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ABSTRACT

This brief report highlights findings from the two assessments in mathematics and three assessments in science conducted by the National Assessment of Educational Progress between 1969 and 1978. In mathematics, average scores declined during the mid-1970s, especially on problem solving. In science, students generally declined in knowledge, skills, and understanding, especially in physical science. These and other results cited have been interpreted as not boding well for the future eminence of the United States in science and mathematics. Key influences were noted, including the emphasis on back-to-basics and the tendency to short-change problem-solving skills; the emphasis on testing of skills, with attention focused on those easily tested; the shortage of qualified teachers; lowered levels of support; and the relaxation of college entrance requirements. Necessary steps to be taken are listed, and a brief list of references is included. (MNS)

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6. Achievement in Mathematics and Science

The Issue

As we enter the high-technology society of the 1980s, there are dire predictions that today's high school graduates are ill-equipped to take their places in this society. Critics of the nation's educational system have claimed that students' preparation in mathematics and science -- learning areas critical to the current technology explosion -- is woefully inadequate.

Do such criticisms have a basis in fact or are alarmists simply creating a "crisis" where none actually exists? What is the status of students' skills in science and mathematics? Has it changed over the years? For a look at achievement trends in mathematics and science on a national scale, we can turn to data from the National Assessment of Educational Progress (NAEP). National Assessment periodically measures skills of 9-, 13- and 17-year-olds in various learning areas to provide a picture of current achievement levels and changes in these levels over time. Many identical items are used in successive assessments to allow comparisons of trends in achievement.

During the 1970s, National Assessment conducted two assessments of mathematics and three of science. Mathematics assessments were conducted during the 1972-73 and 1977-78 school years; science assessments were administered in 1969-70, 1972-73 and 1976-77. These surveys provide a picture of trends in performance in mathematics and science during the mid-1970s. Data from the most recent assessments of mathematics and science, conducted in 1981-82, will be available in mid-1983.

NAEP's assessments are administered to carefully designed samples of the nation's young people so results are representative of performance nationwide. The sample also allows reporting for different groups within the national population, including sex, racial/ethnic group, region of the country, level of parents' education and size and type of community lived in. Approximately 2,000 students responded to each mathematics or science item.

National Assessment Findings

Mathematics. Nationally, teenagers' mathematics achievement fell during the mid-1970s. As seen in Table 1, declines became greater as the age of the students increased.

Table 1: Changes in Average Performance on Mathematics Items Assessed in 1973 and 1978, Ages 9, 13 and 17.

	Average Performance		Change in Average Performance
	1973	1978	
Age 9	38%	37%	-1
Age 13	53	51	-2*
Age 17	52	48	-4*

*Change significant at .05 level.

Although there were fluctuations in computational skills with whole numbers between assessments, performance levels were generally high and declines were in large part offset by gains. Performance in the area of problem solving, however, declined for all three age levels.

Some encouraging trends were noted, however. While still below national levels, 9-year-old black students improved in mathematics even though performance nationally declined, thus narrowing the gap between themselves and national achievement levels. Thirteen-year-old blacks' mathematics skills remined stable while those for the nation declined, again resulting in a smaller gap between blacks, who performed below the nation, and national levels. Similarly, at ages 9 and 13, the gap between the nation and students living in disadvantaged-urban areas became smaller between 1973

and 1978, although the disadvantaged-urban students remained below national levels. However, declines for 17-year-olds from these groups were about the same as that for the nation as a whole.

Results from the latest NAEP mathematics survey also provide evidence that youngsters fail to "think through" problems. For example:

- About 60% of the teenagers knew that the sides of a square are of equal length, and about half the 13-year-olds and nearly three-fourths of the 17-year-olds could calculate the area of a rectangle given its length and width. Yet only 12% of the 13-year-olds and 42% of the 17-year-olds successfully figured the area of a square when the length of only one side was shown.
- Forty percent of the 9-year-olds and 69% of the 13-year-olds correctly calculated the "distance around" a pictured rectangle with only two dimensions given. But only 9% at age 9 and 31% at age 13 could determine how much fencing was needed to go around a rectangular garden that was not pictured, even though the same numbers were used in each problem.

Assessment results also indicate that teenagers do not understand the concepts of fractions, decimals and percents. For example, when asked to estimate 12/13 plus 7/8, only 24% of the 13-year-olds and 37% of the 17-year-olds gave the correct answer of 2. In estimating 250 divided by .5, 25% and 39% of the 13- and 17-year-olds, respectively, correctly answered 500. The largest percentages ignored the decimal point, giving an answer of 50.

Percentages also appear to stump many young people. Only 35% of 13-year-olds and 58% of 17-year-olds could determine what percent 30 is of 60; only 8% at age 13 and 27% at age 17 could calculate 4% of 75. About one-third of the 17-year-olds did not realize that 5% means 5 out of 100.

Science. Between the first and second assessments of science, carried out in 1969-70 and 1972-73, students at ages 9, 13 and 17 declined generally in knowledge, skills and understanding of science. Between 1973 and 1977, this decline tapered off for 9- and 13-year-olds. While some downward trends continued for these age groups, the rate slowed considerably. However, science performance of 17-year-olds continued to fall during the mid-1970s.

