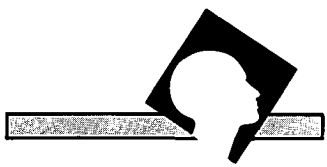
The Crisis in Pre-college Science and Math Education

GLENN T. SEABORG

Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world. . . . If an unfriendly power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. . . . We have, in effect, been committing an act of unthinking, unilateral educational disarmament.

These are the dramatic opening lines of the report "A Nation at Risk: The Imperative for Educational Reform" that the members of our National Commission on Excellence in Education handed to President Ronald Reagan in a ceremony at the White House in April 1983.

The Commission was created in August 1981 by then-Secretary of Education Terrel H. Bell, whom the Seaborg Center is very fortunate to have as chairman of its National Advisory Council. The Commission was charged with reporting on the quality of education in our country and making positive recommendations for remedying our deficiencies. What we learned in the course of our 20-month study and at public hearings across the country was so appalling that we decided to make our report



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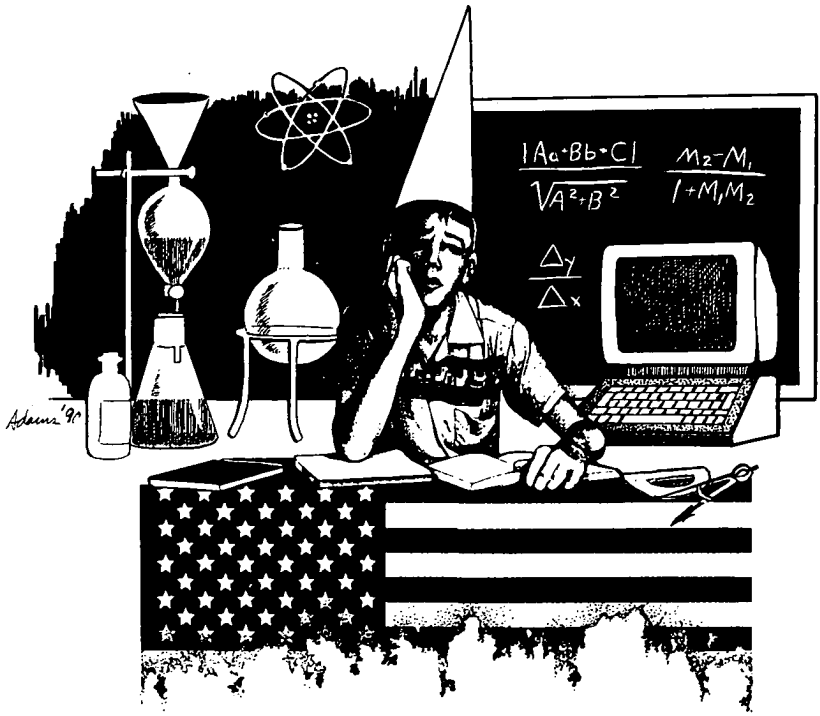

as dramatic as possible to draw attention to these serious problems and to reach maximum readership.

We succeeded in drawing almost unprecedented attention from educators, parents, public, and press. It is now apparent that the educational crisis and the urgent need for reform are broadly perceived as being a top priority. In the last presidential election George Bush made education an important campaign issue, thus putting the need for educational reform at the top of the national agenda. Last year President Bush reaffirmed his commitment to improving education when he visited the exhibits of the 40 Westinghouse Science Talent Search winners. This was the first time in the 48-year history of this competition that the president of the United States made a tour of the students' exhibits. In his remarks President Bush encouraged the efforts of programs like the Science Talent Search and said that he believed that these efforts, aided by the federal government, would result in significant changes in our educational system. He said that "as a nation, we have no natural resource more precious than our intellectual resources" and that he wanted to make science education one of the most important investments for the future of our nation.

So, how bad is the crisis in education in this country?

Since the "Nation at Risk" report, there have been dozens of other reports, by a wide spectrum of American organizations, emphasizing and deploring the state of pre-college education in science and math in the United States today. (See box.) These reports indicate that, while some progress has been made, there is still much work to be done to resolve the crisis in education.

In a recent survey conducted in six nations, 13-year-old American school-

children placed last in mathematics, behind South Korea, Spain, Great Britain, Ireland, and Canada. Moreover, the high-ranking Koreans surpassed the Americans by a wide margin: 78 percent of Korean 13-year-old students have the ability to use intermediate math skills to solve two-step problems but only half as many Americans could do so. Moreover, 40 percent of the Korean children can understand and apply mathematical concepts, but less than 10 percent of American schoolchildren can do so.

