A PLEA FOR MORE EFFECTIVE SCIENCE TEACHING.

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The *Normal School Quarterly* for October last contains a discussion by Fred D. Barber on "The Physical Sciences in Our Public Schools" which, by means of government statistics, tends to show that the teaching of these subjects is on the decline, especially in the high schools. That this should apparently be true, notwithstanding the prodigious strides which the application of scientific principles is making in all the activities of modern life, is a fact of which every teacher of these subjects should take note. While all the causes which underlie this situation may be difficult to determine, yet there is one widely prevalent condition which I am convinced results in an enormous dissipation of the pupil's interest, energy and accomplishment. I refer to the kind of laboratory experiments, especially in physics, which are required of pupils, and the toy apparatus with which they are performed.

If the study of science subjects on the part of the pupil is to be anything more than a perfunctory task, he must be impressed with their importance and immense practical significance. This cannot be accomplished, however, by merely talking about the application of scientific principles to everyday life or by performing simple experiments and demonstrations with such totally inadequate and miniature apparatus as to provoke a smile at their exhibition. The pupil must feel that the problem set him is worth his while to do, and to do well. It must command his respect. In order to be able to present work which will enlist the keen interest and serious consideration of the pupil there should be separate classes for boys and girls. Unfortunately this is frequently impossible.

Although I shall deal principally with the teaching of physics, yet the application may be made to any other science subject. First, let me say that the pupil's interest will be aroused only by making him feel that the problem which he has in hand is a real, live proposition. To illustrate, let us take the parallelogram of forces. As this is usually taught, spring balances registering a kilogram, and more often less, are used and the pupil learns by plotting to scale that the diagonal of the parallelogram is equal in the chosen unit to the reading of the third balance. This is all right but the trouble lies in the fact that the laboratory work and demonstrations frequently end there. To make this principle real to the pupil, it should be followed up immediately with work on a roof truss and a derrick involving weights of from at least 75 pounds to 200 pounds. In the case of the roof truss, it may be shown that the greater the angle of the roof, the greater the horizontal thrust and with a good piece of apparatus the calculated and actual thrusts will come surprisingly close together. A derrick combining the pulley with the resolution of forces and capable of lifting 500 pounds affords a most interesting series of problems. Some work of this kind will drive home the parallelogram of forces and its practical applications as nothing else could. And pupils will work with an interest and intensity hitherto unknown.

Again, in teaching the principle of moments, why put before pupils apparatus calling for the use of only a few ounces or grams, and not taking into account the weight of the bar? It costs but little more to get a piece of apparatus with knife edge supports and a capacity of 100 pounds. The calculated and the actual results, too, with such a lever will come extremely close. With it, each class of lever and the equilibrium of several parallel forces in a plane may be demonstrated. Instead of giving the pupil problems on the lever from a book, make the problems for him, and let him verify his answers for himself. Then the problem becomes a live one, and not a dead one. In the case of the pulley, too, pulley blocks capable of lifting at least 100 pounds should be used and their efficiency determined. A differential pulley hoist of the commercial type will add very much to the pupil's practical appreciation of the mechanical advantages of machines.

In taking up energy, work and power, would it not make the subject a very real one if a one horse power gas engine, connected up with a dynamo, were put before the class and the various transformations of energy traced? Then a problem which makes a very strong appeal is the determination of the horse power of the engine and this problem is not at all difficult. It is one which I do with the members of my general science class. If an observation gas meter is at hand, and the gas company will usually give one to the school, the number of cubic feet of gas necessary to run the engine for a given period may be measured and the cost per horse power determined. By means of a voltmeter and ammeter, the power delivered by the dynamo may be obtained and the efficiency of the engine determined. Now these are problems which arouse the keenest interest on the part of pupils for they feel that they are dealing with real problems.

An experiment which is frequently performed and with very little practical significance, is that of determining the breaking strength of a wire. But if this were followed up by requiring the pupil to calculate the size of wire necessary to act as a stay-wire for the derrick, when bearing a load of several hundred pounds, the experiment would be well worth while. In the study of heat, we ask pupils to determine the specific heat of lead or some other metal. But why not provide a Parr calorimeter of the commercial type, and have them determine the heat value of various samples of coal? If it is impracticable for all of the pupils to do this individually or by working in pairs, let it be given as a demonstration. To my mind, such a demonstration, when properly written up and understood by the pupil, has far more value than several of the usual experiments and ought to be so regarded when presented for college entrance.

