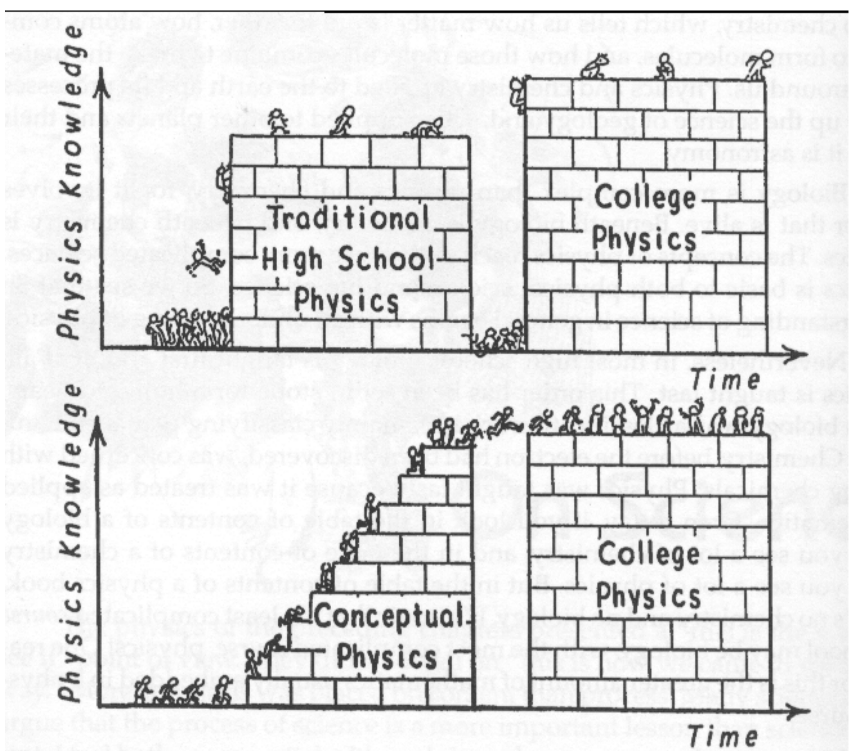
Conceptual Physics



*From Hewitt, p. 162

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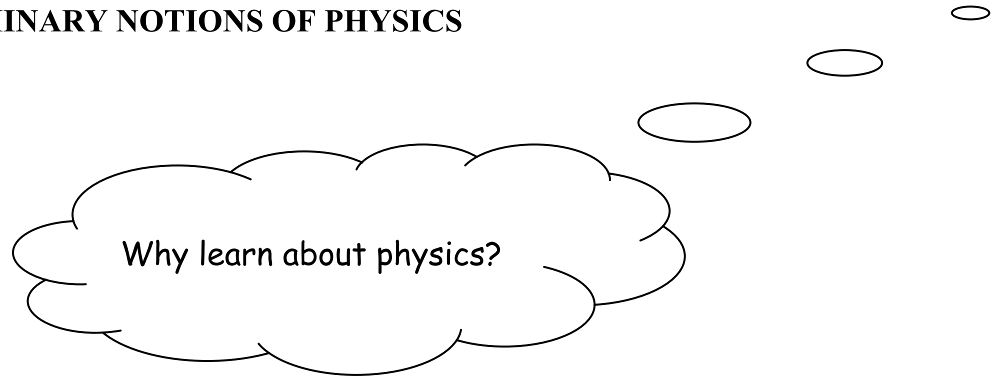
SOME PRELIMINARY NOTIONS OF PHYSICS



To physics teachers, it may be that physics is entirely interesting in it's own right, and worthy of the effort required. For the average student, however, this answer competes with several other disciplines that make exactly the same claim.

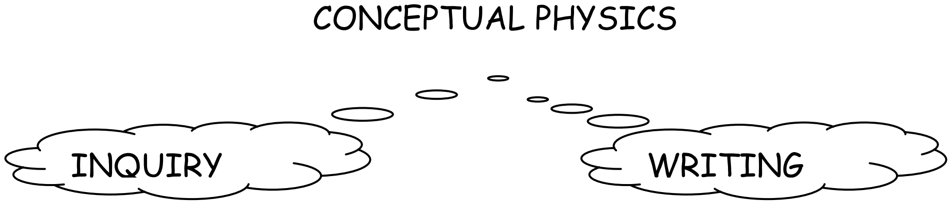
THE SITUATION

Physics used to be called natural philosophy, which was basically the study of unanswered questions about nature. If we look at the order in which students are exposed to science, we find that life sciences are generally taught before physical sciences. Now consider the irony: if we look at a biology textbook we will find lots of chemistry, if we look at a chemistry textbook we will find lots of physics, but in a physics textbook, we find neither biology nor chemistry. So, by teaching life sciences first, we are in fact working backwards towards physics.

