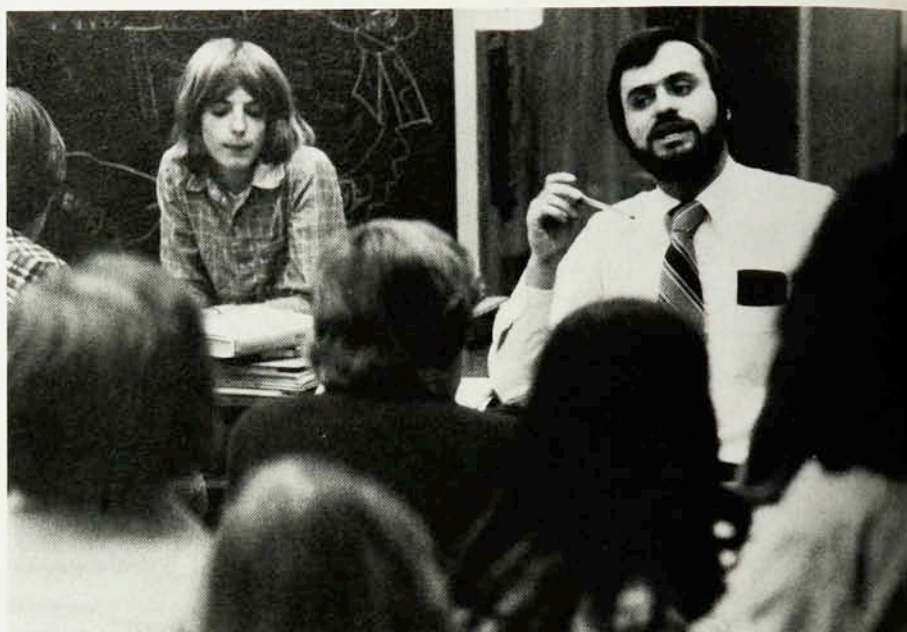


Why physicists leave teaching



A host of problems leads one to wonder who will be there to teach the coming generation of students to work and to succeed in our technological society.

Beverly Fearn Porter and William H. Kelly

Educators have long been concerned about the quality of science and mathematics education in US secondary schools. In recent years, this concern has spread: Congressional task forces, governors, mayors and the media have begun to recognize the serious educational crisis now facing the nation. While this time there is no dramatic event like the Sputnik of 1957 to spur increased attention to education, some fundamental challenges are becoming apparent. These include the decline in this country's competitive edge in many areas of industry and research, the structural change in the nation's industrial base from heavy manufacturing to high-technology and service industries, and the revolution in information technology and exchange. In many ways we are entering a new era, and there are serious questions about how well prepared today's youth and future generations will be to participate in it.

Among many basic questions are these: Who will teach these young generations to think, and who will prepare them to live, work and be productive in this new age? There are

many dedicated science and math teachers working in our school system today, frequently against heavy odds. The schools need more such qualified teachers, however, not only to address shortages in current programs, but to reach out to the many students who are not even involved in these programs. They too will need solid science and math backgrounds to prepare them for the challenges of the technological age they are entering. Traditionally, many of these students have not been exposed to even the basic rudiments of scientific and mathematical thinking. One-half of all recent high-school graduates did not take a math or science course beyond the 10th grade. The quality and quantity of exposure they received earlier can at best be described as sketchy. This presents a major challenge, not only to teachers, but to all of us who are concerned with the future.

Attracting qualified new science and math teachers and retaining the good teachers that we already have should be a goal of high national priority. If we are to work toward achieving such a goal, we will need a better understanding of why new graduates are not becoming secondary-school science and math teachers, and why many of them leave.

While our attention here will be primarily on physics teachers, much of what we will say applies equally to other science and math teachers and,

for that matter, to teachers of other subjects as well. We will focus¹ on three major questions:

► Why are fewer college graduates from physics and science-education departments becoming secondary-school teachers?

► What do physics teachers encounter once they enter the secondary schools?

► Why do physics teachers leave the secondary schools?

We will also see what the answers to these questions mean for the future.

