

ALGEBRA I



$$A = \frac{1}{2}x(h)$$

$$y^2 = x^2 + h^2$$



AMERICA'S MATH REPORT CARD: FLUNKING OUR FUTURE?

By CURTIS C. McKNIGHT

Twenty-five years ago a popular television public service advertisement asked, "Is your child passing his tests but flunking his future?" Who sponsored the advertisement — and why — long ago disappeared into the mists of television history, but the question remains as important today as it was then — or more so.

In recent years parents and other citizens have been cheered by reports that, after a long decline, student scores on standardized tests, such as the SAT (Scholastic Aptitude Test), have "bottomed out" and begun to climb. More recently, Oklahomans have been encouraged by test results that showed a substantial gain for Oklahoma's children on a variety of achievement tests. While these changes are reasons for celebration, they leave unanswered the haunting question, "Are our children passing their tests but still flunking their (and our) future?"

How can that be? The difficulty comes in deciding what score represents a "good grade" on such a test. It is heartening to find improvements over one's own past scores, but such a comparison still amounts to measuring one's self by one's self. This kind of comparison may show changes for the better or worse but cannot determine whether an improved score is yet "good enough."

For instance, Oklahoma's State Superintendent of Public Instruction John Folks reported recently that, although average scores of Oklahoma children on several achievement tests had improved over recent years, their standing compared to national norms (and thus to students in other states) had gone down. If the concern is whether these future Oklahoma workers will be able to compete economically with workers from other states, these results are disturbing. They suggest that the Oklahoma students who did well in comparison to Oklahoma students of past years still may be, in a sense, "flunking their future."

What these test results suggest about Oklahoma students is true for U.S. students generally, at least in the area of mathematics. American society and U.S. industry continually increase their use of and dependence on technology. Today's American workers must excel in the development and use of technology, and tomorrow's workers will need to do so even more. The country must be "high tech." It is a matter of economic survival in the international marketplace of developed countries.

To have a work force capable of excelling in a world becoming more dependent on increasingly more sophisticated technology demands that U.S. students today must do as well or better in learning mathematics and sci-

ence than students from the countries that are and will continue to be America's economic competitors. Competition aside, at least some students in all countries must excel in mathematics and science if the quality of life for all is to be maintained and improved.

Are U.S. students excelling in mathematics in comparison to students from other countries? The Second International Mathematics Study (SIMS), begun in 1977 and publishing its report to U.S. citizens in 1987, was designed to answer this question for mathematics. The answers are disturbing.

SIMS administered achievement tests to thousands of students in more than 20 countries to obtain a national average for each country. Students were tested in two grades—eighth grade and the last year of high school for students taking "college preparatory" mathematics throughout their high school years.

The eighth grade was chosen because it was the last grade in which almost all students in the participating countries still took mathematics. Twelfth grade advanced mathematics classes were chosen because they represented the best that each country's educational system could do in producing students who knew and could use mathematics. Information also was collected about students' attitudes

about mathematics and from teachers on their backgrounds and how they taught particular topics. To guarantee that students were tested on material they currently were studying, Japan tested *seventh* graders rather than eighth graders.

How well did U.S. students do compared to students in other countries? For the eighth grade, students were tested on content from five broad topics—arithmetic, algebra, geometry, statistics and measurement. For three of the topics, U.S. eighth graders scored just under the average of the 20 countries taking part. For the other two topics, U.S. scores were very low—among the lowest one-fourth of the countries (and for one topic scoring higher than only Nigeria and Swaziland).

For 12th grade advanced mathematics students, tests were given for six topics. The results were even more disappointing than for the eighth grade. U.S. scores never approached the international averages, and for five of the six topics, the scores were among the lowest one-fourth of countries participating. About one-fifth of the classes in the United States studied a full year of calculus, and these classes scored above the international average for every topic but never were among the top one-fourth of countries. One person summarized the 12th grade re-

sults by saying, “The best of our better students manage to achieve mediocrity. The rest don’t do that well.”

Not all students need master advanced mathematics, but America needs its better mathematics students to learn to use mathematics well enough to compete economically with other developed, technology-using countries. The exact proportion of U.S. students—the top 1, 5 or 10 percent, etc.—which need master mathematics is not clear. Certainly, however, it is more than a few and seems to be increasing over the years as technology penetrates more deeply into American life.

