

Executive Summary

MATHEMATICS

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 policy makers, educators, researchers, and practitioners with information about educational achievement and learning contexts. The Third International Mathematics and Science Study (TIMSS) is the largest and most ambitious of these studies ever undertaken.

The scope and complexity of TIMSS is enormous. Forty-five countries collected data in more than 30 different languages. Five grade levels were tested in the two subject areas, totaling more than half a million students tested around the world. The success of TIMSS depended on a collaborative effort between the research centers in each country responsible for implementing the steps of the project and the network of centers responsible for managing the across-country tasks such as training country representatives in standardized procedures, selecting comparable samples of schools and students, and conducting the various steps required for data processing and analysis. Including the administrators in the approximately 15,000 schools involved, many thousands of individuals around the world were involved in the data collection effort. Most countries collected their data in May and June of 1995, although those countries on a southern hemisphere schedule tested in late 1994, which was the end of their school year.

Six content dimensions were covered in the TIMSS mathematics tests given to the middle-school students: fractions and number sense; measurement; proportionality; data representation, analysis, and probability; geometry; and algebra. About one-fourth of the questions were in the free-responses format requiring students to generate and write their answers. These types of questions, some of which required extended responses, were allotted approximately one-third of the testing time. Chapter 3 of this report contains 33 example items illustrating the range of mathematics concepts and processes addressed by the TIMSS test.

Because the home, school, and national contexts within which education takes place can play important roles in how students learn mathematics, TIMSS collected extensive information about such background factors. The students who participated in TIMSS completed questionnaires about their home and school experiences related to learning mathematics. Also, teachers and school administrators completed questionnaires about instructional practices. System-level information was provided by each participating country.

TIMSS was conducted with attention to quality at every step of the way. Rigorous procedures were designed specifically to translate the tests, and numerous regional training sessions were held in data collection and scoring procedures. Quality control monitors observed testing sessions, and sent reports back to the TIMSS International Study Center at Boston College. The samples of students selected for testing were scrutinized according to rigorous standards designed to prevent

bias and ensure comparability. In this publication, the countries are grouped for reporting of achievement according to their compliance with the sampling guidelines and the level of their participation rates. Prior to analysis, the data from each country were subjected to exhaustive checks for adherence to the international formats as well as for within-country consistency and comparability across countries.

The results provided in this report describe students' mathematics achievement at both the seventh and eighth grades. For most, but not all TIMSS countries, the two grades tested at the middle-school level represented the seventh and eighth years of formal schooling. Special emphasis is placed on the eighth-grade results, including selected information about students' background experiences and teachers' classroom practices in mathematics. Results are reported for the 41 countries that completed all of the steps on the schedule necessary to appear in this report. The results for students in the third and fourth grades, and for those in their final year of secondary school will appear in subsequent reports.

The following sections summarize the major findings described in this report.

STUDENTS' MATHEMATICS ACHIEVEMENT

- ▶ Singapore was the top-performing country at both the eighth and seventh grades. Korea, Japan, and Hong Kong also performed very well at both grades as did Flemish-speaking Belgium and the Czech Republic. Lower-performing countries included Colombia, Kuwait, and South Africa (see Tables 1.1 and 1.2; Figures 1.1 and 1.2).
- ▶ Perhaps the most striking finding was the large difference in average achievement between the top-performing and bottom-performing countries. Despite this large difference, when countries were ordered by average achievement there were only small or negligible differences in achievement between one country and the one with the next-lowest average achievement. In some sense, at both grades, the results provide a chain of overlapping performances, where most countries had average achievement similar to a cluster of other countries, but from the beginning to the end of the chain there were substantial differences. For example, at both grades, average achievement in top-performing Singapore was comparable to or even exceeded performance for 95% of the students in the lowest-performing countries.
- ▶ For most countries, gender differences in mathematics achievement were small or essentially non-existent. However, the direction of the gender differences that did exist favored boys rather than girls. Similarly, within the mathematics content areas, there were few differences in performance between boys and girls. Again, the few differences that did occur favored boys (except in algebra, where, if anything, the differences favored girls).

- ▶ Compared to their overall performance in mathematics, nearly all countries did relatively better in several content areas than they did in others. Consistent with the idea of countries having different emphases in curriculum, those that performed relatively better in fractions and number sense tended to be different from those that performed relatively better in geometry and algebra.
- ▶ Even though students in the top-performing countries had very high achievement on many of the test questions, both seventh and eighth graders, in most countries, had difficulty with multi-step problem solving and applications. For example, students were asked to actually draw a new 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 (Korea and Austria) did at least half the eighth-grade students correctly draw the new rectangle.
- ▶ Students also found the proportionality items difficult. For example, one of the least difficult problems in this area asked about adding 5 girls and 5 boys to a class that was three-fifths girls. On average, fewer than two-thirds of the students across countries correctly answered that there would still be more girls than boys in the class.
- ▶ In algebra, 58% of the eighth-grade students across countries, on average, identified $4m$ as being equivalent to $m + m + m + m$. There was however, a very large range in performance from country to country. Seventy-five percent or more of the eighth graders answered this question correctly in the Czech Republic, Hong Kong, Japan, the Russian Federation, Singapore, the Slovak Republic, and Slovenia.

