SCIENCE

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PHYSICAL SCIENCE IN THE SECONDARY SCHOOLS.

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In view of the fundamental changes in methods of education within the last twenty-five years in testing experimentally the educational value of subjects which formerly were not recognized as a part of liberal training, it is to be expected that the secondary schools should await the results of such trials in the higher institutions. The time and energy devoted to the comparative efficiency of different methods or the comparative value of different subjects in these schools should be extremely limited. They can afford no loss of time in uncertain paths. It is more reasonable and economical to leave all teaching in experimental methods to the mature judgment and experience of educators who have devoted their lives to this subject, and who have at their command the ample resources of the college or the university, with no constraints in the employment of their best judgment, such as unavoidably exist in the common schools.

With little thought it might seem that the teaching in the common schools, with aims and methods widely divergent from those in the higher grades, can be critically studied only by those who have them in charge. Upon close examination, however, it is evident that this difference is only one of degree, and experience has shown clearly that the best suggestions for elementary training come from persons engaged in higher teaching, or from persons who are able to adapt methods of higher teaching to the wants of younger pupils. Indeed, the methods universally accepted as the most worthy are the results of study and investigation in the fields of advanced knowledge.

Nevertheless, with the best methods and all the wisdom and judgment of generations of experienced educators, any system of education may fail utterly if it is not supported by teachers who have an enthusiastic interest in imparting knowledge. Without the personality of such a teacher, one subject as well as another may fall into a tedious, uninteresting routine Even in laboratory training, in which it is not difficult to maintain a lively interest, the teaching may easily take a form which fails to accomplish the especial objects for which it is intended. The study of natural phenomena under skilful guidance results in the production of self-reliant students.

In the domain of natural and physical science, instruction may now be considered as having passed the experimental stage, not only in the higher grades, but in the common schools, and the educational value of such instruction is recognized as a part of liberal education. Aside from the practical information, which is a part of general knowledge, the characteristic benefits of scientific training appear in the thorough discipline in methodical habits of study and an intelligent use of the perceptions. If these are the results of the study of science in the higher grades, why may not the same methods, simplified and properly applied, form a part of the means for the development of younger pupils? When we consider the great breadth of the field of knowledge and the limited span of the average human life to compass it, it seems a very short intellectual step from the development in the mind of the child to the more mature condition of the youthful intellect as it passes through the various stages of collegiate training.

In most high schools attempts are now made to teach physics and chemistry, but under very adverse circumstances. There are certain difficulties to be overcome in the proper development of such teaching, but they should not be looked upon too seriously. The earlier condition, in which Latin and Greek were selected as soon as the student had covered the ground of the elementary English branches, is, happily, adjusting itself on a reasonable basis. Perhaps it is of more importance that the wide range of subjects included in the average high-school course must result in a slight and superficial knowledge of many things rather than a thorough training with reference to correct habits of thought and study in any direction. Probably the more serious hindrance to laboratory teaching in chemistry and physics to classes of any magnitude is the expense of the necessary appliances and a lack of knowledge of a proper and economical expenditure of time and energy.

The utility of physical science properly taught as a means of mental culture and discipline has been fully demonstrated in the rigorous tests it has withstood in the severe criticism of modern educational methods. The particular value of such teaching is manifest in the opportunities it affords for accurate observation, exercise in methods of inductive reasoning, and practice in recording the impressions in the form of notes. The most satisfactory as well as the most convenient method of imparting knowledge of the principles of physical science to classes is by lecture-table demonstration. Text-books may be used as an aid, but the personality of the instructor behind illustrative experiments is the most direct, and in fact the only method whereby an eager interest can be aroused in the pupil. Lecture-table demonstration and laboratory practice under the immediate oversight of an intelligent instructor should proceed hand in hand.