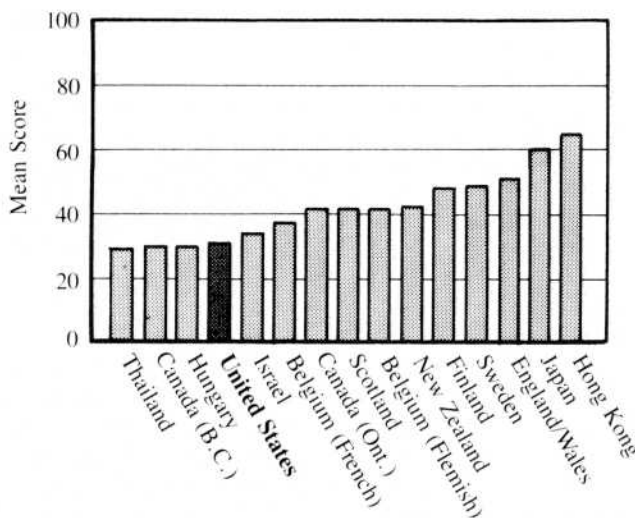
The graph below right pictures the top 1 percent and top 5 percent of U.S. students compared to those of other countries. The top of each bar represents the average score for the top 1 percent of advanced mathematics students from each country. The top of the lightly shaded part of each bar represents the average for the top 5 percent. The top of the heavily shaded part of each bar represents the average for all students tested in each country.

The top 1 percent of U.S. students performed as well as the top 1 percent of only two other countries. The top 5 percent of two countries, Japan and Finland, did better than the top 1 percent of U.S. students. Indeed, the top 5 percent of Japanese students scored

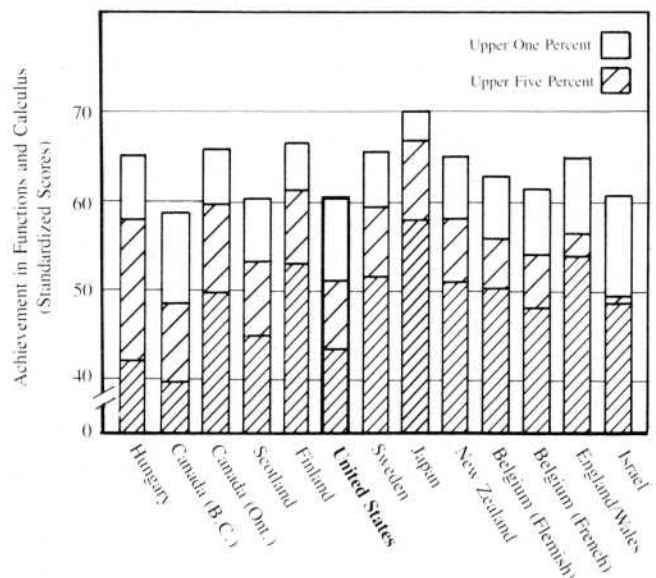
better than the top 1 percent of students in all other countries. The top 5 percent of U.S. students scored lower than the average for *all* students in Japan, Finland, England and New Zealand. Clearly, not enough U.S. students are mastering mathematics well enough for economic competitiveness.

The attitudes of U.S. students documented by SIMS give an additional cause for concern. Most students believed that mathematics was important in U.S. society, but far fewer were prepared to take more mathematics or to work at a job that used mathematics. Asked to agree or disagree with the statement, “It is important to know mathematics to get a good job,” about three-fourths of both the eighth and 12th grade students agreed. However, when questioned about the statement, “I would like to work at a job that lets me use mathematics,” only about one-third of the eighth graders and just over half of the 12th graders agreed.

It is hard to know which is more disturbing. The 12th graders were those still taking advanced mathematics in their senior year—about 15 percent of U.S. high school seniors—yet a bare majority of them seemed willing to enter a career that made use of mathematics. The eighth graders were the pool from which future advanced mathematics students would be

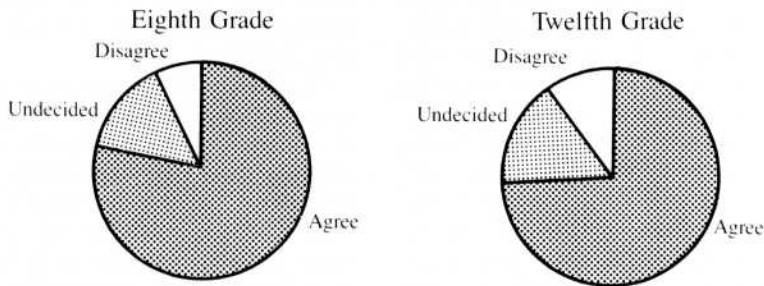


Geometry scores for 12th grade advanced math students in 15 countries rank U.S. students among the bottom quarter.

