**THE SIGNIFICANCE OF THE REQUIREMENTS IN PHYSICS
OF THE COLLEGE ENTRANCE EXAMINATION BOARD.¹**

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Physics is poorly taught in the colleges—quite as poorly taught in the colleges as in the high schools.

The duty of fitting the colleges for the high school graduates is quite as urgent as that of fitting the high school pupils for the colleges.

The colleges should prepare teachers of physics for the high schools but those who are most recently come from college are the most conspicuously unfit for teaching high school pupils.

These conditions must be kept in mind when preparing a syllabus of work for high schools.

By years of contact with high school problems some college graduates who are capable of adaptation have been transmuted into good teachers of physics. Such were the six high school men chosen by the College Entrance Examination Board to prepare the present syllabus.

With the clear understanding of conditions as they exist at present, they did the wisest thing that could be done under the circumstances. Education must be a conservative thing. Changes must not amount to a revolution. What these men did was a step in the right direction, and a sufficiently long step to be practicable, yet it is not the end of progress toward better things, it is merely a small beginning.

It is worth while to remind ourselves that the so-called College Entrance Board is not in reality a college entrance board. It is merely an examination bureau. It has gradually succeeded in getting its certificate accepted for entrance by most of the colleges just as the regents of the state of New York have done, but unlike the regents this board could not continue to exist if its requirements on examinations did not conform pretty closely to what the colleges demand. Its real name is, The College Entrance Examination Board—with the emphasis on examination. By calling it as we do, for short, the College Entrance Board, we sometimes mislead ourselves as to its importance. It cannot be expected to be so much a leader as a follower in educa-

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tional progress. The committee was well aware of the restricted functions of the board and therefore committed it to no embarrassing position.

On the other hand this board as an exponent of the colleges makes it known that the colleges have now for the first time become ready to recognize the fact that the high schools are better able than the colleges to determine what should be expected of high school pupils. It behooves the high schools to get ready for some constructive work and to take a step forward each year in the matter of these physics requirements.

Let us first examine the report of this committee and see what changes they have made and then consider the next changes which should be contemplated.

The greatest hindrance to good teaching is not the syllabus. That like all codes of law is capable of many interpretations and may by exegesis be made to justify all practices; not the examiners, for under the regime of the College Entrance Examination Board they have usually been broad-minded men, and at any rate their sole function is to frame questions—which again are capable of many interpretations—but the real block upon high school teaching are the readers and raters of examination papers and laboratory notebooks. These men are a law unto themselves and their rules of conduct have never been published. It is certain that they have not the same outlook upon education as the board has or as its examiners have, and it is equally certain that they exert ten times as much power as either the board or the examiners in shaping the high school work.

The most unsatisfactory part of the physics requirement (or supposed requirement) has been the laboratory work. I say, supposed requirement, for probably no one in any position to *require* has ever wished for such extremities of mathematical frivolities as many of the recent offshoots from the colleges have vainly tried to implant in high school laboratories. As usual the disciples in trying to imitate their masters have greatly exaggerated their foibles. Unconscious that what is bad for college students is worse for high school pupils, they have seized upon what was either evil or without significance in their own college laboratory work and wrung interminable changes upon it for high school pupils.

The real laboratory requirements, however, as executed by the readers have been a great handicap to good teaching. The reader's interpretation of what an orthodox laboratory notebook

should be has never been authorized and never published. From the record of successes and failures of their candidates the high school teachers have inferred that the readers insisted upon the notebooks containing much of that which I should regard as not physics at all. The high school teachers have likewise found that small credit would be given to that which this committee declares is the very aim of laboratory work, namely, "to supplement the pupil's fund of concrete knowledge and to furnish forceful illustrations of fundamental principles and their practical applications. To perform exercises such as yield results capable of ready interpretation and free from the disguise of unintelligible units . . . Unnecessary mathematical difficulties being avoided and care being exercised to prevent the student's losing sight of the concrete facts, in the multiplication of symbols."

