

THE STATUS OF SCIENCE EDUCATION

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On every hand we hear the statement that we are living in a scientific age; that science means progress and that advances in science are far outdistancing human progress in other fields. From every quarter comes the demand that religion, politics and education move forward to meet the challenge set up by advances in the realm of science. Indeed it is no uncommon thing to hear theologians, statesmen and literary critics reminisce over the golden age of yesterday, but in the field of science no one doubts that tomorrow will dawn brighter than today. H. G. Wells, the historian, says: "When the intellectual history of this time comes to be written, nothing, I think, will stand out more strikingly than the empty gulf in quality between the superb and richly fruitful scientific investigations that are going on and the general thought of other educated sections of the community." While it is unlikely that thinkers in these other fields would care to acknowledge Wells as their authorized spokesman, yet it is quite probable that their own statements on the subject would be in a similar vein.

One would think therefore, that since science is the acknowledged leader in the field of human endeavor, science courses in our schools would outrival courses in other fields in popularity and in richness of content. It would certainly appear that in an age of automobiles, radio and super-power plants, physics courses would be crowded to the doors with eager searchers for truth; that in an age when advances in biological and medical research are adding every few years, an additional year to the expectancy of human life, we would be confronted with a tidal wave of students electing courses in these fields! Strange as it may seem this is not the case. The following figures (Table I) taken from the reports of the U. S. Commissioner of Education show the percentages of students in the various branches of science in the secondary schools of the United States over a period of 30 years.

TABLE I.—Percentage of High School Students Taking Science Courses

	1890	1895	1900	1905	1910	1915	1922
Physics	21	22	19	16	15	14	9
Chemistry	10	9	8	7	7	8	7
Botany					16	9	4
Zoology					8	3	2
Physiology		28	27	22	16	10	5
Physical Geography		22	23	21	19	15	4
Geology		6	4	3	1	.5	.3
Astronomy		5	3	2	1	.5	.1
Biology						7	9
General Science							18

It will be noted that certain divisions of science have practically disappeared from the high school curriculum, while two new fields, namely general science and general biology are on the upgrade. Physics and Chemistry are still in the fight for existence. Geology, Physiology, Geography, Astronomy and Zoology are practically out of the race and even the old reliable Botany is about to give up the struggle.

Now it will be said by some people that this evolution is to be expected because of the general enrichment of the curriculum in recent years by the addition of the newer fields of Music, Art, Commerce and industrial subjects. Students have a wider field of electives and some of these newer subjects give greater promise of vocational value. It is worthy of note however, that in a similar study of the other fields of educational endeavor, no such striking decimation is apparent. Even the much abused Latin is holding an enviable place. Mathematics likewise is holding its "place in the sun", while English and the social sciences are making gains. If the newer fields are cutting in upon the older so-called academic lines, why is science their particular prey? Even if we take into account the increases in the fields of general biology and general science, yet there is a distinct falling off in the percentage of students in science when we compare the years 1895 and 1922. This is not true for the other academic lines. (See Table II).

TABLE II.—Percentage of High School Students Taking Courses Other than Science

	1890	1895	1900	1905	1910	1915	1922
German.....	11	13	15	20	24	24	.6
Latin.....	34	44	50	50	50	39	28
French.....	9	10	10	11	12	11	16
Rhetoric.....		29	34	40	52	30	
English Literature.....			37	41	57	59	79
Algebra.....	43	52	55	56	57	49	40
Geometry.....	20	25	27	28	31	27	23
History.....	28	35	38	41	56	51	77
Music.....						32	25
Agriculture.....					5	7	5
Domestic Science.....					4	13	14
Manual Training.....						11	11
Book Keeping.....						3	11

Teachers of science quite frequently are led to declare that science courses have been put to an unfair disadvantage by school administrators and curriculum makers because science has been left quite generally in the elective field while English, History and some of the other academic lines have been kept in the required group. There may be some truth in this general statement but again we are confronted with the question, "Why are certain courses deemed of sufficient merit to warrant this discrimination?" It is unlikely that administrators will always and consistently ignore the popular demand. If certain courses are put in the required list, they are very likely there because of public

opinion. Neither history nor mathematics would stay in the group of required subjects overnight if there was a popular demand in the other direction.

Thus it seems that we must search for the cause of our trouble in other channels. It might indeed, be fruitful if we teachers of science should make an inventory to see just what sort of science instruction we are measuring out to our students. The mere fact that scientific research is bearing fruit in vast abundance is no assurance that science education may be expected to advance without improvements in technique of teaching compatible with advances in subject matter. The average high school boy or girl who elects physics or botany may enter the class expecting to learn all about the thousands of phenomena of his every day existence, only to be disillusioned by a labyrinth of mathematical formulae, technical discussion and Latin names. He becomes lost in keeping up a notebook or a herbarium crammed full of abstract and medieval data. He loses sight of a physical phenomenon in the intricate and abstract mechanisms by means of which he is supposed to arrive at a scientific truth. He questions the teacher's right to have him waste his time in proving laws and deriving formulae. A chemical change turns out to be an algebraic equation, a beautiful flower becomes a botanical specimen with an unpronounceable name and his radio set becomes so entangled in mathematical formulae that he begins to wonder how the thing works at all. Dumb as he may seem to his teacher, the truth finally permeates into his thinking processes that he is not getting what he anticipated so he either quits in disgust or goes ahead listlessly only to be turned out in the end with little or no knowledge of the subject matter over which he has passed.

