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 primary-school students: whole numbers; fractions and proportionality; measurement, estimation, and number sense; data representation, analysis, and probability; geometry; and patterns, relations, and functions. About one-fourth of the questions were in the free-response 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 30 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.

Of the five grade levels tested, the results provided in this report describe students' mathematics achievement at both the third and fourth grades. For most, but not all TIMSS countries, the two grades tested at the primary-school level represented the third and fourth years of formal schooling. Special emphasis is placed on the fourth-grade results, including selected information about students' background experiences and teachers' classroom practices in mathematics. Results are reported for the 26 countries that completed all of the steps on the schedule necessary to appear in this report.

The mathematics achievement results for students in the seventh and eighth grades were published in *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study*.[1] This report describes mathematics achievement in 41 countries, including results for major content areas, breakdowns by gender, example items, and results for selected background and attitudinal factors. Achievement results for students in their final year of secondary school will appear in a subsequent report.

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

[1] Beaton, A.E., Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., Kelly, D.L., and Smith, T.A. (1996). *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: Boston College.* The science achievement results for seventh- and eighth-grade students are presented in a companion volume, Beaton, A.E., Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., Smith, T.A., and Kelly, D.L. (1996). *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS).* Chestnut Hill, MA: Boston College.

STUDENTS' MATHEMATICS ACHIEVEMENT

- Singapore and Korea were the top-performing countries at both the fourth and third grades. Japan and Hong Kong also performed very well at both grades, as did the Netherlands, the Czech Republic, and Austria. Lower-performing countries included Iran and Kuwait (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 Singapore and Korea was comparable to or even exceeded performance for 95% of the students in the lowest-performing countries.

- Many countries (9 of 12) that performed above the international average at the fourth grade also did so at the eighth grade. However, at the eighth grade, Ireland and Australia were about at the international average, while the United States was below it (see Figure 1.3).

- For most countries, gender differences in mathematics achievement were small or essentially non-existent. However, the direction of the few 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, except in measurement, where the differences favored boys.

- Compared with their overall performance in mathematics, nearly all countries did relatively better in several content areas than they did in others. This is consistent with the idea of countries having different curricular emphases in mathematics.

- Even though students in the top-performing countries had very high achievement on many of the test questions, students generally had the most difficulty with the items in the content area of fractions and proportionality. The least difficult items involved whole number proportional reasoning and recognizing pictorial representations of fractions. In contrast, the more difficult items involved decimals, and students being asked to explain their reasoning.

- In data representation, students had some difficulty moving beyond a straight-forward reading of data in tables, charts, and graphs to actually using the information in calculations or to graphically represent the data. For example, students were asked to use data from a simple table to complete a bar graph. On average, 40% of the fourth graders and 23% of the third graders across countries drew the four bars to appropriate heights. There was, however, a very large range in performance from country to country. For example, about three-fourths or more of the fourth graders completed the bar graph in Hong Kong, Japan, Korea, and Singapore.

- Similarly, students were more likely to be able to recognize simple patterns and relationships than they were to determine the operations underlying the relationships. About half the students internationally provided an answer showing that they understood what to do to get the next number in a subtraction series, where the numbers were decreasing by 4. When given two columns of four numbers, only about one-fourth of the third graders and two-fifths of the fourth graders correctly determined that you needed to divide the number in Column A by 5 to obtain the number next to it in Column B.

Students' Attitudes Towards Mathematics

- Those students who reported either liking mathematics or liking it a lot generally had higher achievement than students who reported disliking it to some degree. The overwhelming majority of fourth graders in nearly every country indicated they liked mathematics to some degree, but not all students feel positive about this subject area. In Japan, Korea, and the Netherlands, more than one-quarter of the fourth-grade students reported disliking mathematics.

- In most countries, fourth graders of both genders were equally positive about liking mathematics. In Austria, Hong Kong, Japan, and the Netherlands, boys reported a significantly stronger liking of the subject area than did girls. However, girls reported liking mathematics better than did boys in Ireland and Scotland.

