

The PSSC course in retrospect

Perhaps you would be interested in the views of an experienced physics teacher regarding Anthony P. French's article "Setting new directions in physics teaching: PSSC 30 years later" (September, page 30).

Directly after completing my bachelor's degree in physics, I began high school teaching in 1962—just after the introduction of the first PSSC course. I was most fortunate to have student-taught under Thomas D. Miner at Garden City High School. My own district, Jericho, has always been most supportive. Like Garden City, it is in turn supported by an above average socio-economic community.

I use PSSC films and PSSC-developed lab equipment, yet I have never taught from the PSSC textbook. The curricular content of what is taught in my classroom has been determined more by the New York State Board of Regents than by the Physical Science Study Committee. It is no doubt true that state education departments (at least a few of them!) determine what is taught in most American classrooms. Creative material on orders of magnitude and scaling will at best be relegated to a minor place if it is not required by the state.

In my particular situation I could have introduced the PSSC course. Why did I choose instead to borrow liberally from it—and from the creative minds of people like Miner, Samuel A. Marantz and Richard M. Sutton—rather than adopt PSSC? The answer, which is ignored by curriculum developers at their peril, is involvement. I have made a conscious effort to purge my mentality of the NIH (not invented here) syndrome. I am pleased to applaud genius wherever I see it. But I cannot always use it in my class. I cannot ask my district to buy a book (which cannot be replaced for five years) if it has an inappropriate reading level and contains only problems designed for fostering creative problem solving in gifted students. PSSC ignored the interests and abilities of the average American student.

Attention must also be paid to the average American teacher. Here PSSC did a better job, with its outstanding support materials and in-service courses. However, of 19 028 physics teachers nationwide, about 12 000 teach only one section of physics, and 29.3% of all high schools offer no physics at all! The AAPT publishes *The Physics Teacher*, and yet the "physics teacher" is a rarity if not an endangered species. "Science teachers" introduce most of our nation's youth to whatever they first see of physics.

Should physics be "watered down"? Of course not. No more than English; certainly no more than math. The solution is to provide exciting, relevant, appropriate materials for our students. The PSSC course was developed by brilliant, well-meaning college professors—without significant involvement of high school teachers or the state education bureaucracies. Thus substantial practical and political problems were never addressed.

In addition to working with college professors on curricular content, a more successful effort might begin by asking high school teachers to send copies of their best laboratory experiments, comments on reading levels, and what they would most like to see in a new course. Perceived needs and realities must also be discussed with state education departments.

We can all pull together, but not when the maximized vector is going off on a tangent!

Reference

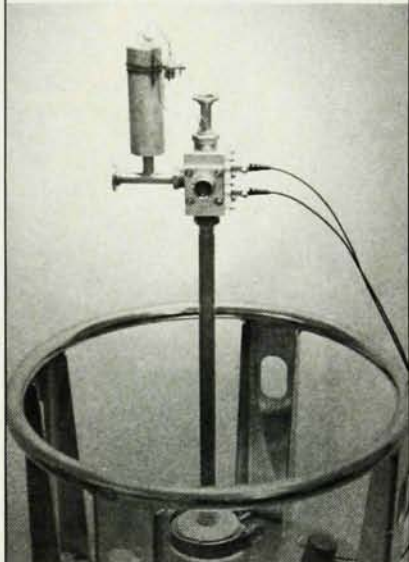
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DAVID S. MARTIN
Jericho Union Free School District
Jericho, New York
9/86

While Anthony French talks about the PSSC course as a "meritorious" undertaking, I would say that the results of

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this great effort were in part poor. I would maintain that students and high school teachers have rejected the "meritoriousness" premise with their feet, avoiding the course. Meritorious for whom? Certainly, when offering the course decreases enrollment (as Peter Froehle reported about his class in his letter to PHYSICS TODAY [October, page 148]), confuses students and turns off prospective young scientists, as I have personally found, there is something fundamentally wrong. For the people involved in the creation of PSSC, it was a great enterprise. For the consumers of this program, high school students and teachers, it left a great deal to be desired. Obviously, despite the testing at all levels of development that French reports, the PSSC course did not take into account the psychology of young high school students taking physics probably for the first time. I believe the failure lies not so much in the typical high school physics teacher's not being a "scientist" as in the course materials' not taking into account the psychology of this high school student.¹