Careers in the high schools

Over the past decade, the supply of new secondary-school physics teachers has been declining across the board. Colleges of education and departments of education produce most secondary-school physics teachers. Others come from the ranks of new bachelor's- and master's-degree recipients trained by university and college physics departments. The number of new science-education graduates produced by colleges and departments of education—and, in fact, the number of these colleges and departments themselves—has been declining steadily. In fact, according to the 17th annual survey² of entering freshmen conducted by the University of California at Los Angeles and the American Council on Education, today's college freshmen are less interested in becoming elementary- or secondary-school teachers than was

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Instruction. The teacher here is addressing students in a secondary-school science class. (Photograph by Jerome Berkowitz.)

any other entering class in recent years. In addition, both the number and the percentage of new physics-degree holders choosing high-school teaching have been dropping, as illustrated in the figure on page 35 (upper left). What has caused these declines, and what do they mean for the future?

Physics graduates have always had a wide spectrum of opportunities for employment, both within physics and in related areas of science and engineering. Recently, many have found employment in the expanding realm of computer technology. In addition to offering challenging and frequently diversified work, industrial employers have been offering physics graduates starting salaries almost double those offered by secondary schools. Inflation has dampened this differential somewhat in recent years, as the plot of starting salaries on page 35 illustrates. However, there has been little monetary incentive for new physics graduates to teach high-school physics.

When employment opportunities were relatively scarce, as they were in the early 1970s, a somewhat higher proportion of graduating physics majors did become secondary-school teachers. More recently, when employment opportunities began to tighten somewhat again, there was a major increase in military employment—also a relatively low-paying area—but only a very slight increase in secondary-school em-

ployment. However, as some bachelor's-degree recipients noted on questionnaires³ recently, the military does provide (at least during a period when the country is not at war) a combination of secure employment and advanced technical training. Although the small numbers involved make it more difficult to document, the effect of widening opportunities for women has probably been to draw many away from the traditional teaching careers and into industrial and, more recently, military careers as well.

Myths and bad advice. What accounts for the decreasing number of graduates from science-education departments? In addition to some of the factors that we have already cited, many individuals who might have been interested in teaching careers were probably scared away by the cries of oversupply that dominated the decade of the 1970s. Although the talk of oversupply did not always refer to science and math teachers then—and certainly does not now, as other articles in this issue underline—the general idea that high-school teaching was an over-saturated area must have affected the career decisions of many young people.

Students considering science education as a career are often discouraged by respected advisors. Even in this age of enlightenment, when there are strong pressures for equal opportunities for women and minorities, school counselors still advise female students that “girls do not do well in math-oriented subjects such as physics.” Thus, women frequently do not even take the high-school math and science courses that would allow them to consider teaching careers in these fields.

Faculty members, counselors and friends frequently advise the brighter male students that teaching is not a desirable profession. The professional education programs that prospective teachers must take to be certified tend to buttress this advice; they are too often among the weakest programs offered. Bright students are both embarrassed and insufficiently challenged by the low quality of many of these course offerings. Others, who do go through the formal training programs, are sometimes discouraged by negative experiences as student teachers. It is not uncommon for the student teacher to get “stuck” with some of the most difficult teaching problems because of the supervising teacher's inadequacies.

Surveys show that only half of the students who train to be math and physics teachers actually go into teaching in the secondary schools. This may be due in part to the unsatisfactory

*the crisis
in high-school
physics
teaching*

educational experiences that we noted above. It may also reflect changes in career direction upon graduation. Furthermore, while today the shortage of qualified math and science teachers is well recognized, it does not necessarily follow that employment is always readily available for new science-education graduates. Some of these graduates, although initially directed toward secondary-school teaching, end up in other jobs upon graduation. This is due in part to the fact that shortages vary by area and region. While PhD physicists have traditionally moved across the country to find both academic and industrial employment, the labor market for high-school teachers is generally more local. To move from, say, suburban Connecticut to a high-school teaching job in rural Arkansas is, of course, possible. But new education graduates are more likely to take non-teaching positions than to move long distances to teach.