- Across countries, the majority of fourth graders agreed or strongly agreed that they did well in mathematics – a perception that did not always coincide with the comparisons of achievement across countries on the TIMSS test. Fourth-grade girls had lower self-perceptions than did boys in Austria, Hong Kong, Japan, the Netherlands, Singapore, and Slovenia.

Home Environment

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

- In many countries, fourth-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 nearly all countries, students reporting more than 100 books in the home had higher mathematics achievement than students reporting fewer books.

- In all but a few countries, 80% or more of the students responded that they always or almost always spoke the language they were tested in at home. Most certainly, these relatively high percentages reflect the effort expended by the participating countries to test in more than one language when necessary.

- In about half the countries, 80% or more of the fourth graders reported that both their parents were born in that country. Yet, the patterns in relation to mathematics achievement varied substantially from country to country. The fourth graders themselves generally were born in the country in which they were tested.

- For normal school days, fourth-grade students in most countries reported averaging approximately an hour (.7 to 1.3 of an hour) outside of school each day studying or doing homework in mathematics.

- Fourth-grade students in all countries also reported that they normally averaged an hour or two each school day watching television. In nearly all countries, students watching more than four hours of television per day had lower mathematics achievement than their classmates who watched less television.

- Besides watching television, students reported spending from one to two hours per school day playing or talking with friends and one to two hours per school day playing sports. (It should be noted, however, that 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 with 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. 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 three or four years of post-secondary education were required, in either a university, a teacher training institution, or both. Almost all countries reported that teaching practice was a requirement, as was an examination or evaluation.

- In most countries, the mathematics teaching force was predominantly female. Ninety percent or more of the fourth-grade students had female teachers in the Czech Republic, Hungary, Israel, Latvia (LSS), Portugal, Scotland, and Slovenia.

- Teachers in most countries reported that mathematics classes typically meet for three or four hours a week, on average. However, more than 5 hours of weekly class time was reported for 50% or more of the fourth-grade students in the Netherlands, Portugal, Singapore, and Thailand. The data, however, revealed no clear pattern between the number of in-class instructional hours and mathematics achievement.

- In most countries, the challenge of catering to students of different academic abilities was the factor teachers mentioned most often as limiting how they teach their mathematics classes. Other limiting factors were a high student/teacher ratio, a shortage of equipment for use in instruction, and the burden of dealing with disruptive students.

- There was considerable variation in class size for the TIMSS countries, with the average ranging from 19 in Norway to 43 in Korea. In a number of countries, however, nearly all students (90% or more) were in classes of fewer than 30 students. At the other end of the spectrum, more than 90% of the students in Korea and Singapore were in classes with more than 30 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.

- Across countries, teachers for the majority of the students reported being fairly familiar with the official national and/or regional curriculum guides in mathematics. Teachers generally reported relying on these guides in deciding which topics to teach. The textbook was the major written source mathematics teachers used in deciding how to present a topic to their classes. 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 to do some type of reasoning tasks in most or every lesson. Using things from everyday life in solving mathematics problems most typically is done in some lessons.

- According to teachers in many of the TIMSS countries, most fourth-grade students never or hardly ever use calculators in their mathematics classes. The exceptions where there was at least weekly use of calculators for the majority of the students included Australia, England, and New Zealand. Both teachers and students agreed that the computer was almost never used in most students' mathematics lessons.

- Internationally, most fourth-grade students were assigned mathematics homework at least once or twice a week, if not more often. Most typically, for the majority of the students, the assignments were 30 minutes or less in length. In all participating countries, for at least 70% of the students, teachers reported at least sometimes, if not always, correcting homework assignments and returning those assignments to students. Yet, in general for the TIMSS countries, teachers reported that mathematics homework assignments contributed only rarely or sometimes to students' grades or marks.