

A PROPOSED IMPROVEMENT IN PHYSICS TEACHING.

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I must ask the privilege of making the subject I have been assigned a part of a larger one, or rather to show that the difficulties attending the improvement of physics teaching are but a phase of a general problem in high school work, for which problem I propose a solution, the case of physics being a concrete application.

Later in the paper I will take occasion to recommend the introduction into the high school course of work not at present approved by the university.* In many schools, the present requirement of 15 units fills the four years to the full and such introduction would be impossible. Realizing that the proposed experiment in the teaching of physics is but one of several departures at present demanding trial, and that nothing short of the data of actual experience will satisfactorily settle the debates arising as to the relative values of subjects and methods, I have proposed a mode of relief, the granting of which would depend upon the University.

The change suggested, while adding materially to the dignity and responsibility of the high schools, would tend to promote rather than diminish the co-operation between them and the University.

I am not to suggest improved apparatus or new experiments, although few can surpass me in my interest in such things. I do not expect to show how largely the percentage of error has been decreased in our laboratories or how our boys are earning renown by original research and new discoveries.

Let me refresh the memories of some of you by reference to the high school physics of twenty-five years ago. Physics was then largely a show subject. The professor in the midst of his machines was the envy of the boys and the bewilderment of the girls. Complex pieces of mechanism gyrated and the universe according to Silliman fell into order. In the course of time it became a matter of common report among educational authorities that in all this the minds of many students failed to keep to the track of strictly inductive reasoning and were rather taking

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what they saw on authority. It is noteworthy in this connection that many leaders of today's scientific world were reared on such unscientific pap and pabulum. There followed a movement toward individual experimentation that was overwhelming. Since the boy could not be trusted with expensive apparatus, or even be furnished with it, cheaper forms came into use. The craze for home-made apparatus spread, and was checked only by the requirement of the higher schools that the pupils know more physics even at the expense of sloyd. The improvement in apparatus for student use has been steady and the equipments of high school laboratories, while leaving much to be desired, are generally effective and growing more so.

The text-book in physics has not varied widely from the beaten track. Some have emphasized the utilitarian side of the subject, others have made much of the literary style. Some books have been poor and many have been good, but all in all, the text-book in physics has remained a pretty constant quantity, its field more definitely limited, its material more logically arranged, than that of any other subject in the scientific curriculum. I think, further, that the mode of presentation of the subject today in laboratory and class is probably as uniform the country over as in the case of any other subject taught in the high school.

Now, in spite of the improvement made in the teaching of this subject and in its material equipment, I question seriously whether results show the same degree of improvement and of superiority over other subjects.

I recognize the need of accurate work as a foundation for engineering and of inductive experiment for scientific attainment. But something vital has been lost in the transition from the old physics to the new. I can remember the time when physics was one of the most alluring and entrancing subjects of the course. I cannot find indications that this is true today. The high school pupils do not choose it at all generally when left free in the matter. Indeed, when they go to the university it is rumored that they do not continue the subject unless compelled to do so from the nature of the course chosen, and as in the case of Latin, it seems necessary to classify it among the "infant industries" to be protected. The spontaneous days when physics was a field of wonderland seem largely to have passed.

Teachers of physics in high schools also complain that the more

recent and exacting phases of physics are apparently totally foreign to the nature of a considerable number of students, especially girls, upon whom the course is thrust. This difficulty is obviated in some schools by making physics wholly optional. But to one studying education in any broad way it is evident at once that this is no solution of the problem at all. Physics is the most fundamental in its conceptions and the most practical in its applications of all the sciences. The proposition to leave any portion of those who take a complete high school course with no knowledge of it, is in itself a complete acknowledgement of the educational inadequacy of the present methods.

I take it that the charge to be brought against the present course and method in physics is that they lack the qualities that take hold of the youth, they do not touch them vitally. The work with micrometers, while a valuable and essential preparation for what the university offers in later courses, lacks life. So called inductive methods demand that there shall be no preconceived notions about results and that no thrill of expectancy shall mar their scientific precision. Self control and death may have some points of similarity but their difference is life. The magnificence of the repressed and controlled and directed power of the great scientist is only simulated by the high school student, but in his case, or perhaps better in *her* case, it is generally nonchalance and patronizing disinterestedness.

It remains to locate the difficulty and recommend a cure. The first part of the task has already been outlined.

First: As already intimated, the elementary physics teaching of today, to a great extent, lacks the larger phases present in the old illustrated lecture plan. The inspiration of wonderful outlooks into the field far beyond where the tyro could expect to go in high school but might hope to tread secure at a later day—this is crowded out for lack of time, and perhaps, as being too sanguine for a cold blooded scientist.