While most American 13-year-old schoolchildren can add, subtract, multiply, and divide, they are seriously lacking in cognitive skills, such as reasoning, investigating, and estimating. However, many entry-level jobs today are demanding workers with high-order, more sophisticated skills for which these students are not being adequately prepared.

In another report, released in September 1988, results showed that, compared with students from 13 other countries, twelfth-grade American students scored in the lower range on mathematics achievement tests. In geometry, American students did only slightly better than those in Hungary and Thailand; in algebra, only Thailand was worse; and the United States ranked last in calculus. Overall the American students obtained only half as many points on tests as those from Hong Kong, the highest-ranking group.

In science, the statistics are just as grim. In the same six-nation survey of 13-year-old schoolchildren, Americans again scored below average. Ironically, the United States came in behind Spain, which does not have a reputation for being in the forefront in science and technology. Again, as in math, when the 13-year-olds were tested for conceptual understanding, interpretation, and application of what they had learned, the performance of the American schoolchildren dropped dismally. At the highest level, 33 percent of Koreans had the skills to apply scientific principles, while only 12 percent of Americans could do so.

In a 13-nation survey of twelfth-graders, American students scored thirteenth in biology, eleventh in chemistry, and ninth in physics.

In report after report, American students consistently score in the lower end of the scale. It is evident that too many students are leaving our schools without adequate skills to be full participants in our increasingly technologically oriented society. By 1993, those 13-year-old students, who today are performing so poorly in math and science, will be voting and entering the work force—the scientific and industrial leadership of our nation will be in their hands.

Already it is evident that the industrial supremacy of our nation is being seriously threatened. Currently only about 6 percent of American adults are scientifically literate. This greatly diminishes their productivity in a more technologically demanding workplace.

Scientific illiteracy also affects the ability to function effectively as citizens and the ability to play an informed role in social and political decision-making on issues with scientific or technological content, such as those involving nuclear power, acid rain, the ozone layer, genetic engineering, chemical warfare, and so forth. The vitality of a democracy assumes a certain "core of knowledge," shared by everyone, that serves as a unifying force.

There can be no doubt that scientific literacy, a solid understanding of science and mathematics, is now more important than ever before—there is irrefutable evidence that the skills of our youth are not only failing to keep

A Litany of Concern

Here are some of the recent reports that have documented and deplored the state of pre-college science and math education in the United States today.

Everybody Counts: A Report to the Nation of the Future of Mathematics Education
National Research Council, National Academy Press, Washington, D.C. (1989)

The Forgotten Half: Pathways to Success for America's Youth and Young Families
The William T. Grant Foundation Commission on Work, Family and Citizenship (November 1988)

1988 Education Indicators
Joyce D. Stern, editor; Marjorie O. Chandler, associate editor. U.S. Department of Education (1988)

Moral Education and Character
Ivor Pritchard, editor. U.S. Department of Education (September 1988)

American Education: Making It Work
"A Report to the President and the American People," William J. Bennett (April 1988). This is a follow-up report assessing the progress that has been made in education since 1983, when "A Nation at Risk" was published.

The Forgotten Half: Non-College Youth in America
The William T. Grant Foundation Commission on Work, Family and Citizenship (January 1988)

Women and Minorities in Science and Engineering
National Science Foundation (January 1988)

The Condition of Education: Postsecondary Education
Joyce D. Stern, editor; Marjorie O. Chandler, associate editor. U.S. Department of Education (1988)

Undergraduate Science, Mathematics and Engineering Education
National Science Board, NSB Task Committee on Undergraduate Science and Engineering Education (March 1986)

up with the increasing demands—but actually are deteriorating at an alarming rate.

This country cannot afford another generation of students who are unprepared to respond to the worldwide rapid growth of scientific knowledge and technological power. The nation's future depends on them. Therefore, we must improve general science and math education for all our young.

The task of guiding the intellectual (and often social) development of our young is all-important. We must begin to recognize teachers' contributions not only by adequately compensating them for their service, but also by giving them the due respect that would motivate them to refine their skills and expand their knowledge to

meet future challenges. While some teachers are eminently qualified, a significant number of them have little background in science or mathematics or have not had any involvement with these subjects in many years and have simply lost touch with changes in their fields.

According to a 1985-1986 national survey supported by the National Science Foundation and released in 1988, many science and math teachers feel they lack adequate training and are not qualified to teach. Indeed, the study showed that only about one in three elementary science teachers has taken a college chemistry course and only one in five teachers has taken a college physics course. While 82 percent of them felt they were very well qualified to teach reading, only 66 percent felt they could teach math. In the science disciplines, fewer than one-third of the teachers felt very well qualified to teach the life sciences and only 15 percent felt very well qualified to teach the physical or earth and space sciences.

