

Executive Summary

TIMSS 2003 is the third in a continuing cycle of international mathematics and science assessments conducted every four years. TIMSS assesses achievement in countries around the world and collects a rich array of information about the educational contexts for learning mathematics and science, with TIMSS 2003 involving more than 50 participants. This report contains the science results for 46 countries and four benchmarking participants at the eighth grade and for 25 countries and three benchmarking participants at the fourth grade. Trend data are provided at the eighth and fourth grades for those countries that also participated in 1995 and 1999 (please see the Introduction for more information about TIMSS 2003.)

Students' Science Achievement in 2003

- At the eighth grade, Singapore and Chinese Taipei were the top-performing countries having significantly higher average science achievement than the rest of the participating countries. The Republic of Korea also performed very well, with average achievement significantly higher than all of the other participating countries except Singapore, Chinese Taipei, and Hong Kong, SAR.
- At the fourth grade, Singapore was the top-performing country with higher average science achievement than all other participating countries. Chinese Taipei had significantly higher performance

than all countries except Singapore, and, in turn, Japan, Hong Kong SAR, and England outperformed the rest of countries except Singapore and Chinese Taipei.

Trends in Science Achievement

- At the eighth grade, several countries showed significantly higher average science achievement in 2003 compared to the previous assessments in 1995 and 1999. Korea, Hong Kong SAR, the United States, and Lithuania as well as the benchmarking Canadian province of Ontario, showed a pattern of improvement from assessment to assessment with significant change over the 8-year period from 1995 to 2003. Of the countries with results only from the 1999 and 2003 assessments, Malaysia, Israel, Jordan, Moldova, and the Philippines showed significant improvement.
- At the eighth grade, countries showing a decrease in average achievement in 2003 compared to previous assessments (1995, 1999, or both) included Hungary, Sweden, the Slovak Republic, Belgium (Flemish), the Russian Federation, Norway, Bulgaria, Iran, Cyprus, Indonesia, and Tunisia.
- At the fourth grade, many countries showed significant gains in average achievement between 1995 and 2003, including Singapore, Hong Kong SAR, England, Hungary, Latvia (LSS)¹, New Zealand, Slovenia, Cyprus, and Iran, as well as the benchmarking province of Ontario. The only significant declines were found in Japan, Scotland, Norway, and Quebec province.

Gender Differences in Science Achievement

- In the majority of participants at the eighth grade (33 out of 49), boys outperformed girls in science, often by a substantial margin. This was attributable mainly to higher performance by boys in

¹ Trend data for Latvia are annotated LSS because they include Latvian-speaking schools only.

physics and earth science, although girls had, on average, higher achievement in life science. In eleven countries, including Egypt, Iran, Chinese Taipei, Botswana, South Africa, Lebanon, Singapore, Estonia, Cyprus, the Philippines, and New Zealand, the gender difference was not significant. In a further seven countries – Macedonia, Moldova, Armenia, the Palestinian National Authority, Saudi Arabia, Jordan, and Bahrain – the gender difference favored girls.

- The trend results at the eighth grade show that girls had greater improvement, on average, since 1999 than boys. Fifteen participants showed significant improvements for girls, and just eight for boys. Both girls and boys improved over previous assessments in nine countries and Ontario province. Reflecting declines in achievement across assessments, both genders had lower achievement in TIMSS 2003 in seven countries. In Indonesia, Macedonia, and the Russian Federation, the boys but not the girls had a significant decrease.
- At the fourth grade, the average gender difference in science achievement was negligible, although girls had significantly higher average achievement in Armenia, Moldova, the Philippines, and Iran, and boys had higher average achievement in the United States, Chinese Taipei, Cyprus, the Netherlands, and Scotland.
- The fourth-grade trend results show that average science achievement improved for both boys and girls since 1995. Both boys and girls improved in eight countries and Ontario province; in England only girls improved; and in Japan, Norway, and Quebec, both boys and girls showed a decline. Boys but not girls showed a decline in the Netherlands and the United States.

Performance at the International Benchmarks in TIMSS 2003

TIMSS identified four benchmark levels to describe what students know and can do in science and demonstrate the range of performance internationally—advanced, high, intermediate, and low. There were large

differences across countries in the percentages of students reaching the various benchmarks.

