CHAPTER 2

2

Performance at International Benchmarks

The TIMSS 1999 international benchmarks delineate performance of the top 10 percent, top quarter, top half, and lower quarter of students in the countries participating in the study. To help interpret the achievement results, Chapter 2 describes eighth-grade science achievement at each of these benchmarks together with examples of the types of items typically answered correctly by students performing at the benchmark.

As countries around the world spend their time and energy on improving science education, it is important that educators, curriculum developers, and policy makers understand what students know and can do in science and what areas, concepts, and topics need more focus and effort. To help interpret the overall achievement results presented in Chapter 1, this chapter describes eighth-grade science achievement at each of the TIMSS 1999 international benchmarks together with examples of the types of items typically answered correctly by students performing at the benchmark.

Exhibit 1.6, presented previously in Chapter 1, shows the percentages of students in each country reaching each international benchmark – Top 10%, Upper Quarter, Median, and Lower Quarter. The benchmarks delineate performance of the top 10 percent, top quarter, top half, and lower quarter of students in the countries participating in TIMSS 1999 (90th, 75th, 50th, and 25th international percentiles, respectively). The analysis of performance at these benchmarks in science suggests that six primary factors appeared to differentiate performance among the four levels:

- The depth and breadth of content area knowledge
- The level of understanding and use of technical vocabulary
- The context of the problem (progressing from practical to more abstract)
- The level of scientific investigation skills
- The complexity of diagrams, graphs, tables, and textual information used
- The completeness of written responses.

For example, there is evidence that students performing at the lower end of the scale could recognize basic facts from the earth, life, and physical sciences presented in non-technical language and could interpret and use information presented in simple diagrams. In contrast, students performing at the higher end of the scale demonstrated a grasp of more complex and abstract science concepts; applied knowledge to solve problems; interpreted and used information in diagrams, tables and graphs; and could provide written explanations to communicate their scientific knowledge.

How Were the Benchmark Descriptions Developed?

To develop descriptions of achievement at the TIMSS 1999 international benchmarks, the International Study Center used the scale anchoring method. Scale anchoring is a way of describing students' performance at different points on the TIMSS 1999 achievement scale in terms of the types of items they answer correctly. It involves an empirical component in which items that discriminate between successive points on the scale are identified, and a judgmental component in which subject matter experts examine the content of the items and generalize to students' knowledge and understandings.

For the scale anchoring analysis, the results of students from all the TIMSS 1999 countries were pooled, so that the benchmark descriptions refer to all students achieving at that level. (That is, it does not matter which country the students are from, only how they performed on the test.) Criteria were applied to the TIMSS 1999 achievement scale results to identify the sets of items that students reaching each international benchmark were likely to answer correctly and that those at the next lower benchmark were unlikely to answer correctly.[1] The sets of items produced by the analysis represented the accomplishments of students reaching each successively higher benchmark, and were used by a panel of subject matter experts from the TIMSS countries to develop the benchmark descriptions.[2] The work of the panel involved developing a short description for each item describing the scientific understandings demonstrated by students answering it correctly, summarizing students' knowledge and understanding across the set of items for each benchmark to provide more general statements of achievement, and selecting example items illustrating the descriptions.

How Should the Descriptions Be Interpreted?

In general, the parts of the descriptions that relate to the knowledge of science concepts and skills are relatively straightforward. It needs to be acknowledged, however, that the cognitive behavior necessary to answer some items correctly may vary according to students' experience. An item may require only simple recall for a student familiar with the item's content and context, but necessitate problem-solving strategies from a student unfamiliar with the material. Nevertheless, the descriptions are based on what the panel believed to be the way the great majority of eighth-grade students could be expected to perform when responding to the item.

1 For example, for the Top 10% Benchmark, an item was included if at least 65 percent of students scoring at the scale point corresponding to this benchmark answered the item correctly and less than 50 percent of students scoring at the Upper Quarter Benchmark answered it correctly. Similarly, for the Upper Quarter Benchmark, an item was included if at least 65 percent of students scoring at that point answered the item correctly and less than 50 percent of students at the Median Benchmark answered it correctly.