It has been suggested that the reason for this discrepancy is largely historical – indeed, science texts have been like this for about 100 years. At this time, biology was basically a classification science (plants & animals), chemistry was concerned with mixing things together (before the electron was discovered), and physics was taught as applied mathematics. And that leads us to:

THE PROBLEM

Physics taught as an applied mathematics course is oriented to students possessing strong mathematical skills. The mathematical emphasis has been a stumbling block to those who are not good at math. It is equally important to note that the mathematical focus has, in many cases, obscured physics even for those who are quite comfortable with mathematics.



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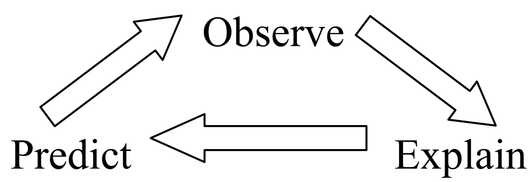
PREDICT, OBSERVE, EXPLAIN

The technique is both an interactive version of the scientific method and a format for demonstrations that promotes a more active approach to learning. The teacher begins by setting the stage for the experiment by defining the materials involved and describing the method. Students are then asked to record their predictions of what will happen given the variables that have been defined by the teacher. The format that the predictive process takes can take on a variety of forms in that predictions can be made as a class, in small groups, or individually. The unifying feature of this process is that students commit to their predictions in writing. The teacher then allows the experiment to occur, and invites students to make observations in their own way. The explanatory process then begins in one of many formats. The usual format is to ask students to independently come up with an explanation for the observation, and then to share the explanations as a class. Often many explanations are equally valid, and the explanations often pose new questions. These new questions can lead to new predictions, and hence a repetition of the P.O.E. cycle. P.O.E. allows the physics teacher to show students that physics is dynamic and circular process rather than a static and linear set of rules.



Criteria for a Good P.O.E.

1. The students must feel like they are capable of giving a prediction – pure guessing is not useful

2. The observation should be clear and concrete.

3. Students should be able to explain the result (don't give a P.O.E. to a grade 6 class that requires grade 11 physics to explain)

4. An observation that is a surprise is useful when P.O.E.'s are used to specifically challenge student viewpoints. The observation should not always be a surprise, because students will tend to have a negative attitude towards the procedure if they feel like they always predict incorrectly.

Consequences of P.O.E.'s

- Must accept experimental findings even when you would like them to be different. Distinguish between what you see, and what you wish to see.
- Teaches that changes and advances in science don't take place by throwing out current ideas and techniques, but by pushing them to reveal new ideas.

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LAB BOOKS

Mathematics is clearly the core method of communicating in the world of physics. Mathematical ideas can be expressed unambiguously, and are not plagued with the double meanings rampant with language. Equations are a convenient short-hand for expressing ideas about the world around us.

That being said, there is a problem with any mathematical equation that cannot be expressed in words as well as symbols. It has been a complaint of many a physics teacher (and more than a few students) that physics neophytes concern themselves solely with learning how to solve physics problems mathematically. Many top students in physics classes are masters of manipulating equations, but have little or no clue about what their solutions actually mean.

A lab book serves as a written record of what has transpired in class. An 80 page, coil bound book will suffice. By using this kind of device, students are not bound by preordained worksheets. The result is a powerful record of the development of the attitude of inquiry and experimentation. as well students should have to provide written explanations as well as mathematical ones.

EVALUATING P.O.E.'s & LAB BOOKS

Evaluating a P.O.E. depends entirely on the format that it was done in class. If the P.O.E. was done entirely as a class, then the mark is basically one of completeness. If students are asked to complete an explanation on their own, it is often useful to give them some questions to consider when they are writing their explanation. Regardless of the evaluation technique employed, however, it is critical that students feel safe and empowered to participate in the POE process. Do not, under any circumstances, take marks away for incorrect predictions.

Lab books take the place of the 'fill-in-the-blank' recipe sheets that often find their way into high school science classrooms. Set out clear expectations of what you are looking for in each experiment that is completed in class. Wherever possible, allow for student creativity throughout the process. For example, you might wish to ask them to determine the relationship between two variables in an experiment, but leave it up to them to design their own method and means of reporting their results.

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