At the eighth grade, students reaching the **advanced benchmark** demonstrated a grasp of some complex and abstract science concepts. At the other end of the performance continuum, those reaching the **low benchmark** recognized some basic facts from the life and physical sciences.

- The highest performing countries –Singapore and Chinese Taipei – had one-third to one-fourth of their students reaching the advanced benchmark. Next came Korea (17%), England and Japan (15%), Hungary (14%), Hong Kong SAR and Estonia (13% each), and the United States (11%.) All other countries had less than 10 percent of their students reaching the advanced benchmark, including 17 of the lowest-performing countries with one percent or less.
- Fifteen countries, the US state of Indiana, and the two Canadian provinces had 95 percent or more of their students reaching the low benchmark whereas seven countries had less than half their students reaching the low benchmark.

At the fourth grade, students reaching the **advanced benchmark** could apply knowledge and understanding in beginning scientific inquiry. Those reaching the **low benchmark** demonstrated some elementary knowledge of the earth, life, and physical sciences.

- With fewer and less variable countries at the fourth grade, Singapore had 25 percent of its students reaching the advanced benchmark. This was followed by England (15%), Chinese Taipei (14%), the United States (13%), Japan (12%), the Russian Federation (11%), and Hungary (10%.) Three of the lowest-performing countries had one percent or less of their students reaching the advanced benchmark.
- Eight countries as well as the US state of Indiana and Ontario province had 95 percent or more of their students reaching the low

benchmark and all except five countries had at least three-fourths of their students reaching this level. In the Philippines, Tunisia, and Morocco, less than half the students reached the low benchmark.

Students' Home Context for Learning Science

- At the eighth grade, students were asked about the level of their parents' schooling and their own expectations. Higher levels of parents' education were associated with higher student achievement in science in almost all countries. Also, students expecting to finish university had substantially greater average science achievement than those without university expectations.
- At both the eighth and fourth grades, in general, students from homes where the language of the test was always or almost always spoken had higher average science achievement than those who spoke it less frequently.
- At both the eighth and fourth grades, across countries on average, there was a clear-cut relationship between number of books in the home and science achievement.
- Science achievement was positively related to computer usage, particularly at eighth grade, with average achievement highest among students reporting using computers at home and at school. Next highest was achievement among students using computers at home but not school, followed by students using computers at school but not home, and then those using computers at other places or not using them at all. At both grades, the percentages of students reporting that they did not use a computer at all varied dramatically across countries – from one percent or less to as many as two-thirds at the eighth grade and three-fourths at the fourth grade.

The Science Curriculum

- Most countries had science curricula defined at the national level (except Australia and the United States) and often supported by ministry directives, instructional guides, school inspections, and recommended textbooks. In 23 countries, science was taught as a single general subject. In other countries, separate courses were offered in the different science subjects.
- At both the eighth and fourth grades, most participants emphasized understanding science concepts and knowing basic science facts. Considerable emphasis also was placed on writing explanations about what was observed and why it happened. Less emphasis was placed on experimental work.
- In relation to the TIMSS 2003 assessment at the eighth grade, on average, participants reported that a great deal of the science content was included in their curricula (71% of assessment topics intended for all or almost all students), with each of the five science content areas included in about equal proportions. About three-fourths of the physics and life science topics (75% and 73%, respectively) were included in their curricula, 70 percent of the chemistry topics, 69 percent of the environmental science topics, and 66 percent of the earth science topics.
- At the fourth grade, on average, 56 percent of the science topics were included in the curriculum. In life science, 60 percent of the topics assessed were included in the participants' curricula, 57 percent of the physical science topics, and 50 percent of the earth science topics.
- Although the relationship was not consistent across all countries, it appears that having at least moderate coverage of the science topics in the curriculum is a prerequisite for high performance, but that high coverage in the intended curriculum does not of itself necessarily lead to high student achievement.

- At the eighth grade, across countries on average, teachers reported that 70 percent of the students had been taught the life science and chemistry topics, 66 percent the physics topics, 61 percent the earth science topics, and 49 percent the environmental science topics.
- At the fourth grade, across countries on average, teachers reported that 69 percent of the students had been taught the life science topics, 58 percent the earth science topics, and 56 percent the physical science topics.

