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 consider 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, antiquated 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 administrators 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.

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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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.
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