2 The participants in the scale anchoring process are listed in Appendix E.

It also needs to be emphasized that the descriptions of achievement characteristic of students at the international benchmarks are based solely on student performance on the TIMSS 1999 items. Since those items were developed in particular to sample the science domains prescribed for this study, neither the set of items nor the descriptions based on them purport to be comprehensive. There are undoubtedly other science curriculum elements on which students at the various benchmarks would have been successful if they had been included in the assessment.

Please note that students reaching a particular benchmark demonstrated the knowledge and understandings characterizing that benchmark as well as the competencies of students at the lower benchmarks. The description of achievement at each higher benchmark is cumulative, building on the description of achievement demonstrated by students at the next lower benchmark.

Finally, it must be emphasized that the descriptions of the international benchmarks are provided as one possible way of beginning to examine student performance. Some students scoring below a benchmark may indeed know or understand some of the concepts that characterize a higher level. Thus, it is important to consider performance on the individual items and clusters of items in developing a profile of student achievement in each country.

Several example items are included for each benchmark to complement the descriptions by giving a more concrete notion of the abilities students were able to demonstrate. Each example item is accompanied by the percentage of correct responses for each country as well as the international average. In general, the five or six countries scoring highest on the overall test also were among the top performers on the items used to illustrate the benchmarks. Likewise, the five or six countries with the lowest overall achievement also tended to have consistently low percentages of correct responses on the illustrative items. Not surprisingly, this was true for items assessing the range of performance expectations – recognizing basic facts; understanding simple and complex information; applying scientific understanding to solve problems and provide explanations; interpreting and using data in tables, graphs and diagrams; and demonstrating scientific investigation skills.

Item Examples and Student Performance

The remainder of this chapter describes each benchmark and presents four to six example items illustrating what students know and can do at that level. For each example item, the percent correct for each of the TIMSS 1999 countries is displayed, as well as the international average. The correct answer is circled for multiple-choice items. For open-ended items, the answers shown exemplify the types of student responses that were given full credit. The example items are ones that students reaching each benchmark were likely to answer correctly, and they represent the types of items used to develop the description of achievement at that benchmark.[3]

3 Some of the items used to develop the benchmark descriptions are being kept secure to measure achievement trends in future TIMSS assessments and are not available for publication.

Achievement at the Top 10% Benchmark

Exhibit 2.1 describes performance at the Top 10% Benchmark. Students reaching this benchmark have demonstrated nearly full mastery of the content of the TIMSS 1999 science test, demonstrating a grasp of some complex and abstract concepts, the ability to apply knowledge to solve problems, and an understanding of the fundamentals of scientific investigation. They typically demonstrated success on the knowledge and skills represented by this benchmark, as well as those demonstrated at the Upper Quarter, Median, and Lower Quarter benchmarks.

2.1

Students performing at the Top 10% Benchmark could communicate scientific information, such as their understanding of plant growth. As illustrated by Example Item 1 in Exhibit 2.2, students could explain why a nail placed in the trunk of a tree remained at the same level from the ground despite the increased height of the tree. Internationally on average, 41 percent of the eighth-grade students correctly explained that trees grow from the tips of their stems or branches. In top-performing Belgium (Flemish) and Finland, nearly two-thirds of the students gave a correct response.

2.2

Students at the Top 10% Benchmark typically were able to apply basic physical principles to solve quantitative problems and support their answers in writing. In Example Item 2 (see Exhibit 2.3), given data on fuel consumption and work accomplished for two machines, students could explain which machine is more efficient. To answer correctly, students needed to interpret data in the table, compute the appropriate ratio, and explain their results. Internationally on average, 31 percent of the students identified machine B and gave an explanation comparing the volumes of water each machine pumped with the same amount of gasoline. Only in the Netherlands, Korea, Belgium (Flemish), and the Slovak Republic did at least half of the students give a fully correct response.

2.3

Students at the Top 10% Benchmark also demonstrated an understanding of gravitational force (Example Item 3 in Exhibit 2.4). On average across countries, 36 percent of students recognized that gravity acts on a rocket while on the launch pad, while ascending under power, and while parachuting back to earth. In only four countries did more than half the students do so (Czech Republic, Finland, Hungary, and Slovak Republic). Nearly one-third of students across countries selected option A, indicating that they have the misconception that gravity acts on the rocket only when it is falling back to earth.