Perhaps more important is the apparent fact that even in districts or schools with severe shortages of science teachers, the new science-education graduate does not necessarily receive first consideration. High-school staffing has always been a very localized and a very political process. Local resources, historically limited, have become increasingly so. Seniority, always important at the secondary-school level, has taken on added importance with the advent of unionization. Thus, if a school needs additional science and math teachers, but has an excess of experienced physical education, English or history teachers with at least some minimal exposure to science or math, these teachers may well be given preference over a highly qualified recent science-education graduate.

De-emphasis of social concern. What does the future hold for new high-school science teachers? Earlier we noted the decreasing number of science-education and physics majors entering high-school teaching over the

past decade. Without major policy changes—or a downturn in the economy, which makes such positions relatively more attractive—we expect this decline to accelerate. There are several reasons for such projections. First are the demographic factors. There will be fewer and fewer college-age people at least through the mid-1990s. Some earlier studies predicted an increase in the representation of minority groups whose members did not typically go on to higher education; however, increased college costs, combined with the recent cuts in Federal support, cast doubt on these predictions. In fact, if these Federal policies are continued, they may even deter those in groups whose members have traditionally sought college educations. In summary, there is little to contradict the assumption that there will be fewer students in our colleges and universities in the next decade.

A second reason to expect a continuing decline in the number of new science teachers involves changes in the motivations and aspirations of col-

lege students. The American Council on Education has been studying changes in student career plans and attitudes over the past decade. While the number of students with plans for careers in business and other “practical” areas has increased dramatically since the early 1970s, the number of plans for careers in science has dropped, and intentions to pursue careers in education have plummeted. In terms of attitudes, today’s freshmen place their major emphasis on financial rewards, power and status. In contrast to students of earlier decades, relatively few freshmen place high value on altruism and matters of social concern. While this may well be a passing phenomenon, it is likely, at least in the near future, to have a negative effect on the number of science majors in general and science-education majors in particular.

The decline in the number of high-school students over the next decade may partially alleviate the extreme shortage of high-school science and math teachers. However, it will not

begin to address the more pervasive problem of the grossly inadequate science and mathematics education available in the secondary schools. As recent articles in the public press have emphasized, the science and math curriculum currently offered to US high-school students is extremely limited, particularly in contrast to the offerings provided by other industrialized countries.

While instruction of college-bound science and math majors is sometimes good, the exposure of others to even the rudiments of science and math remains negligible. This is especially true in those states that require little or no science for a high-school diploma. Thus, even if current programs were not short of science teachers, we would still face the critical problem of encouraging and preparing the many students who do not plan to work in science, but who still have to live in an increasingly technological world.

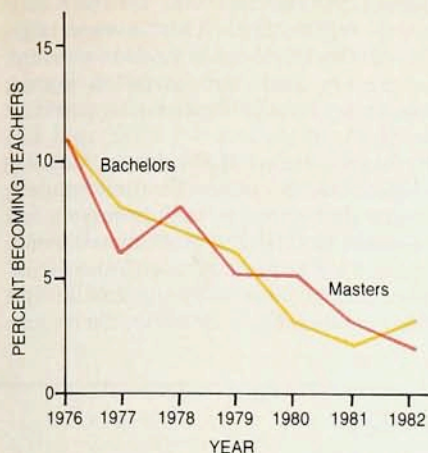
There is another demographic phenomenon that should affect any thinking about the future. While birth rates



◀ **Student and teacher** discuss coursework on a one-to-one basis. (Photograph by Jerome Berkowitz, courtesy of *The Science Teacher*.)



Students working on a class assignment. (Photograph by Jerome Berkowitz.) ▼



High-school employment of new graduates. The proportion of new physics bachelor's and master's degree holders who become secondary-school teachers has declined.

have never climbed back to the level of the 1950s, the children of that large cohort also had children, who are now in or entering primary school. It is not clear who will be there to address the math and science needs of this next generation of high-school students.

Inside the high schools

When one looks⁴ at high-school physics teachers, two things immediately leap to attention: their age, and the wide variety of science and math courses they are expected to teach.

