New Directions

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Widening Doors To Science and Technology

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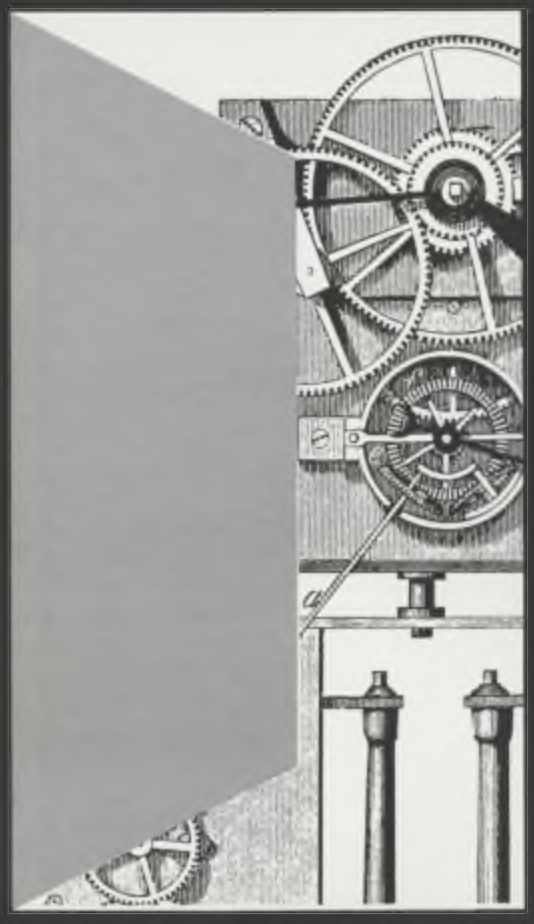


Widening the Doors To Science and Technology

EDITOR'S NOTE: The following was excerpted with permission from "Changing America: The New Face of Science and Engineering," an interim report by the Congressionally-established Task Force on Women, Minorities, and the Handicapped in Science and Technology.

In the year 2000, 85 percent of new entrants to the nation's workforce will be members of minority groups and women. And the number of people with disabilities who can go out into the workplace will rise. These three groups have historicallly been underrepresented in science and engineering. The nation can meet future potential shortfalls of scientists and engineers only by reaching out and bringing members of these underrepresented groups into science and engineering.

America should educate more young people, particularly from the underrepresented groups, in science and engineering not only for the sake of economic strength and national defense but also because such education is part of everyone's right as an American. America owes all its citizens a quality education, including a good grounding in mathematics and science, so all have the chance to develop to their full potential. These skills are essential to fulfillment in life and productivity work.

Changing America

Science and engineering workers are vital to our advanced industrial society. But by the year 2010, we could suffer a shortfall as high as 560,000 science and engineering professionals. As a result America's economic strength, security, and quality of life are threatened.

The percentage of young Americans preparing for careers in science and engineering has been declining steadily. Our most experienced scientists and engineers will be retiring in the 1990s. Meanwhile, by the year 2000 the number of jobs requiring college degrees will increase dramatically. The educational pipeline—from prekindergarten through the Ph.D.—is failing to produce the scientifically literate and mathematically capable workers needed to meet future demand.

America is changing particularly in the composition of its young. Blacks and Hispanics are now 25 percent of all schoolchildren; by the year 2000, they will be 47 percent. This change has already occurred in some regions, such as California, New Mexico and Texas.

Thus, America is today a different country demographically from the one that produced earlier science and engineering feats. By the mid-1990s there will be fewer young people to enter the workforce, and these scarce young workers will have to be highly productive to keep the economy growing. They will have to be versatile and well-educated: many must join the science and engineering professions.

Since the early 1980s, the proportion of U.S. college freshmen choosing science and engineering has been wobbling downward. The drop has been little noticed because many foreign students have been enrolling in these fields; in addition, colleges have been making up total enrollments with older and part-time students who tend not to graduate in science and engineering. If these trends persist, America will graduate fewer U.S. bachelor's degree holders and, after a 8-year lag, even fewer Ph.D.s in science and engineering.

The nation must find ways to bring many more young people—particularly those from underrepresented groups—into engineering and science. More baccalaureates must stay on as graduate students, as postdoctorals, and as teachers of future science and engineering students.

