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Motivation in Physics

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MOTIVATION IN PHYSICS

In recent years there has been a decided trend in high schools the country over toward general science, and away from the particular sciences, physics, chemistry, biology, etc. The proponents of general science seem convinced that this is due to a better choice of subject matter in their field, and to better methods of presentation. However this may be, it will certainly be well for those of us who have to do with the teaching of the special sciences to subject our own work to critical examination. We should aim to discover our faults of whatever kind, and eliminate them. We should also study the aims and methods of general science, and adopt from that field whatever will help to improve the work in our own.

Pupils will develop mentally, and will learn physics or any other subject, not by the good work of a teacher, but by their own activity. These will be the more vigorous, and will show the greater yield in desirable results in proportion as they are strongly and wholesomely motivated. The most important function of the teacher is therefore to establish such conditions in the class as will lead the pupils to interested, enthusiastic and spontaneous effort. How may this be accomplished? That is a problem whose solution will depend in part upon each specific teaching situation. There are a few general principles, however, which are applicable to all. Some of these will be mentioned below.

1. Choice of material.

If the pupil is to become interested in his work it is essential that the material studied should appeal to him as worth while. A kindergarten child, mature beyond his years, once protested against the making of paper chains on the grounds that they were useless. They had not the strength a chain should have. As he expressed it, "They would not hold anything at all.' Older pupils may seldom express themselves so freely at least in the presence of their teachers. But their views of the matter, whether clearly conceived as in the case of this kindergarten child, or whether only subconsciously felt, will be reflected in the interest, or lack of it, with which they respond. It is therefore desirable to keep the student constantly impressed with the significance of the material chosen for study. Much of the content of the Physics course will immediately appeal to all as important. But even so, interest in its study may be quickened if care is taken more fully to acquaint the pupil with its value.

Let us take an illustration from the subject of sound. The pupil observes that an object emitting a sound seems to be in a tremor. Further study shows it to be in a regular vibration, and that this is an essential condition for the production of a musical note. He also observes that a sound once made up is sometimes capable of setting up vibrations in near-by objects similar to those of an object emitting a sound. A shrill note sounded near a piano, for example, may set some of the strings in vibration. These and similar facts lead to the conclusion that sound is transmitted as a longitudinal or compressional wave in the air. This is a fact of nature in which the pupil is mildly interested. Now let him discover that by a suitable arrangement of a diaphragm and stylus which can be set in vibration by such a sound, stylus resting upon a rotating cylinder or disk of wax, a trace can be made in the wax of such character that when the action is reversed the trace will cause the stylus and diaphragm to vibrate just as before, the diaphragm in turn setting up waves in the air which are remarkably similar to those of the original sounds. On making this discovery he is much more deeply interested. He immediately perceives that in this way he can make a permanent record of any sound he wishes, for example of his own voice, and reproduce that sound at will. This thrills him, especially when he realizes that such a sound, reproducing faithfully every tone and accent, might easily be preserved to future and even distant generations.

The above illustration might be carried farther to include the effect of such a sound wave upon the diaphragm of a telephone transmitter or broadcast microphone, with the consequent reproduction of the voice in a distant city, or even throughout an entire continent. When he realizes that he might possibly be heard at once by every listener in the nation, or even beyond, he is not likely to think of the simple vibrations that give rise to sound as of little consequence, and is more inclined to study them with enthusiasm.

A second point to be considered in the choice of material is that it should be adapted in difficulty to the ability of the pupil. If it is a thing the pupil already knows or may learn with little effort he will become bored. If it is too difficult he will become discouraged. How to choose wisely in any particular situation is a difficult question, the more so since every physics class will include pupils of widely differing experience and ability. One aim might be to choose for the pupil of average ability, trusting that the requirements of both the brighter and the slower ones will thus be sufficiently well cared for. Another and better method would be, as well as possible, to adapt the work of each individual pupil, in both amount and difficulty, to his own particular capability. This may be done by means of additional problems or projects for the brighter members of the class, by outside reading on subjects related to those taken up by all, or by special reports, made to the class if that seems desirable, on important engineering projects, ingenious and widely useful inventions, or recent advances in science. The science club may also be made a valuable adjunct in fostering interest and in supplying a field for the activity of the more capable members of the class.

