

PHYSICS IS A FACTOR IN A LIBERAL EDUCATION

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As an instructor in physics in a Normal School and Teachers' College, I conceive it to be my chief duty to give such instruction in physics as will enable my students most successfully to teach that subject in our public schools. With this end in view I feel it my duty to study constantly: First, the prevailing curricula of our public schools, especially our high school; Second, the service which our public schools can render the people of this state and nation; Third, the choice of subject matter and the methods which will best accomplish the desired results. In this paper I shall, therefore, briefly indicate some conclusions bearing upon these points so far as physics is concerned.

In thus confining my discussion to these points I beg you not to suppose that I am unmindful of the importance of research in physics. Without the fruits of research in physics nearly all lines of engineering, as well as the application of physical principles to many trades, to agriculture, even to housekeeping

in the modern home, in fact to nearly all occupations of life must to greater or lesser extent stagnate. To the research worker in physics we must ever look for inspiration and for the further mastery of the physical forces which makes progress along many lines of life's activities possible. All honor to the research worker in physics and his co-workers in allied sciences for the knowledge of the physical world and physical forces which is making possible the engineering achievements in the great world conflict which is upon us. If the United States and her allies shall finally triumph in this greatest of all human struggles, that of democracy in resisting the tyranny of autocracy, and we all believe that we will so triumph, the victory will largely be due to the achievements of research and the inventive genius of the Anglo Saxon in utilizing those discoveries in our defense. And if at the end of this gigantic struggle this war-wrecked earth shall be able again to gather its wasted power and forces together and again become a peaceful and comfortable abiding place for mankind, with humming industries and thriving commerce, with food in abundance, with the common comforts of life and a reasonable measure of life's pleasures available to the masses, the achievement will largely be due to man's mastery over the physical forces about him. We shall ever look to the research worker and his revelations for the knowledge which gives man an ever increasing supremacy over his environment.

It seems certain, however, that the field of research in physics is in little or no danger of neglect. Capital and gigantic industrial organizations hold forth mighty inducements for research work in physics. Moreover, our great universities, many of which are liberally supported from state treasuries, gather together many of our best prepared research workers and place at their disposal abundant means for the prosecution of their work. Even though I thought it desirable, but which I think is quite unnecessary, yet no word I could utter would in the slightest degree stimulate or accelerate research in physics.

It is, therefore, not to the problem of research in physics but to the problem of the dissemination of the fruits of research among the masses to which I wish to call your attention. This, it seems to me, is the great need of the hour. If the value and

significance of scientific research is not revealed to and appreciated by the rising generation there will certainly be fewer research workers in the next generation. Also, if the masses come to regard science instruction in our public schools as of little importance, much of the service which research in science might render humanity will be lost. It is my purpose to point out the fact that at the present moment there is great danger that such an attitude towards science may become prevalent not only among the masses but even that the authorities in charge of our public schools may also assume that attitude. This Academy of Science cannot afford to be indifferent regarding the position in which science finds itself today in our public schools. The attitude of the nation towards science in the years to come will largely be determined by the attitude of our public schools towards science tomorrow.

THE DECLINE OF PHYSICS IN OUR PUBLIC HIGH SCHOOLS

During the past twenty years there has been a constant decline in the *percentage of students* in our public high schools who enroll in physics classes. In the United States as a whole, according to the reports of the Commissioner of Education, the percentages of high school students who enrolled in physics has declined from 19.04 per cent. in 1900 to 14.23 per cent. in 1915, a decline in fifteen years of 25 per cent. In Illinois, during the same fifteen years, the percentage enrollment has declined from 17.40 per cent. to 12.73 per cent., a decline of nearly 27 per cent. While this decline in percentage enrollment has been vastly less marked in physics than it has been in some of the other high school science subjects it has been sufficiently great to cause us to pause and seriously reflect upon its cause and its significance. It should be noted that this decline in the percentage of high school students who enroll in physics has taken place during a period when the control of our physical environment was rapidly increasing as a factor in our national development. That the decline in percentage enrollment other high-school science subjects is still greater is no consolation to the physicist, but rather an added source of alarm. That the decline in percentage enrollment in physics was only between 3 per cent. and 4 per cent, during the five years from 1910 to 1915 affords some consolation. One can not

resist the temptation of asking, however, whether it is probable that the decline in percentage enrollment and apparent appreciation of physics as a high-school subject is about to cease. Can we reasonably expect at the present time to see a reaction set in and to see physics soon regain its former position as a high-school subject? I have been asked to speak of physics only, but what I say concerning physics as a high-school subject today could be reuttered in much stronger terms regarding other high-school sciences.

