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Myths in International Comparisons of Science and Mathematics Achievement

The public perception that the United States is falling behind in science and mathematics is based on a narrow criterion that has serious methodological deficiencies

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The purpose of this article is to reduce the probability that I will be asked at a dinner party, yet again, why the United States ranks near the bottom in international comparisons of science and mathematics achievement. The question is likely to receive even more attention in the context of the fourth national education goal, which holds that U.S. students will be first in mathematics and science by the year 2000.

Ever since international comparisons of science and mathematics test scores began in the 1960s, Americans have believed the myth that U.S. students are outclassed by those in other nations. Yet, after almost three decades of apparent failures on international tests, we have somehow managed to maintain a level of productivity in science and engineering that, by many measures of performance, is overwhelming.

The fact is that international comparisons of test scores are highly misleading indicators of the quality of a nation's education system or the expertise of its students. An emphasis on such comparisons is misleading for two reasons:

- the rankings of nations are biased by serious methodological problems; and
- the preoccupation with the single criterion of test scores as the primary indicator of achievement in science and mathematics—even if methodologically sound—deflects public policy away from far more important issues.

Methodological Problems

The rankings of nations in international test comparisons are meaningless because it is not feasible to control for the major societal differences among nations. The fact is that we do not know what the rankings would be if the comparisons were sound.

The first set of international comparisons, conducted by the International Association for the Evaluation of Educational Achievement (IEA) in the 1960s and early 1970s, did not take into account the percentage of the age group actually enrolled in upper-secondary school. These attendance rates are much higher in the United States than in most other countries. At the time the tests were administered, only about 20 percent of the age group in Europe attended upper-secondary school—the *highest-achieving* 20 percent—compared with 80 percent of the age group in the United States. Thus, the IEA assessments compared the average score of more than three-fourths of the age group in the United States with the average score of the top 9 percent of the students in West Germany, the top 13 percent in the Netherlands, and the top 45 percent in Sweden.[1] It is not surprising that U.S. students did not do well in these comparisons.

Of course, this type of sampling problem is not limited to international comparisons. To a considerable extent, the well-publicized decline in scores on the Scholastic Aptitude Test (SAT) resulted from the fact that more students took the SAT and attended college, and not from a decline in the quality of the educational experience. The relative rankings of states on average SAT scores are also a reflection of the proportion of students who take the test. The states with the *highest* proportions of students taking the SAT tend to have the *lowest* average SAT scores.[2] Indeed, one way to increase a state's average SAT score would be to discourage students from applying to colleges that require the test!

International comparisons of test scores are highly misleading indicators of the quality of a nation's education system or the expertise of its students.

While more recent IEA assessments have tried to deal with the sampling problem by testing only those twelfth-grade students who are in an academic track and taking mathematics or advanced science, these changes do not solve the problem.

Consider, for example, the results for Japan and Hong Kong in the most recent mathematics assessment.[3] The assessment ranks Japan first in a multinational comparison of eighth-grade mathematics, with Hong Kong in the middle of the rankings. By the twelfth grade, when only 3 percent of Hong Kong's young people are taking mathematics (compared with 12 percent in Japan), Hong Kong comes in first and Japan second. The reality is that Hong Kong's schools are not dramatically better in the twelfth grade than in the eighth; the changed rank is simply a matter of extreme student selectivity in Hong Kong.

Similarly, in eighth-grade comparisons, Hungary ranks near the top on international tests. However, Hungary enrolls 50 percent of its students—more than any other country—in twelfth-grade mathematics courses. Not surprisingly, by the twelfth grade, Hungary ranks among the bottom countries. Are Hungarian high schools that much worse than Hungarian middle schools? Or does the normal pattern—more students, lower scores—explain the results?

British Columbia also has a high proportion (30 percent) of its students taking twelfth-grade mathematics. The students scored quite high in three-fourths of the eighth-grade tests. They scored at or near the bottom by the time they got to the twelfth grade.

By contrast, England/Wales, where only 6 percent of the students take twelfth-grade mathematics, ranks among the top countries in the twelfth-grade comparisons—a significant improvement over its rank in the bottom half in most of the eighth-grade comparisons. Did the schools improve, or is it more likely that greater selectivity simply resulted in higher average test scores for those relatively few students who take mathematics in the twelfth grade?