Again, the instruction in the gas engine and the steam engine is given largely from diagrams or from models so small as to be hardly worthy of the name. In my own laboratory we have a one-half horse power gas engine which may be placed upon the demonstration table and studied by the pupils at first hand. In addition a large sized model is provided which may be connected with a spark coil and the whole internal operation of the engine—intake, compression, spark and exhaust—shown perfectly. A well known carburetor company has favored us with a large cut model of their carburetor which shows the modification necessary for use with gasoline. For the steam engine a plant is in use consisting of an engine, boiler and dynamo, the boiler being tested to a pressure of 200 pounds and working under 80 pounds. This is accompanied by a good sized model showing the internal working of the engine. Here again the horse power of the engine may be determined, the amount of gas used as fuel measured, its cost of operation calculated and by measuring the output of electrical energy, its efficiency determined. Such demonstrations are not entertainment, but work of a most practical nature, and such as cannot help but create interest in the subject. I venture to say, however, that the pupil will derive more genuine pleasure from such work than from any which is calculated merely to entertain.

The determination of the specific gravities of liquids is a subject which is usually left with few, if any, practical applications. But would it not be worth while to provide a Westphal balance for determining the specific gravities of a series of water and alcohol solutions and then by reference to the published tables obtain the percentages of alcohol? Or the hydrometer may be used for great accuracy is not the object here, but rather to show the pupil that such determinations have real value. It would also contribute still further to this end if the pupil were allowed to distil off the alcohol from a measured volume of some patent medicine or beverage, dilute to the original volume, and by determining the specific gravity, obtain the percentage of alcohol.

For the study of electricity, every laboratory should be equipped with a 110 volt current, D. C., if possible, and wired to each table. Dynamos and motors that are more than toys should be provided and also double range commercial voltmeters and ammeters of the Weston type. With these instruments a large number of very practical problems may be made. For the study of parallel and series groupings of lamps in light circuits, I have a lamp board, made by one of my boys, and carrying the following combinations of lamps—four in series, four in parallel, eight in multiple parallel, and six in multiple series. By means of this, with a good voltmeter and ammeter, the practical aspects of electric light wiring and the consumption of electrical energy may be taught in a very effective way. In taking up the magnetic effects of the current, it is worth while to make an electromagnet of large capacity. For the heating effects an electric furnace of either the resistance or arc type is easily made. For the arc furnace a mixture of asbestos fibre, fire clay and water glass makes an excellent material. A resistance furnace may be made by winding a grooved alundum cylinder with nichrome steel wire and covering with alundum cement. Alundum is a highly infusible substance manufactured by the Norton Company of Worcester, Mass. The determination of the number of watts used by a lamp circuit, an electric flat iron or toaster and therefrom, the cost of operation is an interesting and practical problem.

While I have pointed out only a few of the ways in which the teaching of physics may be made more attractive to the pupil and grip him with a stronger appeal, I am entirely confident that the present teaching of the subject must be revolutionized along these lines. And what is true of physics is largely true of the other sciences. When the pupil feels that the problems set him are real ones, worth his time and effort, there will be no necessity for driving him, and the science subjects will cease to fall off in the number of pupils pursuing them. It may be said, however, that to equip a school for work along the lines suggested will incur an expense which will be prohibitive. It is true that the expense will be greater than under the old method of teaching with toy apparatus. But if real efficiency is the object of our teaching, then expense is no consideration. The expense of such equipment is not nearly so great as might be supposed. There is much showy and useless apparatus in most of our laboratories which has cost more than the kind of apparatus suggested in this article.

Another agency which is a very strong factor in arousing interest in these subjects is a good science club. For these meetings, which should be held about once a month, speakers and demonstrators from commercial companies may very often be obtained. In my own club I have had demonstrations with thermit and oxy-acetylene welding by representatives of the Goldschmidt Thermit Company and the Davis-Bournonville Company. I have also given demonstrations with liquid air at several meetings. Other similar meetings have been held each year and several are now arranged for the present year.

The chief obstacle to the thorough presentation of science subjects along the foregoing lines in a school which must prepare for college entrance examinations is the fact that so much has been crowded into these courses and is exacted of pupils in their examinations that no one division of the subject can be carried to anything like a complete treatment of it. It is a great pity that teachers in secondary schools must be handicapped by such rigid exactions.

LATITUDE WITHOUT AN INSTRUMENT.

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On page 110 of the February issue of this Journal, Professor Morse shows that: "The declination of an observer's zenith equals his latitude."

If one's school building has a bell tower with the front entrance steps at its base, find your latitude thus: (a) From a star catalogue find a star, the declination of which differs but slightly from your latitude. (b) From a window in the tower run out a lath or pole with a plumb line attached, determine the length of the line when it reaches to within about two feet of the steps. (c) Calculate, n the length of 1″ of the circumference having the length of the plumb line as radius. (d) Calculate the star's time of passing your meridian. (e) At the instant of meridian passage, lying on your back and looking up the plumb line, deflect its lower end, m, sufficiently so that the line points to the star. (f) Find m/n. Apply this number of seconds as a correction to the star's declination. If the deflection was to the *south,* the declination is too great by m/n seconds; if to the *north,* too small by this amount. Seemingly this method should give more accurate results than those obtained by using a portable instrument, in fact, better than any save by a fixed observatory.

I have never seen this method given. However, it may be well known.