With PSSC, Teachers and Students Had To Think

by John S. Rigden [i]

Oh to be back in the halcyon days of Dwight David Eisenhower who said he was always fond of "my scientists," listened attentively to the advice from his scientists, and actually followed it. The Physical Science Study Committee which produced the PSSC physics course began its work in 1956, late in Eisenhower's first term – a delightful accident of timing. The first Earth satellite, the Russian Sputnik, was launched on October 4, 1957; President Eisenhower called a group of leading physicists to the White House 11 days later on October 15 and with that, physics was on a roll.

I. I. Rabi, a friend of Eisenhower, was the leader of this group of physicists and one of the recommendations he made to Eisenhower was to strengthen science education in America. Eisenhower listened carefully to this and six other recommendations and, as Hans Bethe recalled, Eisenhower turned to his adjutant and said, "You see that this is done." The PSSC textbook, *Physics,* with other course materials came out in 1960.

Even had I been smart enough, I was too young to be part of the Jerrold Zacharias-Francis Friedman team at MIT that created PSSC; however, I remember my reaction as I first looked through the PSSC text. First, I remember there were words, lots of words, and few equations. "Words in a physics text?", I asked myself, "Like putting equations in the Bible." Second, the order of the content violated the sacred canonical tradition: Newtonian mechanics always came at the beginning of a physics textbook, but in the PSSC text, mechanics came in the second half of the book. "Like putting Genesis after Chronicles," I thought.

My third memory comes from the early 1960s. Eisenhower fulfilled his promise and, following the advice of the physicists, he made federal money available for programs to improve science education. Throughout the 1960s, NSF-sponsored summer content institutes and academic-year, in-service institutes sprang up across the country. I was involved with these institutes and my memories are all good.

Here is what I remember so happily. During the summer, physics teachers descended on college campuses, took up residence in student dormitories, and began the 5 days-per-week, 6-to-8 hours-per-day, 6-week long content institutes. In-Service content institutes met for 3 or 4 hours-per-week throughout the academic year. In the 1960s, the PSSC course was the centerpiece of many of the content institutes. I also happily remember the enthusiasm of the participating teachers. The teachers, many without strong education backgrounds in physics, were eager to learn. Physics consumed their time; physics dominated their minds. After dinner each evening the teachers would gather on the lawn in front of their dorms to talk, and the talk was mostly about physics. Every morning the day began with questions the teachers had come up with during their discussions the previous evening. It was delightful.

I do have a sad memory, however. Things did not go well for PSSC. As I remember, PSSC captured only about 7% of the high school textbook market. I am not positive about the exact percentage, but 7% is close. Whatever it was, the market share commanded by PSSC was always small.

Why didn't PSSC get more adoptions…many more adoptions? Before I give my answer to this question, I say this: Conscientious physics instructors should conduct a comparative analysis of the PSSC course with those high school and college physics courses popular in the 1960s (and, of course, still popular today); if they did this, I believe some provocative thoughts would assert themselves and some troubling questions would follow. So, why didn't PSSC enjoy greater success? Here is my answer: I believe PSSC failed to capture a sizable share of the market because PSSC required both teachers and students to think. Let me explain.

Consider the following topics: Space, Time, Mass, Measurement, the Atomic Nature of Matter, Functions and Scaling, What is Physics?, Units, Motion Along a Path, the Interaction Concept, and the Nature of Science. The popular textbooks in the 1960s and those popular today – both high school and university – cram topics such as these into 15-some pages of the "throw away" chapter, Chapter One. The instructor says to the students, "Read Chapter One. It is important." And then the instructor lunges ahead to Chapter Two. The students, unimpressed, know full well that nothing from Chapter One will ever appear on any test so they smile and ignore it.

There are physics textbooks, however, where "Chapter One" cannot be ignored. For example, Richard Feynman devotes 8 chapters (81 pages) to topics such as those listed above. For reasons quite apart from these 81 pages, I realize that the Feynman *Lectures ON Physics* is no candidate for mass adoptions. I mention the Feynman approach because Feynman was no dummy. Feynman, an unusually gifted physicist, obviously had reasons for starting his *Lectures* the way he did; at least in part, I believe Feynman started with these topics because he wanted his lectures to be *On* physics, not *In* physics. Feynman was not alone. Robert Karplus, who wrote foundational papers in QED, had thoughts similar to Feynman's. In his failed textbook, *Introduction to Physics*, Karplus developed such topics in 4 chapters (107 pages). Can an instructor ignore 107 pages? And finally, PSSC, which preceded both Feynman's *Lectures* and Karplus's *Physics*, introduced these basic topics in 10 chapters (178 pages). No instructor can "throw away" 10 chapters.

All physics instructors, high school or university, would, I believe, acknowledge that topics like Space, Time, and Mass and the others listed above are important; in fact, most physicists would acknowledge that an understanding of these fundamental topics would provide a conceptual base that would facilitate a student's learning of physics. These topics, however, require students and instructors alike to *think*; if students and instructors are to understand the significance of these ideas and appreciate some of their nuances, they must think. Instructors cannot escape to the cozy comfort of blackboard equations to explicate the Nature of Science, the Role of Measurement, the place of the Atomic Theory of Matter in the conceptual hierarchy of physics. No, instructors must think. To approach these qualitative topics, instructors must engage students' minds and do so without chalk in their hands. This is difficult and requires careful and deliberate preparation, that is, thought. In a similar vein, students cannot understand the meanings of Space, Time, and Mass by memorizing equations and learning some algorithms. No, students must also think.

I believe Part I of the PSSC textbook, these first 10, largely qualitative chapters, made a large contribution to its failure. But the PSSC-failure goes beyond Part I.

Part II of PSSC, Optics and Waves, is presented in a style similar to the first 10 chapters: the burden of the presentation is carried by words and diagrams. Students were expected to follow the textbook's development of optical concepts and come to accurate conclusions. In these 9 chapters, students must think about optical phenomena – think like a physicist. In turn, instructors must find words that complement those in the text and words that embellish the physical phenomena being presented. Again, instructors must think.

Finally, in Part III (page 307) of the PSSC text, the authors begin dynamics. (Karplus begins kinematics on page 348.) Mechanics is hard; its concepts are counterintuitive, its basic concepts are couched in vector mathematics. The authors of PSSC concluded that mechanics is *not* the place to begin a student's study of physics; rather, they developed an intellectual base and moved gently into mechanics (Motion Along a Path) before they burdened students with the demands of dynamics.

Some time early in the life of PSSC, the label "Hard" got attached to it. In many schools, PSSC became the "hard" physics course and was taught as a second-year physics course following the "easy" equation-driven course. When PSSC obtained the reputation of being "hard," its adoptions dwindled.

PSSC required thinking. The PSSC laboratory experiments were not laid out in a series of well-described steps for the student to follow dutifully; rather, students had to read the lab book, think about the words they read, and translate those words into specific actions.

In those introductory physics textbooks that have enjoyed wide adoption, equations drive the content. Equations are powerful because one equation can summarize a page of words, but as a result, the equation short circuits the necessity of thinking. The authors of PSSC wanted students to become familiar with physical phenomena and to think carefully about them; in this process, students might have the exciting experience of an equation coming, not from the external page of a textbook, but from within.

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