National Assessment found that at all three ages students in extreme-rural areas showed a steady improvement in science achievement during the eight years spanned by the three surveys. In 1970, rural-area students at ages 9, 13 and 17 performed below national levels. Each age group showed consistent improvement in succeeding assessments, and by 1977, the three ages in rural communities were performing at or near the national level.

In measuring changes in achievement, the science assessments concentrated on knowledge and skills related to the physical and biological science.

Findings indicate that:

- Neither 9- nor 13-year-olds declined in biological sciences between 1973 and 1977. However, both age groups continued the decline in physical science that was evident between the first and second surveys, although the decline in physical sciences for 13-year-olds was less from 1973 to 1977 than it was between the first and second surveys.
- In physical science, 17-year-olds showed a continuous decline from the first to the second assessment and on to the third. An encouraging finding in the data for 17-year-olds: the decline in physical science does not appear to be as steep from 1973 to 1977 as from 1970 to 1973. And, in biology, the decline across the three assessments was less than that for the physical sciences.

In a study of science attitudes, done only in the latest science assessment, data showed that more than three-fourths of the teenagers support scientific research. However, support is stronger for applied than basic research. Some students may not realize the role of basic research or the essential need it fills.

Confidence in science is fairly high among youngsters across the country. Asked if science and technology have changed life for the better or the worse, about one-third of the teenagers said that life has been changed for the better. A substantial number -- about half of the teenagers -- believe that life has been changed both for the better and for the worse.

Implications of the Findings

Educators asked by National Assessment to help explore the implications of the results agreed that the findings do not bode well for the future eminence of this country in science and mathematics. They targeted a number of factors as perhaps having an influence on the declines seen.

One key influence, in the view of these educators, has been the trend toward "back to the basics" in education. Mathematics specialists felt strongly that the "basic" mathematics curriculum tends to emphasize drill and memorization, often at the expense of problem-solving skills. Science educators noted that biology, which often consists largely of memorization of terms in early courses, did not decline. Skills in the physical sciences, more dependent on the application of concepts, did.

The emphasis on "basics" rests in part on the theory that if one knows the foundations of a subject, this knowledge can easily be applied to solve problems. NAEP findings and other research indicate that this is not necessarily the case. Youngsters need specific instruction in applying skills to synthesize information or solve problems, instruction of a different type than that effective for teaching lower order skills. In the emphasis on basics, development of problem-solving abilities may be unconsciously neglected.

The tendency to shortchange problem-solving skills has been exacerbated by the recent increased emphasis on testing. This trend may well encourage teachers and students to dwell upon easily tested, recall skills rather than devoting time to more complex tasks whose accomplishment is not so readily quantified.

The number of qualified secondary mathematics and science teachers is declining. Teaching has lost its allure for many who would be qualified graduates, and sizable numbers of those in the profession are leaving, attracted by the higher salaries and better working conditions in business and industry. In many states, mathematics and science requirements for elementary teachers are far from stringent, leaving teachers not as well qualified as they might be in these areas.

Support for teaching mathematics and science has not been high over the past decade. Although mathematics is part of Title I of the Elementary and Secondary Education Act (which provides federal funds for compensatory education), it has not received as much emphasis as reading. Science educators noted that science had been almost universally deemphasized during the seventies, with less time and money devoted to science at the lower grades and fewer required science courses at the senior high school level.

Mathematics and science college entrance requirements were relaxed considerably in the early 1970s. As a result, many students were understandably reluctant to tackle subjects often perceived as difficult without the incentive of requirements.

What Should Be Done?

An essential first step must be to increase public awareness of potential shortcomings in science and mathematics achievement. Steps in this direction are being taken. National and state commissions have been established to examine the current status of mathematics and science education and to suggest directions for the future.

Among other suggestions made by mathematics and science educators:

- o Since performance improved for some groups of typically lower performing students, it would be advantageous to examine which strategies worked for them. Since other students did not improve, different approaches may be needed for different groups of students.
- o Educators stressed that teaching of problem-solving or analytic skills and of more basic knowledge and skills should proceed simultaneously. In this manner, the learning of more advanced skills should reinforce learning of basic skills and provide meaning for their application.
- o Teaching salaries and working conditions must be upgraded to encourage people to enter and remain in the teaching field. Teacher training programs should be scrutinized to ensure they provide teachers with the necessary background and the skills to teach problem solving and critical thinking.
- o Mathematics and science requirements must be reinstituted and strengthened and expectations for students' performance raised. Without a climate of high expectations and a sense that achievement in these areas is important, students may well not be inclined to pursue the rigors of mathematics and science courses.

What to Read

Attitudes Toward Science, no. 08-S-02, Denver, Colo.: Education Commission of the States, 1979. $7.20

Changes in Mathematical Achievement, 1973-78, no. 09-MA-01, Denver, Colo.: Education Commission of the States, 1979. $4.10

Howe, T. and Gerlovich, J., "National Study of the Estimated Supply and Demand of Secondary Science and Mathematics Teachers," 1982.

Science and Mathematics in the Schools: Report of a Convocation, Washington, D.C.: National Academy of Sciences, National Academy of Engineering, 1982.

State-Mandated Graduation Requirements, 1980, Reston, Va.: National Association of Secondary School Principals, 1980.

"The Information Society: Are High School Graduates Ready?" Denver, Colo.: Education Commission of the States, 1982. $4.50

Three National Assessments of Science: Changes in Performance, 1969-77, no. 08-S-00, Denver, Colo.: Education Commission of the States, 1978. $4.

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