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Long-Term Strategies for Improving Science Education

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I don't think I need to preface my remarks today by commenting on the sorry state of instruction in general—and science and math education in particular—at our nation's schools. We're all familiar with the statistics showing the decline in science and math test scores of elementary-school and secondary-school students in the US. We're all aware of the poor showing of even the best of our graduating high-school students compared to their peers in other developed nations. And we know that fewer and fewer of these graduating students choose to major in math or science in college.

The problem of science and math education is so large, so extensive, and so important that a short-term quick fix is not a viable solution. A successful strategy for solving the science and math education problem must have a long-term time horizon and must focus on the kindergarten through 12th grades. Elementary and secondary schools are the pipeline from which will emerge the scientists, engineers, and technicians of the twenty-first century. These young students are the people who will go on to discover, develop, apply, and manage the scientific and technical innovation that will determine our nation's economic competitiveness in the 1990s and beyond.

Other members of this panel are better qualified to address the question of educational reform in our schools—how we might improve science and math curricula and the way these subjects are taught, how to improve science and math textbooks and other instructional aids, how to ensure greater numbers of better qualified science and math teachers, and other strategies that focus on the classroom. However, classroom reform is necessary, but not sufficient, to solve the problem of science and math education.

In my opinion, a successful long-term campaign to improve science education must be waged not just in the classroom but on three other fronts:

- First, in the *home*, to reach parents, who shape their children's decisions about course enrollment and future careers;
- Second, in the *media*, to reach the "image brokers," who influence the public's perception of science; and
- Third, in *government*, to reach our elected representatives, who decide how much money is spent in support of science and math education.

Why are parents important in any effort to improve science and math education in our schools? Because parents directly influence the attitudes children develop early on about science, its value to society, and its appeal as a career. Consider the following findings. Psychologist Jacquelynne S.

Eccles, University of Michigan, Ann Arbor, reports that elementary-school students already have formed negative stereotypes about scientists and mathematicians. They see them as "loners who have little time for their families or friends because they work long hours...on abstract problems that... have little immediate social implications."[1]

Robert E. Yager, former president, National Science Teachers Association, and John E. Penick, University of Iowa, Iowa City, report that attitudes toward science become more negative as children grow older.[2] While 90 percent of elementary-school students believed that science would be valuable to them in the future, only 75 percent of seventh graders and only 20 percent of young adults felt this way. These stereotypes and increasingly negative attitudes about science translate into lower enrollment in science and math courses. In 1986 only 15 percent of high-school graduates had studied physics. Only 30 percent had studied chemistry. And only about half had studied algebra.

The way science is taught or presented in the classroom is no doubt partly responsible for turning young people off to science. But just as certainly, parents are to blame. In 1985 Jon D. Miller, Public Opinion Laboratory, Northern Illinois University, De Kalb, found that only 5 percent of US citizens had some idea of what scientists do, what the impact of science on society is, and what some very basic concepts and terms of science mean.[3] Parents who are scientific illiterates—and the vast majority are—serve as very poor role models for their children. The greater the parents' misunderstanding or ignorance of science, perhaps the less likely their children will be motivated to pursue science as a course of study or as a career. Some, like me, may be cynical about this, since we pursued scientific careers even though our parents weren't interested in science. But they were interested in *learning*.

Parents can also have an adverse impact on science and math education by perpetuating stereotypes about their children's abilities in these areas. Parents are more likely to encourage their sons rather than their daughters to learn science and math. And they tend to exaggerate the science and math abilities of boys, while underestimating the capabilities of girls.

Eccles says that these gender-biased perceptions of parents even outweigh children's own grades in the development of their self-image, confidence in their math and science abilities, and their future enrollment in science and math courses.[1] As the demographics of the US work force continue to shift toward equal representation of men and women, the scientific and technical professions must find ways to attract greater numbers of women and minorities to their ranks. To achieve this goal, long-term strategies for improving science and math education must work to overcome the gender-biased stereotypes of parents as well as their scientific illiteracy.

The mass media are also responsible for perpetuating negative stereotypes and perceptions about science and scientists. Elementary-school and secondary-school students spend an astonishing amount of time watching commercial television. How are scientists portrayed on commercial television, and what effect does exposure to these images of scientists have on viewers? George Gerbner, dean, Annenberg School of Communications, University of Pennsylvania, provides some telling answers to these questions.[4]

Gerbner and his colleagues monitored US network programming broadcast in prime time between 1973 and 1983. They found that "scientists, while on the whole positively presented, have a greater share of ambivalent and troublesome portrayals [than other professionals].... Scientists are a bit older and stranger than other professionals and are more likely to be foreigners. For every villainous scientist in a major role there are five who are good. But for every bad doctor there are 19 good; for every bad law enforcer there are 40 good."[4]

Gerbner added that scientists fail more often on television than other professionals and

that scientists are the most highly victimized group—10 percent are killed outright. Gerbner concluded that "exposure to science and technology through television entertainment appears to cultivate a generally less favorable orientation toward science."[4] This conclusion held true even among those viewers who also regularly read newspapers or watched science documentaries such as "NOVA."