Teachers of Science

- Science teachers reported considerable teaching experience. At the eighth and fourth grade, on average, students were taught by teachers with 15 and 16 years of experience, respectively.
- On average, 79 percent of the eighth-grade students and 65 percent of the fourth-grade students were taught by teachers with at least a university degree.
- Most eighth-grade students (82% on average) had science teachers with a science subject major (biology, physics, chemistry, or earth science) and more than one-third (37%) with a major in science education or both. Biology was the most popular science major, followed by chemistry, physics, and earth science. At the fourth grade, teachers typically studied primary or elementary education (80% of the students with such teachers, on average).
- At both grades, schools reported that their professional development programs emphasized improving content knowledge and teaching skills. More than 80 percent of students were taught science by teachers having at least some professional development training in these areas.
- Across the science content areas assessed, teachers reported being ready to teach nearly all the major topics tested by TIMSS. Almost

all of the eighth-grade students were taught by such teachers – 90 percent or more for 16 out of 21 topics (all but three earth science and two environmental science topics). At the fourth grade, teachers reported being less well-prepared. In only 8 of the 19 topics were 90 percent or more of the fourth-grade students taught by teachers reporting readiness for teaching (2 of 6 life science topics, 2 of 7 physical science topics, and 4 of 6 earth science topics).

Classroom Instruction

- In general at the eighth grade, students in countries with separate science subjects had more instructional hours in the sciences. Annual hours of science instruction ranged from 284 hours in the Slovak Republic, where students take biology, chemistry, physics, and earth science simultaneously, to 69 hours in Italy, where science is taught as a single, integrated subject. There was less instructional time for science at the fourth grade, with annual hours ranging from 176 in the Philippines (the most by far) to 33 hours in the Russian Federation.
- At the eighth grade, on average, teachers reported that 27 percent of the instructional time was devoted to life science, 24 percent to physics, 21 percent to chemistry, 13 percent to earth science, 9 percent to environmental science, and 5 percent to other. At fourth grade, with fewer content areas, the profile was different. Life science received 41 percent of the instructional time, earth science 28 percent, physical science 24 percent, and other 8 percent.
- At the eighth grade, on average, students reported a moderate degree of emphasis on a range of activities related to science investigations. For example, in integrated-science countries, about two-thirds of students, on average, said that, in at least half of their lessons, they were asked to write explanations about what they had observed and why it happened (66%) or watch the teacher demonstrate an experiment

or investigation (64%). At the fourth grade, most students reported that they watch the teacher do a science experiment, and write or give an explanation for something they are studying in science, once or twice a month or more (69% of students for each activity).

- At both eighth and fourth grades, the textbook was often the foundation of science instruction. On average, more than half of students at both grades (56%) had teachers who reported using a textbook as the primary basis for their lessons, and many more as a supplementary resource (39% at eighth grade and 26% at fourth grade).
- On average, the three most common instructional activities in science classes (totaling 57% of class time) were teacher lecture (24% of class time), teacher-guided student practice (19%), and students working on problems on their own (14%).
- Although the curriculum contained statements about computer use in science in about half of the countries, access to computers remains a challenge in many countries. Teachers reported that, on average, internationally, computers were not available for 62 percent of the eighth-grade students and 54 percent of the fourth-grade students. Even in countries with high availability, using computers in science class was extremely rare at either grade.
- At the eighth grade, on average, almost all students (88%) were taught by teachers who used only or mostly constructed-response tests (28%) or an equal mixture of constructed-response and multiple-choice tests (60%). Very few students (13%, on average) had teachers who used only multiple-choice tests, and these students had lower average achievement than did students whose teachers used only constructed-response tests or a combination.

School Contexts for Learning and Instruction

- At the eighth grade, average science achievement was 51 points higher for students in schools with few students from economically disadvantaged homes than for students attending schools with more than half their students from disadvantaged homes. At fourth grade, the difference was 43 points.
- At both eighth and fourth grades, there was a strong positive relationship between the principals' perception of school climate (based on seven questions about behaviors of teachers, parents, and students) and average science achievement. Asked the same seven questions, teachers had a somewhat more gloomy view of school climate than principals, but the relationship with achievement still was positive.
- Teachers were asked about the safety of their schools' neighborhoods, how safe they felt in their schools, and the sufficiency of security policies and practices. On average, 70 percent of eighth-grade students and 76 percent of fourth-grade students attended school characterized as safe by their teachers. At both grades, there was a positive relationship between school safety and science achievement.

