Creation of a mature course in high school physics is this committee's goal.

Elbert P. Little

PSSC: A Physics Program

LAST summer more than 600 high school teachers from all parts of the country spent part of their summer vacations in college, learning about a new program for high school physics. More than half of these teachers began teaching the new course in September. Those who could not make arrangements for using the new program this year were strong in their statements that they would not teach their conventional physics courses in the same old way any more. Only a very few did not like the new program.

Such is the reaction of practicing high school teachers to the PSSC program. They agree that the subject matter of physics courses has become cluttered with the technological details of our industrial civilization. They find that the modern concepts of physics are interesting and understandable. They know that their students will find a pleasure in the challenge to study carefully, think clearly, and participate vigorously in a mature course in physics.

The Physical Science Study Committee is a young organization, stemming from informal meetings of college physicists in Cambridge, in early 1956. First thoughts were to make first class teaching films and new kinds of laboratory apparatus to aid high school teachers in presenting the fundamental topics in physics. Examination of high school textbooks of physics revealed the terrible abyss between the material being presented as physics and the professional physicist's concept of his subject.

Greater changes in knowledge and understanding have taken place in the last 50 years than in the preceding 500, yet the textbooks contained almost none of the modern concepts. Laboratory work, confined to confirmations of existing knowledge, presented no challenge to the student because he knew the answer before he entered the laboratory. Resource materials to which the able student could turn to satisfy his desire to go beyond the confines of the course material were almost nonexistent. In a country proud of its educational system, the high school physics course was found woefully inadequate.

A New Physics Course

The original group of physicists found that others all over the country were interested in the situation. A grant from the National Science Foundation pro-

vided a means of organizing a working group. College, university, and industrial physicists; high school physics teachers, school and college educators joined in laying the foundation for a new course in high school physics.

From the beginning it was apparent that the problems were tremendous. A completely new set of learning aids was needed, including text, laboratory instructions, apparatus, films, examinations, teachers guides, and resource material for extra reading. At the same time it was painfully obvious that a careful selection of topics was required. All of our knowledge in physics could not be crowded into a one year high school course. A carefully considered syllabus was developed, with topics chosen because they were basic to pupils' understanding of both classical and modern physics.

Many honorable but timeworn topics were excluded. Simple machines, hydrostatics, elementary heat were suggested as suitable for eighth to tenth grade general science courses. Sound was dropped as an explicit topic because an expanded use of wave concepts was proposed for the section on light. The details of four cycle engines, radio circuits, the weather, and other interesting but not pertinent material were dropped for lack of time and textbook space.

The final syllabus was divided into four parts:

1. *The Universe,* for an understanding of measurements in time, space and matter; speed, acceleration, and the use of vectors; the fundamental experiments revealing the nature of matter, both chemical and physical.

2. *Optics and Waves,* beginning with geometric optics, developing a corpuscle theory of light to explain geometric optics, finding that it will not work, and finally developing a wave model, leading to an understanding of diffraction and interference.

3. *Mechanics,* starting with Newton's Law of Motion and encompassing motion at the earth's surface as well as in space, through careful development of concepts of momentum, energy, and the great conservation laws.

4. *Electricity and Modern Physics,* including the fundamental experimental evidence in electricity that has opened the way to developments in modern concepts of atomics, light, and energy.

Experimental Use

During the summer of 1957 enough progress was made on a text and on apparatus to convince the high school teachers working with the committee that they could teach the course. Five schools, in 1957-58, constituted the first test group, and from their experience much valuable information was gleaned. Reactions of students were unexpectedly favorable in spite of the troubles always present in a new course. Both students and teachers worked harder than usual but they received correspondingly greater returns.

In the summer of 1958 more than 350 teachers from high schools all over the country had a chance to become familiar with the course, now revised and expanded as a result of the first experimental year of use. About 270 of these teachers elected to use the course for its second experimental year. Close contact was maintained with these teachers.

