Preface

This technical memorandum augments OTA's report, ***Educating Scientists and Engineers: Grade School to Grad School,*** [1] focusing on the factors that prompt students to plan science and engineering careers during elementary and secondary education, and the early stages of higher education. While examining the problems and opportunities for students, OTA offers no comprehensive assessment of the system of American public education. Rather, it takes this system as the context for understanding, and proposes changes in preprofessional education.

Most educators and parents regard science and mathematics as basic skills for *every* high school graduate. By upgrading mathematics and science literacy—making more graduates proficient in these subjects—most believe that the pool of potential scientists and engineers would be larger and more diverse. At the same time, broader application of basic skills in mathematics and science would benefit the entire U.S. work force. Perhaps then concern for the future supply of scientists and engineers, as one professional category of workers among many, would recede as an urgent national issue.

As this is not the case, the problem of educating scientists and engineers is unabating; the scrutiny of schools, teaching standards, and student outcomes is intensifying; and calls for improved Federal action grow louder, As Paul Gray, President of the Massachusetts Institute of Technology said: "Americans must come to understand that engineering and science are not esoteric quests by an elite few, but are, instead, humanistic ad*ventures* inspired by native human curiosity about the world and desire to make it better. "[2]

OTA takes a long view of the science and engineering pipeline and does not dwell solely on those whose scientific talents are manifested at early ages. The science and engineering pipeline includes all students during elementary and much of secondary schooling. But as students move toward undergraduate and graduate school, smaller proportions form the talent pool. Students make choices over long periods and are influenced by many factors; this complicates analysis and makes it difficult to ascertain specific influences or their degree of impact on careers.

Although most students' career intentions are ill-formed, some decide to pursue science and engineering early in life and stick with that decision. This "hard-core group" is joined by many companions later on. **Chapter 1, Shaping the Science and Engineering Talent Pool,** concerns both the hard core and those whose plans are more malleable. As this latter group is uncertain about what major to choose, it may be more susceptible to parents' wishes, financial incentives, and the attractiveness of science and engineering careers. Whether students respond to a professional "calling" or hear the call of the marketplace, they are lured to some careers and away from others—and schools are agents of this allure.

For many children, the content of mathematics and science classes and the way these subjects are taught critically affect their interest and later participation in science and engineering. **Chapter 2, Formal Mathematics and Science Education,** reviews concern over the pace and sequence of the American mathematics and science curriculum, the alleged dullness of many science textbooks, and the extent to which greater use of educational technology, such as computers, could improve the teaching of mathematics and science.

This responsibility falls primarily on the teaching profession, together with school districts and teacher education institutions. **Chapter** 3, **Teachers and Teaching,** discusses predicted shortages of mathematics and science teachers, and concern about the poor quality of teacher training and inservice programs in all subjects, The quality of teaching, in the long run, depends on the effectiveness of teachers, the adequacy of their numbers, and the extent to which they are supported by principals, curriculum specialists, technology and materials, and the wider community. Teachers of mathematics and science need to be educated to high professional standards and, like

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[1] U. S. Congress, Office of Technology Assessment, ***Educating Scientists and Engineers: Grade School to Grad School,*** OTA-SET-377 (Washington, DC: June 1988).

[2] Paul E. Gray, "America's Ignorance of Science and Technology Poses a Threat to the Democratic Process Itself, " ***The Chronicle of Higher Education,*** May 18, 1988, p. B-2.

members of other professions, they also need to update their skills periodically.

At the same time, research on teaching of mathematics and science suggests that some techniques, not widely used in American schools, can improve achievement, transmit more realistic pictures of the enterprise of science and mathematics, and broaden participation in science and engineering by women and minorities. **Chapter 4, Thinking About Science Learning,** asks: How can more students be successful in science and mathematics? Does science and mathematics education search for and select a particular type of student, one with a certain learning style? This chapter describes other efforts to correct misconceptions (held both by students and teachers), spur creativity, develop "higher order thinking skills, " and to place more students on pathways to learning science and mathematics.

The out-of-school environment offers opportunities to raise students' interest in and awareness of science and mathematics. **Chapter 5, Learning Outside of School,** highlights "informal education" activities that draw strength from the local community—churches, businesses, voluntary organizations, and their leaders. All are potential agents of change. All are potential filters of the images of science and scientists—often negative, almost always intimidating-transmitted by television and other media. Science centers and museums, for example, can awaken or reinforce interest, without raising the spectre of failure for those who lack confidence in their abilities. Intervention programs, aimed especially at enriching the mathematics and science preparation of women, Blacks, Hispanics, and other minorities, can rebuild confidence and interest, tapping pools of talent that are now underdeveloped.

The problems that face mathematics and science education in the schools are complicated and interrelated. **Chapter 6, Improving School Mathematics and Science Education, proposes a sys**temic approach to these problems, requiring a constellation of solutions. Reforms, however, tend to be incremental. Change in any one aspect of mathematics and science teaching, such as course-taking, tracking, testing, and the use of laboratories and technology, is constrained by other aspects of the system, such as teacher training and remuneration, curriculum decisions, community concerns and opinions, and the influences of higher education.

Finally, this report illuminates the gulf between knowing and doing, between recognizing "what works" and replicating it. On many educational issues, experts are groping to specify the boundaries of their ignorance; on others, there are massive data on causes and effects, but little wisdom on how to implement change. It is this latter need that invites Federal initiative, whether "seeding" a program or showing how various partners might collaborate to approach a nagging problem in a novel way. The Federal Government is pivotal for sustaining the policy climate and catalyzing change: If there is a national will, there is a way.