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ABSTRACT

This document explains the importance of problem solving in the high school physics curriculum and points out the lack of opportunities in textbooks for students to practice their problem solving skills. The necessity of having introductory-level work texts cannot be ignored and having a work-text book would be beneficial from the teachers' point of view. (Contains 12 references.) (YDS)

THE HIGH SCHOOL PHYSICS WORKBOOK: A NEEDED INSTRUCTIONAL DEVICE

BY

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High school students who take introductory physics are often confused and immediately immersed in an abstract higher level course that proceeds rapidly (B.G. Aldridge, 1989). One of the fundamental skills to be mastered in high school physics is problem solving. This skill should be a major part of the course. Problem solving in high school physics is also the hardest part of the course (J. Larkin, and F. Reif, 1979) as it is in college and university physics. This is mainly because complicated problems are very frequently given to the students who many times have no background or schema to solve them (B. G. Aldridge, 1989). The course is then made unncesssarily difficult since the majority of students encounter obstacles in the problem solving and this tends to turn teenagers especially away from physics. To complicate matters, most problem solving behaviors are established by the modeling effect (F. Reif, 1981) or by examples in the text (J. Rigden, 1987) and practice (F. Reif, J. Larkin, et al, 1979). The high school and college physics texts frequently do not give examples for all problems in the text and the student is usually caught in a dilemma since he has really little background for solving the problems and has few examples illustrating how to solve them. The student must then rely upon a problem solver such as Shaum's Outline or must get help from a knowledgeable person such as a cousin or older brother who has had the course before in some form.

My solution is to develop a workbook that has exercises of a simple nature in problem solving but also more advanced problems as well. The general format of most mathematical type physics texts, high school or university, is that a principle or law is stated in mathematical form, commonly called a formula, and the student applies the formula to situations given in the form of exercises. In the high school introductory course as well as in the university introductory course, these formulas are generally in terms of algebraic and trigonometric language of about the Algebra II level in high school.

In a number of high school texts such as in Modern Physics, (Various editions), the most widely used text in America, most problems are given once. If the student can solve a given problem, he has no practice with this type of problem and tends to forget how it was solved. If the student cannot solve the given problem type, the teacher must show the student how to solve it and the student gets little experience solving the problem since he has no problems to practice on for mastery. In both cases the student cannot integrate the solution technique into his problem solving schema, and it is not available for later use.

The writers of these introductory high school and college texts seem to have forgotten how humans, as well as other animals, learn. These authors have forgotten a fundamental law of learning established by Thorndike, that practice makes perfect (G. LeFrancois, 1986). Further, another law discovered by Thorndike early in this century was the law of effect which states that responses followed by a satisfying state of affairs will be remembered. How can a student remember a formula or a solution to a problem type unless he has some satisfying experience such as being able to solve a basic problem which he can continue to try to do until he is perfect at it through practice? The models that should be used in physics texts and courses are drill and practice models that are used successfully in mathematics. As Gagne has pointed out the solving of complex problems requires prerequisite skills in many cases. A prerequisite skill for solving a complicated physics problem is often being able to apply formulas to a simpler situation and then transferring them to the more difficult, or at least it is a great deal easier to solve a more complicated problem in physics once the simpler problems are mastered (C. Middlecamp & E. Kean, 1987). The mastering is done through practice.

In order to facilitate problem solving on a basic level, students must have an opportunity to solve problems using the simple formulas that students usually get in high school physics. Also, they must have practice so that the basic formulas will be put into the students' memories and that the students will then have command of the formulas. Only they can they apply the formulas to appropriate situations in physics and later build on them for more sophisticated work in the subject. Also, terms, ideas and pictorial models and diagrams must be mastered in a high school physics course. Physics texts have neither the space nor the inclination to give students, especially high school students and beginning college students, the help that is needed for mastery, practice and isolation of key ideas on a subject such as Newton's Laws of Motion or Wave Motion or Light.