Israel, which also has only 6 percent of its students in twelfth-grade mathematics classes, is an exception to the pattern. Israeli students rank approximately the same (in the middle of the distribution) in both the eighth- and twelfth-grade comparisons.

The comparative rankings of the nations also reflect differences in curricula across countries. In the IEA assessment, for example, U.S. students who took calculus which is included on the test met or exceeded the international average. Not surprisingly, those who did not study calculus scored well below the average. In most other countries in the assessment, *virtually all* advanced mathematics students take calculus. In the United States, however, only about one-fifth of students taking twelfth-grade mathematics study calculus.

Clearly there is room for debate about whether a higher proportion of U.S. twelfth-grade mathematics students *should* take calculus, but this issue cannot be resolved by examining the results of international comparisons. If we think it wise to teach calculus to a larger proportion of twelfth-graders, let us do so after an analysis of the issue on its merits—Who would teach it? What course would it displace? Are students who take calculus for the first time in college at a disadvantage?—and not on the basis of the lower test scores of students who have never taken the subject.

The International Assessment of Educational Progress

In addition to the assessments conducted by the IEA, the Educational Testing Service initiated the International Assessment of Educational Progress (IAEP) in 1988.[4] This assessment, which tested 13-year-olds in mathematics and science, placed the United States last among the participating countries. But because of the small sample size and acknowledged methodological problems, the assessment was labeled a "pilot"—although this label has not been reflected in public rhetoric about the findings.

Only a few countries participated in the assessment: Ireland, Korea, the United Kingdom, the United States, and Spain, along with some Canadian provinces that were further subdivided according to language group. I will not try to unravel all the sampling problems, but some deficiencies are particularly striking.

For example, we do not know the representativeness of the samples in each country with respect to socioeconomic status or geographic location. Thus, when the entire United States is compared with individual Canadian provinces, we do not know whether any differences in scores might be attributed to differences in the quality of education or to differences in the socioeconomic status of the students tested. When only the largest of several language groups in Spain is represented in the comparisons, we do not know enough about the correlation between language, geographic location, and socioeconomic status in Spain to interpret the findings. Similarly, when the Inner London Educational Authority chooses not to participate in the assessment, we do not know how its exclusion affects the representativeness of the sample of British students actually tested.

The reports on the assessment do not provide these data. The general public understandably concludes that differences in rankings reflect differences in the quality of education across entire nations. Yet it is just as likely that a large portion of the difference is accounted for by artifacts of sampling.

The IAEP pilot has been greatly expanded and currently includes 20 countries that are conducting assessments during 1990–1991. The Soviet Union has been added to the list, as have several developing countries, including Brazil, China, and Mozambique.

With the introduction of many additional countries, the sampling problems become even more troublesome. My concern is that the comparisons will be seriously biased because only the most prosperous regions or the most elite schools and students will be sampled in some of the participating countries. The findings will be no more useful to a developing country struggling to maintain an appropriate balance in the allocation of its scarce educational resources than they will be to the countries that rank poorly because their samples are more representative of the entire population. The citizens of each of the participating countries deserve clear information about how to interpret the findings. They cannot be expected to review the fine print that tells them that, because of "technical" difficulties, they should not really believe what they have just read.

However, the issue is not the statistical expertise needed to design a strong sampling plan, but practical considerations that make implementation extremely difficult. There are logistical problems in administering a standardized test across vast areas and remote regions of such countries as China and the Soviet Union. Reliable data are not available on which to base a national sample that reflects the entire population. Political realities make it difficult to include very poor regions or those that have a tenuous relationship with the central government. Many decisions made for practical reasons—e.g., to include only Mandarin-speaking students in China or Russian-speaking students in the Soviet Union—strongly bias the samples toward the most elite regions or schools. Moreover, countries are likely to differ in the criteria they set for excluding regions, schools, students within schools, or ethnic and language groups. All of these factors will significantly affect the countries' rankings.