Second: The lack of a preliminary acquaintance with the field is another conspicuous source of weakness. That boys in general surpass girls in the subject, tends to confirm the supposition that this is a source of difficulties in physics teaching.

Much gain in time and in effectiveness will be obtained in any field of study if an adequate survey of the entire field precedes the detailed attack upon any part of it. This principle is nat-

urally more effective in closely organized subjects. The lack of such preliminary survey, or preview, is the source of much waste of time and energy through the entire educational course. Did you ever know of a railroad setting its grade stakes without a preliminary survey? Did you ever listen to a person read aloud who gave equal emphasis to all words, including the a's, and's and the's? The result is an early and profound weariness on the part of the auditor. It is the business of the reader to furnish by reasonable emphasis, perspective for the hearer who is so situated as to render a survey of what is coming impossible. The effort of the auditor is then distributed proportionately to the importance of the parts of the sentence and discourse, and economy of effort produces a maximum of interest. The value of the preview of a lesson which teachers are frequently urged to give their pupils, lies in the perspective thereby furnished the pupil. He sees the relativity of its parts and can use his forces economically.

With these ideas pressing themselves home upon me, I have attempted to remedy the defects evident in the physics work given under my direction.

The subject of physics has its five departments of mechanics, including dynamics, heat, sound, light, and electricity, each with its principles to be elucidated, comprehended and applied—departments that are practically separate so far as concerns any co-ordination that will materially aid the beginning pupil—and I came to the conclusion some time ago that the time allotted to these five fields, after considering the sort of work that is to be done in them, was disproportionately small. Accordingly, I lengthened the course in physics to a year and a half with some improvement in results. But the main objections first enumerated still applied. Inspiration, experience, and perspective were still inadequate. I then arranged the work as we are now successfully giving it and it meets the difficulties that have been mentioned, as well, I believe, as they can be met in the time allowed and under existing conditions.

The aim of the present plan is to give a half year's preliminary survey of the subject, covering the field, and making it familiar in a large way.

For the last half of the third year a course in physics is one of the assigned subjects. No text-book is required or desired. It is non-essential as to where a beginning is made. Complexity is no

barrier. "From the simple to the complex" is the motto of past work in physics. "From the near to the remote" is the motto of the proposed plan. Under this plan, a steam engine can be more profitably studied by the beginner than the simple lever. The need of the study of the simple lever may then be made to appear. We study the simple lever in the light of the steam engine rather than *vice versa*. As a matter of fact, we have begun our course with the study of light. A beam of light from the window or lantern is under control on the lecture table and essential materials are at hand. A list of the questions to be answered is on the board when the class arrive, and the present status of the knowledge of the class is briefly ascertained, together with their shrewd guesses at what results should be. The answers are obtained from the experiments. Questions from the class are encouraged and are rationally answered, if possible. Before the next recitation the pupil writes up carefully notes on what he saw and learned, the same constituting his ticket of admission to the next day's period of experiments and discussion. Little effort is made to test the pupil's knowledge, the aim being to concentrate interest and inspire pupils to interpret what they see in rational terms, and to enlarge the field of view and give bright glimpses of fields beyond. To pull up the sprouting seeds every few days to ascertain progress is discouraging to the growth of infantile ideas.

The actual results with a single class have been favorable, among the most noticeable improvements are:

First: A portion of our pupils who probably could not do satisfactory work in quantitative physics are now given an outlook into the field and a familiarity with it that every rational citizen in an educated community ought to have. Further work in the subject is wholly optional.

Second: The majority that go on and take the final year of physics, with its text-book and individual laboratory work have enough perspective to be able to economize time and effort.

Third: The increased interest in the subject and in the solution of its problems by those who have continued the subject is clearly manifest.

Fourth: The effectiveness produced in the study of the theory is equally perceptible in the handling of apparatus. A clear knowledge of the end and aim of experimentation and an interest in results tends toward mastery.

The objection which may be made that a preview of the subject interferes with strictly inductive methods might once have had influence with me, but it seems to me without force, after having given both methods a trial. Impartial justice is of slow growth. It is not founded on ignorance. Justice is wrongly represented as blind, although much so-called justice is of the blind sort. Scientific honesty is not best cultivated in darkness.

The remaining and telling objection against the suggested course in California is that the university allows no credit for it, but if the schools are given an opportunity to show the course valuable, the university will doubtless in time allow credit for it. All that is needed is some liberty on the part of the schools to use their own discretion in a small portion of the course. Regarding this limitation of our liberty to attempt this, or any other original work in our courses, I wish now to speak.