Also, French says that one reason PSSC films are not used today very much, save *Frames of Reference*, is that the hairstyles of the film participants are outdated. I disagree. I have shown many films, some dating to World War II, to high school science students, and rarely do the students laugh. The students do not respond when the films are not relevant or interesting to them. My students have responded positively to the White series of physics films, which by the way were discarded when the PSSC and Harvard Project Physics films were made. The White series, among other things, simply explained how to do the physics problems that the students had in their homework. Probably, this is because our physics students know that foremost they want to pass a physics course, not listen to a famous physicist tell about his work, as some PSSC films offer. A film on how to do homework problems is very valuable to a beginning high school physics student since it has immediate relevance. *Frames of Reference* offers novelty and thereby generates interest on the part of the student. Obviously, the PSSC creators did not take into consideration interest, immediacy or other principles of teaching science to young people.² I further believe that the problem in high school physics is in part improving the quality of teaching,² this belief stemming from my having taught in a number of high school physics classes in different schools.

References

1. F. Reif, PHYSICS TODAY, November 1986, p. 48.
2. S. Brekke, *Sci. Teach.* 53(8), 80 (November 1986).

STEWART E. BREKKE
Paul Robeson High School
Chicago, Illinois

11/86

I read Anthony French's article on 30 years of the PSSC course with much interest. Here in Venezuela all secondary school students receive at least one year of physics and about 85% receive two more. This promising picture, however, produces few results, due to dismal texts, a majority of poorly prepared teachers, and very few laboratories (and these equipped with almost nothing).

The effects of PSSC here were mainly in three areas: programs, texts and teacher "physics consciousness." The Ministry of Education's physics programs were completely reformulated in the early 1970s in accordance with PSSC, changing from a data acquisition and problem solving approach to a study of processes and methods. The old program opened with the use of the vernier; the new one, with the importance of observation.

Although new textbooks appeared immediately, it took until the early 1980s for the philosophy to penetrate to the core of the newer ones, which in addition to incorporating PSSC principles now do pretty well as "show business" as well.

But the most valuable effect of the PSSC course in Venezuela was in teacher preparation, which logically must precede that of the students. In a country where rote learning not only is the rule but also "rules" within the system (a teacher who does not dictate the things to be learned is considered inept), the exposure of even this small group of educators to a system of inquiry and investigation produced highly beneficial waves that propagated in all directions.

Unfortunately the effects did not reach higher administrative levels and the creation of adequate laboratories has remained insignificant, producing in both teachers and students an effect of "physics is a nice thing to do somewhere else."

At the laboratory level the PSSC course was of great value, showing how important principles could be demonstrated at low cost. (Previously we imported expensive German equipment, which was always incomplete.) But many experiments simply cannot be done here. Electrostatics is out in the 35 °C heat and 90%-plus relative humidity, and closing all the windows

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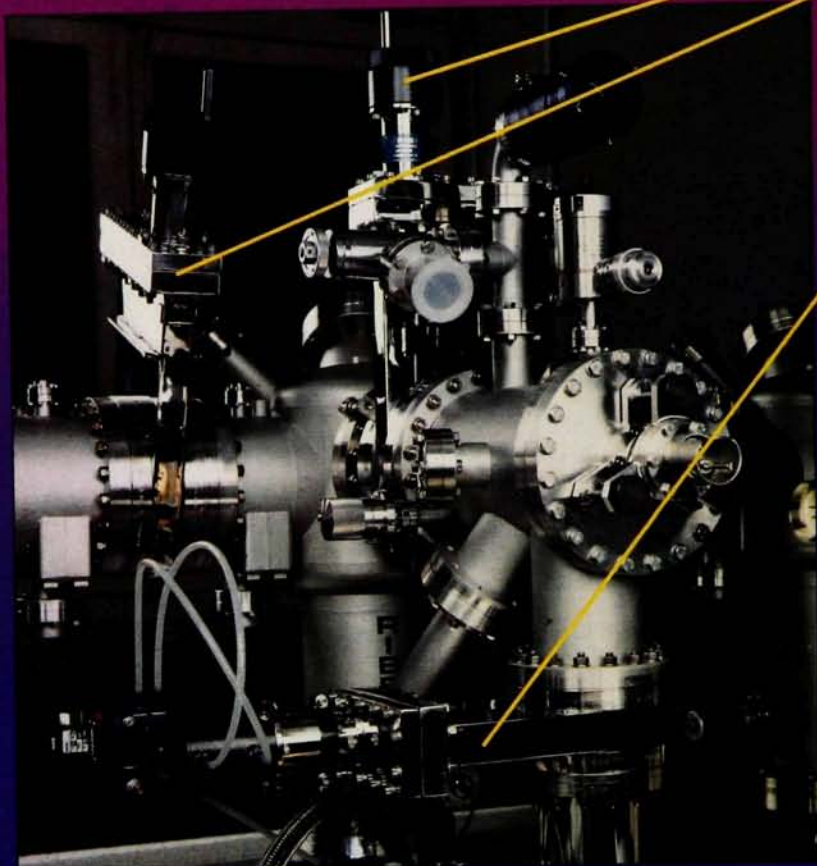
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letters

of the laboratory for half an hour to eliminate the breeze so one can do some sensitive measurements requires a degree of sacrifice and dedication to science that Jerrold Zacharias and his colleagues, in their tweed suits and neckties, really did not foresee.