As we indicated above, fewer and fewer new graduates are entering high-school physics teaching. It should be no surprise, then, that we find few teachers in their twenties in the nation's schools. Most secondary-school physics teachers are in their forties—somewhat older on the average than other science and math teachers.

These teachers have an average of twenty years' experience teaching science, and, with some glaring exceptions, have thirty or more college science credits preparing them to teach physics. Despite such extensive backgrounds, nearly half of the physics teachers in a recent small sample said further physics preparation would be useful. Few, however, have recently taken any courses to address that need.

Computer science is one area in which many science and math teachers agree that further preparation is essential. To a greater extent than others, physics teachers have recently been taking courses in computer science. One should be heartened by the fact that physics teachers have had the opportunity to avail themselves of the recent advances in computer science. However, physics has also been changing over the last two decades, and there has been little opportunity or incentive for these dedicated physics

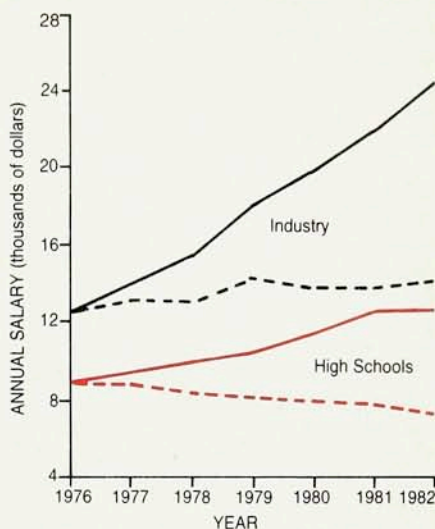
teachers to keep up with the field.

One reason for this becomes clear when we take a closer look at the actual job of "the physics teacher" in the typical school. There are some teachers who conduct classes and laboratories only in physics. They are, however, a small minority. In most high schools, the physics teacher has a multiple assignment. These assignments may be straightforward combinations of physics and math or physics and chemistry. More frequently, however, the assignments also include one or more courses in physical science, general science, biology or a nonscience subject. Three and four subject preparations per day are not uncommon. A successful high-school physics teacher, therefore, must not only be knowledgeable in physics, but must also be conversant with a variety of other related areas of science. For those teachers who have the background, interest and ability to communicate, teaching physics can be exciting, even under difficult circumstances. For those who are forced by shortages to add physics as a tertiary subject, teaching can become a chore that presents difficulties for both teachers and students.

The ideal and the typical. In addition to varied and frequently heavy course loads, the work environments of teachers have other positive and negative qualities. In the ideal situation, most often found in well-funded suburban and specialized science high schools, interested and involved teachers work with supportive administrators, talented colleagues, and curious, motivated students. They have the time to prepare their classes and demonstrations and to interact closely both with their students and their students' parents.

A good teacher, it has been said, should have a strong interest in young people, a solid knowledge of the subject matter, the ability to communicate both the content and the excitement of the subject, and the ability to command respect and maintain discipline. When such a teacher can work in the environment described above, the experience will be a positive one, not only for the teacher, but for the young people he or she is exposing to a world of new ideas. The low salary scales of secondary-school teachers, shown in the figure at the right, may even force some of these teachers to leave the profession, but many more will stay on and work with enthusiasm to share their love of science with the next generation.

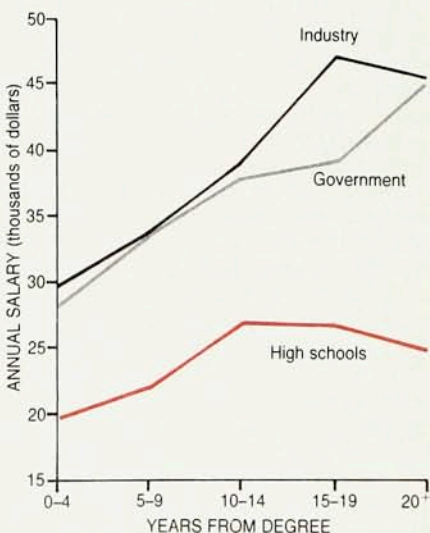
Anecdotal information cannot replace solid statistical studies; but in the absence of the latter, we would like to describe a particular case with the hope that it may perhaps highlight some of the apparently minor factors that, when compounded, can make teaching



