

**ELEMENTARY SCIENCE: ITS VALUE AND PLACE IN THE
SECONDARY SCHOOL CURRICULUM.¹**

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The last thirty years have seen a remarkable development in the direction of scientific education. Before that time science was largely a collection of knowledge possessed by the teachers in colleges and universities. At certain times during the year certain apparatus was dragged forth and a few simple illustrations were performed. These illustrations together with an exhaustive course of lectures constituted the work in practically any science. Now the colleges and universities have swung to the other extreme. Their courses are highly specialized and research work is the order of the day. The result is that the subjects known as elementary chemistry, general physics, elements of geology, etc., formerly taught in the colleges, have been thrown back into the high school, which has been making an heroic effort to bear up under this burden that has been imposed from above. It has been trying to teach an extensive body of scientific facts and at the same time give much training in scientific method to pupils a number of years younger than those of former years who were taught the above subjects in colleges. In attempting this the high school has undertaken a difficult task. The great majority of the pupils fail to get hold of the facts and are sadly lacking in scientific method. The reason for this has been a puzzle to science teachers in general.

May it not be a fact that this failure to do the work expected of the pupils in formal high school science, such as physics and chemistry, is due to the following causes:

First, the pupil, as a rule, is quite young and, as our courses are prescribed at present, is required to do too difficult reasoning when such power has not yet been developed, even in a small degree? Never before in his whole life has he been required to make clear distinctions and draw general conclusions.

Second, the average pupil has in his own experience practically no fundamental basis of facts and natural phenomena. Experience may never have taught him that he can secure an advantage in moving a heavy board by grasping it at the end rather than in the middle. He may never have noticed how a

¹Read before the high school department of the Pennsylvania State Educational Association at Harrisburg, 1910.

street car is guided around a corner, but may think that the motorman steers it around in the same way that a chauffeur does an automobile. It should be borne in mind that the average pupil of sixteen has not paid much attention to the things that have been happening around him all his life. How then can we reasonably expect him to take up a course such as is prescribed for entrance by our leading colleges and do the work with much satisfaction, either to himself or to those interested in him as a pupil?

The majority of science teachers in our high schools feel that the work in subjects such as physics and chemistry is very poorly done. They also feel that they cannot give, in one short year, a course such as is at present demanded. All science teachers of considerable experience have seen the truth of the following: A number of pupils come to us whose previous training has been identical, they have all been considered excellent students, and have made practically the same grades in the same studies. We expect them to do fine work in, say, physics; but from the very beginning we see a great difference in their ability to comprehend the subject. A few do excellent work; some with much effort do fair work, and many seem to be hopelessly lost and to stay lost in spite of our most heroic efforts as teachers to make the subject plain to them.

What is the cause of this great difference to understand regular high school science, when the pupils in all previous work have been practically equal? Is it not due to the fact that these students have had widely different natural experiences? Some have been quick to see every little thing that has happened, every little peculiarity; others have gone through childhood with eyes practically closed, and could not so much as tell you the color of paper in their own rooms at home. So it would seem that the question just asked finds its answer in this: Many pupils have no adequate groundwork of experiences upon which to base formal high school science, or if they have had such experiences they did not pay sufficient attention to them to fix them in mind.

A loud demand is being made by teachers of the sciences of the later high school years for a preliminary course in general, elementary or first year science. Many of them believe that such a course would give the pupil a broad basis of natural facts and experience in several divisions of science, such as physics, botany, physical geography, etc., with the result that he could do

much more satisfactory science work in the later high school years.

It seems to me there are other very important reasons why such an elementary course should be given. In the first place, a great many, about thirty per cent, of our first year pupils drop out of school before the beginning of the second year, or shortly thereafter. Many of these pupils have never had any instructions in science, not even in physiology. What right have we to allow a boy to go as far as the second year in high school without knowing something of the elements of a number of the sciences? Is it right that a boy at the age of sixteen should be in total ignorance of one of the greatest departments of human knowledge? It is true that many high schools teach botany or physical geography in the first year, yet there is a growing opinion that any one science at this stage of the pupil's development is too much specialized, too narrow in its application to his immediate and pressing needs.

Then, too, if the pupil continues in school he will be better able to do successful work in the more rigorous physics, chemistry, and geology of the later years. Furthermore, having learned something of the elements of a number of sciences he will be able to make a wise selection of further work in science. Many a pupil takes up work in physics or chemistry only to find after a short time that he is totally unprepared for that work. If he had had a preliminary course in the elements of several sciences, he would know that he has no ability in that line and could choose some other subject better suited to his taste and his work in after life.

Again, the elementary science course affords a fine opportunity to discover the gift of capacity of each individual pupil. Since almost all of our pupils get their entire training for life, so far as our schools are concerned, in the high school, is it not very important to discover their gift or capacity early in the high school course rather than at its close? There are so many misfits in life that any help the high school can give toward preventing them will be gladly welcomed.

Lastly, in practically every other department of high school instruction an adequate groundwork is first laid which is closely connected with the more advanced work. This is particularly true of English, Latin, and mathematics. Is it not as sound pedagogically to give pupils a general, elementary knowledge of the field of science as to give them such knowledge in Eng-

lish, where language work precedes technical grammar and rhetoric? And then, again, we must bear in mind the fact that in the first year of high school the pupil's power of sustained attention is small. He cannot long keep his mind fixed on any one thing. He is always on the lookout for new experiences and unless they are forthcoming his attention wanes. He can study for four weeks to much better advantage four new things, each interesting in itself, than he can any one thing intensively for the same length of time. It is to meet this condition of his mind that we offer a course in the elements of several sciences rather than the elements of any one science stretching out through the year.