The problem is compounded by differences in the percentage of low-income students actually enrolled in school in the various countries. We know from many studies that there is a high intercorrelation between family income, family educational level, and student achievement. Therefore, countries with substantial proportions of low-income students taking the test tend to score lower than countries with less poverty or than those whose low-income students are not tested simply because they are not in school. Significant differences in the incidence of poverty—even among industrialized countries—will affect the relative performance of countries in international comparisons. However, the developing countries, which have the highest incidence of poverty, also tend to have the most elitist school systems and the highest proportions of their students out of school and therefore not tested. Thus, the scores of developing countries on international comparisons are inflated because only a small proportion of their student population is tested, as compared with the broader testing in more affluent countries.

Indeed, many students in some developing countries have left school by the eighth grade—the main grade included in the assessment. While data specifically for the eighth grade are not available, we do know, for example, that in Brazil only 39 percent of the secondary school age group (defined as approximately ages 12 through 17) is in school; in China, the percentage is 43 percent; in Mozambique, it is only 5 percent.[5] Thus, even if the students still in school in eighth grade were accurately reflected in the sample, the results would be seriously biased by the exclusion of the substantial proportion of the age group no longer in school and therefore not tested.

China illustrates the sampling problems. Like many other developing countries with scarce resources, China has a highly elitist education system that provides advanced mathematics and science instruction to only a very small proportion of its students. The majority of Chinese young people have never studied the material covered by the assessment and are unlikely to be represented in the sample taking the test.

With a low level of resources to spend overall, China has chosen to concentrate on "key schools" that provide a high-quality education to very few selected students. These key schools receive the highest concentration of resources, including the best teachers, many of whom are university graduates. For the large majority of students, however, the average per-pupil expenditure is well under $100 per year, and it is common for teachers to have only an elementary-school education. The problem is compounded by vast differences between urban and rural areas.[6] A comparative assessment, therefore, is meaningless if the test is given only in selected schools. An oversampling of elite schools in China will distort the results in the same way as would a U.S. sample composed primarily of students from the Bronx High School of Science.

In short, the results are likely to provide little information about the quality of education in any country. Instead, they will simply reflect a combination of sampling artifacts and the practical difficulties of implementing a broad and high-quality assessment.

Prognosis for Future Studies

Some observers have argued that forthcoming studies will do a better job of addressing the problems than previous studies have. Perhaps. But the evidence suggests the contrary.

For nearly three decades, statisticians have worked on the methodological problems of international assessment. They have not been able to solve them—not because they were unable to develop elegant statistical designs, but because it was unrealistic to attempt to implement these designs in the real world. It is simply not a statistical problem. It is a problem of trying to compare highly diverse societies and education systems.

Consider, for example, the implications of the following practices for international assessments:

- Some countries exclude from the testing significant numbers of low-achieving schools and schools in which the curriculum is considered inadequate.
- In other countries, many students who are in industrial apprenticeship programs do not participate in the test comparisons.
- Several countries track students for all subjects in separate classrooms or separate schools as early as 11 years of age. We do not know which students are represented in the test comparisons.
- In some countries, students take courses almost exclusively in their field of specialization after age 16. Therefore, high school students who are tested in science and mathematics have studied essentially *only* science and mathematics from age 16 on. These students are compared with students in comprehensive schools in other nations.
- There are large differences among nations in the criteria used to assign students to academic and vocational tracks, the relative emphasis placed on public and private education, and the relative weight given to various subjects. Clearly, each nation also differs in the way all this plays out with respect to students' language, social class, ethnicity, race, religion, or immigration status. We simply do not have the data to understand how

these societal differences affect the international comparisons: who is—or is not—tested and what their educational experiences have been. We are not even able to describe clearly the various countries' education systems—let alone devise an appropriate sampling design that would enable us to look at the outcomes of those systems and "rank" them, or determine whether differences in the quality of education account for differences in test scores.

- The problems are compounded in developing countries, where scarce resources make it possible to provide a high-quality education to relatively few, highly selected students and where a large proportion of students have left school by the time the tests are administered.

Given the difficulties, it is not surprising that our studies are flawed and that we have not yet developed a high-quality design for future studies. In my view, it would clearly be inadvisable to undertake the "heroic" measures that would be needed even to begin to address the methodological problems. Would our children's education improve if we established rigid international controls on each nation's sampling design or attempted to locate out-of-school (or homeless) children and test them on science and mathematics? And even if we did so, what is the chance that the test score differences could be attributed to the quality of each nation's education system? Yet that is the primary rationale for conducting the studies in the first place.