PreK–12 Education

A child born today will be in the sixth grade in the year 2000. That child will graduate from high school in 2006, from college in 2010, and enter the workforce when American society is about equally divided between young and old. That child will live in a world in which science and engineering will be crucial to the workplace and the economy.

Because children start to become engineers, scientists, or science-literate early in life, the nation should provide preschool programs that lay the groundwork for academic skills. This is especially important for the 14 million children who live in poverty, one-third of whom are from minority groups.

Minority students are concentrated in large urban school districts. These students tend to drop out of college-track mathematics and science early. These schools suffer from chronic shortages of good mathematics and science teachers, little or no hands-on laboratory science, and low teacher expectations. The situation is a Catch-22 for students who do not believe they can learn and therefore decide to avoid "hard" courses. The result is not only lower achievement scores for the nation as a whole, but personal hardship for those students who have not been taught the skills they need to take full part in our advanced industrial society.

Junior high school is one of the key points at which most students in the United States drop off the mathematics-science pipeline. The decisions about which mathematics and science courses to take at this time could foreclose choices later. The little science presented is frequently taught by rote, and tests are often out of date. The need for improvements in the science and mathematics preparation of all of our students, especially in the K-8 educational pipeline, is urgent.

The pattern of low expectations continues in high school, when students generally can choose general mathematics instead of college preparatory mathematics. For example, girls may consider physical science and mathematics to be male subjects and may not enroll in those classes without specific encouragement from parents, teachers and counselors. Students with disabilities frequently do not take laboratory science because of discourage-

ment from teachers. Consequently, U.S. elementary and high school students take fewer math and science courses and learn less than do students in most other developed countries. As a result, they score very low on international tests and on national achievement exams. In 1988, for example, only 48.5 percent of U.S. 17-year olds could pick the right multiple choice answer to the question: What is the area of a rectangle 4 cm by 6 cm?

We should change the climate in which students learn and teachers teach mathematics and science. We should instill the expectation—in parents, teachers, principals, and students—that students of all backgrounds can learn and be at ease with mathematics and science. These improvements require systemic change.

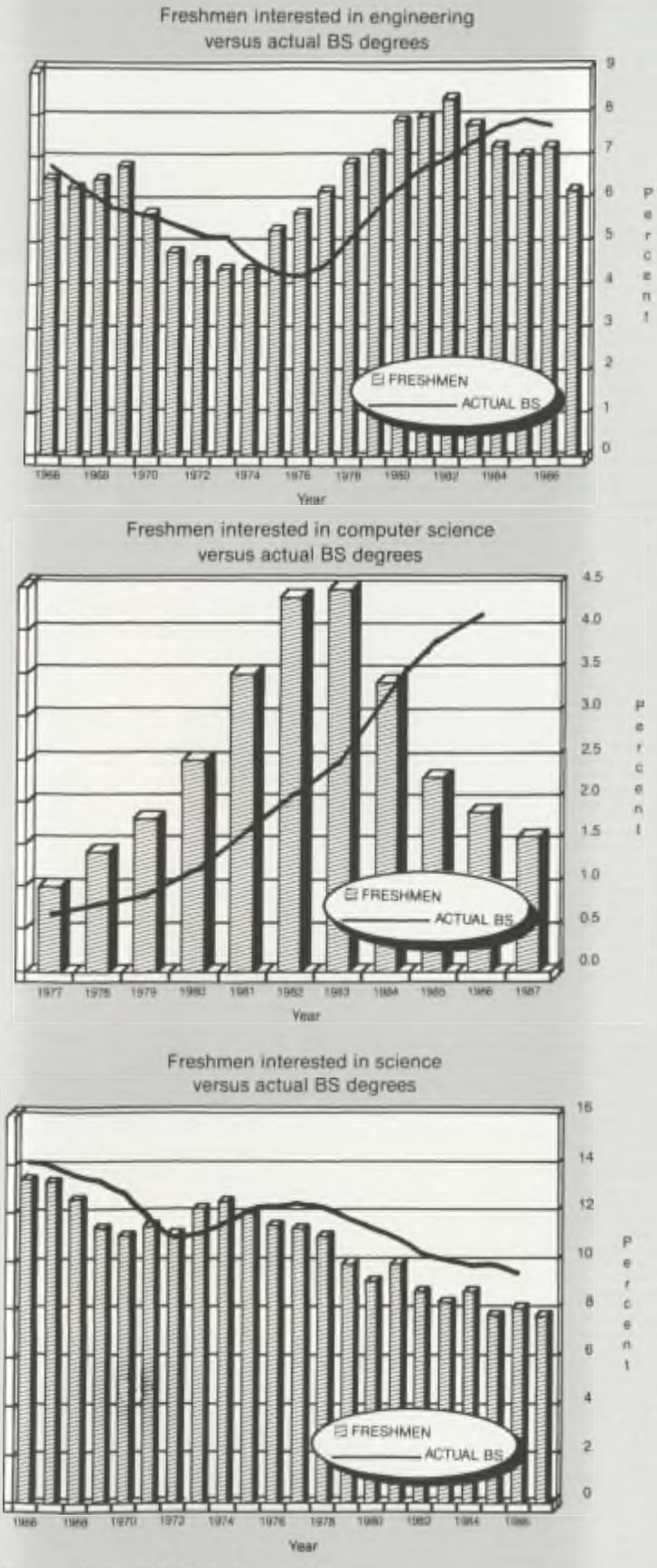
We commend the many schools that have begun to remedy this situation. The Education Commission of the States reports that since 1980 at least 45 states and the District of Columbia have strengthened graduation requirements. Generally, mathematics and science courses have led the increase. Three years of mathematics is the goal of these efforts; in many states, most students now take only 2.5 years. The momentum should continue. High schools should require at least 3 years of mathematics, including precalculus, and plan to raise that to 4 years.