Most of the unjust rating of candidates for admission to college has been the result of the absurd attempt of human minds not widely trained to estimate the value of the laboratory work of a total stranger by glancing over in four minutes the notes which required a year in the writing. No demand has been more insistent than that this abuse be stopped. A majority of that committee of high school men went into the meeting fully determined that it must be stopped.

The first and most important reform which they have brought about is that The College Entrance Examination Board will no longer undertake the marking or examination of laboratory notebooks. The high school teacher is to certificate the laboratory work wholly according to his best judgment. It is no longer indicated to him by the syllabus what shall be the nature of the laboratory work.

It will doubtless need to be that which will best help the pupils to pass the topical examinations, but I estimate that fully one half of the time now given to laboratory work in many of the best schools does nothing toward helping the students to pass the examination questions and does nothing toward giving them a clearer understanding of physical principles. Since half of the time given to the study of physics in these schools is devoted to the laboratory the way is now open for them to save one quarter of their efforts for work that is worth while. If the committee had done nothing else than to abolish the rating of laboratory notebooks by readers, we could easily have been sat-

isfied for one year. For now there is no reason why a capable teacher may not make all of his laboratory teaching fruitful. Before, much of it had to be barren by specific requirement.

In the number of topics which appear in the syllabus the committee left a larger prescription than the high school teacher can do well—but it probably did all the pruning that it was safe to do this time. The most efficient teachers are the ones who will see the largest possibilities in each topic for instruction and will therefore feel the greatest burden. Many complaints from such persons are coming in, and now that the high school teachers have their hand in they will doubtless bring about a reduction in the number of topics when the syllabus is next revised. The committee probably had in mind that the field was too broad to cover thoroughly when they made their second recommendation which reads as follows: "We urge upon those who prepare the examination questions that these be so planned that students who have received fair preparation on the work as here outlined may reasonably be expected to pass." This sounds very different from the boast which has been made that after casting out one-third of each class during the four years of the high school course we serve the cause still farther by knocking out half of those who try for admission to college. This committee of high school men speaks with some of the missionary spirit appropriate to those who in the service of the people are trying to extend the benefits of education.

It is not expected, I presume, that I should discuss with this audience the specific additions or omissions in the list of topics. You care not, I presume, whether $f=ma$ is included or excluded. Yet I must tell you that a considerable amount of such pestiferous knowledge has been removed from the syllabus.

Now a few words as to the future. I am speaking to an audience composed of principals of secondary schools and of the teachers of all the various high school subjects. We all have, however, a common cause and it is upon our common problems that I wish to speak. The same thing is the matter with physics teaching as with all other subjects. I saw a young college graduate teaching a high school class in English. She had detained them six weeks on the first third of *Ivanhoe*, using the method of the higher criticism. She informed me that it was the only way to get them ready for college. Which is true. It is also true that it was the only way she knew for teaching *Ivanhoe* and for

both of these the colleges are to blame, but, worse than all, when after attending educational meetings and reading educational literature and having a few years' more contact with the high school pupils she learns a better way of teaching *Ivanhoe*, she will be prevented by college requirements from using it, unless the high school men reform the requirements.

I saw another college graduate teaching botany in a Western high school—a school accredited by the state university. They had for many weeks been examining plant cells with a compound microscope and filling many pages of notebooks with drawings of them. I asked if so much of this work were desirable. She said, "No, but the university inspector requires it." There was lying upon her desk a copy of *Bailey's Botany*, full of useful knowledge such as those high school pupils need. I asked her if it would not be better to give them that. She said, "The university would not approve it." It perhaps should be said in justice to the universities that such approval or disapproval generally comes from a minor officer—but so long as the universities allow their minor officers to act as their spokesmen they cannot escape the charge of being either ignorant of or indifferent to the cause of secondary education. These are not peculiar cases. There is no subject which can be well taught in the high schools to-day for the simple reason that the colleges prevent it.