Beyond Test Comparisons

Let us assume, however, that the methodological difficulties are resolved and that the test results accurately portray the relative rankings of the participating countries. Let us also assume that the questions are a reasonable measure of mastery of the subject matter—also a highly controversial issue. We are still left with the matter of whether the test scores are a useful measure of those things that are most important to us—or to other nations—in the fields of science and engineering education. I would suggest that even a methodologically sound study of test performance does not address far more important issues with respect to science and engineering education, nor does test performance necessarily correlate with these other matters. Indeed, our preoccupation with test comparisons may lead us to implement "solutions" that are counterproductive to the long-term improvement of science and engineering education. The comparisons clearly do not reflect the breadth of a nation's accomplishments or address its real problems.

For example, how productive is the United States in basic and applied research? What does the marketplace say about the research opportunities in our institutions of higher learning? Where are students from many other countries taking their advanced degrees in science and engineering? What are our accomplishments and failures in making major technological advances? Are we successful in turning our scientific and technological advances into products that are competitive in the international marketplace? Are science and engineering fields attracting high-achieving students? Is there a shortage of students or faculty members in science and engineering? Are we making progress in attracting women and minorities to science and engineering? Does the teaching environment in our schools and colleges encourage students to select—and continue to study—science and mathematics? Does the educational experience give students who do not major in these fields a meaningful understanding of key scientific issues and methods? Do we provide the general student population with an opportunity to gain the skills needed to be competitive and productive in the workplace? Are we maintaining the technical expertise of the work force?

The developing countries tend to have the most elitist school systems and the highest proportions of their students out of school and therefore not tested.

The answers to these questions are mixed, but they are far more meaningful measures of our national accomplishments and problems than are international comparisons of test scores. More important, they focus on policy matters that most need attention. While a full analysis of such questions is clearly beyond the scope of this article, the discussion below suggests a few examples of the data that might be used to assess our status in science and engineering.

Consider, for example, what the United States produces in basic and applied research as measured by the number of scientific publications. In 1986 U.S. publications in science and engineering accounted for more than a third of the world's technical publications, a figure that has remained approximately the same since 1973. The next highest-ranking nations are the United Kingdom, Japan, and the Soviet Union, at about 8 percent each.[7]

A further measure of our accomplishments in scientific research is the high enrollment of foreign students in U.S. universities. Indeed, it is generally acknowledged that no other nation's system of higher education offers the breadth and quality of the research opportunities available to students in U.S. institutions.[8]

Our success in turning U.S. scientific and technological advances into marketable products is questionable. However, that matter relates less to science education or test scores than to far more subtle factors: the global economy, the lack of incentives for industry to invest in long-term product development, financial incentives that lead to offshore manufacturing, licensing practices, the links between academic scientific research and industrial competitiveness, and the emphasis placed on military at the expense of civilian research.

Another indicator of the future strength or weakness of U.S. scientific research is our success in attracting and retaining highly qualified students of science and engineering. Our record in this area is mixed: bachelor's degrees in engineering showed large increases between 1977 and 1987; degrees in the physical sciences declined.[9] Yet an emphasis on test performance provides little information about the nature of the problem or about the factors that influence students' choices. For example, an analysis of mathematics scores on the SAT shows that there is no shortage of highly qualified students. The scores of top students have actually risen in recent years. In 1977 the 90th percentile score was 628; in 1986 it had risen to 642.[10] And U.S students continue to excel in competitions that reward excellence in independent research, such as the Westinghouse Science Talent Search.

It is true that in recent years a smaller proportion of students chose to major in physics or mathematics. But that has nothing to do with any lack of proficiency in these fields. These students are simply aware of projections that show that the physical sciences (with the exception of materials science) are not expected to be high-growth fields in the 1990s.[11] And they are not unaware of the fact that other fields, such as engineering, business, and law, are more financially rewarding. They too want to pay off their student loans!

The fact is that students who do choose to enter science and engineering fields continue to rank well above the national average on academic measures. Students in the physical sciences, mathematics, engineering, and the biological sciences rank particularly high with regard to both SAT scores and class standing.[12]

The most difficult challenge may not be improving the quality of education for science and engineering majors, but providing a better education for other students in a world that requires ever-greater technological skills.

