



CREATE NEWS

Consortium for Research on Educational Accountability and Teacher Evaluation

This issue of CREATE NEWS contains an overview of the results of the Third International Mathematics and Science Study (TIMSS) for middle-school students. A description of the TIMSS project and general international results are presented here in an article authored by researchers at the TIMSS International Study Center at Boston College. More specific information about the performance of U.S. middle-school students, teachers, and curricula follows the international overview.

Mathematics and Science Achievement in the Middle School Years: An International Perspective

ALBERT E. BEATON, MICHAEL O. MARTIN, INA V.S. MULLIS, EUGENIO I. GONZALEZ,
THERESA A. SMITH, DANA L. KELLY
Boston College

Since its inception in 1959, the International Association for the Evaluation of Educational Achievement (IEA) has conducted a series of international comparative studies designed to provide policymakers, educators, researchers, and practitioners with information about educational achievement and learning contexts. The Third International Mathematics and Science Studies (TIMSS) was the largest and most ambitious of these studies ever undertaken.

Forty-five countries collected data in more than thirty different languages. Five grade levels were tested in the two subject areas, totaling approximately 15,000 schools, and more than half a million students tested around the world. This review focuses on middle-school mathematics and science. Six content dimensions were covered in the TIMSS mathematics tests given to middle-school students—fractions and number sense; measurement; proportionality; data representation, analysis, and probability; geometry; and algebra. Five content dimensions were covered in the TIMSS middle-school science tests—earth science, life science, physics, chemistry, and environmental issues and the nature of science. One-third of all testing time was devoted to free-response questions that required students to generate and write their answers.

Because the home, school, and national contexts within which education takes place can play important roles in how students learn mathematics and science, TIMSS collected extensive information about such background factors. The students who participated

completed questionnaires about their home and school experiences related to learning mathematics and science. Also, teachers and school administrators completed questionnaires about instructional practices. The following sections summarize the major findings for middle-school students in mathematics and science.

Students' Mathematics and Science Achievement

- Singapore was the top-performing middle-school country in both mathematics and science. Korea, Japan, and Hong Kong also performed very well in mathematics, while the Czech Republic, Japan, and Korea performed well in science. Lower-performing countries in both mathematics and science were Colombia, Kuwait, and South Africa. Of the twenty-five countries that followed all TIMSS requirements, the United States scored below the international average of these countries in mathematics and below the average of these countries in science.
- Perhaps the most striking finding was the large difference in average achievement between top-performing and bottom-performing countries in both subject areas. Despite this large difference, when countries were ordered by average achievement, there were only small or negligible differences in achievement between top- and bottom-performing countries. Nonetheless, from beginning to the end of the rankings, there were substantial differences. For example, average achievement in top-performing Singapore was comparable to or exceeded performance for 95 per cent of students in the lowest-performing countries.
- For most countries, gender differences in mathematics were small or essentially nonexistent. However, what differences there were favored boys rather than girls. In most countries and internationally, boys had significantly higher mean science achievement than girls. This is attributable mainly to significantly higher performance by boys in the earth science, physics, and chemistry areas.
- Even though students in the top-performing countries had very high achievement on many of the mathematics test questions, students in most countries had difficulty with multistep problem solving and applications. For example, students were asked to draw a rectangle whose length was one and one half times the length of a given rectangle and whose width was half the width of that rectangle. In only two countries did at least half the students correctly draw the new rectangle. Students also generally found proportionality items difficult.

Student Attitudes Toward Mathematics and Science

- Within nearly every country, a clear positive relationship was observed between a stronger liking of mathematics and science and higher achievement. Even though the majority of students in nearly every country indicated they like mathematics and science to some degree, clearly not all students felt positive to these subject areas.

In no country did girls report a stronger liking of mathematics than did boys. However, boys reported liking mathematics better than girls in several countries, although not necessarily the highest-scoring countries. A similar pattern was evidenced in science.

- In all except four countries in mathematics and three countries in science, the majority of students agreed or strongly agreed that they did well in mathematics and science, a perception that did not always coincide with the comparisons in achievements across countries on the TIMSS tests. Interestingly, the exceptions to the above included two of the highest-performing countries—Japan and Korea—where in both mathematics and science fewer than 50 per cent of the students indicated that they agreed or strongly agreed that they were doing well.
- Internationally, the most frequently cited reasons for needing to do well in mathematics and science was to please parents or to get into students' desired secondary school or university.

Home Environment

- Home factors were strongly related to mathematics and science achievement in every country that participated in TIMSS. In every country, students who reported having more educational resources in the home had higher mathematics and science achievement than those who reported little access to such resources. Strong positive relationships were found between mathematics and science achievement and having study aids in the home, including a dictionary, a computer, and a study desk or table for the student's own use. Also, the more books students reported in the home, the higher their mathematics and science achievement.
- In every country, the pattern was for students whose parents had more education to also have higher achievement in mathematics and science.
- Beyond the one to two hours of daily television viewing reported by a majority of students in all countries, the amount of television students watched was negatively associated with mathematics and science achievement.