There is still another view, which, it seems to me, is worthy of consideration. Probably no one will deny that practical knowledge should be imparted whenever it is consistent with proper mental discipline. Certainly there are important reasons for including as much practical information as possible in any high-school course. Most of the young men who graduate engage in business, and a comparatively small number of the young women continue their studies beyond the high school. Any young man in business has a constant use for knowledge of the chemical composition of substances, their physical and chemical properties, and their uses. Much of such information may easily be included in elementary courses of instruction. Every young woman should understand the principles of ventilation, of sanitary appliances, the applications of weights and measures in the household, and the ordinary chemical changes which are the basis of the preparation of foods, as well as the influence of temperature upon such changes. The ordinary chemical changes in bread-making, in fermentation, in decay, and similar operations should be common knowledge; yet there are, doubtless, very few of the young lady graduates of the high schools who possess a correct knowledge of this subject.

I am well aware of the apparent difficulties in the way of developing laboratory instruction, and I shall venture to propose methods which may be readily applied in any high school. If it is granted that the results of suitable instruction in elementary physical science are worthy of the effort, these difficulties are limited to two directions, and they may be easily overcome. Perhaps the most serious obstacle is the expense of equipment and maintenance of laboratory practice. In a room 40′ by 30′ forty-eight desks may be arranged with ample accommodations for ninety-six students working in two divisions, or for one hundred and forty-four students working in three divisions, with separate drawers and lockers for the apparatus of each division, and with all necessary hood-space and sinks. The cost of the arrangement of such a laboratory, including all gas-fitting and plumbing, and all reagent bottles, in fact fully equipped, except with apparatus for individual students, should be less than $1,500. The cost of apparatus needed by each student should not exceed

$5. The cost per year of chemicals and of apparatus to provide for breakage should not exceed $6. A class of twenty-five students can be accommodated in a room 20′ by 27′, and the expense of a complete equipment should not exceed $700. For smaller classes the cost should be proportionally less. These estimates are based on the results of extended experience in the construction and arrangement of several laboratories, which it has been my fortune to superintend.

The second obstacle mentioned above has reference to the large teaching force which would apparently be required in such instruction, but it would seem that it is rather a result of a want of knowledge of the best methods of teaching physical science, both on the part of executive boards and of many teachers themselves. From the results of my own experience in similar grades, as well as in more advanced instruction, I am convinced that this difficulty is only apparent. In a high-school course of three or four years, physics should be taught during the junior year and chemistry in the senior year.

In chemistry, two hours a week should be devoted to lecture demonstration, with two afternoons, of two hours each, to laboratory work, and one hour to a recitation on the subjects of the lectures and laboratory practice. The same method should be adopted in the physics of the third year, although from the nature of this subject perhaps a text-book may be used more freely.

The same laboratory will serve for both physics and chemis ry, and in physics the same apparatus will serve for different students. Hitherto the chief difficulty in teaching experimental physics has been the high cost of the apparatus; but suggestions concerning inexpensive forms of apparatus have recently been given for the benefit of the secondary schools by professors of physics, especially by the professors at the Jefferson Physical Laboratory of Harvard University, and such apparatus is for sale by the dealers at a small cost. The same instructor may have charge of physics and chemistry, and the success of such teaching would depend upon his particular qualifications. He should be allowed at least eight hours a week to prepare for class-room and laboratory exercises, with some aid from the janitor or other servant. He should still have considerable time which could be devoted to such other teaching as might seem expedient, perhaps in some other branches of science. In the high schools outside of the larger cities the annual salary of an instructor should be between $600 and $1,500, depending upon the size of the school. One instructor can easily teach a class of thirty members; in the larger schools, laboratory assistants would be necessary; lady teachers with suitable preparation are very successful in laboratory teaching, and this service could be combined with other duties.

