Executive Summary

SCIENCE

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.

Four content dimensions were covered in the TIMSS science tests given to the primary-school students: earth science, life science, physical science, and environmental issues and the nature of science. About one-fourth of the questions were in 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 20 example items illustrating the range of science 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 science, 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 science. 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' science 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 science. Results are reported for the 26 countries that completed all of the steps on the schedule necessary to appear in this report.

The science achievement results for students in the seventh and eighth grades were published in *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study*.[1] This report describes science achievement in 41 countries, including 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.

Students' Science Achievement

- Korea was the top-performing country at both the fourth and third grades. Japan, the United States, Austria, and Australia also performed very well at both grades. 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 science 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 each 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

[1] 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: The IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College. The mathematics achievement results for seventh- and eighth-grade students are presented in a companion volume, 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: The IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College.

differences. For example, at both grades, average achievement in top-performing Korea was comparable to or even exceeded performance for 95% of the students in the lowest-performing countries.

- Many countries (9 of 13) that performed above the international average at the fourth grade also did so at the eighth grade. However, Ireland, the United States, Canada, and Scotland were above the international average at the fourth grade, but just at the average at the eighth grade (see Figure 1.3).

- In about half the countries and internationally, boys had significantly higher mean science achievement than girls at both the third and fourth grades. This is attributable mainly to significantly higher performance by boys in earth science and physical science. In few countries were significant gender differences found in life science or environmental issues and the nature of science, although in life science one such difference favored girls in New Zealand at both grades. Gender differences at the third and fourth grades were much less pervasive than at the seventh and eighth grades.

- Compared with their overall performance in science, many countries did relatively better or worse in some content areas than they did in others. Consistent with the idea of countries having different emphases in curriculum, some countries performed better in life science, some performed better in physics, and others performed better in chemistry.

- Internationally, students found many of the physical science items quite challenging. For example, an item that required students to understand what happens to the level of water in a watering can as the can is tilted was answered correctly by less than a fifth of both third- and fourth-grade students on average. Fourth-grade students, in general, performed better than third-grade students on this item, but in only one country (Singapore) did 30% or more of fourth-grade students correctly draw a line showing the level of water in the tilted can.

- In general, students had slightly less difficulty with the life science items, although there were some difficult items in this content area. A free-response item requiring the students to write down one thing that the heart does to help other parts of the body was answered correctly by 28% of third-grade students and 40% of fourth graders. Only in Australia, England, and the United States did more than 60% of students correctly mention the heart's role in pumping blood around the body.

- One of the relatively easier earth science items was a multiple-choice item that asked students to indicate why the moon shines at night even though it produces no light. About two-thirds of both third- and fourth-grade students correctly recognized from a list of four options that the moon reflects the light of the sun. More than 80% of the fourth-grade students in Hong Kong, the Netherlands, Norway, and Singapore answered this item correctly.

Students' Attitudes Towards Science

- Four-fifths of the fourth graders in every country except the Netherlands indicated that they liked science to some degree. In the Netherlands, a third of the students reported that they disliked science.

- In most countries, fourth-grade students of both genders were equally positive about liking science. However, a greater percentage of boys reported liking science in Austria, Japan, and Korea, and a greater percentage of girls in Iceland and Ireland.

- In all except three countries, the majority of students, male and female, agreed or strongly agreed that they did well in science – a perception that did not always coincide with the comparisons of achievement across countries on the TIMSS test.

Home Environment

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

- In most countries, fourth-grade students who reported having more educational resources in the home had higher science achievement than those who reported little access to such resources. Positive relationships were found between science 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 science achievement.

- 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.

- Students having both parents born in the country had higher average science achievement than those with one or both parents born abroad in about a quarter of the countries (e.g., Austria, Canada, Cyprus, England, Greece, and the United States).

- For about half of the TIMSS countries, students born abroad had lower average science achievement than students born in the country.

- For a normal school day, fourth-grade students in most countries reported spending between half an hour and an hour studying or doing homework in science.

- Beyond the one to two hours of daily television viewing reported by close to the majority of fourth graders in all participating countries, the amount of television students watched was negatively associated with science achievement.

- Besides watching television, students reported spending from one to two hours each day playing or talking with friends and one to two hours 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 science achievement and home factors, the relationships were less clear between achievement and various instructional variables, both within and across countries. Obviously, educational practices such as tracking and streaming can 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 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 every country except Greece and the Netherlands, the majority of fourth-grade students were taught science by female teachers. For seven countries, the percentage of students taught by female teachers was 90% or more (the Czech Republic, Hungary, Israel, Latvia (LSS), Portugal, Scotland, and Slovenia).

- Teachers in about half the countries reported that science is taught in their class for less than two hours a week. In Austria, Japan, Korea, Kuwait, and Singapore, the norm for science teaching was between two and three hours per week, while in Canada, England, Portugal, Thailand, and the United States, more than 20% of students have three hours or more of science weekly. The data, however, revealed no clear pattern across countries between the number of in-class instructional hours and science achievement.

- Science is taught as a separate subject in all fourth-grade classrooms in Israel, Japan, Korea, Kuwait, and Singapore, whereas for large percentages of students in Iceland, Ireland, New Zealand, Norway, Portugal, Scotland, and Thailand, science instruction is integrated with the teaching of other subjects.

- In most countries, almost all fourth-grade students were taught science by teachers who teach both mathematics and science. The exceptions were Hong Kong, Israel, and Kuwait, where most students had different teachers for mathematics and science.

- In most countries, the challenge of catering to students of differing academic abilities was the factor teachers mentioned most often as limiting how they teach their science 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 across the TIMSS countries. Science classes were relatively small in a number of countries, with an average class size of 25 or fewer in 13 countries. Norway had the smallest fourth-grade science classes, with 57% of students in classes of 20 or fewer students. At the other end of the spectrum, the average size of science classes in Korea was 43, and 69% of the students in that country were in classes with more than 40 students. The TIMSS data showed different patterns of science achievement in relation to class size for different countries.

- Across countries, science 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. Working without teacher assistance was less common in most countries. Working together as a class with students responding to one another was a common approach in Japan, Korea, and the Netherlands.