2.4

At the Top 10% Benchmark, students typically demonstrated knowledge of most of the chemical concepts covered by the TIMSS 1999 science test, including the structure of matter as well as chemical and physical changes. As shown in Example Item 4 in Exhibit 2.5, students could apply knowledge of the process of filtration and the difference between solutions and mixtures to identify a separable mixture. While 39 percent of students internationally correctly identified the heterogeneous mixture of pepper and water, a nearly equal number exhibited the misconception that a solution could be separated by filtration (option D or E). The Czech Republic and the Slovak Republic had the highest performance, with 62 to 64 percent of their students responding correctly. An additional eight countries had about half (50 to 54 percent) of their students responding correctly. Of the top 10 countries on this item, seven were countries where chemistry is taught as a separate subject at grade 8.

2.5

Students at the Top 10% Benchmark demonstrated some detailed knowledge of environmental and resource issues not seen at the lower benchmarks. Example Item 5 in Exhibit 2.6 shows that students recognized rising ocean levels as a predicted result of global warming. Internationally on average, only one-third of the eighth-grade students responded correctly. In contrast, two-thirds of the Japanese students did so. Internationally, many students incorrectly identified the thinning ozone layer (option D) as a result of global warming.

2.6

Exhibit 2.1 Description of Top 10% TIMSS International Benchmark of Science Achievement

TIMSS 1999 8th grade Science

• Top 10% Benchmark

Summary

Students demonstrate a grasp of some complex and abstract science concepts. They can apply understanding of earth's formation and cycles and of the complexity of living organisms. They show understanding of the principles of energy efficiency, phase change, thermal expansion, light properties, gravitational force, basic structure of matter, and chemical versus physical changes. They demonstrate detailed knowledge of environmental and resource issues. They understand some fundamentals of scientific investigation and can apply basic physical principles to solve some quantitative problems. They can provide written explanations and use diagrams to communicate scientific knowledge.

Students can apply knowledge about earth processes such as formation of mountains and underground caves. Given a soil profile diagram, students can identify the layer containing the most organic material. They can diagram all steps in the water cycle, determine the direction of water flow from a contour map, and recognize precipitation patterns from a diagram of elevation and temperature. They also recognize that the seasons are related to the tilt in earth's axis.

Students show some understanding of the complexity of living organisms. They recognize the hierarchy of organization in living organisms, the definition of tissue, and some animal adaptations needed for survival including physical characteristics and temperature regulation. From a list of organisms, students can identify which one has been on earth for the longest time. They demonstrate understanding of tree growth and of the interrelationships in a food web. In addition, they are able to name a digestive substance found in the human stomach and describe its function.

Students show understanding of physics principles, including efficiency, phase change, thermal expansion, properties of light, and gravitational force. Given data on fuel consumption and work accomplished, students explain which of two machines is more efficient. They also can explain that mass does not change and temperature remains constant during phase change. They can apply knowledge of gas pressure and thermal expansion to explain the effect of heat on the volume of a balloon. They recognize why a red object appears black in green light and explain that a white reflector is more effective than a black one. They also can apply some properties of lenses to human vision and identify the ray diagram depicting light passing through a magnifying glass. Students recognize that gravity acts on a rocket at rest, while ascending, and when returning to earth. They also understand that the surface of a liquid remains horizontal in a tilted container.

Students demonstrate an understanding of the basic structure of matter as well as of chemical and physical changes. They recognize that the nuclei of most atoms are composed of protons and neutrons and that an ion is formed when a neutral atom gains an electron. They can distinguish between chemical and physical changes and recognize that a compound results from the reaction of two elements. They identify oxygen as the gas that causes rust formation and explain why steel beams should be galvanized. Students can distinguish between a pure substance and a mixture, identify a mixture that can be separated by filtration, and recognize that sugar molecules continue to exist when sugar is dissolved in water.

Students show familiarity with environmental and resource issues. They recognize that global warming may lead to rising ocean levels and can explain how acid rain is formed from the burning of fossil fuels. In addition, they can give two reasons why famine occurs.

Students demonstrate understanding of some fundamentals of scientific investigation. They can describe a simple procedure for investigating the effect of exercise on heart rate and recognize the need for repeated measurements.

Students can communicate scientific information. They apply basic physical principles to solve some quantitative problems and develop explanations involving abstract concepts. They can provide answers containing two reasons or consequences and also use diagrams to communicate knowledge.