I regard it as most timely that this Academy has at this meeting turned its attention to a consideration of science as a factor in our common school educational system. A widespread spirit of unrest and a prevalent dissatisfaction with our school curricula coupled with a strong popular demand for efficiency and conservation in all life's activities are making new demands upon common school education. Nor, in my judgment, will this demand cease with the close of our present struggle for the maintenance of our national freedom. On the contrary, I believe, that the period of reorganization which will follow the close of the war, if the perpetuity of democratic institutions is guaranteed, will demand that our system of public school education shall be thoroughly reorganized with a view of making it more efficient and of greater value to the masses.

THE SMITH--HUGHES ACT

The demand for greater efficiency on the part of our public schools, so far as it relates to the training of the masses of young people who will of necessity, in a large measure, become the producers of the next generation, is clearly shown by the passage by Congress of the Smith-Hughes Bill. By the terms of this act many millions of dollars will be available as federal aid for the promotion of strictly vocational training to be given within our public high schools. This act seeks to encourage the public high school to provide technical training for boys in agriculture and the industrial trades and for the girls in domestic economy. Moreover, this technical training is to begin with the entrance of the pupil into the high school, that is, at the age of about fourteen.

No one can today safely predict to what extent this act by the federal government will have upon the public high schools of Illinois and of the nation. Nothing is more certain, however, than the fact that when the federal government holds out a substantial bonus to the high school which will conform to the curriculum prescribed many high schools will conform and the act will be a large factor in the reshaping of high-school curricula in the immediate future.

To appreciate the possible effect of the Smith-Hughes Act upon science in the high school we need to recall some of its provisions. In order to receive federal aid, as I understand the law, every student in the class must devote one-half of his time to strictly vocational studies, the announced purpose of which is strictly the mastery of some industrial trade, or of agriculture, or of home economics; one-fourth of his time may be devoted to closely allied subjects, such as "applied mathematics" or "applied science"; the remaining one-fourth of the pupil's time may be devoted to what are commonly called culture studies. Detailed statements regarding the conditions under which federal aid may be secured are given in the Educational Press Bulletin, No. 124, issued by the State Department of Public Instruction for February and several bulletins issued by the Federal Government.

My only purpose in referring thus briefly to the provisions of the Smith-Hughes Act is to point out the fact that in order to enjoy federal aid the curriculum of the high school, or at least the portion of it which will receive federal aid must be intensely practical. For instance, there is no place provided for cultural science; the science taught must be applied science and have a direct bearing upon vocation chosen. Listen to some of the terms used to describe the character of the science which may be taught: "Prerequisite science", "agronomy", "soil physics", "soil fertility", "animal husbandry", "horticulture", "general science", "applied science", "household physics", "household chemistry", "science essential to competency in the trade or industry which the pupil is preparing to enter". To be sure, the teachers of these courses are required to have training in "related science work such as botany, zoology, chemistry, physics, geology, and mathematics" or as stated in another

place "trade mathematics, trade science, and trade drawing from the standpoint of methods of teaching and teachable content of the trades".

In this statement we have a view of the outlook for high-school science under the provisions of the Smith-Hughes Act. This law as I understand it has the approval of Governor Lowden and of the Department of Public Instruction. Three weeks ago today the Schoolmasters' Club of Illinois was in session at Decatur. As is well known that organization is representative of the school administrative forces of the state. The topic under discussion at both sessions was the Smith-Hughes Act. Its provisions were explained by those who will have its administration in charge. Not a single superintendent present raised his voice to ask whether it is to be the chief function of the public school to give technical training to boys in agriculture and the industrial trades and to girls in domestic economy. On the contrary, to all appearances, it was a scramble on the part of superintendents to learn the exact conditions with which their schools must comply in order that they may share in the distribution of federal funds.

I have long felt that the physics taught in our public high schools has not been well adapted to the needs of the masses. I have long felt that the decline in the percentage of students enrolled in physics was largely due to that fact. From long experience with students coming from our public high schools I speak with positive certainty when I say that physics as usually taught in the high school is both distasteful and uninteresting to a majority of high-school students, especially the girls. It does not appeal to them as worth the effort required to secure the passing grade. It has been, to a large extent, a misfit in the curriculum if it is the purpose of the public school to develop the boy or girl by natural and psychological instruction into men and women who shall appreciate science and shall be able to apply its principles to their own environment. I have long felt that not only physics but all high-school science needs reorganization. If high-school science is to be saved, in my judgment it must be reorganized and adapted more closely to the immediate appreciation and the ultimate needs of the masses. But it also seems to me that the present tendencies

in public school education, if those tendencies are truly represented by the shifting enrollment in high-school subjects and by the provisions of the Smith-Hughes Act, are based upon a misconception of the real immediate appreciation and the ultimate needs of the masses.

