

expanding against pressure, the steam engine is something more than the plaything of an hour.

He must take his sweets as dessert, not before meat.

I have briefly outlined some of the matter and the methods which we employ and believe in employing in the school which I represent. Throughout the course we try to avoid two extremes—one that of making the subject too scientific, the other the too utilitarian point of view.

We do not wish to make physics like the theory of numbers—the favorite subject of a certain mathematician because, as he said, “It has never been prostituted to any practical use.” Nor do we care to have the pupil mistake the laboratory for a toyshop.

A satisfactory foundation is laid for later college work in the subject and excellent preparation given those whose formal education ends with the secondary school.

I believe I shall be well within the limits of the truth if I say that in my city the powers that be, educationally speaking, are convinced that the more than two hundred pupils who study physics in the high school are satisfactorily employing their time and justifying the use of the five thousand square feet of floor space given over to their work.

If these people are correct in their views it is because the laboratory is an instrument for training in the highest types of honesty; because the course gives greater breadth of view and a better attitude toward life; because the pupils are trained to think and to do.

ADJUSTMENT OF HIGH SCHOOL COURSES IN PHYSICS TO MEET THE INCREASED SCOPE OF ELEMENTARY PHYSICS.

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Physics, like other sciences, has in recent years greatly increased its scope. Whole subjects, such as wireless telegraphy, X-rays, the phonograph, theories of solution, liquefaction of gases and spectroscopy, have been added by the discovery of new principles. Old principles have acquired greater application and the

water wheel, the dynamos, the motor, the storage battery, the transformer and the electric lamp constitute a body of knowledge as extensive as all the other subjects of physics combined.

In view of the fact that all of this knowledge can not be satisfactorily covered in a high school course in physics, and yet that it is desirable to cover as much of it as possible, the questions arise, what conditions or factors may serve as guides in the determination of such a course (or in the selection of the subject matter of such a course)? Moreover, we may well ask, what constitutes elementary high school physics? What we, ten years ago, called an elementary high school course in physics now would seem incomplete and inadequate for our present progress and needs. The addition or material change of some subject is almost a biennial occurrence. We seem, in fact, to be confronted with the problem that elementary high school physics is rapidly progressing, while the student's ability to learn and the teacher's power to impart knowledge are but slowly advancing to keep pace with it. We may believe that it is not necessary that elementary high school physics should keep up with the progress of physics; that as the scope of physics increases, so the student and teacher increases in power to deal with the subject. Whatever view is taken of the matter, we have a real problem which demands attention and thought.

Of first importance in deciding what shall constitute the subject matter of an elementary high school course in physics is doubtless the question of adaptation to age, mental attainments, previous preparation, time and equipment for work.

Ordinarily, the older a student is the better he is capable of understanding physics. This is not alone due to greater preparation, which he may have had in other branches, but also to greater strength of will in maintaining an attitude of inquiry and discovery towards facts. Physics in the senior year in the high school course is in its right place. As much may be claimed for other branches, of course, but it is probable that in no branch is there as much real advantage as in physics.

Regarding previous preparation, nature study in the grades is a very positive factor in determining the high school course in physics. So much so, in fact, that we feel warranted in saying that

if we are to broaden our courses in physics commensurate with the progress of science and of education, much of the very elementary qualitative work which has heretofore been included in the high school course must be taught in the grades. If such facts as the existence of an atmosphere around the earth, the weight and composition of air, motion of air producing wind, existence of water vapor in air, condensation of vapor to produce clouds, rain and snow, are to be taught in physics, then we shall have scant time for such subjects as barometers, atmospheric pressure, density of air, humidity and the general properties of gases and the explanation and illustration of the laws of Boyle, Charles and Dalton. Likewise, the existence of gravity and the attraction of bodies to the earth, the existence of static electricity and various ways in which it may be made visible, buoyancy of liquids and other common properties of matter are facts which should be known to the beginner in physics. It would seem, in fact, that to claim any progress in science in the schools, such elementary facts must be acquired previous to the high school course in physics. It is not necessary to accomplish this to advocate a course in physics in the grades. The usual correlation with language and geography suffices, but it is desirable that certain known amounts of the work be done.

A further preparation for physics is the requirement that students take a course in physical geography before taking physics. This may seem like overdoing preparation for a branch which should meet the conditions, as many other branches do, without regard to previous preparation. But there is no good reason why physical geography may not serve as a preparation for physics just as physiology does for biology, algebra for geometry, composition for rhetoric and literature.

In mathematics, a year and a half of algebra and half a year of geometry, or two years of algebra and geometry along with physics, should be the minimum. Problem work in composition and resolution of forces and velocities, motion on the inclined plane, gravity and gravitation, the pendulum, circular motion, electrical resistance, and the determination of force, work, energy and power can not be carried on to advantage without it.