90th Percentile: 616

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

Exhibit 2.2 Top 10% TIMSS International Benchmark – Example Item 1

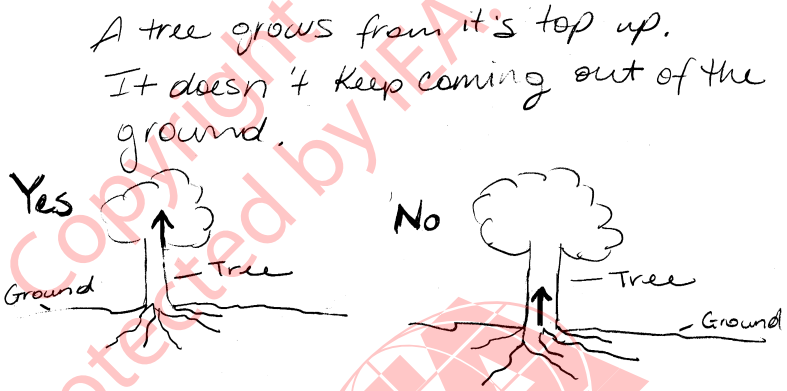
An Item That Students Reaching the Top 10% International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Life Science

Description: Applies knowledge of tree growth to explain why a nail placed in the trunk of a tree remained at the same level from the ground despite the increased height of the tree.

Ethan hammered a nail into the trunk of a young tree. Explain why the nail was still at the same height from the ground twenty years later even though the tree had grown to a height of 22 meters.



The answer shown illustrates the type of student response that was given credit.

	Overall Percent Correct
Belgium (Flemish) †	65 (3.5) ▲
Finland	64 (2.6) ▲
Canada	59 (1.9) ▲
Australia	57 (2.6) ▲
Japan	57 (1.9) ▲
Netherlands †	56 (3.6) ▲
New Zealand	56 (2.4) ▲
Thailand	55 (2.7) ▲
Slovak Republic	55 (3.0) ▲
England †	55 (2.9) ▲
Chinese Taipei	53 (2.0) ▲
Moldova	53 (2.3) ▲
Hungary	50 (2.8) ●
Singapore	49 (2.8) ●
Czech Republic	48 (3.1) ●
Russian Federation	48 (2.7) ●
Cyprus	47 (2.7) ●
Slovenia	45 (2.2) ●
United States	45 (2.2) ●
Turkey	44 (2.4) ●
Italy	43 (2.7) ●
Latvia (LSS) 1	42 (2.8) ●
International Avg.	41 (0.4)
Hong Kong, SAR †	40 (2.1) ●
Israel 2	38 (2.4) ●
Iran, Islamic Rep.	37 (2.0) ●
Lithuania 1‡	36 (2.9) ●
Romania	36 (3.0) ●
Malaysia	33 (1.8) ▼
Korea, Rep. of	33 (1.9) ▼
Chile	30 (1.8) ▼
Bulgaria	29 (3.1) ▼
Jordan	24 (1.6) ▼
Indonesia	23 (1.8) ▼
Tunisia	22 (1.9) ▼
Macedonia, Rep. of	21 (2.1) ▼
Philippines	9 (1.4) ▼
South Africa	8 (1.3) ▼
Morocco	2 (0.5) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.3 Top 10% TIMSS International Benchmark – Example Item 2

An Item That Students Reaching the Top 10% International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Physics

Description: Given data on fuel consumption and work accomplished, determines and explains which of two machines is more efficient.

Machine A and Machine B are each used to pump water from a river. The table shows what volume of water each machine removed in one hour and how much gasoline each of them used.

	Volume of Water Removed in 1 Hour (liters)	Gasoline Used in 1 Hour (liters)
Machine A	1000	1.25
Machine B	500	0.5

a) Which machine is more efficient in converting the energy in gasoline to work?

Answer: B

b) Explain your answer.

1000 ÷ 1.25 = 800
500 ÷ .5 = 1000

Machine B is more efficient because for every liter of gasoline used it removed 1000L of water. With 1L of gasoline Machine A only removes 800L of water.

The answer shown illustrates the type of student response that was given credit.

