

# 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.

Five content dimensions were covered in the TIMSS science tests given to the middle-school students: earth science, life science, physics, chemistry 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 25 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.

The results provided in this report describe students' science 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 science. 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' SCIENCE ACHIEVEMENT

- ▶ Singapore was the top-performing country at both the eighth and seventh grades. The Czech Republic, Japan, and Korea also performed very well at both grades. 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 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 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.
- ▶ In most countries and internationally, boys had significantly higher mean science achievement than girls at both the seventh and eighth grades. This is attributable mainly to significantly higher performance by boys in earth science, physics, and chemistry. 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 one country at the eighth grade.

- ▶ Compared to 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 had the most difficulty with the chemistry items. For example, an item that required students to explain how carbon dioxide fire extinguishers work was answered correctly by about half or fewer of both seventh- and eighth-grade students in many countries. Eighth-grade students, in general, performed better than seventh-grade students on this item, but in only four countries did 70% or more of eighth-grade students correctly explain the displacement of oxygen required for combustion – Austria, England, Singapore, and Sweden.
- ▶ A multiple-choice physics item requiring students to demonstrate knowledge of the earth’s gravitational force acting on a falling apple was of similar international difficulty, with about half or fewer of the students in many countries selecting the correct response. Except in the Czech Republic and the Slovak Republic, where about three-quarters or more of students in both grades responded correctly, students’ responses to this item indicated a common misconception internationally that gravity does not act on a stationary object when it is on the ground.
- ▶ One of the more difficult earth science items was an extended-response item requiring students to apply scientific principles and draw a diagram to explain the earth’s water cycle. Internationally, about a third or fewer of both seventh- and eighth-grade students provided a completely correct response that included all three steps in the water cycle – evaporation, transportation, and precipitation. Performance on this item varied widely across countries, however, with percentages correct ranging from less than 10% in Lithuania and South Africa to 60% in Flemish-speaking Belgium.

## STUDENTS’ ATTITUDES TOWARDS SCIENCE

- ▶ Even though the majority of eighth-graders in nearly every country indicated they liked science to some degree, clearly not all students feel positive about this subject area. Among countries where science is taught to eighth-grade students as a single subject, boys reported liking science more than did girls in England, Hong Kong, Japan, Kuwait, New Zealand, Norway, and Singapore. Where the major scientific disciplines are taught as separate subjects, the major gender differences were found in physical science, with boys expressing a liking for this content area more often than girls.

- ▶ In all except three countries, the majority of students agreed or strongly agreed that they did well in science or science subject areas – a perception that did not always coincide with the comparisons in achievement across countries on the TIMSS test. Interestingly, the exceptions included two of the higher-performing countries – Japan and Korea – where only 45% and 35% of the students, respectively, agreed or strongly agreed about doing well (the third was Hong Kong).
- ▶ In the majority of countries, for eighth-grade students, pleasing their parents and getting into their preferred university or secondary school were both stronger motivators for doing well in science than was getting their desired job.

## HOME ENVIRONMENT

Home factors were strongly related to science 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 science achievement than those who reported little access to such resources. Strong 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 every country, the pattern was for the eighth-grade students whose parents had more education to also have higher achievement in science.
- ▶ 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 science 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 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 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 that teach integrated science reported that science classes typically meet for at least two hours a week, but less than three and one-half hours. At the extremes, less than two hours of in-class instruction was most common in Switzerland whereas three and one-half to five hours was most common in Singapore. The data, however, revealed no clear pattern across countries between the number of in-class instructional hours and science achievement.
- ▶ There was considerable variation in class-size across the TIMSS countries. 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, 89% of the students in Korea 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.
- ▶ In most participating countries, teachers reported using a textbook in teaching science for 95% or more of the students. Reasoning tasks were reported to be very common activities in science classes, with the majority of students in all countries being asked to do some type of science reasoning task in most or every science lesson. Using things from everyday life in solving science problems appears more common in countries where science is taught as an integrated subject than in countries where science is taught as separate subject areas.

- ▶ Demonstrations of experiments by the teacher were common in almost all countries where science is taught as an integrated subject, and were also common in chemistry and physics classes. In most countries with integrated science where students reported high frequencies of teacher demonstrations, there was also a high percentage of students that reported doing experiments or practical investigations in class. In countries where science is taught as separate subjects, according to students teachers performed demonstrations more frequently than students themselves did practical, hands-on work, particularly in physics and chemistry.
- ▶ Internationally, science teachers reported that most eighth-grade students were assigned science homework at least once a week, although most typically, the majority of students were assigned up to 30 minutes of homework once or twice a week. Student reports of the amount of time spent on science homework suggest higher levels of assigned homework.
- ▶ In some countries, students reported a lot of student assessment in their science classes, while in other countries there was apparently less reliance on quizzes or tests in science lessons. Of the countries where science is taught as an integrated subject more than half the students in Austria, Canada, Colombia, Cyprus, England, Hong Kong, Iran, Kuwait, Singapore, Spain, Thailand, and the United States reported having a quiz or test pretty often or almost always in their science lessons.