogma,⁷ something that is direly needed these days. (3) Instruction in scientific methods of procedure. This is of great importance where it is properly adjusted to the abilities and interests of the pupils.

It is through these,—the what, why, and how of science—that we should succeed in teaching the next generation of this country how to properly interpret and apply the facts we want them to master, and how to draw proper conclusions and generalizations from the facts they have mastered. Through these principles we should succeed in establishing the habits of asking, what are the facts in the case and what is the reliability of those facts? Our students should thus learn how to analyze facts and formulate assumptions on their own account, and when they have acquired the ability and habit of doing that, the principal duty of the science teacher has been performed.

But in the process of acquiring the implied attitudes, habits, skills, and abilities to evaluate, we shall want to use an enormous amount of scientific data. There is plenty to select from and the temptation is to follow beaten paths—courses taken, familiar textbooks, etc.,—because this is easy. Bearing in mind the many limitations that hamper the science teachers in secondary schools, there is some justification for their following the road of least resistance. Whenever conditions permit, however, much more effective procedures should be followed. With a well selected text as a nucleus there should be a branching out that would tap all available sources of material which have any bearing on the questions and problems under consideration. All material that was found to contribute to the following fields of human activities, in any

⁵ *Schools of Tomorrow*. J. Dewey. E. P. Dutton & Co., N. Y., 1915. Chapters I, II and III.

⁶ *The New Decalogue of Science*. A. E. Wiggam. Bobbs-Merrill Co., 1922-1923. p. 186.

⁷ *Scientific Education as a Defense Against Propaganda and Dogma*. B. E. Gruenberg, Addresses and Proceedings. Natl. Ed. Assn., 1925, p. 598.

worth-while degree, would then become part of the course, providing, of course, that time and other factors would warrant its inclusion.

(1) The physical, mental and moral health and happiness of the individual.

(2) Family relations or the health and happiness of the home.

(3) Community or small group co-operative activities.

(4) State and national or large group co-operative interests and activities.

(5) International or broad human co-operative relations.

These are all fields in which free individuals of a modern democracy are called upon to exercise their powers and the science that has nothing to contribute to the solution of problems in these fields should show good cause why it should be included in the study program of an individual who is not to become a regular science student. Just what the objectives in the above fields are, which science students in secondary schools could profitably use, are questions of curriculum making⁸ and much excellent work is now being done in this field.⁹

Yet, when the science teachers in secondary schools have gotten their bearings, found their objectives, and selected their material, the task still remains to organize this material so the best possible results may be obtained. Much excellent work has been done to aid them in this respect. The most obvious of such work is seen in the appearance of such courses as General Science and Biology, which have, to a great extent, replaced the traditional courses in physics, zoology, physical geography, etc. That such courses are better adapted to meet the science needs of many individuals is amply illustrated from their general success. But it seems neither necessary nor desirable to eliminate the traditional science courses from the curricula of our secondary schools. They have much to contribute to the keener minds of that school population, wholly aside from their professional preparatory values. What the status of the various science courses shall be is again a question which only time can answer but we may feel fairly sure that they will gradually find their places very much in relation to their contributions to the above list of objectives. But whatever the science courses are that find their place in our secondary school programs, the material used will, in each case, require organization of a definite so-called *unit type* to give the best results.¹⁰ Some very interesting experiments are being carried on along this line and already we have a few textbooks¹¹ written from this new point of view.¹²

I have attempted, in the foregoing, to show how individuals who specialize in science in our colleges and universities are likely to find themselves in a predicament when they take to teaching science in a secondary school. To fit in with their work, they must undergo many

⁸ Curriculum Construction. W. W. Charters. Macmillan Co., N. Y., 1924. Chapters II and III.

⁹ How to Make A Curriculum. F. Bobbitt. Houghton Mifflin Co., Boston, 1924. Chapter VIII.

¹⁰ Morrison, H. C., *loc. cit.*

¹¹ Everyday Problems in Science. Pieper, Ch. J. and Beauchamp, W. L. Scott Foresman & Co., Chicago, 1925.

¹² General Science. Bowden, G. A. P. Blakiston's Sons & Co., Philadelphia, 1923.

changes, and one can but venture a wild guess at the number that lost heart and quit in that period of change. Certainly, when the outlook, ideals, objectives, and methods of such individuals must be so radically changed, there seems little they have in common with those who taught them science in our higher institutions of learning. We may perhaps here make a distinction by calling our science instructors of the higher institutions *seekers of knowledge* and those of secondary schools *humanizers of knowledge*. The former has hitherto dominated the world of science, but the latter is becoming more and more important if science is to thrive and prosper. The accumulation of new and vital ideas will do but little good when they are buried in professional literature, for, in the words of one of our most distinguished scholars,¹³ "just as long as we allow these tonic ideas and energizing ideals and creative spiritual values to be unused in the corners of obscure laboratories, in the far-from-the-world philosopher's closets, and in the brains of more or less inarticulate scholars, our common life will be captured by catchwords, ruled by snap judgments, and rifled by special interests." That such is actually the case, the recent Scopes trial in Tennessee and similar happenings elsewhere, bear ample evidence.

"The humanizing of knowledge" then comes to be a special form of science work, and it is in that special form of science work that our science teachers in secondary schools should make it their particular business to excel. Although some might hold that this is not science in any real sense of that word, there are others who think that "devices and inventions which relate to the putting together of facts should rank in importance with the discovery of the facts themselves."¹⁴ Certainly, within the field of science teaching in secondary schools there is plenty of opportunity to exercise one's ingenuity with regard to such devices and inventions. But why worry about the particular scientific status of the generalist? Let him prove his worth as time goes on. The fact we need to worry about is that the tendency is for the best minds of science to be drawn into research in some highly special and technical field. That is, these minds are practically drawn away from contact with our everyday world. Either science must encourage some of its better elements to act as interpreters, as new Huxleys, or it stands in danger of losing that contact with the world which alone can counteract such outbreaks of intolerance as we see about us, and which may prove the most serious enemy to science itself.

We are all interested in the success of science, and we now have the opportunity of shaping the attitude of the coming generation toward science. Let us secure the understanding and appreciation of that generation and the foundation for further advancement has been laid. That understanding and that appreciation can best be secured through our science teaching in secondary schools. It is in these schools then that we should center our efforts, not only to create an understanding and an appreciation of science and its value to humanity, but also to sift out

¹³ The Outlook for Western Civilization. Frank, G. The Journ. of the Natl. Ed. Assn. October, 1925. p. 205.

¹⁴ The Humanizing of Knowledge. Robinson, J. H. Geo. H. Doran Co., N. Y., 1923.

and inspire the future banner-bearers of science—whether they become specialists or generalists. In our educational field much is done for that cause, and in our scientific field such efforts should not be met with mere general approval but with specific co-operation. We can well afford to direct all good efforts to the end that those individuals who are, by nature, best fitted for science teaching in secondary schools also become best fitted through training both in education and science.