Will we have "enough" scientists and engineers? Some analysts predict shortages based on declines in student interest in certain fields and on the smaller numbers of students now passing through the education system. Others conclude that any shortages that do occur are part of the normal operation of the labor market and will be remedied over time. In engineering—one of the few professional fields in which the undergraduate degree is the basic educational requirement for good job opportunities—students have been highly responsive to the labor market. Bachelor's degrees in engineering awarded to U.S. citizens and permanent residents rose from approximately 46,000 in 1977 to 85,000 in 1987.[13] Economic studies over the past 30 years generally support the assumption that the labor market for scientists and engineers does make the necessary adjustments, although there may be temporary spot shortages because of the time needed to complete the educational process.[14]

There is evidence of shortages of precollege and college faculty members in certain technical fields and in certain regions of the country. At the precollege level, we know that teachers are often assigned to science and mathematics classes for which they have not been specifically trained. Moreover, the number of new graduates prepared to teach in these fields has declined. Although efforts to raise standards and to recruit more teachers appear to be making some difference, the basic fact remains: students who graduate with science degrees have job opportunities in fields that are considerably more lucrative than teaching.[15]

Faculty shortages in higher education are also caused, in part, by the lack of financial incentives for engineers and computer scientists to consider careers in academe. Many students choose not to enroll in a costly and time-consuming doctoral program that leads to a relatively low-paying university position when private industry offers greater financial rewards and does not generally require a doctorate. Science and engineering graduate programs have also faced some strong competition from such fields as investment banking, where the rewards can be greater still.[16] Indeed, shortages of doctoral degree candidates in engineering, physics, and mathematics exist for the same reason that shortages of Ph.D. faculty members exist in business schools: incomes are higher outside academe.

Women and minorities continue to be seriously underrepresented in science and engineering. While women have made large gains, they still account for only a small proportion of physicists and engineers. They are also less likely than men to hold senior positions in universities or in industry. Minority students have made gains in engineering over the past decade, but their numbers still remain small. In some fields, such as the physical sciences, their representation is extremely low. Minorities are also seriously underrepresented in faculty positions in all fields.[17]

Many of the factors that contribute to this underrepresentation have little to do with the quality of education. They include, for example, the effects of poverty and discrimination, the increasing costs of higher education, and the decline in the real value of student financial aid. These are important policy issues that need to be addressed. And while none of these problems will be easily solved, we do know that they cannot be alleviated by administering yet another round of standardized tests.

We also have evidence—although most of it is still anecdotal—that the teaching environment makes an important difference in student achievement and persistence in science and engineering. Interest has been growing in redesigning courses to give greater emphasis to major scientific concepts, scientific issues in the context of public policy, research methodology, and—in the case of mathematics—statistics and problem solving.[18] However, an emphasis on standardized, multiple-choice tests—which has increased even apart from the international assessments—is likely to have a deleterious effect on the quality of teaching and on the curriculum. These tests, which generally deal with isolated facts, are inconsistent with the kind of curriculum changes that would increase students' knowledge of key issues and perhaps their motivation to study science and engineering. I suggest that curriculum changes that will increase the emphasis on key scientific concepts are highly unlikely until teachers are freed from the pressure of rote examinations on material so limited that it can be measured by multiple-choice items across countries.[19]

I believe that the most difficult challenge may not be improving the quality of education for science and engineering majors, but providing a better education for other students—who represent the large majority—in a world that requires ever-greater technological skills. U.S. society will grow increasingly polarized if a significant proportion of our population lacks the skills needed to compete for jobs that provide a reasonable income. The number of traditional manufacturing jobs requiring less than a high school education has declined in large northeastern and midwestern cities. Although inner-city residents with higher levels of education have access to new job opportunities in high-technology or information industries, those with less education often remain unemployed or find jobs only in low-paying occupations.[20] And because poverty correlates so highly with educational problems, these problems are likely to be exacerbated over the years if current trends continue.

