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Missed Opportunities: How Mathematics Education in the U.S. Puts Our Students At a Disadvantage and What Can Be Done About It

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Data collected as part of the Third International Mathematics and Science Survey have produced some important new findings on the mathematics preparation of U. S. 8th grade students. These findings illustrate several fundamental obstacles to student success in middle school mathematics, and they may point to similar problems in other subject areas and at other grade levels. At the same time, the TIMSS findings also suggest action that educators and policymakers can take to improve opportunities to learn for U.S. students.

Background

The Third International Mathematics and Science Survey (TIMSS) has produced a gold mine of information about the relative health of American math and science education. TIMSS tested large and representative samples of students from around the world to measure their math and science knowledge and skills. The results place 8th grade students in the U.S. below the international average in mathematics, with 20 countries scoring significantly higher than the U.S. and only seven countries scoring significantly lower (see international comparisons chart on page 2).

These results show that the U.S. is far from achieving the goal, established by the National Education Goals Panel, of U.S. students ranking first in the world in math and science. TIMSS data also show that, by the final year of high school, only two countries (Cyprus and South Africa) perform worse than the U.S. in general math knowledge. When it comes to the performance of advanced math students, the U.S. ranks at the bottom.

TIMSS has more to tell educators and policymakers than how U.S. students rank compared to their peers in other countries. TIMSS also collected detailed information about the kinds of math courses available to students, and about

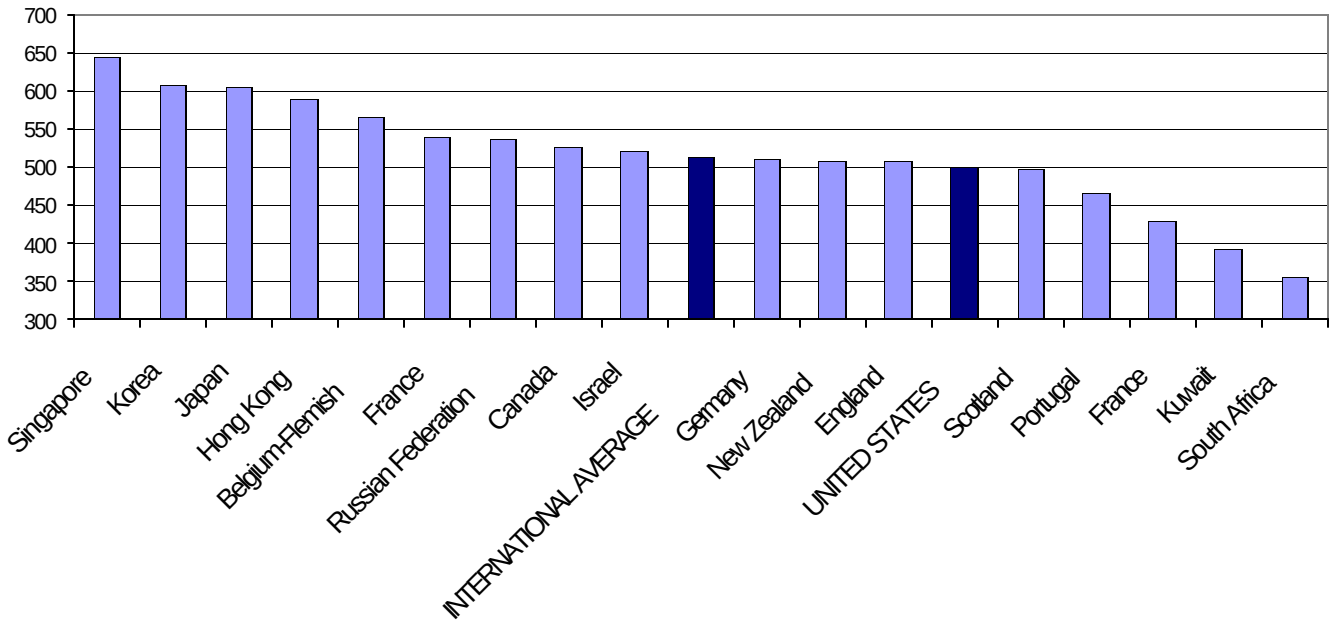
the textbooks and curricula they use. Analyses of this background information are now being published, and the results offer important insights to policymakers trying to improve our schools. The bad news is a deeper understanding of why U.S. students fare poorly in international comparisons, and why large-scale change in education will be hard to achieve. The good news is that student achievement – the primary goal of education policy – is related to opportunity to learn, regardless of family background.

This brief summarizes some of the findings of [recent research conducted by researchers at Michigan State and Northwestern Universities/ Leland Cogan, William Schmidt and David Wiley].