To meet raised expectations of parents, teachers, and students, we need human and financial resources. Large school districts must have practical and systemic plans to raise mathematics and science achievement levels. They can be assisted by the federal government in ways that preserve the government's limited role.

Intervention programs, if replicated with care and given stable funding, can make a difference. For example, Southeastern Consortium for Minorities in Engineering (SECME), sponsored by 27 universities and 45 corporations, coordinates intervention programs across the southeast United States to reach more than 200 schools, 27 universities and 45 corporations, and approximately 15,000 minority students a year.

The Comprehensive Math and Science Program (CMSP) in New York City randomly selects students in 9th grade and, using in-service teachers, offers them 4 years of college preparatory mathematics, including calculus. CMSP has reached more than 6,000 students to date. On New York State Regents mathematics exams taken

Student Interest and Degrees Earned in Science and Engineering, 1977–1986



Source: National Science Foundation

in 1987, twice as many CMSP students as non-CMSP students passed. The program is being extended to some schools in Atlanta, Georgia.

Higher Education

Our colleges and universities train our nation's science and engineering workforce and perform cutting-edge research. They have a key role in producing an adequate supply of science and engineering degree-holders to meet demand and in giving all groups in society access to the skills and knowledge that make America great. Fulfilling these responsibilities is especially important in a period of large-scale demographic change.

Historically, the number of bachelor's degree graduates in science and engineering has been a fixed percent of the nation's 22-year-old population. This proportion rose in the 1970s when computer science became popular. However, graduates in science, minus computer science, have declined as a percent of all college graduates. Although the number of women, Blacks, Hispanics, and American Indians in engineering increased through the early 1980s, the absolute numbers were small, and they are now declining. Since 1983, fewer freshmen have been planning to major in science and engineering, including computer science, so the percentage of degrees will continue to drop.

The declining enrollment of U.S. graduate students is masked by recent high enrollments of foreign students in these fields, especially engineering. Today 75 percent of the graduate students receiving financial support from university engineering departments are foreign nationals.

Graduate departments in the United States not only train relatively fewer Americans, but they train even fewer graduate scientists and engineers who are Black, Hispanic, American Indian, or female. In 1986, 3,376 Ph.D. degrees were awarded in engineering by U.S. universities. Of this number, 1,661 went to U.S. citizens including, 139 to women, 25 to Hispanics, 14 to Blacks, and 6 to American Indians.