Clearly, a long-term strategy to improve science and math education must include an initiative to change the negative and distorted image of science and scientists on commercial television. Other groups have lobbied successfully against demeaning stereotypes on television. There is no reason scientists, educators, and others who support science should not adopt a campaign against science stereotypes on commercial television.

While I'm on the subject of television, I'd like to say that educators should recognize—and take advantage of—the fact that children today are far more sophisticated about video technologies than any other generation. The rapid spread of cable programming, videocassette recorders, and home video games, not to mention traditional network television, is making our children intensely involved in video technologies. Educators can take advantage of this by incorporating another important video technology—the personal computer—in their classrooms.

It was only eight years ago that IBM developed its first desktop personal computer. Today there are an estimated 40 million personal computers in US homes and offices. According to Dataquest, a California research firm, one out of every five homes now has a personal computer. By 1995 personal computers will be in one out of three US homes.[5] Similar percentages can be expected elsewhere in the developed world.

Working with a computer at home or at school, a child will be able to receive information in written, aural, or visual form. He or she will be able to interact with the system and pursue a subject to the depth of his or her capabilities and interest. Computer systems can be geared to a child's grasp of a subject, speed of learning, and personal preferences for how the information is presented.

Any long-term strategy for improving science and math education in the precollege grades must incorporate computer technologies as a teaching aid in the classrooms. Students should also be trained, at all levels in their education, in information retrieval techniques. If a student knows how to find the answer to his or her "why questions" easily and quickly, discoveries and learning will come in a more satisfying and exciting way.

Knowing how to find the answers to questions is virtually the same as self-education. Because scientific knowledge is progressing so rapidly, this know-how is increasingly important, not only during the school years, but in adulthood as well. I don't presume that computers and information retrieval networks will replace teachers in the future. Rather, personal computers and electronically accessed knowledge bases will work most effectively as a student's personal tutor, a sophisticated teacher's aid.

Finally, I'd like to turn to the role of government in long-term efforts to improve science and math education. Whatever strategies are finally recommended, they will succeed or fail on one basic consideration—funding. Unless our elected representatives are themselves educated about the importance of science and math, and their societal and economic value, the commitment to fund science and math education will be lukewarm and short-lived. And unless we lobby our elected representatives effectively and consistently on this issue, we may all be back here 10 years from now to talk again about what's wrong with science and math education in the US.

When President George Bush was on the campaign trail as Candidate Bush, he made a lot of promises to the American people about becoming the Education President. We're not naive, and we realize that the art of political campaign rhetoric is in creating an image. But President Bush's budget mes-

sage to the Congress is encouraging, and I'm willing to hope, if not believe, that there is some substance behind his image as the Education President.

Bush has proposed a $441 million increase over what former President Ronald Reagan requested for education in the fiscal year 1990.[6] This increase will primarily benefit elementary and secondary schools and students. For example, $25 million of this $441 million increase is earmarked to help states and school districts design and implement alternative teacher certification programs. These programs will make it easier for professional scientists, engineers, and mathematicians who are retiring from their careers to become teachers. This will help to alleviate the already acute shortage of qualified science and math teachers in our schools.

In addition, $8 million of Bush's proposed increase will go to reward excellent teachers in each state—an average award of about $5,000 per teacher. This will help to raise the status of teachers as well as provide them with some financial reward to compensate for historically low salaries. Obviously, much more needs to be done to raise the status and wages of teachers to attract to the profession competent and qualified individuals who would otherwise choose careers in private industry.

Finally, Bush is proposing a $250 million program to reward 2,500 schools across the country that are doing a good job of educating students—an average of $100,000 per school that can be used however its administrators choose.[6] I'd like to see an equal or greater amount dedicated to schools that *aren't* doing well so they can improve their record and the abilities of their students.

Of course, these budget amounts are proposals only. How these proposals will fare in congressional debates about funding priorities remains to be seen. Even within the Department of Education there are competing interests on the agenda. Many educators are complaining about English and reading comprehension, foreign-language competence, and ignorance about current affairs and geography, not to mention science and math illiteracy. There is no reason a curriculum cannot be developed that will improve instruction in all these subjects by *integrating* these subjects. For example, a foreign-language course might include reading texts on science history, and a science course might focus on contributions from various cultures or examine societal implications as evidenced by acid rain or other current news issues.

In conclusion, I cannot overemphasize the point that we must commit ourselves to lobby long and loud in support of science and math education at all levels in our school system. We lost the momentum gained after the post-Sputnik heyday of support for science and math education in America. We cannot afford to become complacent again about this issue.

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