What is needed is some kind of work text in physics, high school and introductory college, to help students learn the basics. At present, there are two outdated high schools work texts which also double as laboratory manuals. One is published by CEBCO (1964), and the other by AMSCO (1967). The group that puts out the "Conceptual Physics" material has a separate workbook-type publication on the ideas of physics (1987), but does not have quantitative problem solving in any large measure. College physics packages often contain solution manuals and student study guides, but really are not work texts in which students can write answers. answer questions, draw relevant diagrams and get practice solving basic physics problems based on examples immediately available to the student. Some of the material for physical science, a lower level high school course, that accompanies physical science texts, especially in the qualitative aspects of physics, I have found to be very useful. Such material includes puzzles, exercises, reviews of terms and ideas and often clarify concepts to the higher level physics students. At this stage computer assisted instruction is being developed and may be useful in some respects to enhance student learning in the introductory physics course in high school and college, but there is no substitute for students writing in the answers on a worksheet or solving physics problems using pencil and paper. Further, all students do not have computers at home, and if they do, the computers may not be compatible with the software accompanying a course package. Therefore, from the student learning standpoint, current work texts are needed, especially at the introductory level in high school and college.

According to B. F. Skinner, the teacher is basically responsible for the subject matter skills and knowledges and Skinner contends that there are some general rules of thumb for classroom learning. The rules are "1) the student learns by doing, 2) the student learns from experience, and 3) the student learns by trial and error" (Bell-Griedler, 1986). A work-text in any subject, not only in introductory physics, will help to reach these objectives although Skinner would prefer them to be more specific. In a work-text the student will actually work with the material in the course, answering questions, drawing diagrams, and most of all, solving problems on a basic level. The work text will give the student basic experiences in the subject. While a student does not necessarily have to learn by trial and error (Bell-Griedler, 1986) as Skinner points out, answers for, say odd numbered problems, will provide feedback for the student so that the trial and error process is minimized as well if there are examples to help solve the problems in the work-text. Skinner also says that the teacher should construct the behavioral repertoires to maximize learning and should generate motivation for learning (Bell-Griedler, 1986). A work-text would be especially useful for introductory high school and college physics since the subject matter in these courses is basically the same the world over and since a student would be dealing with subject matter made simple, he would tend to be self-motivated especially if he was successful with the work since the reward for successful problem solving would be validation of the correct answer. In order to generate success, at least in part, models or examples for doing the problem solving will be provided. Problem solving is the major part of any reputable physics course and success in this area will generate enthusiasm on the part of the typical student.

As Skinner has pointed out, there are punishing contingencies in the traditional school method of "assign and test" (Bell-Griedler, 1986). Most physics students in any level of physics have difficulty with the course material, mainly the problem solving. Because they must sink or swim since the grade in a physics course is based upon tests, students often have an aversion to physics courses in general. The average student tends to do badly in this situation since he often does not have available responses to solve the required problems especially and gets punished for his wrong answers with a low grade or failure in the course. The student must be taken through a carefully planned sequence of behaviors in order to master the required material, or in the case of physics, the problems and exercises in the physics book. A work text will meet this lack of available responses to physics problem solving and will provide behaviors that will help him/her master essential material.

From the teacher's point of view, a work-text would help the learning of students if one were available. Time constraints often make it impossible to provide introductory physics students, as well as students in other subjects, with proper materials that enhance learning. Teachers frequently are engaged in administrative duties such as record keeping, extra teaching duties such as hall guard and counseling so that they have neither the time nor expertise to make good learning materials (AAAS, 1989). Further, a ready made lesson for class or homework frees the teacher so that he/she could help the students more often provided the lesson was meaningful and pertinent to the course. In physics the course work is the same everywhere so good materials, providing solid basic instruction would help the teacher to teach the course with few local alterations. By making the materials primarily basic all the high school physics students will be able to master them and for those with poor skills, the teacher will have some time to help them. Finally, a work text with meaningful quality learning material will also help in classroom management since students will be busy doing their seat work in the work text with success. From this, a better classroom atmosphere in the physics course will result not only from the success of most of the students, but also from the ability of the students to do some of the higher level materials since they will have some of the prerequisite skills needed for them which were developed in the work text. The teaching of chemistry is under constant attempts to improve itself through better learning materials. There are many many chemistry workbooks for instance and because of this, the teaching of chemistry has improved. The teaching of physics, high school and college, needs to have this approach if we are to retain the students we now have in physics and encourage more students to take physics.

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