But there is another and even more important phase of prep-

aration pertaining to the power of the mind of the student to see relations between percepts and elementary concepts. Our sense organs, the eyes, ears, nose, mouth and skin, are, in a sense, "look-outs," constantly being impressed with things around us which is not part of us and beckoning the mind to notice. These effects of external things on our senses are what we know as sense impressions; when the mind takes notice of a sense impression, an image of the thing called attention to is formed in the mind, and this constitutes what we know as a percept. Percepts correspond, therefore, to things around us—cats, dogs, horses, wagons, cars, engines, houses, and other things innumerable. Now, it may be that some of these percepts have certain common characteristics, in which case they may be placed together in a group, and then we have what we know as a concept. This grouping may continue and groups may be placed together in classes, and classes in orders, and so on to the limit of conception. In each case a concept more complex than the previous is formed. Concepts, therefore, differ widely in content, by which we mean usually the number of included percepts or more elementary concepts. Some concepts have enormous content, as, for instance, animal and plant. These two concepts include, in fact, every living thing on the face of the earth. Every common noun in the dictionary and out of it is a concept. Every definition is the summary of relations in a complex concept. Concepts are not the product of one mind alone, but they are handed down from generation to generation, and are constantly undergoing change, which is usually an increase in content. Cuvier left the concept fish very large, but Agassiz left it larger, and Goode left it still larger.

The acquisition of these concepts is the problem of the modern student, and not that alone, but the elementary concepts must be acquired in as short a time as possible. It is the work of the teacher to aid the student by calling his attention to the relations between percepts and elementary concepts in order that new and more complex concepts may be formed in the student's mind. The skillful teacher selects, not any number of percepts or concepts which may be related and bear upon the subject, but type concepts, which will enable the student to see quickly the relations sought.

The student brings to the subject in hand his experiences, which are, for the most part, percepts and elementary concepts. If these are not sufficient for the work, he is not likely to meet with success. He does not see relations, for the reason that there is not in his mind the necessary percepts and concepts to establish relations. He needs more training in the acquisition of sense percepts. It may be nature study, it may be arithmetic, or some other foundation study. The teacher, who has the student in charge, will do well to teach the student these elementary facts, but this can be done only to a very few. If the student's work is planned rightly, however, his preparation in one study will fit him for the next. The belief in the idea that a student needs all the preparation he can get for a difficult subject is well founded. It is founded upon sound psychological principles. The idea that a student can cope as successfully with a difficult subject during the first year in the high school as during the third or fourth must be founded on either a wrong notion of the subject or a wrong notion of how knowledge is acquired. Moreover, the indiscriminate mixing of Freshmen, Sophomores, Juniors and Seniors in classes, taking the same subject, as is done in some schools, may be justified in a way, but there is certainly no valid psychological or pedagogical basis for it.

The time devoted to physics is now almost without exception a year, which is sufficient, providing the most elementary facts of physics are known as a preparation for the course.

The matter of equipment ought not to effect the scope of a course in physics, except in relation to laboratory work. If there is little or no quantitative laboratory work, much of the problem work in physics will be burdensome and uninteresting, as, for example, the reduction of gas volumes, density and calorimetry, and it would be well to eliminate it. Laboratory work, which is mostly qualitative, is seldom as valuable as it is supposed to be and is sometimes detrimental. Students waste time doing things without having any definite accomplishment in view or obtaining any definite result which will react and stimulate to harder and better work. Qualitative experiments are performed to the best advantage and with the best results by the instructor before the class.

But in the absence of equipment it might be necessary to curtail even these.

Utility as a basis for the determination of what shall constitute the subject matter of a course of study in physics deserves careful attention. Subjects relating to matters of utility are usually closely related to the student's experience and are exhaustless sources for concrete illustrations and practical applications of principles. Moreover, utility wields a strong influence for reasons of business. On the utility basis, much of what is included under static electricity might well be omitted; so also a portion of magnetism, calorimetry, light relating to optics, sound relating to music, and a number of other subjects equally destitute of the practical. On the other hand, secondary batteries, the dynamo, the motor, the transformer, the incandescent lamp, the arc light, the telephone and telegraph should receive the fullest treatment.

Furthermore, considerations of interest deserve recognition. Subjects which are currently much heard of and read of awaken a curiosity and interest which is indispensable to good work in physics. This is particularly true of subjects like wireless telegraphy, the X-rays, the phonograph and liquefaction of gases. A course in physics could not be considered sufficiently complete without including one or more of these subjects.

These, then, are guiding principles in the selection of a course of study:

1. Requirements corresponding to the age, mental attainments and previous preparation of the student.
2. Requirements corresponding to equipment and facilities for work.
3. Requirements of utility, and
4. Interest requirements.

How much under each of these is to be taught in an elementary high school course is largely determined by the requirements of the first, and particularly previous preparation.