The data collected by TIMSS allowed researchers to ask, "What math opportunities do U.S. schools offer, and what math did students take?" The answers are surprising. For example, the notion of a uniform "8th grade math" course is more myth than fact; not all students take the same math course. More significantly, not all schools offer the same selection of math courses. Moreover, courses with the same course title – such as standard math or advanced math – differ widely in content, emphasis and rigor.

One finding from the analysis should not surprise anybody: students who took more demanding courses fared better on the TIMSS exam than their peers who did not.

Nations' Average Math Performance Compared to the U.S.



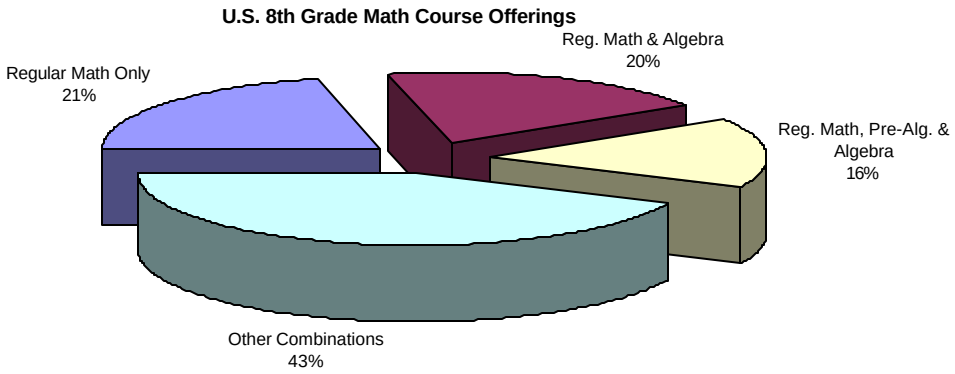
A Closer Look

There's no such thing as "8th grade math":

TIMSS data confirm what many parents already know: there is no single math course that all 8th grade students take. Although they are not yet high school students, most students in the U.S. are already "tracked" into courses with different content and difficulty levels by the 8th grade. Across the United States, about 57 percent of 8th graders take regular math, about 20 percent take Algebra I, and about 17 percent take a pre-Algebra course. Fewer than 3 percent take a course labeled "remedial" math. Tracking has been an established part of schooling in the U.S. for decades, but one of its consequences is a lack of agreement on what mathematics students in 8th grade should study. This lack of uniformity makes the U.S. unique among countries participating in TIMSS.

Schools vary in the number and types of math courses they offer to their students:

The data also show what kinds of math courses schools offer to 8th grade students in the U.S. Based on course titles, TIMSS researchers identified six basic course offerings – remedial, regular and enriched math, pre-algebra, algebra and geometry. With six types of courses, and schools that offer one, two, three or more options, calculating the number of possible variations is itself an intermediate math problem. Researchers found 29 different combinations of math offerings in U.S. schools. The most common variation – a single course offering of regular math – was found in only 21.4 percent of schools. Barely one-half of the nation's 8th grade students attend a school offering regular math, regular math and algebra, or regular math, pre-algebra and algebra (see pie chart).



More than 80 percent of U.S. 8th grade students attend schools that offer regular math, but only 66.5 percent attend schools that offer algebra, and only 37% attend schools that offer enriched math. This means that one in five students cannot take regular 8th grade math and one in three students does not have the opportunity to take algebra. Almost two of every three students cannot enroll in an enriched math course because there is no enriched math course at their school.

TIMSS researchers also looked for patterns in course offerings to see whether there are patterns in the distribution of course offerings for different students. They found a significant association between the variety of course offerings and student family background, as measured by school size, location and minority enrollment. For example, 81 percent of suburban students attended schools that offered math courses in algebra or beyond, but only 58 percent of rural students and 61 percent of urban students had those opportunities. Suburban and mid-sized city schools with a larger minority enrollment were less likely to offer the more challenging types of mathematics.

Courses with the same course title – such as algebra – differ widely in content emphasis and rigor:

TIMSS data confirm that, by the time they reach 8th grade, students in the U.S. take different math courses. It also shows that the courses available to students differ by school, and that those differences are often connected to school size, location and minority enrollment. Most remarkably, analysis of the TIMSS data reveals that courses with the same titles differ significantly in the kind of texts they use and the topics they cover. Common course titles mask large disparities in course content. TIMSS collected data on the kind of textbook schools use in math courses, as well as the number of math topics covered and the amount of time devoted to teaching each one. They found that only 70 percent of 8th grade students in the U.S. use textbooks that match the courses they are taking, and that more than 12 percent of students were using a less advanced book than the course title indicated. For example, some students use regular math textbboks in their algebra courses.