A third consideration in the choice of subject matter is to include in proper measure material which is already known to the pupil, and material which is new. The main objective, of course, is to furnish conditions essential for the most rapid mental development of the pupil, and for the greatest increase in his range of knowledge. Neither of these aims would be accomplished if the material were all new. Mental development, and increase in knowledge can come only as a result of seeing and pondering the new in relationship to what is already known. That is the justification for the use of analogy in the study of physics, such, for example, as the flow of water to illustrate electric current, and of water level or pressure to illustrate electro motive force. It is for this reason also that the teacher of physics may well refer to every sort of familiar device or mechanism in teaching a new principle. Fortunately there is abundance of such material from which to choose, as the following very fragmentary list of household and other devices will show:

Levers — Typewriter; piano; human skeleton; scissors.

Elasticity—Spring balance; bed or cushion springs; rubber heels; pneumatic tire.

Gears—Clock; watch.

Centrifugal force—Vacuum cleaner; cream separator; banking of highways at turns.

Heat conduction — Cooking utensils; furnaces; stoves.

Heating effect of electric current — Incandescent lamps; flat iron; toaster.

Mechanical effect of current—Electric door bell; Auto starter; washing machine motor.

Friction—Automobile brake.

Finally in connection with the choice of material, it will be found desirable to give at least some attention to the history of the subject, particularly to biographical sketches of great scientists, and the stories of their most important discoveries or inventions. Accounts of Franklin and his kite, Faraday and his wound iron ring, Edison and his electric light, Marconi and his wireless telegraph, may well be used to add vitality to the study of the whole field of electricity. So also the stories of Benjamin Thompson, afterward Count Rumford, an American whose life reads like a romance; and of Joule, a wealthy English brewer, for heat; and of Michelson, the first American Nobel prize winner, who recently died, for light. Living scientists, such as Millikan, Einstein, Madam Curie, Rutherford and J. J. Thompson may also well be given some attention, especially for the message they will carry that physics is not a thing completed and henceforth unalterable, but that it is constantly developing, now more rapidly than ever before, and that the way is still open for new discoveries, perhaps as great as any that has ever been made in the past.

2. Methods of presentation.

This phase of the subject, though of major importance, will have to be dealt with rather briefly.

The first suggestion is that the teacher consider well the advantages of the inductive method. By assembling and presenting the various lines of evidence bearing upon a certain point, or so leading the pupil that he will be enabled to do this for himself, and then asking him to draw the conclusion, the teacher is accomplishing a twofold object. He enables the pupil both to widen his range of knowledge and to acquire training in judgment, in intiative, and in the methods by which scientists work to add to our already existing store of knowledge. The pupil is gradually led away from the attitude which impels him to ask the teacher the question "How is it supposed to be?", and to the attitude which asks of nature herself the question "What are the facts in the case?", or "How does it function?"

Another meritorious method of instruction in physics is the problem method. By this is meant not the solution of the lists of problems given in the text book, though this may also have merit. A problem, in the sense used here, is any situation not yet understood by the pupil, but to the understanding of which he applies himself. The pupil, for example, might study an electric door bell in order to gain an understanding of how it operates. Such a task involves the application of knowledge already in his possession to the particular new situation to be studied. Paragraph 237 in the text book may give a full and clear discussion of the bell, but the choice of the bell as the subject of study is greatly to be preferred to that of paragraph 237, for many good reasons, one of which is that it sends the pupil to the bell itself for information. To see this, handle it, and watch it operate is far more instructive and interesting than paragraph 237 can be, however well written.

A third method of instruction is by means of a project. While the first method mentioned offers the pupil facts, and practice in weighing their significance, and the second offers him a concrete situation to the understanding of which he applies his mental power and his already acquired store of knowledge, the project offers him a definite thing to accomplish. He must not only remember and think. He must also do, and through doing he can not fail to learn. This method also calls for the exercise of thought and judgment, and constantly tests the correctness of these by application to the concrete situation in hand. If for example the pupil were to take the project of constructing a door bell and making it operate there would be no lack of opportunity to ponder and judge, as well as to do, unless, indeed, he were satisfied with unthinkingly making a duplicate of a bell already at hand. And the quality of thought and judgment employed would be immediately revealed by the progress and success of the project.

There is also the contract method. This is not in reality a method of instruction, but a method of division of labor in cases where the course includes a greater variety or amount of material than can be closely studied by all.

Of the methods mentioned one will be found better adapted to one subject or situation, another to another. All have the merit of fostering interest, and so of making effective the efforts of both teacher and pupil in the yielding of desired and permanent results.

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