Starting salaries for new physics master's degree recipients in secondary schools and industry, 1976-82. Dashed lines represent salaries in constant (1976) dollars.

difficult. In the early 1960s Porter returned to study⁵ the school system in which her mother taught. Her mother's high school was not one of those "horror cases," occasionally mentioned in the media, where teachers work with little community or administrative support in a deteriorating physical plant, functioning mainly as policemen over disruptive and potentially dangerous students. The school was an ordinary one, neither a horror nor an ideal, and her situation there was not unusual.

In comparing her situation with ideal conditions, the most glaring discrepancy that shows up involves time. Despite long evening hours, there was never enough time to correct home-



Master's degree salaries for physicists employed in high schools, industry and government, plotted as a function of time from receipt of the degree. Data are from a 1982 survey.

work, to prepare fully the desired new approaches to class assignments, to develop new skills, or to deal individually with students and parents. She made efforts and had successes, but time was always the scarce commodity.

The administrators in this local school were generally supportive. The school board's reactions to new ideas were more varied. They were representatives of the community and were seriously concerned with education, but they were also wary of anything new, controversial or costly. (In the box at the right, James Mowbray gives an example of this problem.) Regular battles with the school board became endemic. Some administrators could cope with a fractious school board, others could not.

Over the years, community support, or lack of it, became the most important factor affecting education in this town. Good teachers may not always have received recognition from their professional colleagues, but they had received respect in this community. Respect was one thing, money was another. As the community aged, and fewer households had children in the schools, one school budget after another went down to defeat. "Frills," including labs and released time for teachers, were cut back. While concern for education has increased throughout the nation, so has the fraction of citizens without school-age children. While these voters care about the education of the young, they see many other areas competing for their tax dollars.

Leaving the high schools

We have given a few suggestions as to why many high-school physics teachers leave the schools. The reasons, however, are myriad. Opportunities for alternative employment and higher salaries, as illustrated in the figure at the bottom of page 35, certainly play a part. But teachers leave for a wide variety of less obvious, although equally important reasons, some of which we will outline below.

Because there are so few data on the subject, we contacted many physics teachers in different parts of the United States and discussed briefly the reasons their friends and acquaintances have left high-school teaching. The reasons are often complex. It is clear from our more limited discussions with teachers in other fields that many of the reasons teachers have for leaving are not specific to physics. However, we should note that physics teachers, as well as other science and math teachers, have skills that are in greater demand by industry than are the skills of their nonscience colleagues. Thus, while the problems mentioned below may pressure many teachers to consid-

er leaving the high schools, physics teachers often have the greatest real opportunity to do so.

In the following outline, we look beyond the obvious problem of low salaries to consider some of the subtler issues involved:

► *Poorly equipped instructional laboratories and inadequate budgets (if any) for significant improvement.* While physicists may pride themselves on their creativity in mounting demonstrations with limited materials, anti-

quated instruments and facilities can prove frustrating. This is especially true for teachers not trained in how the laboratory and demonstration equipment they have inherited is supposed to work.

► *Isolation and difficulty in keeping professionally active.* Limited budgets mean that there is seldom money for teachers to travel to professional meetings, to keep up to date with the major advances in their fields and to talk with their colleagues. Because there are

Leaving teaching: a difficult choice

James E. Mowbray

Science is an adventure of the whole human race to learn to live in and perhaps love the universe in which they are. To be part of it is to understand, to understand oneself, to begin to feel that there is a capacity within man far beyond what he felt he had, of an infinite extension of human possibilities. . . . I propose that science be taught at whatever level, from the lowest to the highest, in a very humanistic way. It should be taught with a certain historical perspective, with a certain philosophical understanding, with a social understanding and a human understanding in the sense of biography, the nature of the people who made this construction, the triumphs, the trials, the tribulations.