Although women enter graduate school at about the same rate as men, they are considerably less likely than men to reach the Ph.D. level. They tend to be self-supporting rather than supported by graduate departments. They cluster in the biological and health sciences.

These trends among the traditionally underrepresented groups need not continue; they can be reversed. On campuses where change has occurred, the president, deans, and department heads have provided strong leadership.

At the traditionally male Massachusetts Institute of Technology, for example, women have made up 38 percent of all freshmen for the past three years. As a result of institutional leadership, 100 of its 950 faculty are women. To encourage women to pursue research careers, MIT offers fellowships and other programs that carry high prestige and have helped many young women pursue academic research careers.

But colleges and universities cannot reach out to all groups, particularly the rapidly growing Black and Hispanic student pool, without first having faculty who themselves are from underrepresented groups. Graduate departments are cultures in themselves. These cultures must be changed to reflect and attract the traditionally underrepresented.

Federal Research and Development

The nation spent $123 billion, or 2.8 percent of the gross national product, on research and development in 1987. Of this amount, the federal government spent approximately 50 percent, or $60 billion. These federal funds are being spent not only within federal agencies, but in industry, nonprofit institutions, and universities. They are most visible on university campuses, where federal funds support nearly two-thirds of all research and development.

The federal government is a pacesetter in the nation's research and development enterprise. An important issue of federal science policy, therefore, is how the federal government can use its research and development leverage with educators and industry to build a world-class science and engineering workforce that reflects and exploits the new demographics of changing America.

However, the Task Force found that federal agencies have neither recognized nor begun to address the demographic issues that will affect the conduct of research and development in the 21st century. The role of minorities, women, and people with disabilities in science and technology is widely seen only as an equity issue, not as the key to future national security and economic competitiveness.

The Task Force, for example, made a major effort to identify how federal research and development programs affect the development of the scientific and engineering workforce, particularly its impact on the careers of underrepresented groups. Only one federal agency, the National Science Foundation (NSF), representing 3 percent of the 1987 total federal research and dev lopment budget, keeps data to monitor the demographic characteristics of those who receive its grants. These statistics show that in 1987 9 percent of all NSF awards were made to women, 0.6 percent to Hispanics, 0.5 percent to Blacks, and 0.2 percent to American Indians.

Of federal programs established to give minorities and women access to science and engineering, we found the Minority Access to Research Careers (MARC) of the National Institutes of Health closest to what we need today. MARC is a prime example of a successful federal intervention program. It was established to remedy the low numbers of minority biomedical scientists nationwide. A 1984 survey found that 76 percent of former MARC students had enrolled in a graduate or professional school program. The National Institute of Health's Minority Biomedical Research Support (MBRS) is also effective in enhancing the research careers of faculty.

The Government as Pacesetter

In changing America, all sectors must increase the number of women, minorities, and people with disabilities in the science and engineering workforce. Major improvement will not occur, however, unless members of underrepresented groups also see the workplace as accessible, equitable, and even favorable.

Historically, underrepresented groups tend to cluster in fields they perceive as friendly and where they cven exercise their talents fully, without discrimination and with good chance of recognition and reward. Employers nationwide must make science and engineering jobs attractive to these groups. If they fail to do so, minority-group members, women, and people with disabilities will see little or no role for themselves at the top of the science and engineering professions. Employment policy, therefore, is a critical part of any plan to change the makeup of the science and engineering workforce and expand participation of underrepresented groups.

The federal government has been a path for career entry and advancement for underrepresented groups. Federal employ-

ment has been open, for example, to people with disabilities due to veterans' preference rules adopted after World War II. Affirmative action and equal opportunity laws have spurred hiring and promotion of women and members of minority groups.

