Physics Teaching in Ninth Grade: Identification of Learning Difficulties, Development of A Remedial Teaching Method, its Implementation and Assessment

Thesis For The Degree Doctor Of Philosophy By Joshua Idar

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Abstract

The course "Electricity and Energy" is an inquiry-oriented physics course for the 9th grade, that was developed at the Science Teaching Department of The Weizmann Institute Of Science. Starting with the treatment of simple D.C. circuits, this course proceeds to the concepts of heat , electric energy, other forms of energy and conservation of energy. Following the implementation of this course in Israeli schools, over a period of five years, it was found that the performance of average and low ability 9th grade students in this course was not satisfactory, and that they encountered serious difficulties in following the material and understanding the concepts developed in the course. These findings were confirmed by information provided by teachers who taught this course .

According to one of the hypotheses most frequently raised by experienced teachers these difficulties originated mainly, from the discrepancy that existed between the prerequisites of the curse, and the students' ability at the beginning of their studies in the 9th grade. However, at the beginning of the study we did not have enough information for either testing this hypothesis, or for deciding which changes should be introduced in the contents of the course, or in the way it was taught, in order to adapt it to needs and capabilities of weak students. This situation formed the background for the formulation of the objectives of the present study:

(1) To diagnose the difficulties that 9th grade students, in low and mixed-ability classes, encounter during the study of physics, concentrating in particular on the course ' Electricity and Energy.'

(2)To develop a teaching method that will make it possible to treat the learning difficulties identified, in normal classroom conditions.

(3)To implement the new teaching method, in a controlled experiment in normal classroom conditions, and to test its impact upon 9th grade students' achievements and attitudes toward the study of physics.

At the first stage of the study, we performed a detailed mapping of the prerequisites of the course, through a careful examination of all the written explanations, instructions and questions included in the textbook. The results of this mapping were used in the preparation of four background tests ('Algebra', 'Graphs',' Reading

comprehension in Physics', and 'Analysis of Experimental Results'), a laboratory practical test (of the 'unseen' type), and a follow-up questionnaire for teachers. These tests and instruments were administered to a sample of 9th grade students (in low and mixed ability classes), and to a sample of teachers. The results obtained, enabled us to identify substantial misconceptions in several areas, in which a sound understanding in required of the student for the comprehension of the material taught in the course. We found that even after months of study and laboratory work, a considerable number of students still misunderstand basic concepts in physics that were taught in the course. It became clear, that the more exposure of students to the experience of discovering (through guided experiments) physical phenomena and laws, was not, by itself, sufficient for building up a sound understanding and appropriate ways of thinking. We also found that while most of the students tested were able to perform simple mathematical operations, both in the areas of algebra and graphs, only a few of them were able to understand more complicated operations, similar to those included in the advanced chapters of the course. We obtained similar findings in the areas of reading comprehension and logical thinking, in the context of analyzing experimental results.

During the following stage of the study, we examined the correlation coefficients between students' scores in the four background tests, and their scores in physics achievement tests that were prepared specially for this study. These correlation coefficients showed that the four background tests, together, could explain about 29% of the variance in the average score of the achievement tests. The data obtained indicated, that a poor background in logical thinking ability affects the achievements in the first chapter of the course more significantly than in the following chapters. A poor background in mathematics, apparently had a stronger influence on the achievements in the second and following chapters. The influence of the reading ability was, as expected, similar in all the chapters tested. The findings outlined so far placed a serious doubt on the question whether weak students could significantly benefit from the course, when taught in the conventional ways.

The findings of the first stage of the study, and the results of a comprehensive review of the literature, served as guidelines for the design of a new remedial teaching method. This method, according to our hypotheses, could well improve the achievements and attitudes of weak students, without requiring a substantial reduction in the amount of material covered, or in the depth of treatment of this material. The new teaching method, was based on the extensive provision of immediate, content related, feedback to the student, about his progress in the study of the course. This feedback was supposed to improve: (1) the understanding of the physical phenomena and laws taught in the course, (2)The skill in the different techniques for processing data obtained in the experiments, (3) the understanding of the relationship between the experiments performed in the laboratory and the topics studied in the classroom. Three premises served as guidelines in the preparation of the learning materials required for the implementation of the new teaching method: (1) content related feedback was provided to each student, individually, immediately after he finished the study of a specific topic, (2) students were asked questions which could expose misconceptions and misunderstandings that were already diagnosed in the previous stage of the study. (3) the feedback materials included

drawings and pictures as similar as possible to the experimental equipment and set-ups that the student met in the laboratory.

A set of 20 diagnostic self-test booklets were prepared, along with their corresponding answer booklets for immediate feedback. The new method and materials were so designed that they could be integrated within the regular course of study, in normal classroom conditions. Through the use of these materials, each student could test himself at the end of each unit of study, and detect any fault in this understanding of the subject. By reading the explanations that accompany each answer, the student could also substantiate his comprehension. The teacher could obtain immediate, content related, feedback on his teaching, and easily identify the specific weaknesses of each one of his students, and of the entire classroom.

A the third and last stage of the study, a group of teachers tested the new method and materials in their regular classes. Another group of teachers, of similar professional background and teaching experience, served as a control group. They taught the course in their usual manner, as they had done previously. The results obtained by the comparison of the achievements of both groups, clearly indicate that the new method significantly improved the level of achievement and the attitudes toward the study of physics in the experimental group. The new method proved to be effective even after a period of several months of study, in the normal classroom conditions. The teachers who used the new method and materials, reported no serious difficulties in their use, and they found that students liked the methods and enjoyed their work.

We believe that this improvement in achievements, coupled with favorable attitudes, of 9th grade students is extremely important: It can have a strong influence on their tendency to study physics, and on their attitude toward related topics in future years.

Department of Science Teaching, Weizmann Institute of Science