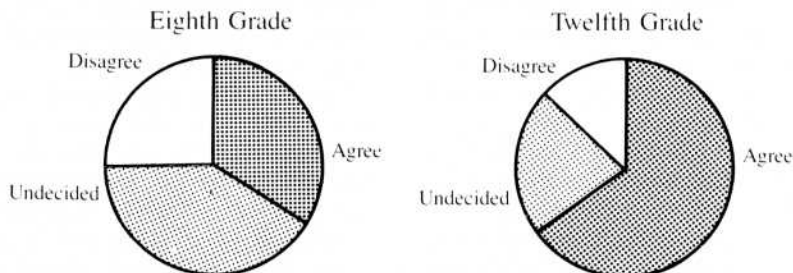


Performances of the most able advanced math students in each country reveal how disturbing the U.S. results are.

**It is important to know Mathematics
in order to get a good job.**



**I would like to work at a job that
lets me use Mathematics.**



Although many U.S. students realize mathematics is important, far fewer indicated a willingness to enter a career that used mathematics extensively.

drawn, and their attitudes suggested that many would avoid taking further work in mathematics as soon as possible. Clearly these results suggest another way in which the United States may be failing its future—failing to develop the people resources needed for the future.

Why did the United States compare so badly to other countries? Nothing is more natural than the desire to find some cause—one villain to blame for all difficulties. This, unfortunately, would do more harm than good here. The causes for U.S. school mathematics problems are many, and any solutions will have to deal with those many causes. First, however, it is very important to be clear about some things that are *not* to blame.

It is certainly not true, for instance, that U.S. students are dumb. U.S. students are as intelligent as those from any other country and often can be seen to be more creative, curious and independent than their counterparts internationally. Any solution proposed should not underestimate the abilities of U.S. students and should be prepared to capitalize on their particular strengths.

Further, it is certainly not true that U.S. teachers are lazy. American teachers are among the hardest working in the world, often putting in a 55-to-60-hour week, often supervising 150 or more students per day, and almost always paid far less than is appropriate for the difficult and important job they do. SIMS found the majority of U.S. mathematics teachers to be well-trained and experienced, comparing favorably with the teachers of all other participating countries.

Other explanations have been offered in recent years for U.S. educational woes, but SIMS data showed that many of these “explanations” were deceptive and explained little. For instance, there was no systematic relationship between achievement and the number of hours devoted to mathematics during the school year or the length of the school year. Some high-achieving countries (e.g., Japan) invested far fewer hours per year in mathematics than did the United States. Further, there was no clear relationship between achievement and class size. Countries with large average class sizes were among both the highest and the lowest achieving

countries. Japan's average class size was about twice that of the United States.

Nor is the answer to be found in the fact that the U.S. educational system is comprehensive—that it tries to educate a larger percentage of its students than do the systems of other countries. The United States had about 15 percent of its seniors taking advanced mathematics classes compared to 13 percent for Japan, 50 percent for Sweden, 100 percent for Hungary, and more than one-third for several other countries. Clearly, other explanations must be sought, preferably ones which suggest practical remedies for U.S. problems.

Part of the explanation may be cultural differences. U.S. classrooms have an average of 26 students while Japanese classrooms may have 41, but those 41 are *Japanese* students. Japanese students have different traditions and expectations for the importance of school work, the necessity to excel, the respect which is due teachers, the politeness and involvement expected when attending class, etc. The strengths of U.S. students—ingenuity and independence—do not always make them the easiest to manage in a classroom, nor do they often have a deep respect for their teachers and for learning.

These attitudes of U.S. students are not surprising given the common attitudes of society and their parents toward teachers and given the low level at which many U.S. parents are able to be involved in their children's educations. Japanese mothers have a cultural tradition and a role which leads most to monitor the content of their children's homework each day (not just whether the homework was done but also how well). Many even attend class and take notes for an ill child. Few American mothers (or fathers) can have that kind of involvement in a society which increasingly makes necessary two wage earners in a family. Solutions for the educational problems of the United States must make use of the strengths of its parents and students and not foster unrealistic expectations of making major changes in traditions deeply embedded in its culture.

Yet there is hope. Some of the under-

lying difficulties in U.S. school mathematics involve things which can be changed. Unfortunately, educational problems are usually complex and require complex solutions. More unfortunately, complex solutions in a public enterprise such as education typically are pragmatically difficult, economically draining and politically dangerous. Certainly they require large resources of time and continued public concern and support.