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through visits, area meetings, and questionnaires. In this way the 270 schools and 12,500 students constituted a test and evaluation group of major significance, matching in scope and critical judgment the radical changes in content and teaching philosophy embodied in the new course.

Reports were not unanimously favorable. Some teachers felt that the course was suitable only for the academically talented students. *The Universe* proved to be a stumbling block—the scope of interest awakened in the students produced so many questions and new projects in class that it was hard to move on. The examinations, produced by PSSC staff people working with Educational Testing Service, were unexpectedly difficult. Grades were all relative but Johnny (and his parents) found it hard to understand that 25 correct answers to 40 questions could indicate a high achievement. The new kinds of laboratory experience either were damned as completely unworkable or were hailed as providing first class research experience for young minds.

Evaluation

The vast majority of reports gave vivid pictures of teachers, and their students, working harder than ever before but finding a reward almost unique in their school experience. Most students enjoyed the chance to reason closely and arrive at answers they did not already know. The girls found that they were on the same footing with the boys because the course was not based on the man's world of machines and gadgets. Laboratory work was more than mere confirmation of values or laws already known. The films showed physicists and teachers as normal human beings, talking respectfully and with interest about the subject matter and apparatus in the course. The teacher's guide, with the films, helped the teachers over the rough spots, the new material and problems, the new approach to the laboratory work, the little techniques for leading the students into productive channels of thought and analysis. Without the teacher's guide, the second test year, with its wide diversity of teachers and students, would not have been so successful.

On the whole, experience with the PSSC program was overwhelmingly favorable, for only about twelve of last year's teachers have rejected the course. A few others have shifted schools, but 250 of last year's teachers are giving the course again in 1959-60. Another 350 teachers, participants in Summer Institutes or In-Service Institutes, have joined the program, making a total of 600 schools and about 20,000 students for this year.

The subject matter included in the PSSC program is not unique. It does represent the carefully considered choice of a thoroughly competent group of college physicists and high school physics teachers. In defining the course, they had definite objectives in mind and chose topics to support these objectives.

The major lessons to be learned from the whole PSSC program fall in another category. They present us with strong evidence that: (a) High school teachers and college teachers can work together, and the experience is stimulating to both; (b) Subject matter revision should be made by practicing specialists in a field (in this instance college, university and industrial physicists); (c) High school students will respond to an intellectual

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the improvement in personal adjustment shown can be attributed to maturational factors. While those in the experiment felt that the special classes had been responsible for much of the improvement in personal adjustment, the control group improved an equal amount.

As the level of abstractions demanded by the curriculum rises in late grade school and in secondary school, the number of individuals identified as slow or as mentally retarded rises sharply. However, since most of these handicapped individuals are capable of holding a job and raising a family, society no longer labels them as different. Thus by the age of 17, it appears that the worst years are over for the slow learners, even though as a group their personality adjustment is still below average. The slow learner has either made the adjustment to high school or has gotten a job as a wife or a wage earner after leaving school.

Conclusion. A special program in the ninth and tenth grades was fairly successful in improving the social adjustment of an experimental group of slow learners in both the school and the community, while the control group during the same period tended toward a worse social adjustment. Personality and school achievement were not significantly affected, but there are indications that these might be improved by an early elementary program.[2]

—GORDON P. LIDDLE, *assistant professor, Committee on Human Development, University of Chicago, Illinois.*

[2] Reported in "Experimental Room for Slow Learners," by Gordon Liddle and Dale Long, in the *Elementary School Journal*, December 1958, p. 143-49.

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presentation of subject matter, in which rational thought and analysis are more important than brute force memory; (d) High school teachers, with proper support, can teach subject matter far beyond the limits of what they studied in college; (e) Proper support consists not only of subject matter but of the points of view, attitudes and concepts of the specialists; (f) An exceptionally favorable method for providing this kind of support is through the use of teaching films in which these specialists are the film personalities, seen and heard by the students.

For the fall of 1960, commercial versions of the text will be available. Commercial production of the new kinds of apparatus may take longer because of new manufacturing and procurement problems. Films, examinations, and resource books will be available if the demand warrants it.