At the high school level, less than one in three teachers had included earth and space sciences in their undergraduate curriculum. The report also states that "more than half of all secondary science teachers have never had a college computer-science course and almost half have had no college calculus."

However, most science and math teachers feel that they would enjoy teaching these subjects if they had adequate preparation. Whatever their situation, these teachers need opportunities to upgrade their math and science teaching skills. Thus there is not only a need to increase the available pool of qualified math and science teachers, but there is also a need to enhance the capabilities of those now teaching these subjects.

The Lawrence Hall of Science is an institution committed to improving the quality of mathematics and science instruction for pre-collegiate students. For more than two decades the Hall has dedicated its superior resources as part of the University of California to the continuing battle against educational mediocrity.

The Lawrence Hall of Science, which I serve as chairman, was conceived in 1958 and built in 1968 as a memorial to Ernest O. Lawrence, the University of California's first Nobel Laureate and inventor of the cyclotron. As a dynamic research and educational institution, the Hall continues today, 22 years after its dedication in 1968, to focus its efforts on three main objectives:

- To improve the quality of mathematics and science instruction for the benefit of pre-collegiate students through the development of innovative math and science courses and accompanying curriculum materials and teacher training services.
- To augment the mathematics and science instruction provided by our schools by offering special mathematics and science courses at the Hall.
- To enhance the knowledge, appreciation, and enjoyment of mathematics and science for the general public by providing the community with a math and science center.

In its efforts to improve instruction in math and science the Hall has developed programs for students and teachers in their own schools. Two particular programs that have been recognized for their excellence are CHEMStudy, a comprehensive high school chemistry curriculum, and the Science Curriculum Improvement Study (SCIS), an activity-oriented science program for children K-6 that was developed in the late 1960s and is now used in more than 20 percent of the nation's elementary schools.

Through its in-school programs, the Hall reaches more than 122,000 children every year in the San Francisco Bay Area.

The Hall sets as a priority the development of programs that deal with the issue of attracting and retaining underrepresented students—such as young women and minorities—in mathematics and computer education.

For more than two decades, the Hall has also provided innovative leadership in pre-collegiate math and science education through the publication of major curricula. These learning materials are utilized by millions of students in the United States and around the world. Curricula and exhibits developed by the Hall are currently used by schools and science centers in more than 30 countries. Each year, more than 700 educators from around the world visit the Hall to learn new techniques to improve science and mathematics instruction.

The Lawrence Hall of Science has achieved national and international prominence as a result of its innovative and effective programs. However, despite the Hall's numerous discoveries and noted accomplishments, much more work still needs to be done.

There is a need for more institutions like the Hall. Therefore, I was deeply honored to participate recently in the dedication ceremonies of another institution committed to improving the education of our young—the Glenn T. Seaborg Center for Teaching and Learning Science and Mathematics. As part of Northern Michigan University (NMU), the Seaborg Center is in a unique position to provide, through its services, resources, and programs, quality education for students and teachers of the Upper Peninsula.

The Seaborg Center, while still young, is rapidly gaining a national reputation that has brought funding agencies to the Center with specific requests. The Lawrence Hall of Science at the University of California at Berkeley, the Kellogg Foundation, and the Public Service Satellite Consortium have all sought out the Seaborg Center and Northern Michigan University to direct or participate in programs that will impact not only the Upper Peninsula but teachers and students throughout the United States.

The Lawrence Hall of Science and the Seaborg Center can join forces to help achieve the goal of educational reform so urgently needed in our country today. We all have a vested interest in education and we must all work together, employing all our resources, to reform and improve our educational system and ensure a prosperous future for our nation. Whatever the expense of improving education, it is an investment in the future we must make. Excellence costs. But in the long run mediocrity costs far more.

Glenn T. Seaborg, University Professor of Chemistry at the University of California, Berkeley, and associate director of the Lawrence Berkeley Laboratory, is one of the nation's most distinguished scientists, educators, and statesmen of science and has been active in science-education issues throughout his career. He has been chairman of the Atomic Energy Commission and president of both the American Chemical Society and the American Association for the Advancement of Science. In 1951, Professor Seaborg received the Nobel Prize in Chemistry. This essay is adapted from a talk he gave at the opening of the Glenn T. Seaborg Center for Teaching and Learning of Science and Mathematics at Northern Michigan University.