—I. I. Rabi

For eleven years physics was my hobby, and, fortunately for me, my source of employment. As a physics teacher in the public school system, Rabi's words served as the philosophical basis of my teaching long before I ever read them. I had a love affair with physics—its mysteries, its doers and shakers, its application to the benefit of human beings and society. I tried to develop a cohesive teaching strategy consistent with this philosophy that would instill in my students a similar love of physics and appreciation for the work of mankind in unlocking the secrets of nature.

Marvelously, after years of revisions and rethinking, the approach seemed to work. Physics enrollments increased, national norms were exceeded, measures of cognitive abilities showed remarkable improvement, and, most importantly, my students seemed to enjoy physics and often chose it as a college major. With the success of my students came an associated growth in my reputation as a physics teacher. Slowly but surely, physics teaching became something that gave me a great sense of personal pride and enjoyment. I was enjoying what all successful teachers experience when they are at the top of their form.

However, a year and a half ago I taught my last physics class. I became a victim of something that teachers everywhere have come to know increasingly well—economics. Like most physics teachers, I watched my students go off to college and then to careers in science and engineering. For years my rather stagnant economic condition did not seem to matter much in light of the other benefits I was deriving. As the years wore on, however, and my worth to the school system and to my students grew, so did my responsibilities to my wife and children. Thus, I began to question my ability to remain in my chosen profession.

The questions to ponder were enormous. What price was I willing to pay to stay in a profession I loved so dearly? What moral responsibility did I have to use my talents for the good of society? Could I expect the best education for my own children if I wasn't willing to contribute? What did I owe my teachers who had prepared me to succeed them? Could I expect my family to understand a decision that would cost them at least one-half million dollars over the course of my working life? Like most people in this situation, I began to call on colleagues and administrators to help me wrestle with the issues. In the end, however, it was the local school board that helped finalize my decision, and in the process, poignantly brought to light many of the problems facing school systems today.

School boards as employers

A fellow teacher who became notorious after stating in a published interview that "School systems are lousy employers," was perhaps a little ahead of his time. As the chairman of the math department, he was concerned about the school's ability to attract new math teachers to replace those who were leaving for better paying jobs as programmers and computer scientists. For several years he attempted to get the school board to act, but the board did not implement a single program to stem the exodus of the qualified teachers it so desperately needed. It is surprising that no incentives were provided to keep and attract qualified science and math teachers, who are the only ones capable of helping the students ask the kind of questions that will help them develop into intelligent members of a sophisticated technical society.

relatively few science teachers in a high school, it is difficult for them to find intellectual stimulation there in their own fields.

► *Duties not related to teaching, excessive paperwork for accounting to local administrators and to state and Federal agencies.* These additional activities increase the time pressure on science teachers, who often carry heavy lecture and laboratory loads.

► *The lack of understanding and concern on the part of many school admin-*

istrators regarding the value of high-quality teaching. The struggling teacher often feels he or she is going it alone with little or no administrative support.

► *Lack of respect within the community.* Teachers are frequently considered to be unimportant as contributors to the quality of community life. They are often the target of critical and even derogatory remarks during school-board meetings and during campaigns for tax-rate increases. This general

atmosphere also encourages conflicts between teachers, parents and students over grades and classroom discipline problems.

► *Strong public pressure to cut taxes.* The defeat of school bond issues appears to many communities to be one way of keeping local taxes under control, even if it does cause a reduction in the teaching force.

A number of other problems contribute to the loss of high-school teachers, but they are too numerous to elaborate in a brief article. They include the lure of higher-paying administrative positions, the lack of teaching materials that are sufficiently challenging to many teachers, and the psychological phenomenon known as "burnout," which results from a compounding of heavy loads, strong external pressures and demanding but monotonous routines.

Physics teaching has proven rewarding and exciting for many teachers, even against difficult odds. Opening young minds to a subject one loves and seeing students begin to understand concepts of science can be extremely stimulating. We hope, then, that the sometimes bleak picture we have presented will not deter those talented, dedicated students now preparing for careers as high-school science teachers. Rather, it should alert policy makers at all levels—and communities throughout the country—that these science-education students represent a precious resource, and that we need additional incentives to encourage others to enter such important careers. Without their much-needed contribution, the scientific and mathematical literacy and the success of the next generation will be in jeopardy.

