

## THE PROBLEMS OF SCIENCE TEACHING.\*

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A battle that has long been waging has been won—the battle for the recognition of science in the courses of study in schools and colleges. I remember well my first experience as a teacher of chemistry. I had accepted a position in one of the small New England colleges without having examined the equipment. When I arrived in the fall ready to begin work, I found that the institution did not possess a laboratory. I at once applied to the president for one, and he replied: "What for? I have taught chemistry, and I thought successfully, without a laboratory; and if I could do it, I think you can. This is not a technical school; what the students want is the broad general principles of chemistry." So I tried to teach without a laboratory. I was wholly unsuccessful; the students learned nothing—in fact, some of them told me so in later years. The experience was, however, very useful to me. I learned a great deal from it.

Now science is recognized; we have laboratories everywhere and laboratory training is regarded as indispensable. It is therefore fitting to ask: What are we doing with our facilities? What results are we obtaining? When the battle was on, men lost their heads—men must lose their heads in order to fight. We thought that if only we could get laboratories, the problems of education would be solved. Is this true?

Pedagogical problems are hard to solve—it is very difficult to get sound conclusions. How can we tell whether the scientific training is more effective than that of the older type? This is a problem that cannot be solved by sitting down and thinking about it; it can be solved only by research and experiment. I do not myself know whether scientific training as now conducted is producing the results hoped for. Yet I am convinced that scientific training, when properly conducted, may be of the greatest value as an educational force. This is quite a different thing from saying that that particular thing now known as science training is of great value. It all depends upon how it is done.

Personally I have been guilty of all the sins possible for a teacher of science. I have been experimenting to find out how

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\*Read before the joint session of the American Federation of the Mathematical and Physical Sciences and Section I, of the American Association for the Advancement of Science.

to teach chemistry; and it is the most difficult experiment I have ever tried. My own experience in school was very instructive to me, for my own education was most unsatisfactory—in fact, I never was educated. My first experience with chemistry was gained in a course of lectures one hour a week by one of the greatest chemists of this country, Professor Wolcott Gibbs. Yet from this course I learned nothing. My second experience came when I had taken up the study of medicine. The teacher knew little chemistry, and I was asked to assist him in preparing the experiments for his lectures. He had a large practice, and left me alone to prepare experiments that I had never seen. I am almost ashamed to confess what happened that year—there were explosions and fires and bungling beyond words. I had little or no guidance.

In my first course the instruction had been “theoretical;” in the second I had the “practical” galore. I therefore thought I was an experienced chemist and could go on and take an advanced course. It was a sad awakening when I found that I knew practically nothing of the subject.

But to return to our theme: Are we doing the best that is possible with what we now have? Do the results obtained justify the equipment and time devoted to scientific study? I am not qualified to answer these questions for the schools; but speaking for the colleges, I may say that in my opinion the results are frequently quite unsatisfactory. The reason is that we have not yet learned how to deal with the subject. It is not hard to teach chemists chemistry, but it is very hard to teach beginners something that is worth while about chemistry in one year. What can be expected of a one-year course? Have you ever seen students who obtained an intelligent knowledge of any subject in one year? We cannot expect anything of great value in that limited time. If getting knowledge of a subject is the object, we cannot expect much of even the best teachers. But the important point is: Are we doing the best we can under the circumstances?

There are two points in which it seems to me we might do better—two defects that might be remedied. One defect is that the student is not subject to enough supervision in his laboratory work. He is very much in the condition in which I found myself when turned loose in the laboratory to prepare experiments I had never seen. He is turned loose with a book, and

then left alone. This is not conducive to scientific work. School authorities do not realize the need of enough teachers for the sciences. The head teacher generally expounds the subject and leaves the laboratory work to inexperienced assistants. It is too much work for the professor to have to spend four or five hours a day in the laboratory with the students. If we could get teachers with deep interest in their subject and in their students, it would solve the problem; but in science, as in other subjects, we are not going to find these often. Unless we can find out how to produce good teachers, we shall fail to get the best results.

The second important defect in the present teaching of chemistry in college is the absence of repetition. There are too many fleeting impressions. There is a little about a great number of things, as oxygen, hydrogen, chlorine, nitrogen, phosphorus—each being treated as something new with no reminders. In language there is much repetition; each new lesson continually connects with the past work. Yet it is only by repetition that we learn. We do not learn a game by being told how to play and then trying it once. Repetition is largely lacking in science teaching. We cover too much ground. The student gets only a veneer. Knowledge of this sort is not of much use, and the drill given by such study is not effective. We must introduce into science teaching the drill element that comes only from repetition of the sort that is characteristic of languages and mathematics.

Chemistry has one kind of work involving repetition of the right sort, namely, qualitative analysis. This field offers good educational possibilities, but the work is in great danger of becoming mechanical. The student is prone to go through the motions with his mind on his book, to guess at the results, to report, watching the reaction of the teacher closely, and to get credit. In order to introduce this element of repetition, quantitative work has been introduced to save the situation. Some quantitative work is desirable. It makes it possible to keep a student at one experiment till he has obtained good results. Such work is monotonous, though it has the advantage of not requiring the student to cover too much ground.

The remedy for these two important defects is unfortunately unattainable at present. We must get good teachers. Much is being done in the way of training teachers, and much that is good is coming from this work. Yet we must not forget that

good teachers are not easily made. It is harder to train a teacher to conduct laboratory work efficiently than to train one to teach mathematics or a language. In science the laboratory presents a new problem, and serious errors have occurred and are occurring. Yet, in spite of this, great progress is being made, and there is little doubt that in the end scientific training will fully justify itself in the schools and colleges.

In closing let me again specifically state that I do not consider myself competent to speak of science training in the secondary schools; all that I have been saying applies, so far as my own definite knowledge goes, only to the colleges.

### A RETROSPECT AND A VISION.\*

BY WILLIAM E. STARK,

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One can always see a thing in truer proportion by viewing it from a distance. In the last three years since I gave up teaching physics, my confidence in the validity of some of the principles to which I had clung for years has gradually weakened and the number of things which I think that I would do differently, if I were to teach the subject again, has gradually increased. I have no intention of making a sweeping criticism of present conditions and I do not presume to be qualified to judge your work. I propose merely to speak of the misgivings which have come to me about my own teaching and of an occasional vision of something far better which has appeared within range in moments of optimism. I hope that my experience may touch yours closely enough to make my confessions and my suggestions of interest. I shall be particularly interested to know how far you men who are teaching physics regularly will agree with my notions.

As a schoolboy, I had the Harvard course in physics soon after it was devised, and in all the years of my teaching of the subject, I have had college preparatory pupils. It is not surprising, therefore, that the forty experiments should have filled a large place in my conception of the proper course for high school pupils. I was always rather more fortunate than the average teacher of physics, in regard to time allotment, and was,

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\*Paper read before Physics Club of New York, March 7, 1908.