The case of high school physics to-day is analogous to a situation which obtained for Latin thirty years ago. It was the practice of some teachers then to spend two or three weeks previous to the teaching of *Virgil* in training pupils in the rules of the grammar which applied to scanning poetry. These rules with their exceptions numbered several scores. They were learned, "and stored in memory so that pupils might have them to use when they came to the business of reading *Virgil*." It often happened that *Virgil* was taught by another teacher and frequently this teacher made no mention of scanning but of course if he did he discovered no ability in the class to use those rules of grammar. This is precisely the case of high school physics to-day. The high school teacher feels obliged to teach what might be very well called the rules of physical grammar. Some teachers know that language teaching must come before grammar, but the real powers that prescribe the work for all teachers, good and bad alike have not yet got beyond the a-b, ab method of teaching. After compelling the high school teachers

to teach by an impossible method and one long since discredited in other subjects, these college people are surprised to find that the high school pupils do not understand physics.

This topical syllabus is a list of principles. A few teachers are urging that some practical applications be added, as if to say, "Some few sentences from good literature should be appended to interpret the rules of grammar," but for every one teacher who dares to suggest this a dozen will respond, we have not time to teach applications, the list of principles is so long and in any case we cannot teach applications before we teach principles. And the readers of examination papers on their part say, "We cannot rate questions on applications of principles; they are too indefinite; we must mark on the principles and particularly on the mathematical work, for that is definite." The examiners have on several occasions attempted to encourage teachers to enrich their work in physics by asking some general question about, say, the heating of buildings. Such questions cause great perplexity to the readers and they decide by conference what specific answer will be given full credit and allow nothing for any other. As, for example, if the candidate explains specific heat in answer to the above question it will be rated correct but a paragraph or a page of other replies, however intelligent, will be rejected without credit.

The makers of the syllabus and of the examination questions are still further moved to eliminate applications because applications in physics must of necessity vary with locality, occupation, sex of pupils, etc., and the whole business of standardizing physics and bringing about a glorious uniformity runs counter to this.

The truth is that the so-called fundamental doctrines of physics are fundamental neither to the science of physics nor to the teaching of that science. Our doctrines in physics are no more fundamental than they are in religion. We change them oftener. Neither are these principles any more help to the *teaching* of physics than Calvinism is in the *teaching* of religion.

I hope the high school men, pushed on by the public which is behind them, will gradually change that list of principles in physics to a list of physical phenomena or rather experiences which one may encounter in life and of which the ordinary man desires an explanation. And I predict that when high school pupils have been taught to notice the experiences of

a physical sort which their lives present to them and to classify them so that one fact throws light on another, they will come to the college instruction with a gratifying ability to grasp physical principles. But it must be their own life experiences, found outside of the conventional laboratory—and not such as may be prescribed for them by some central body, whose only anxiety is to rate and uniformitize the contents of pupils' minds.

Our besetting sin in physics teaching is something which goes under the euphonious name of thoroughness. We have a block-measuring mania in some parts of the country.

Pupils are required to measure the four edges representing the length of a block of wood to the tenth of a millimeter which is $1/254$ part of an inch. These are to be averaged and the result taken as the true length. In like manner, the four edges representing the width and the four representing the thickness are to be treated and then these results are to be multiplied together and the volume recorded in terms which represent less than $1/1,000,000$ of a cu. in. The pupils know that the exercise lacks common sense, since the measuring sticks are crude, the edge of the blocks are battered, their faces are not perfect planes, and the human eye is incapable of reading such microscopic dimensions. If such training has any effect it would seem rather to disqualify them for making useful measurements like the length of the school room or estimating its height. Consider the years spent in drill. The elementary school-teacher devotes a very large portion of time to drill upon mathematics. The high school teacher thinks the grammar school training is defective and he takes up the drill upon mathematics. The college teacher believes the high school training is defective and he attempts the same drill. In this series of onslaughts upon the students the college teacher effects the least results and the elementary school-teachers' work is the most efficient. Investigations show that drill in mathematics beyond a certain few years of it have no effect upon the pupils' abilities.