References

1. Information in this article derives from data produced by the American Institute of Physics, the National Science Teachers Association, the National Science Foundation, special studies by others, and the authors' own personal experiences. While many of the available data are suggestive, the absolute numbers of secondary-school physics teachers involved are generally too small to be statistically reliable. We hope that, in the future, more extensive data on secondary-school teachers will be collected regularly.
2. Cooperative Institutional Research Program, *1982 Freshman Survey Results*, UCLA Graduate School of Education, Los Angeles (1983).
3. *1981-82 Survey of physics and astronomy bachelor's degree recipients*, American Institute of Physics, New York (April 1983), publication number R-211.14.
4. *Teachers Survey data tape*, National Science Teachers Association, Washington, D.C. (1983).
5. B. F. Porter, *Local Community Power Structure*, master's thesis, New York University, New York (1964). □

School boards are often short-sighted—and even vindictive—in the way they deal with local manifestations of the prevailing economics that cause science teachers to leave the schools. The story of my own resignation, unfortunately, is a good example. Because of my roles as teacher, department chairman, coordinator of gifted and talented education, science-fair adviser, coordinator of science seminar programs for the Maryland Academy of Sciences, state curriculum study committee member and principal of summer school, I was fortunate to have contact with teachers on a scale much broader than ordinarily possible. These interactions helped me grow as a professional, and helped me gain influence with the other teachers in the school system. When informed that I was considering leaving teaching, administrators at the highest levels decided on two courses of action. One was to threaten a legal suit against my prospective employer. The other was to ask me personally to use my influence to keep other teachers from reacting negatively to the threatened suit; the administration felt that its action might provoke teachers into a system-wide backlash (which it did).

Many months have passed since then, and many teachers have followed their associates in leaving the profession. Each one faced the same sort of reaction from their employer that I did. As one might expect, with each resignation the morale of the remaining teachers has not improved, and the same problem remains. What, then, are some positive solutions to the problem of the flight of qualified teachers from the classroom? I hope that some of the steps that I suggest below will be used to help keep others from leaving teaching, and will allow me to return to the vocation that I love and to which I could contribute most.

► *Encourage business and industry to support science and math programs in local schools.* Business and industry have much to gain from strong and viable local science and math programs. Attracting professionals to work in new locations is easier when school systems have strong reputations. Finding technologically skilled labor is also easier when there is an ample supply to draw from.

► *Develop legislation to allow tax incentives for science and math teachers.* This type of legislation, along with reform in the method of taxing for local schools, would do much to improve the economic condition in which many teachers find themselves today.

► *Encourage bonus payments or special salary increments for teachers who continue to develop educationally and who are continually rated superior by administrators, colleagues and parent groups.* The longer a teacher is in the school system the greater the teacher's salary becomes. This system should be replaced with a rating system that provides additional increments for meritorious service, special skills or measured excellence in teaching.

► *Question the value of retraining as a solution to the current shortage of math and science teachers.* The suggestion that "If you can't get new blood the only thing you can do is retrain what you have," is frightening. Is the solution to a teacher shortage in science and math to send in the physical education teacher? Would retrained teachers have the inclination and insight to do the job "in a humanistic way, with a sense of biography"? Could we expect them to develop a curriculum that teaches mathematical thinking and logical reasoning? If we asked them if the teaching of facts should be part of the science curriculum, would they even appreciate the meaning of the question? As the University of Chicago's Izaak Wirszup puts it, will the result be "the drill and boredom of arithmetic taught by elementary-school teachers not trained to teach modern mathematics"?

All of us are aware that any solution to this problem will require insight, creativity and money. Perhaps we would see results sooner if we considered the education of students in science and mathematics to be a unique part of our National Defense program. As Robert Wilson so aptly said,

It has only to do with the respect with which we regard each other, the dignity of men, our love of culture. It has to do with, are we good painters, good sculptors, great poets? I mean all the things we really venerate and honor in our country and are patriotic about. It has nothing to do with defending our country except to make it worth defending.

* * *

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