Instructional Contexts and Practices

- In comparison to the positive relationships observed between mathematics and science achievement and home factors, the relationships were less clear between achievement and various instructional variables, both within and between countries. Obviously, educational policies and practices such as tracking and streaming serve to systematically confound these relationships. Also, the interaction among instructional variables can be extremely complex.
- The qualifications required for teaching certification were relatively uniform across countries. Most countries reported that four years of postsecondary education were required. Almost all countries reported that teaching practice was a requirement, as was an examination or evaluation.

- Teachers in most countries reported that mathematics and science classes typically met for at least two hours a week but less than three and one-half hours. The data, however, revealed no clear pattern between the number of in-class instructional hours and mathematics or science achievement.
- Across countries, mathematics and science teachers reported that working together as a class with the teacher teaching the whole class or having students work individually with assistance from the teacher were the most frequently used instructional approaches.
- Students reported substantial variation in the frequency of testing in mathematics and science classes. In a number of countries, the majority of the students reported having quizzes or tests only once in a while or never. In contrast, one-third or more of the students in a number of countries including the United States, reported almost always having quizzes or tests.

The following reports provide additional information about the TIMSS international results.

Beaton, A.L., et al. (1997). *Mathematics achievement in the middle school years: IEA's third international mathematics and science study.*

Beaton, A.L., et al. (1997). *Science achievement in the middle school years: IEA's third international mathematics and science study.*

Beaton, A.L., et al. (forthcoming). *Mathematics achievement in the primary school years: IEA's third international mathematics and science study.*

Beaton, A.L., et al. (forthcoming). *Science achievement in the primary school years: IEA's third international mathematics and science study.*

These and other reports can be obtained at TIMSS International Study Center, CSTEPP, Campion Hall 323, Boston College, Chestnut Hill, MA 02167, USA, phone 617-552-4521, fax 617-552-8419, and web site <http://www.csteep.bc.edu/timss>.

For more specific information about the performance of U.S. students, see the following:

Peak, L., (1996), *Pursuing excellence*, U.S. Department of Education, National Center for Educational Statistics. NCES 97-198. U.S. Government Printing Office, Washington, DC U.S. National Research Center. Report 7, December 1996. 436 Erickson Hall, College of Education, Michigan State University, East Lansing, MI 48824-1034

Highlights of Mathematics and Science Performance by United States Middle School Students

- In mathematics, U.S. students scored below the international average of the TIMSS countries. In science, U.S. students scored above the international average of the TIMSS countries. U.S. students perform on a par with other industrialized nations like

Germany and England. At present, TIMSS data indicate that U.S. students are well below the level needed to meet the Goal 2000 calling for U.S. students to be “first in the world in mathematics and science achievement by the year 2000.”

- Unlike the high majority of countries participating in TIMSS, the United States does not have a national curriculum in either mathematics or science. The mathematics content taught in the U.S. is less challenging in comparison to other countries, and topic coverage is less focused than that in Germany and Japan. There is more similarity between U.S. science curricula and those of other countries.
- U.S. teachers emphasize breadth more than depth of knowledge in their teaching, unlike teachers in other countries such as Japan, where teachers emphasize depth of knowledge, not breadth. Compared to Japan and Germany, U.S. teachers require less higher-level thought from students and focus more on procedural knowledge than conceptual knowledge. Although mathematics teachers in the United States are aware of reform recommendations for teaching mathematics, they implement these recommendations to a lesser degree than Japanese teachers.
- A survey of eighth-grade mathematics classrooms collected video tapes of 100 lessons in Germany, fifty in Japan, and eighty-one in the United States. Analyses of these tapes revealed a number of differences among the three countries. For example, German and U.S. teachers’ lesson goals in mathematics were to teach students to solve problems, while Japanese teachers’ goals focused on understanding mathematics. The structure of lessons also differed. German and U.S. teachers follow a lesson format of instruction followed by application, while Japanese teachers followed a format of problem solving, reflection on the problem, discussion of solutions generated, and joint work to develop understanding of the mathematics. More than 90 per cent of the time German and U.S. students were working on mathematics they were practicing routine procedures, compared to 40 per cent for Japanese students.
- In considering this brief outline of the U.S. TIMSS results, it is important to bear in mind that the generalizations made are just that, generalizations, and do not apply equally to all schools or teachers in the United States. They do provide a glimpse into how U.S. students compare in achievement to their international peers, but they do not necessarily provide reasons for differences in performance among nations.

The following sources provide additional information about the U.S. TIMSS results:

National Center for Education Statistics, Office of Educational Research and Improvement, U.S. Department of Education, 555 New Jersey Avenue NW, Washington, DC 20208-5574, phone 202-219-1395, web site <http://www.ed.gov/NCES/timss>.

United States National Research Center, Third International Mathematics and Science Study (TIMSS), 463 Erickson Hall, College of Education, Michigan State University, East Lansing, MI 48824-1034, phone 517-353-7755 or fax 517-432-1727.

Compiled by Peter W. Airasian, School of Education, Boston College, and Sandra Horn, Knox County (TN) Schools and University of Tennessee Value-Added Research and Assessment Center.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.