To me it is unbelievable that the primary function of the public high school is to start our boys and girls at the age of fourteen upon a strictly vocational training. I can not bring myself to believe that boys and girls of that age are ready for any kind of specialization in education. I believe that at least the first two years of high-school training should be devoted chiefly to the acquisition of knowledge concerning their social, economic and natural environment. If democracy is to survive is it not evident that to the largest possible extent a common pabulum of environmental understanding is essential? The very hope of democracy rests upon the possession by the masses of a common pabulum of understanding. Surely we are not ready to concede that the capacity to earn ones living is a sufficient qualification to assure good citizenship in a free democracy; the possession of superior skill in a certain trade is no guarantee of good citizenship. I cannot believe that the American people are ready to cast aside the long cherished conviction that general education, general enlightenment is the foundation and bulwark of real democracy.

If narrow vocational education of the type indicated by the provisions of the Smith-Hughes Act shall become the prevailing type of our public school education there will practically be no place in the high-school curriculum for physics or for any other special science. The cultural element of science, the historical element of science, the general enlightenment of science—all these elements of a scientific education must go. The common pabulum of knowledge concerning our natural and physical environment must go. The Spencerian idea of science as a foundation for all solid and substantial education must go. Social solidarity will go. Society will tend more strongly towards stratification for we shall then be turning out from our high schools a body of specialized wage earners lacking social conscience and social coherence. Can democracy survive such a condition?

I believe that a violent reaction is bound to come against this extreme type of vocational education if it is ever accepted for trial by the American people. But I also believe that the present inclination to accept for a trial this extreme type of vocational education is a well-merited rebuke, at least so far as physics is concerned, for the kind of science instruction we have been dealing out to our high-school students. We shall have our rebuke, I fear, in good measure. May we profit by it but at the same time I trust that we may never agree that the narrow, scanty, purely mercenary training in science, a training intended merely to meet the demands of a specific trade, is an adequate training in science for the coming citizenship of America. Such a training in science can no more prepare the masses for citizenship in a democracy than did the abstract, so-called logical training in science, which we have indulged in so largely during the past quarter of a century, prepare the masses for earning a living.

Somewhere between these two extremes must lie the happy mean. The high-school course in physics almost universally offered in the past has consisted of some two hundred or three hundred physical principles, abstractly stated and inadequately illustrated. Many of those principles have no essential relation to the daily life of the pupil. The laboratory work has generally consisted of blind and often unsuccessful attempts to manipulate with manual dexterity certain apparatus the like of which was never seen outside of the laboratory. The hundreds of set problems have usually been equally remote from the pupil's life experiences. The physics possible under the provisions of the Smith-Hughes Act will be found in limited quantities in the course in general science and possibly in some additional cases where physical principles are clearly required for an understanding of some process in a trade or occupation. No opportunity will be offered for the study of physics for the purpose of giving the student an understanding of or a mastery over his physical environment.

I deem it quite unnecessary that any argument be made before this body to show the necessity of disseminating as widely as possible knowledge concerning the fundamental principles of physics. If any one of the sciences is more fundamental than

the other sciences, if any one has more universal application to human welfare than the other sciences, that science is universally acknowledged to be physics. A fair knowledge of the fundamental facts of physics is important to the farmer, to the industrial trade worker, and to the housewife in the modern home but is no less important as part of the equipment of the citizen for national, state and municipal government is nowadays largely a matter of applied science. I conceive it to be a part of the work of every high school to give something like an adequate training, not only in physics, but also in all the fundamental sciences to all the pupils in that high school.

Somehow, in some manner, we must so modify our science instruction so that it will appeal to school authorities as being of vital importance; science must be made to appeal to the pupils much more strongly than it appeals to them today. Only in this way can we hope to check the declining percentage enrollment in the sciences in our public high schools.

Science in the high school is today in a precarious condition. The seriousness of the situation is not easily overstated. This Academy of Science can certainly, it seems to me, do no better work in behalf of science than to study the high school situation. We should realize that the public high school is the chief medium for the dissemination of the fruits of scientific research and the chief source of future research workers. And above all this Academy should take a stand squarely upon the proposition that the first duty of the public high school is to train up our boys and girls into highly intelligent, public spirited citizens, with lofty social ideals and clear-cut social consciences that they may form the bulwark of democracy. Only secondarily shall our public high school be devoted to the task of producing skilled artesans.