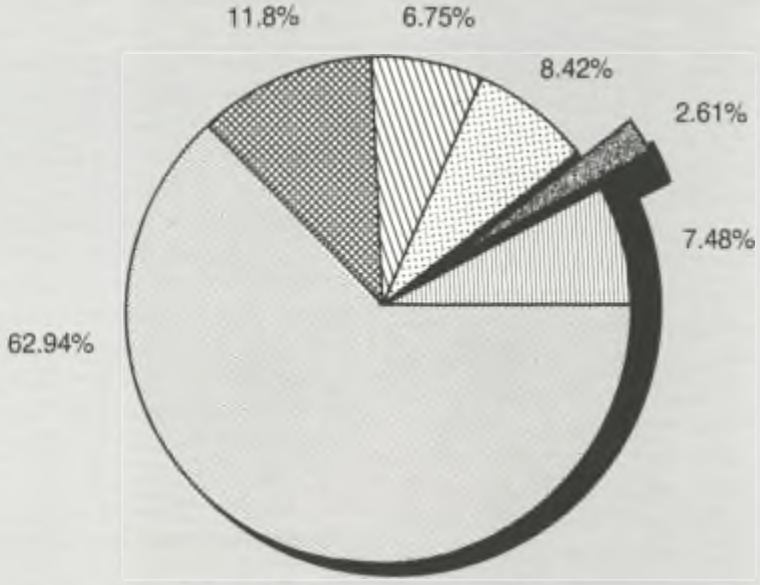
The Task Force recommends that the federal government now recognize as an additional urgent role the need to use its employment practice as a lever for expanding and diversifying the nation's science and engineering workforce at all levels. The system should be as open as possible to entry-level personnel. It can widen the pool of entering scientists and engineers by providing internships for aspiring professionals. It can extend efforts to recruit scientists and engineers from among minorities, women and people with disabilities. It can make known the way benefits of federal service compensate for salaries that are lower than in industry.

But in addition to competing for the present pool of underrepresented scientists and engineers, the federal government can help "grow its own" by involving itself in the entire education pipeline, working with the schools to identify and encourage budding scientists and engineers. It can also widen the pool by encouraging federal employees wishing to enter science and engineering or upgrade their skills to obtain the necessary education, job experience, and training.

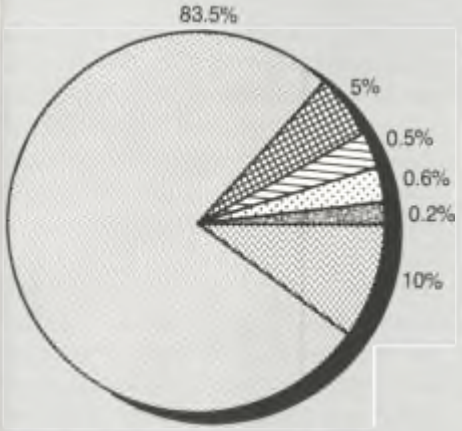
With the assistance of the Office of Personnel Management, the Task Force studied 236,757 current full-time scientists and engineers employed by the federal government in 1987. The aim was to determine the representation and rank of men and women, Blacks, Hispanics, Asian-Americans, American Indians, and employees who identified themselves as disabled. Overall, employment of federal scientists and engineers increased 24 percent between 1977–87 while employment of women and minorities approximately doubled. An important opposite trend was 4.9 percent decrease in the number of employed scientists and engineers with disabilities.

Although substantial gains have occurred, federal employment has not kept pace with the increase in women scientists and engineers emerging from the education pipeline. In 1987, only 10 percent of the Ph.D.s employed were women, although women earned 17 percent of the degrees awarded in science and engineering. Further, their proportion of the entire Ph.D.

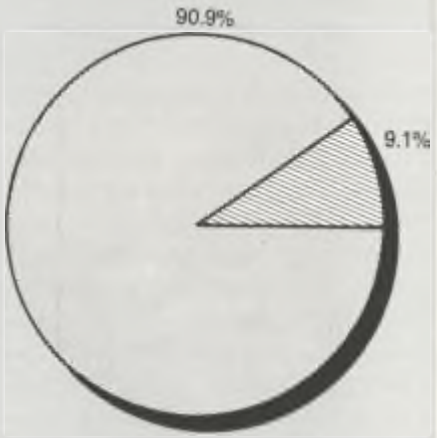
Federal Research and Development Dollars
% by Agency
Total = $60B



National Science Foundation
% dollar awards by minority group



National Science Foundation
% dollar awards by sex



population had risen to 15 percent.

In a matched cohort of Ph.D.s, in 1987, after 10 years in the federal service, 57 percent of all women, 65 percent of the Black, Hispanic, and American Indian men, 71 percent of the Asian-American men and 75 percent of white men scientists and engineers were making $50,000 or more a year.