STUDENTS' ATTITUDES TOWARDS MATHEMATICS

- ▶ Within nearly every country, a clear positive relationship was observed between a stronger liking of mathematics and higher achievement. Even though the majority of eighth graders in nearly every country indicated they liked mathematics to some degree, clearly not all students feel positive about this subject area. In Austria, the Czech Republic, Germany, Hungary, Japan, Korea, Lithuania, and the Netherlands, more than 40% of the students reported disliking mathematics.
- ▶ In no country, did eighth-grade girls report a stronger liking of mathematics than did boys. However, boys reported liking mathematics better than girls did in several countries, including Austria, France, Germany, Hong Kong, Japan, Norway, and Switzerland.

- ▶ In all except four countries, the majority of students agreed or strongly agreed that they did well in mathematics – a perception that did not always coincide with the comparisons in achievement across countries on the TIMSS test. Interestingly, the exceptions included three of the highest performing countries – Hong Kong, Japan, and Korea – where more than 50% of the students disagreed or strongly disagreed about doing well (the fourth was Lithuania). It should be noted, however, that within nearly all countries there was a clear relationship between perception and performance, with those students reporting higher self-perceptions of doing well in mathematics also having higher average achievement.
- ▶ Internationally, the most frequently cited reason for needing to do well in mathematics was to get into students’ desired secondary school or university.

HOME ENVIRONMENT

Home factors were strongly related to mathematics achievement in every country that participated in TIMSS.

- ▶ In every country, eighth-grade students who reported having more educational resources in the home had higher mathematics achievement than those who reported little access to such resources. Strong positive relationships were found between mathematics achievement and having study aids in the home, including a dictionary, a computer, and a study desk/table for the student’s own use.
- ▶ The number of books in the home can be an indicator of a home environment that values and provides general academic support. In most TIMSS countries, the more books students reported in the home, the higher their mathematics achievement.
- ▶ In every country, the pattern was for the eighth-grade students whose parents had more education to also have higher achievement in mathematics.
- ▶ Beyond the one to two hours of daily television viewing reported by close to the majority of eighth graders in all participating countries, the amount of television students watched was negatively associated with mathematics achievement.

- ▶ In most countries, eighth graders reported spending as much out-of-school time each day in non-academic activities as they did in academic activities. Besides watching television, students reported spending several hours, on average, each day playing or talking with friends, and nearly two hours playing sports. (It should be noted, however, the time spent in these activities is not additive because students can talk with their friends at sporting events or while watching TV, for example.)

INSTRUCTIONAL CONTEXTS AND PRACTICES

In comparison to the positive relationships observed between mathematics achievement and home factors, the relationships were less clear between achievement and various instructional variables, both within and across 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 and merits further study.

- ▶ The qualifications required for teaching certification were relatively uniform across countries. Most countries reported that four years of post-secondary education were required, even though there was a range from two to six years. Almost all countries reported that teaching practice was a requirement, as was an examination or evaluation.
- ▶ Teachers in most countries reported that mathematics classes typically meet for at least two hours a week, but less than three and one-half hours. Weekly instructional time of from three and one-half hours up to five hours also was common for a number of countries. The data, however, revealed no clear pattern between the number of in-class instructional hours and mathematics achievement.
- ▶ There was considerable variation in class size. In a number of countries, nearly all students (90% or more) were in classes of fewer than 30 students. At the other end of the spectrum, 93% of the students in Korea were in classes with more than 40 students. The TIMSS data showed different patterns of mathematics achievement in relation to class size for different countries.
- ▶ Small-group work was used less frequently than other instructional approaches. Across countries, mathematics teachers reported that working together as a class with the teacher teaching the whole class, and having students work individually with assistance from the teacher were the most frequently used instructional approaches.

- ▶ In most participating countries, teachers reported using a textbook in teaching mathematics for 95% or more of the students. Relatively uniformly, the majority of students were asked both to practice computation and do some type of reasoning tasks in most or every lesson.
- ▶ Regarding the use of technology, teachers in many countries reported three-fourths or more of the eighth graders used calculators almost every day in their mathematics classes, often for checking answers, routine computation, and solving complex problems. An exception was Korea, where it was reported that calculators were seldom used. Teachers and students agreed that the computer was almost never used in most students' mathematics lessons.
- ▶ Eighth graders in about half the countries reported doing an average of two to three hours per day of homework, with those in many countries reporting studying mathematics for roughly an hour each day. There was a range from half an hour to two hours per day spent on mathematics homework and about two to five hours overall, but the relationship between amount of homework done and level of mathematics achievement was inconsistent.
- ▶ Eighth-grade students reported substantial variation in the frequency of testing in mathematics classes. In a number of countries, the majority of the eighth-grade students reported having quizzes and tests only once in while or never. In contrast, one-third or more of the students reported almost always having quizzes or tests in Colombia, Hong Kong, Kuwait, Romania, Spain, and the United States.