Allow me to preface any criticism I have to make as to the practical effect of university domination of our American high school curricula with the statement that I fully appreciate what the universities have done in building up high schools and securing improved scholastic standards. And to any who feel inclined to believe that a total separation from the university is preferable to our present plan of co-operation let me suggest that the independent university, setting its own entrance requirements, virtually establishes the curriculum of tributary secondary schools and the real needs of the high school have then no channel through which the university may be reached, as is the case where co-operation is attempted.

Co-operation between these institutions has been helpful to the high school. I have worked in high schools of two states in which high schools have been largely dominated by the university and in one where no such influence was felt, and I am ready to testify from experience and observation that the advice of the university and its backing form a remarkable stimulus to schools and communities, and that its high and uniform standards serve to overthrow much self-sufficient quackery in teaching. The growth of high schools has been most remarkable where the co-operation has been most pronounced. The admirable high school systems of Michigan, Wisconsin, Minnesota, and California testify to the value of university co-operation. It also behooves us to remember how the backing of the universities has changed

our high school certificates from the wild cat currency of former days into diplomas that have some uniformity of value—even though we may not bank them with these same universities.

Having said this, I wish to insist sharply that there should come a time in the life and development of an institution, as of an individual, when, though still receiving the expert advice of its elders, it should yet be largely freed from the dictation that up to that time may have been highly essential to its welfare.

I believe that the time has arrived when the high schools of California should have growing liberties in this matter of the curriculum and the presentation of subjects in the curriculum, but we are met by filling to the full the four years of our course with work handed down to us—"all the traffic will bear." Again, there are those of us teachers who are next to the problem and the patient, who cannot think we are presumptuous in feeling that our prescriptions ought to be more valuable than prescriptions coming from absentee authority, even though that be expert in its line; and it is to be said that our present curricula as handed down by the "powers that be" are frequently not professional prescriptions at all, but rather, compromises among the apothecaries working for opposition shops.

If past history and present conditions may be taken to indicate the future, high school curricula will change materially in the next one or two decades. Whether such changes will represent merely the shifting ascendencies of university departments or healthy growth from within will depend on whether or not the high schools are given some room for self-directed growth. At present the University of California requires definitely 15 year-units out of a possible 16. It is not to be presumed moreover, that any fallible committee will have fitted all the requirements to the capacities of all the schools. Indeed, I am told that most of the high schools find the proper presentation of the $1\frac{1}{2}$ units of algebra of the university requirements in a year and a half inadvisable to attempt, and later some other subject will doubtless be out of joint. Again, local situations arise where owing to the poor preparation of a class, or to poor teaching, it may be advisable to spend more time with one class than with another. Under present conditions, the temptation to pass such a class is very strong. In our own school we are using a half unit extra in the half year of physics required without university credit. Thus a half year-unit or less is the present limit of high school liberty.

All that we need ask from the university to insure continued but conservative changes—such as both university and high school may easily accommodate—is that the diplomas from such schools as may be fully accredited should be accepted for two of the 15 required units. I would not ask a reduction in the number of required recommended units, but simply two year-units which we may assign along lines which we may think best for the good of the cause, the school, the class, and the individual. Let the privilege and responsibility be extended under such safeguards as seem best, I have confidence that it will finally meet general approval, and that it will be a source of healthful growth in the high schools, and will awaken interest among university people in the real problems of secondary education.

I crave your pardon for this digression from the subject assigned to me, but before much can be done in the way of improved methods in any line of the preparatory course, more freedom of action is absolutely essential.

Referring to the main argument under my subject I will sum up by saying that I would have the conventional course in physics optional and preceded by a required half year covering the field. it being the attempt of the teacher to give the pupil, by means of directed observation, well-conducted experiments, and conversation, a coherent and luminous view of the field of physics from all its greater eminences.

It is my belief that such a course is valuable to those of our graduates who do not go on to college that they may become intelligent members of society, able to some extent to discern between science and pseudo-science in the current literature of the day, and to have a sympathy for what is scientific in a scientific age. That it is a course of great interest to them I have proved in practice.

It is my further belief verified by some experience, that those who take the college preparatory year-course in physics, after this preliminary course, will do so with more vital interest in the subject and more efficiency because of the perspective gained.

Finally, should the university repose such confidence in selected and accredited high schools as I have here proposed, I predict such an outcome for the experiment as would vitally improve the educational system of the state and be of more than state interest and importance.