The percentage of high school pupils studying mathematics increased during the fifteen years, 1890-1905, from 66% to 88% and during the same time the percentage of those studying physics decreased from 22% to 15% and as though that were not bad enough we have tried to convert physics into mathematics, and we have been told that this was in the interests of thoroughness.

I predict that school pupils will some time have the privilege which we, who have got beyond the domination of our school-masters, enjoy of learning many things with the intention of forgetting them immediately—more than half of the subject of physics should be so treated. If we adults had to learn thoroughly and retain for somebody's examination one tenth of that which we find it both delightful and profitable to learn each day we should be miserable.

These children know wherein we wrong them and the best of them are longing for the time when they may rise above us. Is there any reason why we should not be willing that the children should learn by the same method which we find profitable? We learn by the smattering method—first a passing introduction—a mere fleeting impression—then time for the ideas to incubate, and after a while another meeting with these ideas from perhaps a different standpoint followed by casual meetings at intervals. The method of the daily newspaper reader is producing clear thinkers.

Another privilege which every person young and old rightly prizes is that of learning something about many things which we cannot understand and ought not to be examined upon. The requirements in physics should be cut down so that there may be time to thus enrich the work in physics by lectures and outside reading. We have preached against mere memoriter work until our preaching has taken some effect in high school teaching but we continue to give examinations which no amount of general intelligence would enable one to pass. No faculty nor body of graduate students could pass the entrance examination—only those can pass them who have recently crammed their memories with the conventional material which appears nowhere else than in examinations. We have heard that high schools are deteriorating because their pupils do not pass entrance examinations to college, West Point Military Academy, and the like. I undertake to say that the more rational our instruction becomes the less will our pupils be able to pass the examinations as now given. Perhaps it is a commendation of the high schools that the secretary of the College Entrance Examination Board notes in his last report that a larger number of candidates than usual failed to pass the examinations.

An eminent authority says, "Really educated people are just those who have forgotten more than others." It is essential to

good thinking that one should not retain in memory much unorganized and useless material. Ideas sometimes require a long period of incubation. Inner intellectual life of extraordinary wealth is often hidden because of lack of means of adequate verbal expression or perhaps lack of the special gift of passing written examinations.

It might be well for this association to appoint a commission to investigate the returns now on file with the secretary of the College Entrance Examination Board. It is idle for individual pupils or teachers to attempt the matter of appeal but it is the duty of the secondary schools to have a commission for this purpose. I believe there are just as good persons kept out of college as are admitted by these examinations. The high school-teachers know before the examinations who are qualified to enter college and they know what ones have injustice done them by the examinations. It is the duty of someone to defend the pupils and to defend the good name of the schools.

The calorific value of ten tons of peat, freshly dug and untreated, is assumed to be equal that of one ton of ordinary coal. There are in Ireland 2,800,000 acres of unutilized bog land with a depth varying from 16 to 30 feet. There are 18,231 tons of peat to one acre of bog and this would be equivalent to 1,823 tons of coal. Accordingly, the total calorific value of the bog lands of Ireland is estimated as equal to that of 5,164,000,000 tons of coal. Moreover, at least half of this quantity could be conservatively counted on as available ultimately for steam-raising purposes. Peat fuel equal to coal could be produced in selected localities in Ireland at \$1.75 per ton. Some authorities maintain that the peat bogs are reproductive, and that in some cases the bogs increase in thickness 5 or 6 inches a year, according to the nature of the flora. This is simply theory, however, and there is doubt as to whether they are recuperative at all. In case reproduction be at all feasible, the life of the bogs as a fuel reserve would, under adequate conservation, be capable of indefinite extension.