It seems strange indeed that in a field of subject matter which should lend itself naturally to the concrete, so much which is abstract and uninteresting can be conjured. The fault must lie with the teacher and with his teachers in the teacher training institutions from which he has received his training. A little of the right kind of training in science teaching most assuredly would lead a prospective teacher of science to the knowledge that university methods of instruction are not conducive to best results in high school science. If there really is such a thing as technique of teaching, and educators assure us that there is, it is not at all unlikely that a study of teaching methods might help matters. It certainly must be a fact that there is some way to present subject matter of a scientific nature which will appeal to the student and which will give results. At any rate it cannot be denied that in the main our present methods of science instruction are not attended with success. As an example of the failure of high school science instruction let us call to mind the results of a test given under the direction of Dr. A. L. Foley of Indiana University in 1922. This was a test to ascertain the college student's knowledge of high school physics. The test was participated in by 1058 students in beginning courses of college physics in several of the colleges of the state, including the State Normals. The questions were simple enough and were scattered over the field of high school physics. It is not likely that

any high school physics teacher would consider the questions unfair. No high school physics course could have been imagined which did not emphasize every one of the points covered by the questions. The results obtained were startling, the grades ranging from 8.7 per cent for C. N. C. to 24.9 for Valparaiso. State Normal students averaged 21.9 per cent and Indiana 19.8 per cent. This test may not mean very much but it shows one thing and that is that some of the things which we expect high school students to get from a study of high school physics are not obtained. Surely there must be some way to get better results.

Of course it is an amusing pastime for college teachers to criticize high school work and for high school teachers in turn to criticize grade school teaching and so on down to the kindergarden, and it is only when the criticisms are supported by studies such as that made by Doctor Foley that we need take the trouble to heed them. In the December, 1925, number of *School Science and Mathematics* and in the November, 1925, number of *School and Society*, Dr. R. A. Millikan, head of the Norman Bridge Laboratory of California Institute of Technology, writes at some length upon the question of secondary science teaching. In this paper Doctor Millikan deals with several phases of the science teaching problem. One of the points which he stresses and the one in which I am particularly interested has to do with teacher training. He says in part that we have been spending too much time upon technique courses and not enough upon training teachers in subject matter. He says also that teachers' colleges are not training, and cannot by their very nature train science teachers. He furthermore states that the technique of science teaching has been fully developed and that it is merely incidental at best. In other words he challenges the teacher colleges' right to existence in so far as training high school science teachers is concerned.

Now I do not agree with Doctor Millikan at all on several points. If the technique of science teaching has been fully developed I have not heard about it. If any atmosphere is adapted to developing such a technique surely the teachers' college should have it, and not the great university. The very fact that such a technique has not been developed and put into successful practice does not speak well for our teachers' colleges for it is their business to do it. I am speaking primarily about science but I have no doubt that the training of teachers in other fields might admit of improvement. It has been my observation that a great number of university men are in accord with Doctor Millikan's ideas concerning teachers' colleges and we must not forget that their opinions have considerable weight in moulding public opinion against the ability and right of teachers' colleges to train high school teachers. There is no reason why teachers' colleges may not have faculties in science who are quite as well prepared, in so far as subject matter is concerned, to give instruction as do the great universities. As a matter of fact, a very considerable amount of the teaching of undergraduate science in the universities is carried on by instructors and assistants whose ground-

work in the fundamentals of the subject matter is quite limited. Men like Millikan do little if any undergraduate teaching.

In my opinion, the teaching of science in college to students who are going to be engineers or enter the medical profession is quite a different problem from that of training high school teachers of science. Furthermore, if there is a technique of science teaching or indeed of any kind of teaching that technique must be specifically applied in the courses of instruction given college students to fit them for high school teaching. What I mean by this is that every course should be taught with the definite teacher training aim in view. The place to apply teaching technique is in the class room where science teaching in college is carried on. Teachers of high school science teach very much as they have been taught. If their college teacher knows something about the high school problem and teaches his course with that definite aim in view, the teachers so trained should be better able to interpret and understand the needs of high school students and to put the subject matter on a plane which will appeal to them. I do not mean by this that teacher training courses in science need be of a "wishy-washy" character or of an undignified nature. I cannot see why it need be in any way less collegiate or less dignified than pre-med or pre-engineering science. In my opinion, the very fact that in the main, teachers of science in teachers' colleges have failed to recognize this aim constitutes one of the principal reasons why science instruction in high school has not been conducive to the best results. And while I believe that the same criticism applies to some extent to the other academic fields, yet the unique fact that the percentage of high school students taking science is falling off year by year indicates that in the other fields something is being done to attract students.

There is another phase of this situation which in all probability accounts for the falling off of high school students' interest in science and that is the very unsatisfactory high school science curriculum. Time does not permit, nor am I prepared to deal intelligently with this phase of the subject, but it seems to me that a revision of the science curriculum is imperative if we are to expect satisfactory results. But again this is a problem for teacher training institutions. There should be a science sequence developed, and the subject matter should be brought up to date. Motivation should be the keynote of all science teaching if we wish to make a lasting appeal to high school students. The subject matter of science is interesting enough and the present day need of scientific knowledge for everybody is unquestionable. The failure in my opinion lies in the fact that in the choice of subject matter and in the method of presentation of scientific instruction to high school students we have failed. I cannot bring myself to the thought that science is going to disappear from our high school curriculum. Something will be done by some agency to put it in its proper place. There is no agency better adapted to this task than the teachers' college.