One factor contributing to U.S. problems clearly seems to be working conditions for teachers and their status as professionals. SIMS data suggested that a typical workweek for teachers consisted of 55 to 60 hours, counting time in class and time outside of class for preparation and grading. Not included were school responsibilities not directly related to classroom teaching, time out of class spent working with individual students and time devoted to in-service and continuing education (which is often mandatory, as it is in Oklahoma).

SIMS data further suggested that the typical U.S. mathematics teacher was very isolated, having few opportunities to work with teacher colleagues to solve teaching problems. Departmental meetings, when held, dealt most often with school procedures and organizational matters rather than with how better to teach mathematics. One mark of a working situation for someone with professional status is opportunity to consult with professional colleagues.

When problems arise, doctors consult other doctors, lawyers consult other lawyers, engineers consult engineers and so on. When problems arise for teachers, they most often can consult with other teachers only by investing time over and above the already long workweek. These conditions are not typical for Japanese teachers, who usually have fewer hours in their workweek (teaching only three or four classes) and have ample time during the day to work with other teachers on pedagogical problems.

In short, American mathematics classrooms (and, indeed, most U.S. classrooms of any type) are work places in which it is difficult for teachers to function as professionals,

in which resources of time and energy are scarce and in which it is difficult to deliver one's best teaching week after week. In such a work place, the textbook becomes a survival mechanism to cope with an almost impossible situation. It is hardly surprising that many teachers are attracted to textbooks that do most of the planning for them, organizing each few pages into a lesson for one day's class.

In addition to the above limitations for teaching as a profession are salaries typically far below those of other professionals trained for similar lengths of time. Also a limitation is the low status given to teachers by many in the United States, in part, perversely, because teachers are willing to do such difficult jobs for such relatively low pay.

Another major factor contributing to U.S. difficulties is the organization of the mathematics curriculum as seen in most textbooks and lists of objectives. The most recent SIMS report was titled *The Underachieving Curriculum: Assessing School Mathematics from an International Perspective*. Its first major section began, "In school mathematics, the United States is an underachieving nation, and our curriculum is helping to create a nation of underachievers." This title and opening statement were intended to identify clearly the mathematics curriculum as one of the major "culprits" contributing to low mathematics achievement in the United States.

In particular, the U.S. mathematics curriculum devotes small amounts of time to many topics rather than more concentrated, larger amounts of time to selected topics essential to further learning. U.S. school mathematics appears also to have lost sight of its goals, most often substituting extensive lists of objectives or "learning outcomes," which specify in great detail each individual skill and subskill that must be mastered but which are not organized to accomplish a few clear goals.

Further, each content area, at least through eighth grade, is visited again each year for further learning. As a result, there are typically few learning "milestones" in the U.S. mathematics curriculum, that is, few clear expectations that certain skills and ideas will be mastered by most students at spe-

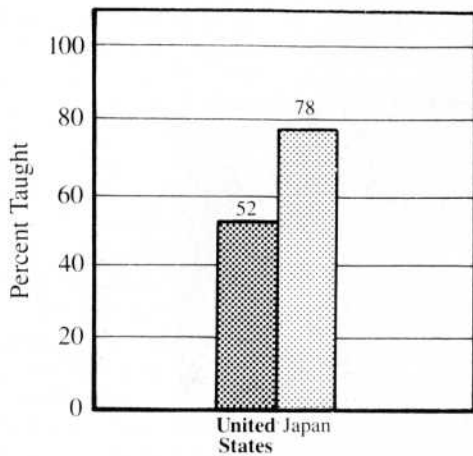
cific points in the curriculum and hence need not be taught again. Instead these skills will be applied in mastering other, more complex skills and ideas.

One result of this lingering, yearly reappearance of objectives and content is that the U.S. mathematics curriculum, more than the curriculum of any other country studied, devotes time to review and to reteaching previously covered material as if it were new. This idea that content always can be mastered at some later point contributes to the large amount of remedial mathematics that must be provided at most colleges. College is seen as just one more chance to master previously unmastered content.

This is not the only possible organization for the mathematics curriculum. In some countries the curriculum is organized to deliver significant blocks of time for mastering a smaller number of selected content topics. Teachers, students, parents and the society at large share expectations that almost all students will master the content by the appointed time. After this group investment of time, it becomes each individual's responsibility to master the content, a responsibility underwritten by his parents and motivated by future competitive examinations that determine admission to college.

