THE TEACHING OF PHYSICS[1]

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Statistics published by the United States Commissioner of Education in 1916 show that from 1895 to 1915 the percentage of high school students taking physics dropped from 23 to 14. Except for the brief stimulation toward the study of physics during, and immediately following, the World War, and perhaps another slight revival following the advent of radio broadcasting, the popularity of physics in the high school and in the college has decreased. This has come in spite of the most wonderful advancements in theoretical physics and during the most rapid application of physics in developing the means of amplifying our lives that the world has ever known. The newspapers and magazines abound with references to the wonders of modern science, a true appreciation of which requires some knowledge of physics. In this "scientific age" everyone must know how to drive a car and to use many different types of machines and instruments, which requires considerable knowledge of the fundamental principles of physics to be able to use them effectively. Why, then, do so few students in high school and in college elect the study of physics?

Of course, all those contemplating a medical or an engineering career realize they must take physics, though they seldom appreciate how fundamental the study of physics has become in the medical as well as in all the engineering courses.

In an article on *The Plight of College Physics,* School Science and Mathematics, April, 1928, Dr. John G. Frayne, of Antioch College, says that the chief reason for lack of interest in physics is the poor methods used in teaching it. Some of his reasons are summarized as:

1. The best physicists are devoting all their efforts to research in the subject matter of physics.
2. There is no research in the methods or technique of teaching physics.
3. Promotions are made for productivity in research work, while teaching ability is ignored.
4. Physics is still taught very largely as it was in 1900, though the subject matter has changed considerably.
5. The general A.B. student gets very little of the new physics.
6. The elementary physics is very largely in the hands of inexperienced teachers.
7. The text-book is followed closely and the laboratory exercises require no thought or imagination.
8. The experiments are isolated from the rest of the work.

[1]Presented before The Tennessee Academy of Science, April 27, 1929.

9. A list of dont's is required to protect the delicate laboratory apparatus.
10. The accuracy and speed demanded in the laboratory lead to purely mechanical operations.
11. The lectures are usually the only interesting parts of the course.
12. The recitations are boring to all except the flunkers.
13. College physics is so dull that less than 1 per cent of those in this course take any more advanced work in physics.
14. Research work does not necessarily improve one's teaching ability.
15. Research men are not interested in elementary physics and often make a fizzle in trying to teach it.
16. Teaching ability should be put on a par with research, but no isolated institution can afford to do this alone.
17. Experimental methods should be adopted with a view to improving teaching.
18. Instruction with, and without, laboratory might be compared.
19. There are a great many problems in the teaching of physics that should be discussed and tried out.
20. Master's theses should be either on the problems of teaching or on the subject matter of physics.
21. Doctor's theses might be limited to the subject matter.
22. "There is at present no institution in the country that is capable or desirous of doing this job."
23. The most important matter facing the physicist today is that of interesting the general public in the absorbing problems of physics.
24. There is no "course taught anywhere today that is designed to arouse the intelligent interest of students" in the liberal arts courses.
25. The public is not satisfied with the physics that is being taught.
26. Better teaching is sure to redound to the benefit of research.
27. Something should be done very soon to put physics in its rightful place on the campus and also in our daily lives.

Most of these points may be true for many of our colleges and universities, but Dr. Frayne is evidently not aware of the modern trends in science education as shown by the more recent textbooks and by the published researches in the teaching of physics and the other sciences. Miss Van De Voort's report shows that courses in the "Teaching of Physics" have been given at many of our teachers' colleges for years, and some research work in the methods of teaching physics has been carried on at a few of these institutions. Just now, there is considerable discussion as to the value of individual laboratory work in the elementary courses. In the January number of School Science and Mathematics, W. C. Croxton has an article entitled *Shall Laboratory Work in the Public Schools be Curtailed?* in which he tries to show

from the researches of Cunningham and others that the individual laboratory work gives the most lasting and important results. In the last number of this journal, E. R. Downing publishes a criticism of that article, claiming that Professor Croxton was biased in his interpretation of these researches, and that several investigations have shown that the demonstration laboratory method is superior to the individual laboratory method both in immediate and in lasting results. To me, the whole trouble seems to revolve around the type of individual laboratory work investigated. Downing and most all other investigators have compared the results of modern methods in conducting demonstration laboratory experiments with the kind of individual laboratory work Dr. Frayne is talking about. Professor Croxton and some of the rest of us are just as certain as Dr. Downing is about the inefficiency of the old type of individual laboratory work in which the student goes into the laboratory to verify some law or principle that he is already supposed to know.

When the laboratory work presents, through a process of reasoning from one's own observations, the fundamental laws and principles, the apparatus must be very simple, so that as little time as possible is lost in learning how to use it. Yet, it must be sufficiently accurate that, in the hands of most of the students, it will yield results which clearly show the fundamental principles involved. Such a laboratory course has been conducted during the summer quarters at George Peabody College for Teachers since 1915, and since 1927, throughout the year. Many new types of simplified apparatus had to be invented before this type of course could be carried out successfully in all its phases. No publicity has been given to this course because it has not seemed wise for the average teacher to try to use this method until the special apparatus needed for it could be made available. So far, the laboratory manuals designed for this course have been restricted to the use of teachers who have seen and handled the apparatus specified therein. (A bulletin describing all the apparatus needed for this manual is finally nearing completion and will soon be ready for distribution by one of the standard apparatus manufacturers.) The primary object of this laboratory course is to lead the student to think out from his own "directed experience" the reasons for all the phenomena he observes. This method has been advocated by several noted teachers and has been used by some of them in a few of their experiments. Each laboratory exercise becomes a project, with all the advantages proclaimed for that method.

Let me quote the conclusions from an article by Prof. W. S. Franklin in "Science," April 12, 1929.

> "I know from experience that most of our students like physics when the teaching is directed insistently towards the development and use of precise ideas or towards what may be called training in analytical thinking; and I know that our students can be carried far in this mildly difficult but highly profitable business. In fact, I have always found my students to be so eager and enthusiastic that I could not wish them to be more eager or more enthusiastic.

> "In my opinion and according to my experience interest in the study of physics is *not* dependent upon the introduction of descriptive physics or on the application of any of the principles to practical engineering problems except of the simplest and most familiar kind; an almost purely analytical course in elementary physics arouses intense interest if one heeds Bacon's admonition and connects every detail of analytical method with actual conditions and things. The greatest fault of an earnest, hard-working teacher is to be exacting—and unintelligible.
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> ". . . The only object worth talking about is training in analytical thinking. Increase of our powers of thought is the greatest gift of the sciences to mankind."

It has long been the belief at Peabody College that the most important function of a teacher's college is the training of teachers in the methods that will best develop that type of analytical thinking which Franklin believes so important. Of course, much research work is required to find out the most effective methods of training such powers of thought.

Various accrediting agencies have frowned upon any non-quantitative experiments, but I believe there are some qualitative experiments which develop to a greater extent the powers of accurate analytical thinking than many of the older types of quantitative experiments. As an illustration, I have set up here a model telephone line, with the parts so simple and easily studied that students can easily follow the instructions and learn the functions of each of the essential parts. Finally, they connect it up as here shown, and are able in the end to trace out the nine energy transformations between the vibrating vocal cords at one end and the vibrating ear drum at the other end of a long distance telephone line. The students get a real kick out of talking to each other over such a line into another room. This microphone may be made more sensitive than the regular commercial transmitter as it will pick up and transmit a conversation from a distance of ten to twenty feet. The instrument will be demonstrated at the end of the morning session.