The Influence of Culture

Parents and the home shape values. They can give children positive attitudes and skills that make them interested in and comfortable with mathematics and science. There is strong evidence that parents' expectations are strongly associated with children's participation in science-related activities. Some homes, including many Asian-American ones, are conducive to nurturing these values.

But young people, particularly youth and children from low-income families without benefit of other, countervailing images, are also to a great extent influenced by the popular culture—television, movies, video, music. Much of our youth's indifference to mathematics and science—and even fears—can be attributed to television and movies. Young people—tomorrow's workforce—watch enormous amounts of television. The percentage of 17-year-olds watching television 3 or more hours a day, rose from 26 percent in 1978 to 56 percent in 1986. This increased exposure to television may be negating some of the positive effects of recent education reforms.

In addition, the Task Force heard many complaints during public hearings that the entertainment industry has created powerful negative stereotypes. Scientists are depicted as mad wizards or "nerds"; women are shown as helpless ("Snow White needed the Seven Dwarfs"), or sex objects ("the Madonna-syndrome"). The industry glorifies the human body as "good" only when it is beautiful and complete. Disfigured people are often portrayed as oddities and rarely shown as competent or as heroes, let alone as scientists.

The entertainment industry's portrayal of high technology as evil or laughable, along with the industry's stress on materialism and instant gratification, are antithetical to the values required to pursue science or engineering. It is hardly surprising that so many students drop mathematics and science as soon as the decision whether or not to continue is put in their hands.

The entertainment industry and television can be a powerfully positive tool in a national initiative to bring more people into science and engineering. A television series on lawyers sparked a rise in law school enrollments. A recent movie about Navy fliers increased naval recruitment. A film such as "Stand and Deliver" can excite youth about learning mathematics. "Square One" and "3-2-1 Contact" are public television shows that engage young children in mathematics and science. A recent survey, for example, found that 50 percent of all U.S. 10-year olds had watched "3-2-1 Contact" at some time, and 13 percent had watched it regularly.

More than half of the children who watched also engaged in some science activity as a result—a finding that suggests that the power of television is underexploited. And it is important to note that positive responses did not vary with socioeconomic status, sex, or race.

The entertainment industry can do much to instruct and build positive attitudes. We call on it to act in partnership with schools, business, and the community to increase the attractiveness and importance of mathematics and science to American youth and to purge negative images.

Conclusion

The problem the nation faces in science and engineering professions stems from powerful underlying forces in society, including discrimination, poverty, and deficits in education.

Poverty continues to grip a large number of children, particularly a disproportionate share of minority children. The nation's public schools have traditionally provided a common pathway to the American dream of economic opportunity, but today the schools are hard pressed to serve the needs of children-at-risk.

Most elementary and secondary schools do an inadequate job of preparing students in mathematics and science.

Colleges and universities recruit too few science and engineering students, particularly students from underrepresented groups, and do not retain enough through completion of the bachelor's degree.

Graduate departments are not widening their pool of Ph.D.s with enough American students, especially those from underrepresented groups. The problem is continued by employers who have not yet opened career paths widely and visibly enough to prospective talent.

Each sector of the nation's science and engineering workforce, accustomed to operating independently, must work with all the others towards a set of common goals.

The America we have taken for granted for more than a generation—is changing.

Our society is changing: More people are old, fewer are young, more come from minority groups.

Our industry is changing: We are not the world economic leader we were for so long, but a competitor with other industrial nations.

Our education system is changing: Although our colleges and universities are the envy of the world, they are becoming more and more dependent on foreign students and faculty. Our precollege education system has reached a crisis state in which U.S. students are no longer competitive with those in other industrialized countries.

Our present scientific and engineering workforce—the foundation for U.S. technological, economic, and military leadership—is eroding due to retirements and declining student interest.

The educational pipeline from prekindergarten through the Ph.D.—is failing to produce the workers needed to meet future demand. Indeed, unless parents, schools, colleges, professional societies, industry, state legislatures, federal agencies, the President, and Congress act in concert, our national science and engineering workforce will continue to erode and the prospects for maintaining an advanced industrial society will diminish. □