I am aware that excellent training in elementary physical science is given in some of the high schools in the larger cities; but, notably throughout the West, such teaching, when it is given at all, is usually confined to routine text-book methods, with little, if any, experimental illustration, at least by the students themselves. Such a system as the one herein described requires certain small expenditures, but the efficiency of the high-school instruction would thereby be greatly improved, and the public would soon appreciate the importance of sustaining efforts leading to broader and more practical training.[1]

If at first the governing boards of high schools should feel the need of suggestions in the preparation of plans and estimates for equipment of laboratory rooms, I am sure that professors in charge of laboratories would gladly render such assistance. The success of this system requires a knowledge of special methods, which many teachers do not possess, but they are enabled to acquire it in laboratories which are open during a part of the summer vacation. The chemical laboratory of Harvard University was first opened during the summer of 1873 for the benefit of teachers, and many now have charge of responsible teaching through the knowledge acquired by continuous attendance during successive vacations.

[1] Every citizen is directly interested in the welfare of the public schools, and all parents will heartily support any endeavor looking towards the attainment of the greatest amount of useful knowledge, as well as the best mental development for their children.

What has been said about physical science in the secondary schools may apply in a different sense and on a higher plain to the condition of scientific training in many colleges. The increasing demand for the admission of college graduates to advanced standing in schools of science should be encouraged, since the discipline of a collegiate course is an excellent foundation for advanced scientific study, provided it includes thorough instruction in the elementary branches of science. A college course should offer, as a part of its required work, comprehensive training in general and descriptive chemistry and descriptive physics with extensive laboratory practice in both subjects. Most colleges can also give elective instruction in qualitative chemical analysis, with some additional study in quantitative analysis Graduates from such courses, which should also include French and German, are well qualified to enter the junior year in the best scientific schools. Unfortunately, at present, not all colleges give a sufficiently thorough drill in elementary physical science, in consequence of which many graduates who desire to enter schools of science labor under a serious disadvantage from a want of the more elementary knowledge. Most colleges, doubtless, feel that they devote as much attention to scientific subjects as is consistent with the thorough general training that is expected in a college course. While this may be true in part, it must be admitted that thorough training in physical science should now have as important a place in a college course as mathematics or the ancient languages. It is not to be expected that the college can provide the expensive equipment for the study of science that is the foundation of the school of science. But every college can afford the small expenditure that will thoroughly equip and maintain working rooms for the use of elementary physics and chemistry, with sufficient instruction to render this study interesting and profitable. The feeling of mutual interest and dependence between the secondary schools and the scientific schools, and perhaps in a less degree between the college and the scientific school as a professional school, should be promoted and encouraged; and whatever aid it is possible to render in either direction should be cheerfully granted.

OUR VACANT PUBLIC LANDS.

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THE total area of the public lands vacant in 1892 has been estimated by the Commissioner of the General Land Office at, in round numbers, less that 568,000,000 acres, these being located in 25 states and territories. Of this total by far the greater part, as is generally known, is in the western half of the United States and mainly west of the 100th meridian. Taking therefore the Dakotas, Nebraska, Kansas and Texas, and the states and territories to the west of these, numbering in all 16, these contained nearly 542,000,000 acres, or about 95 per cent of the vacant public lands. The remaining 26,000,000 acres in the nine political divisions to the east of the states named may be considered as of little value, at least for homesteads. A great part of this is in the swamps of Florida and Louisiana or in what are generally considered non-agricultural regions of Arkansas, Michigan, Minnesota and Wisconsin. The very fact that these lands have not been taken up, although open to settlement for many years, testifies as to the doubts or failures of would-be settlers.

The rate at which the public lands are being sold is also should in the reports of the officer above mentioned, from which the following figures have been culled:

Disposal of Public Lands.

1890	12,798,837	acres
1891	10,477,700	"
1892	13,664,019	"

During the year 1892, the disposal of lands has been abnormal in quantity, owing doubtless to several causes, but mainly from the legislative or official side rather than from increase of settlement. As a rule it may be said that the sales of public lands have been steadily decreasing year by year until 1892, when