GEORGE E. CLEARY JR
El Socorro, Venezuela

Anthony P. French points out in his discussion of the PSSC course that an excellent program developed for the high schools by distinguished physicists was followed by "declining enrollment figures for physics in the high schools—from about 25% of those who graduated high school in 1955 to about 15% today."

While we were busy trying to "turn on" high school students to physics, the elementary school teachers of the nation were busy turning their students off. Elementary school teachers may well be the key to physics literacy. High school may be too late to get physics to those students who have already been turned off in elementary school. L. B. Resnick, discussing recent contributions from cognitive research to the teaching of science and mathematics, indicates that children's naive notions about how the world works must be challenged by scientific theories at an early stage, not left alone until high school.¹ Bassam Shakhshiri, interviewed on the National Science Foundation's revamped science education directorate, indicated a major thrust in programs for the elementary schools.² Shakhshiri said: "We believe that attitudes develop in that age group, opinions harden. By the time students get to high school their minds are made up that science is too hard and math is not for them."

I described in a previous letter (March 1986, page 167) one program that trains elementary school teachers in teaching physics.

References

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HAROLD L. STOLOV
City College of the
City University of New York

As a result of letters that I have received, I should like to make corrections or amplifications of a few statements in my article on the PSSC course.

With regard to National Science Foundation support of the PSSC program, Stephen White has drawn my

attention to the major role played by the late Harry C. Kelly, then assistant director for scientific personnel and education in the NSF. In White's words, it was Kelly who, "more than any other person, pressed NSF into the support of pre-college curriculum reform, and who encouraged and assisted every one of the reforms that followed after Sputnik." White also informed me that the final total of PSSC films was 60—not 50, as I had stated.

Uri Haber-Schaim has written to me to comment on several points in my article, particularly with regard to the PSSC textbook. He makes it clear that I was mistaken in attributing the changes in content and order of topics to "pressure from the educational system." The preparation of later editions (now up to the sixth) of the textbook was in the hands of an author group led by him. Experience had shown that the PSSC course in its original form was considerably more than a full year's work. As a response to this problem, Haber-Schaim took a leading part in initiating a pre-PSSC program that became the Introductory Physical Science course for junior high schools. Much of the basic material from part I of the PSSC course was transferred into it. By the time the third edition of the PSSC text was produced, IPS had become the most widely used physical science course in the country, with over a million copies of its text in the schools. This transfer was certainly the biggest change in the PSSC textbook. The other major difference between the current edition and the first one is the placing of mechanics before optics, which I personally regret but which (to quote Haber-Schaim) he and his coauthors "considered to be a price worth paying to be able to present a modern particle model of light as an integral part of optics."

I may have been too conservative in estimating the extent of the use of PSSC. Haber-Schaim cites evidence that at its peak PSSC was reaching at least 200 000 students,¹ as compared with the "more than 100 000" that I reported. We are in agreement that the introduction of Harvard Project Physics, although an excellent course, did not significantly increase the percentage of high school students taking physics, but instead provided an alternative path for those who elected to take physics at all. The latest figures indicate that PSSC and HPP are about equally popular, each reaching about 15% of those who take physics; the sum of the two is about 70–75% of what PSSC alone reached at its peak, before HPP was available.

I may also have been too pessimistic

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about the current use of the PSSC experiments. Haber-Schaim tells me that the sales of the laboratory guide are running about on a par with those of the textbook. Since I believe that the PSSC course, with its various components, is still the best high school course in existence in this country, I am happy to be corrected in this regard. Also, since in my article I lavished praise on the laboratory part of PSSC, I should like to take this opportunity to recognize Haber-Schaim's prominent role in its development.