The result is often tremendous growth in a short time. For instance, the Japanese defer almost all beginning algebra content until the seventh-grade year and spend much of that year presenting it for the first time. Similarly, although they devote considerable time to decimal fractions before the eighth grade, the French defer common fractions ($1/4$, $3/5$, etc.) until eighth grade and spend considerable time on them during that year.

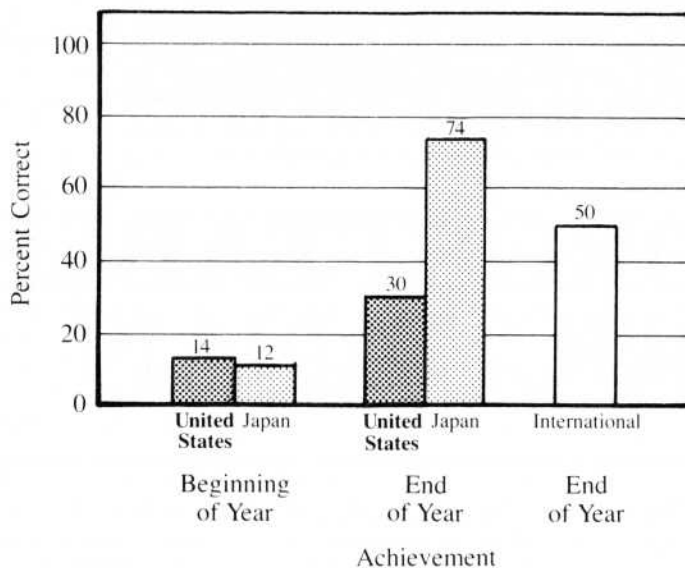
SIMS data, from testing students at both the beginning and end of the school year, showed that in both cases above there was tremendous growth during the year targeted for mastering the content. The Japanese and French students, who began the year with far less knowledge than U.S. students about the targeted content, ended the year by knowing far more than U.S. students who had studied it a little for each of several years. Alternative or-



Simplify:
 $5x + 3y + 2x - 4y$

A $7x + 7y$
 B $8x - 2y$
 C $6xy$
 * D $7x - y$
 E $7x + y$

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Fewer Japanese students than U.S. students start the year able to work this simple algebra problem, but far more Japanese students can solve it by year's end.

organizations for the mathematics curriculum should be explored seriously.

What can be done to renew school mathematics in the United States and to end this country's status as an "underachieving nation"? Much is happening at the national level. The National Academy of Sciences has appointed a Mathematical Sciences Education Board whose responsibility is to develop guidelines for what the mathematics curriculum should be and how it might be better organized.

Local control of schools is one of the American system of public education's strengths, and it certainly is not desirable to have a single national curriculum in mathematics. Surely, however, good information and guidelines on how better and more effectively to organize the mathematics curriculum

can be widely agreed upon and will be of much use to textbook developers, state educational agencies and local school boards.


Other agencies are looking into ways to make schools into better work places for teachers and to help teachers receive both the status and rewards of professionals and the opportunities to better act as the well-trained professionals they are. Many states have made changes to improve teacher salaries and have explored some possible tools, such as merit pay and career ladders, for encouraging professional growth for teachers.

Within Oklahoma and many of its school districts, exciting things are happening as well. Recently some Oklahoma students have been recognized through mathematics competi-

tions as being among the best in the country, one being selected as a member of the small U.S. team for the next International Mathematics Olympiad, the most prestigious student mathematics competition in the world. Plans also are now under way for a new special high school for Oklahoma students gifted in mathematics and science.

High school graduation and college entrance requirements are being raised to include more advanced mathematics. The University of Oklahoma, working with Oklahoma State University, is piloting a program for testing high school juniors to see how much college preparatory mathematics they have mastered and what they should accomplish in their senior year to be ready for the program in which they wish to major at an Oklahoma college or university.

The times are both disturbing and exciting for school mathematics in the United States. Problems are being recognized and changes considered. Yet real solutions will be difficult, time-consuming, expensive and will demand continued support from an informed Oklahoma public.

The state and its schools must be held accountable by the parents of Oklahoma students and by other citizens. However, they also must receive the encouragement and long-term support of those parents and citizens. Test scores are improving, and there is hope for even greater improvements to come. For now, however, all citizens must face honestly "America's mathematics report card" and continue to ask, "Are our children passing their tests but flunking their future?" until the day comes when it can be said, "Not only are they passing their tests, but the future looks bright." 

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