

utilitarian character, that Physics—and here I must include Chemistry—should form widespread subjects of education. The present century has seen discoveries in Physics which have not only exerted a most decisive and favourable influence upon our whole culture, but which have led to so great and novel general principles in Physics that those who are best able to judge of the range of these principles express an opinion that we are only at the beginning of a great era of still more astounding discoveries. That facts and principles of so vast promise and importance should, by means of the various channels of national education, become the common possession of all classes, has very naturally been the most anxious desire not only of distinguished men of science, but also of enlightened statesmen over the civilised world; for it is seen at once that a sound knowledge of these facts and principles would most probably stir up mankind to make new exertions for discovering still unknown realms of science.

It is only just to say, that these claims of Physics to be one of the recognised subjects of education, have not been utterly disregarded in this country. The number of science schools where Physics forms a prominent subject, of science teachers, and of youthful students, is undoubtedly, although very slowly, increasing; and something is done by Government and by private support to advance physical research. But has the teaching of Physics so far really fulfilled the expectations and promises of those to whose opinions I have briefly alluded? It is far too early to answer this question; but if the value of the knowledge of Physics imparted in our schools is to be judged from the published results of different examinations carried on for the purpose of testing the amount of general education attained by the candidates, we should arrive at a most disheartening conviction. The average number of pupils who present themselves in Experimental Physics at this College is never more than between 4 and 5 per cent, of the total number of pupils examined at each examination; but a worse feature in the case is, that out of 100 pupils who take up Physics, only three or four give accurate answers to some of the proposed questions; 20 or 30 per cent, give answers bearing in a very vague manner on the question. The remainder are mostly totally unacquainted with the subject. Glance again at this result as a whole, and it comes to this, that out of 1500 boys and girls only about three are able to give a correct answer to a few simple questions about natural phenomena which can be observed and experimented on every day, in every place, and should be so studied in every school. At the London University the number of failures in "Natural Philosophy" is a striking feature in the Matriculation examination, being usually as much as the failures in three other subjects taken together, and nearly always greater than the number of failures in any other subject. At this examination the number of questions set to the candidates has recently been swelled to sixteen; and if, as I understand, correct answers to two, or at most three, of these sixteen questions qualify a candidate to pass, the expectations of the examiners have sunk very low indeed.

Now if we admit that physics is a subject of great importance from an educational as well as a material point of view—and no one will probably be prepared to deny this presumption—the time has clearly arrived when teachers should without delay ascertain the present state of physical science teaching, investigate the causes of such strikingly unsatisfactory results as I have sketched in the few instances that have come within my knowledge, make further inquiries whether

there exist other facts connected with the question of a more hopeful nature, and mutually exchange their experiences; and it is only in the light of a communication to you of my own personal experience as a teacher of Experimental Physics that I wish you to consider the following remarks and suggestions on the subject.

There are at present three different methods of teaching Physics principally in use. The first of these consists in purely oral instruction. The teacher states some physical fact, and elicits perhaps by his questions some illustrations of the fact from the individual experience and recollections of his pupils. As a mere mental exercise nothing could be said against this method, which, however, is equally applicable to history, geography, or in fact any kind of knowledge. But a fact in Physics differs in this precisely from all other facts, that our own senses supply the only evidence for its truth. It follows that the chief aim of the teaching of Physics must naturally be solely to train our senses so as to perceive the facts, and then to show how to separate the accidental from the essential, to connect effects with their causes, and thus to see not only the truth in a single fact, but the agreement of many facts in one definite principle, and so to lead the mind to the recognition of that one principle, or law of nature, which embraces all the solitary facts. No mere description of physical facts would ever make a discoverer; indeed, it is well known that a method of learning something about physical facts has at all times produced considerable harm. The class of projectors and sham inventors is principally recruited from mere readers of books on Physics; their conclusions are derived from erroneous ideas about facts which they have never really seen, and are naturally of a kind to vanish in the air when put to the test of actual experiment. A method of teaching physics without the basis of experiment stands thus really in direct contradiction with its essential purpose. As a matter of fact such a mode of teaching is utterly tedious to learners; it must lead to errors and misunderstandings; and moreover it is extremely limited in its range, because many facts and phenomena are quite beyond all comprehension, unless they are perceived by the senses. It appears from the examination papers which are presented to me from time to time at this College, that such a method is unfortunately still pursued in many schools; the confusion produced in the mind of the pupils of these schools manifests itself in every statement, and stand in remarkable contrast with the clear and truthful answers given by those few who have obviously seen what they describe. Written examinations are not a very high test of knowledge attained; but they prove something, and, as matters are, we are bound to accept what they prove.

A second method consists in oral instruction by lectures, illustrated by experiments performed by the teacher before the whole class. At first sight this seems to be an irreproachable method, and undoubtedly it is the best and only one by means of which some information on physical phenomena can be conveyed to large audiences. Nor seems there any other way of exhibiting before a body of students or educated people some result of recent discovery, or giving them a connected exposition of some great principle, with the leading steps or precursory experiments that have prepared its adoption or established its power. But I fail altogether to see its advantage as a school method. We do not teach writing, reading, or arithmetic, by confining ourselves to writing letters or sentences on a black-board, or by reading the alphabet or a page out of