Having considered the necessity for a course in first year or elementary science, as well as its place in the high school curriculum, let us now turn our attention more particularly to the nature of such a course.

The subject matter for this course should be very carefully selected from three or four divisions of science, such as chemistry, physics, astronomy, botany, zoölogy. In Pittsburgh it was thought well to incorporate these in our course, because those studies would best meet the practical needs of our pupils, who represent almost exclusively a manufacturing community. This accounts for the large amount of physics and chemistry in our course.

The subject matter should be closely related to the needs of the pupil and the common things in his life. Things the pupil sees and handles and talks about furnish abundant material for such a course. Yet, *in the selection* of the subject matter we are likely to make the mistake. Things that seem to be so common to us as science teachers, are by no means so common to our boys and girls. The pupil is much more likely to notice movement or mass than phenomena; he has a great dislike, as we well know, for abstractions or precise definitions. If we give him one simple principle and twenty living applications we are much more likely to interest him than if we give him twenty principles and only one application.

The elementary science course should seek to give a large body of useful information, but great care should be exercised in the selection of things to be particularly emphasized. In many respects the interests of the country boy and the city boy are different. The country boy is more closely associated with nature and her mysterious workings; the city boy is acquainted to a greater extent with things of man's construction. The country

boy would be much interested in common pumps, for he would have need of such knowledge. He would like to know about the flowers, about the insects that destroy his crops, also why some water is "hard" and some is "soft," as well as how to make the "hard" water "soft." The city boy is much interested in why street cars run, where they get their heat, how artificial ice is made, how elevators are made to run, etc. It is evident, therefore, that the subject matter as well as the emphasis placed upon the various lessons should be, in a large measure, determined by the daily experiences of the pupils and the conditions under which their lives are passed.

Mental discipline should not be overemphasized in the elementary science course, for the course is primarily to give an interesting, extensive, and useful body of common facts. While the teacher should eagerly grasp every opportunity to improve the pupil's reasoning powers and to lead him to express himself in an intelligible manner, yet nothing should be embodied in the course solely on the ground of mental discipline. Everything that is not closely related to the life of the pupil should be excluded.

The development of a course in elementary science suited to all the various conditions of the different high schools of a city or large town is a matter of almost individual concern with that city or town. City high school authorities are constantly crying for more room and smaller classes. Laboratory equipment and apparatus are taxed to the utmost by the regular classes in science, and schedules are harder to arrange than Chinese puzzles. In many smaller towns it is a very difficult matter to get money for the equipment of laboratories for the regular science work, and any request for money for first year science would be looked upon with disfavor by the board.

The cost of introducing and maintaining for a year a course of elementary science such as we have in Pittsburgh should not be too large for the average high school. Exclusive of laboratory desks, gas and water, the total expense for the first year will be between three and four hundred dollars. After the first year an expenditure of about seventy-five dollars per year would be sufficient to cover breakage and chemicals. In the larger high schools, where there are as many as six first year classes, the same sets of apparatus may be used by six or by twelve different pupils. The difference in expense for a large high school and for a small one would be the additional cost of chem-

icals and glassware. Individual laboratory work is the basis of our course and consists of the following lessons.

The speaker then gave in length the subject matter of their course in Pittsburgh which may be had from the author, adding: Our course is in many respects far from perfect, but we believe we are working along the right line; and that with careful revision from year to year our elementary science will steadily increase in value. A greater interest is being developed in our pupils in the objects about them in nature; they are using their eyes, and are quicker to observe resemblances and differences. There is an improvement in both oral and written expression, a better understanding of objects mentioned in other studies, and a quickening of mental power which ordinary school subjects do not give.

CONCRETE SPRAYING.

A pneumatic concrete spraying machine for coating surfaces with concrete mortar has been sent to the Isthmus of Panama, and it will be tested for a period of 30 days in coating the surface of rock in Culebra Cut, for the purpose of preventing deterioration. Much of the rock in the Cut, which is hard and firm when first excavated, crumbles rapidly on exposure to the air.

ANALYSIS OF FURNACE GASES.

In connection with its investigations bearing upon the improvement of furnace conditions and on efficiency in the use of fuel, the Bureau of Mines has just issued a bulletin describing the apparatus and methods in use by the bureau for the sampling and analysis of furnace gases. The authors, J. C. W. Frazer and E. J. Hoffman, say in their foreword, "The furnace conditions prevailing both in small plants and in large industrial establishments in this country are frequently far from satisfactory. If such conditions are to be improved, they must be more thoroughly understood, and means must be found to insure complete combustion of the fuel, and yet to permit operation with such an excess of air as will result in the greatest efficiency.

"In this work the services of the chemist are indispensable. A very important problem is the determination of the small percentage of unburned combustible matter that escapes from the furnace in the flue gases. Under ordinary circumstances so little as 0.1 per cent of unburned combustible matter of a furnace gas is equivalent to about one per cent of the fuel used; and for the determination of such small percentage of gas more accurate and refined methods are required than have ordinarily been available before."

This bulletin, which is No. 12, may be obtained by those interested by writing to the Director of the Bureau of Mines, Washington, D. C.