Reference

1. U. Haber-Schaim, *Phys. Teach.* **6**, 66 (1968).

ANTHONY P. FRENCH

Massachusetts Institute of Technology
11/86 Cambridge, Massachusetts

Research in the colleges

In "Physics in the colleges" (June, page 28), Jerry Gollub and Neal Abraham assert that "research [in undergraduate institutions] enhances the education of their students and the professional life of their faculty," and they recommend that colleges take steps to increase the research output of their physics departments. Yet some of their own observations highlight the inevitable conflict between education and research. They say, "Probably the single greatest challenge that college departments face is providing an adequate diversity of upper-level offerings while reserving sufficient time for meaningful research." And later: "A second major challenge... is the development... of first-rate programs of laboratory instruction," because "typically no individual has time to devote a major fraction of his or her effort to such work." But if college faculty spend more time writing grant proposals and papers, won't they have less time to develop upper-level courses and instructional laboratories? The authors recognize that "science graduates with liberal arts backgrounds... have traditionally been valued for the breadth of their intellectual training," but they also argue that undergraduates who participate in research may gain "several years in practical scientific maturity over their counterparts who lack research experience." Here again, we see a basic conflict. A student who spends many hours in narrowly focused research has not spent those hours gaining intellectual breadth. For some students, the tradeoff is

worthwhile. For others, perhaps it is not.

Gollub and Abraham display bar graphs that indicate that the "research support raised by college faculty members from external sources" and the "productivity of colleges in training future physicists" (that is, turning out future PhDs) both vary widely among institutions. But is there any connection between these quantities? Using the same source of data,¹ I found no correlation between PhD productivity and either external funding or number of publications, on a per-faculty basis. Perhaps better data would show such a correlation, but if so, let us see them. It seems to me that the burden of proof rests with those who promote increased research in undergraduate institutions and regard PhD productivity as a significant indicator of educational performance. Can they link those two phenomena with anything more substantial than anecdotal data and rationalizations?

Suppose they can. (Even I would expect some correlation.) Let us grant, provisionally, that research in the colleges contributes significantly to their development of future PhDs. Don't physics faculty have other important responsibilities? What about teaching physics to majors in the other sciences? What about providing non-science majors with some understanding of physical science, its technological applications and their impact on society? To me, the real challenge for college physics departments lies in making their curricula more broadly accessible and relevant. Why isn't physics a more attractive pre-medical degree? What about physics pre-law? Or pre-business? Developing research-oriented protégés of research-oriented faculty is not the only educational activity that is (or could be) pursued by undergraduate institutions. What, therefore, would be the broader impact of an increased emphasis on research?

Gollub and Abraham claim that "institutional pressure on faculty members to do research recognizes that their vitality and their ability to remain abreast of current knowledge are at stake." But are grants and publications the only measures of intellectual vitality? Is being at the frontier of a narrow research specialty quite the same thing as being "abreast of current knowledge"? Is it not possible that the effort of a faculty member to maintain currency across a broad range of knowledge may be impeded by pressure to produce new results in one area? Gollub and Abraham warn that "many of the best young physicists would not choose this environment [college] if opportunities for serious research were

unavailable." By "best young physicists" they mean, of course, "best young researchers." But do the best researchers necessarily make the best college faculty? Even assuming that they are the best teachers and role models for future PhDs, what about the other physics majors? The non-physics majors? The non-science majors? Even assuming that the best researchers are the best communicators of physics to all audiences, is that the most effective use of their talents? Or is society more effectively served if the best researchers concentrate more on their research? Will increased emphasis on research result in a net gain for physics education, due to an influx of research-oriented faculty into the colleges? Or will there be a net loss, as the present faculty divert time away from course preparation? Where will the money come from to finance increased research opportunities? In other words, what are the tradeoffs here?

Personally, I agree with Gollub and Abraham that research can and does play a useful role in undergraduate institutions, but I think it is already somewhat overemphasized.

Reference

1. Brian Andreen, ed., *Research in Physics and Astronomy at Private Undergraduate Institutions*, Council on Undergraduate Research and the Research Corporation, Tucson, Ariz. (March 1986).

ALLAN WALSTAD

University of Pittsburgh at Johnstown
8/86 Johnstown, Pennsylvania

GOLLUB AND ABRAHAM REPLY: Allan Walstad has articulately emphasized the fact that research activities inevitably compete with instructional activities for the limited time and attention of college faculty. In our article we qualified our emphasis on the benefits of research by a brief discussion of some of these conflicts and a plea that colleges that wish to encourage research provide the time and resources to make this possible. One should certainly not expect everyone to choose traditional research programs. Colleges are in a position to encourage interdisciplinary ventures and imaginative enterprises that might be too risky in universities. There is no reason to measure success primarily by numbers of publications or to pressure faculty who are not much interested in research to undertake meaningless activities.

For those who are interested in doing research, the problem of funding is serious but not usually prohibitive. NSF funding for college research has increased substantially and the Research Corporation is also planning a