More demanding courses produce better prepared students:

This text-course mismatch is important, because the type of textbook used in a class has an impact on student learning opportunities that go beyond the obvious consequences of tracking students into different courses. Although TIMSS was designed to answer questions about student knowledge and skills across countries, analyses of the data illuminate connections between the rigor of U.S. courses and student results on the TIMSS. For instance, researchers found that the rigor of the courses, as measured by their course titles, textbooks used and topics covered, accounted for nearly 40 percent of the variance

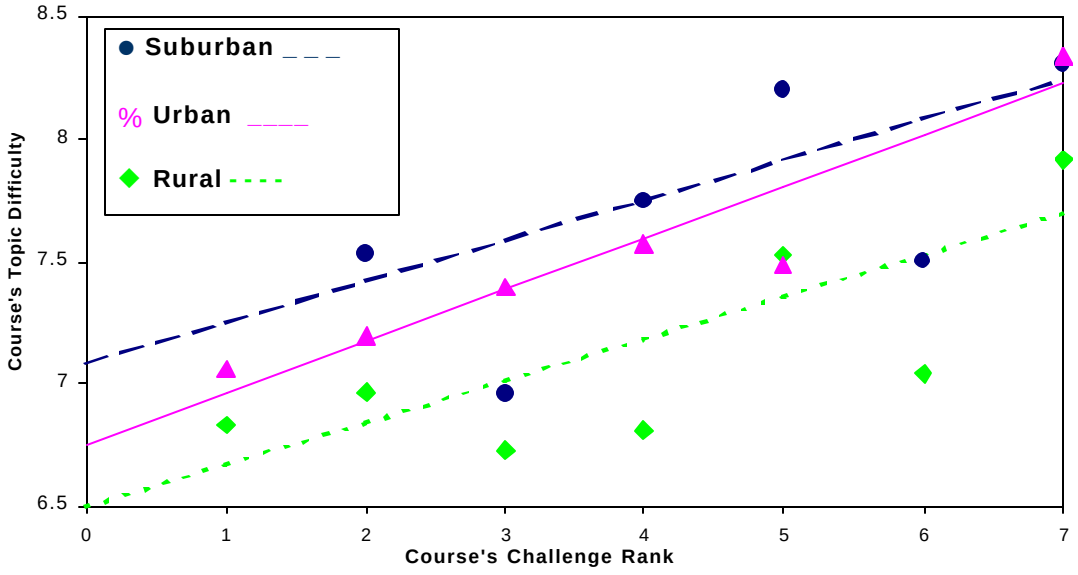
in U.S. student scores across classrooms. In other words, students in classes exposed to more challenging topics and using more challenging texts scored significantly higher on the TIMSS than their peers in less challenging classes. As seen in the figure below, they also found real differences between urban, suburban and rural schools in the rigor of the topics presented to students (see Figure 1).

Such disparity in the kinds of opportunities offered to students across the U.S. begins to explain our lackluster performance on international comparisons of math achievement.

Implications for Policymakers

The data collected by TIMSS and analyzed by Schmidt et al identify several of the challenges facing educators and policymakers today. It is difficult to fix 8th grade math, for example, because there is no "8th grade math" in the sense of a unified, cohesive course of study offered to students across the country. Not all students take the same math course; not all schools offer the same math courses. Most disturbing is the finding that courses with the same course titles often offer different learning opportunities to students – the algebra that one student takes can be very different from that taken by another student, either because of the text used, the topics covered, or both.

The primary concern of policymakers should be to decrease the disparity of learning opportunities offered to students. Some of this disparity is obvious, such as when opportunities vary by school location, size and percent of minority enrollment. Further disparity is masked by common course titles that belie significant differences in text used and topics covered. Whatever the cause of the lack of opportunity, students can't learn what isn't covered when the course isn't available, the textbook isn't suited to the course, or the topic isn't covered in class.



Math education in this country could benefit greatly from the current trend of establishing educational standards, although in this case the standards needed first are not those for student achievement, but rather standards for course, textbook and topic rigor. Expecting all students to pass algebra before graduation, for example, will mean little if algebra means one thing in Maine but something else in Arizona.

Policymakers should also consider the implications of these findings for other grades and subjects. It is unlikely that differences in opportunities to learn suddenly appear in the 8h grade; these differences almost certainly begin in earlier grades. Moreover, it is unlikely that differences in opportunity to learn are unique to the subject of math; science, reading, writing and other subjects equally important to the success of U.S. students are likely to suffer similar problems.

If there is a silver lining to this story about the challenges of improving mathematics education in the U.S., it is that opportunity to learn is a solvable, if formidable, problem. Solving it will require far more uniform standards, curricula and materials than Americans are accustomed to, but it is clear that the current diversity in opportunities to learn costs some students – and our nation as a whole – dearly.

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