Expenditures on education also greatly favor the most affluent regions, schools, and students. The fact is that low-income and minority students, on average, have less opportunity to study science and mathematics than do other students. They have less access to the most qualified teachers, to adequate facilities and equipment for learning science and mathematics, and to the types of curricula and instructional strategies considered particularly effective with all students.[21]

* * *

It is quite true that difficult challenges confront the American education system. But the public perception that the United States is falling behind in science and mathematics, embodied in the fourth national goal for education, is based on a narrow criterion that has serious methodological deficiencies. The risk is not simply that we will underestimate our accomplishments. Of far greater importance is the likelihood that too narrow a definition of the problem may lead us to implement "solutions" that are at best trivial and may be counterproductive to addressing far more important matters.

Clearly, we have problems in science and mathematics education. But the bottom line is not so grim as the current rhetoric would have us believe, nor are the problems identified by that rhetoric the ones that are most troublesome to the welfare and productivity of the society as a whole. Let's focus our attention on the difficult public policy issues to be addressed rather than on comparisons and rankings.

Notes

1. Torsten Husén, "Are Standards in U.S. Schools Really Lagging Behind Those in Other Countries?" *Phi Delta Kappan*, March 1983, pp. 455–461.

2. *College-Bound Seniors: The Class of 1990* (New York: College Board, 28 August 1990); and Iris C. Rotberg, "A New Perspective on Math and Science Education," *Phi Delta Kappan*, June 1984, p. 671.

3. *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective* (Champaign: International Association for the Evaluation of Educational Achievement, University of Illinois, January 1987).

4. *A World of Differences: An International Assessment of Mathematics and Science* (Princeton, N.J.: Educational Testing Service, January 1989).

5. The World Bank, *World Development Report 1990* (New York: Oxford University Press, 1990), pp. 234–235.

6. Iris C. Rotberg, "Elitism in Tiananmen Square," *Education Week*, 15 November 1989, p. 23.

7. *Science and Engineering Indicators—1989* (Washington, D.C., National Science Board, December 1989), Ch. 5.

8. Jean-Jacques Servan-Schreiber and Herbert Simon, "America Must Remain the World's University," *Washington Post*, 15 November 1987, pp. C1–C2.

9. *Women and Minorities in Science and Engineering* (Washington, D.C., National Science Foundation, January 1990), p. 136.

10. Jerilee Grandy, "In Search of the Next Generation of Scientists," *College Board Review* Summer 1990, pp. 2–9, 28.

11. Robert Pool, "Who Will Do Science in the 1990s?" *Science*, 27 April 1990, pp. 433–435.

12. Jerilee Grandy, *Trends in SAT Scores and Other Characteristics of Examinees Planning to Major in Mathematics, Science, or Engineering* (Princeton, N.J.: Educational Testing Service, April 1989), pp. 16–27.

13. *Women and Minorities in Science and Engineering*, p. 136.

14. See, for example, Michael G. Finn, *Trends in Science and Engineering Education and the U.S. Labor Market* (Washington, D.C.: National Research Council, 1 June 1989), pp. 6–7, 24–25.

15. Linda Darling-Hammond, Lisa Hudson, and Sheila Nataraj Kirby, *Redesigning Teacher Education: Opening the Door for New Recruits in Science and Mathematics Teaching* (Santa Monica, Calif., RAND Corporation, March 1989), pp. 5–7.

16. Iris C. Rotberg, "Resources and Reality: The Participation of Minorities in Science and Engineering Education," *Phi Delta Kappan*, May 1990, p. 678.

17. Ibid. pp. 672-679; Sheila E. Widnall, "AAAS Presidential Lecture: Voices from the Pipeline," *Science*, 30 September 1989, pp. 1740–1745; and *Women and Minorities in Science and Engineering*, op. cit.

18. See, for example, Iris C. Rotberg, "A New Perspective," pp. 671–672; and idem, "Resources and Reality," pp. 673, 678–679.

19. See, for example, *From Gatekeeper to Gateway: Transforming Testing in America* (Chestnut Hill, Mass.: National Commission on Testing and Public Policy, Boston College, 1990).

20. United States House of Representatives, *Technology and Human Resources* (Washington, D.C., Committee on Science, Space, and Technology, Technology Policy Task Force Interim Report, December 1988), p. 1.

21. Jeannie Oakes with Tor Ormseth, Robert Bell, and Patricia Camp, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science* (Santa Monica, Calif., RAND Corporation, July 1990).