Netherlands †	58 (3.9) ▲
Korea, Rep. of	52 (1.8) ▲
Belgium (Flemish) †	51 (3.5) ▲
Slovak Republic	50 (2.9) ▲
Singapore	49 (3.2) ▲
Australia	48 (2.8) ▲
Japan	46 (2.1) ▲
Chinese Taipei	44 (2.1) ▲
Canada	43 (1.9) ▲
New Zealand	42 (2.6) ▲
England †	42 (3.0) ▲
Finland	40 (3.0) ●
Lithuania †‡	38 (2.8) ●
Hungary	38 (2.5) ●
Israel 2	35 (2.6) ●
Slovenia	33 (3.0) ●
Russian Federation	33 (2.6) ●
Hong Kong, SAR †	32 (2.0) ●
International Avg.	31 (0.4)
Czech Republic	30 (2.6) ●
United States	30 (1.9) ●
Thailand	28 (2.2) ●
Bulgaria	28 (3.2) ●
Cyprus	27 (2.3) ●
Latvia (LSS) 1	26 (2.5) ●
Italy	23 (2.3) ●
Romania	22 (2.8) ●
Iran, Islamic Rep.	21 (1.8) ▼
Macedonia, Rep. of	20 (2.5) ▼
Malaysia	20 (1.8) ▼
Indonesia	20 (2.1) ▼
Moldova	19 (2.0) ▼
Jordan	19 (1.9) ▼
Tunisia	19 (1.9) ▼
Turkey	17 (2.3) ▼
Chile	8 (1.3) ▼
Morocco	7 (1.0) ▼
Philippines	4 (0.9) ▼
South Africa	3 (0.7) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.4 Top 10% TIMSS International Benchmark – Example Item 3

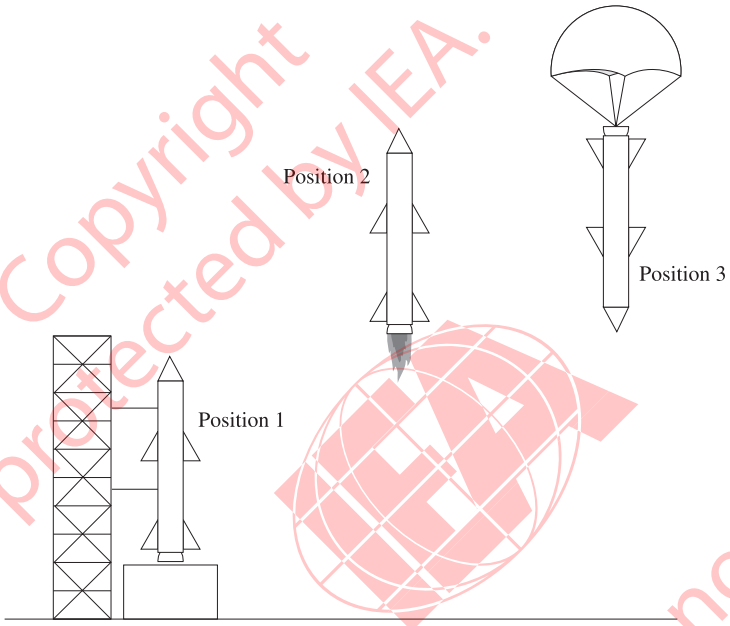
An Item That Students Reaching the Top 10% International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Physics

Description: Applies knowledge of gravitational force by recognizing that gravity acts on a rocket at rest, while ascending, and when returning to Earth.

The drawings show a rocket being launched from Earth and then returning.



In which of the three positions does gravity act on the rocket?

A. 3 only

B. 1 and 2 only

C. 2 and 3 only

(D.) 1, 2 and 3

	Overall Percent Correct
Slovak Republic	68 (2.3) ▲
Czech Republic	65 (3.1) ▲
Hungary	65 (2.7) ▲
Finland	53 (3.0) ▲
Singapore	49 (2.8) ▲
Chinese Taipei	48 (2.3) ▲
Lithuania 1‡	48 (3.1) ▲
Slovenia	46 (3.0) ▲
United States	46 (2.3) ▲
Russian Federation	46 (3.4) ●
Australia	45 (2.3) ▲
Canada	45 (3.3) ●
England †	43 (3.0) ●
Moldova	42 (2.9) ●
Japan	40 (2.0) ●
New Zealand	39 (2.5) ●
Netherlands †	39 (5.3) ●
International Avg.	**36 (0.4)**
Jordan	36 (2.2) ●
Bulgaria	35 (2.5) ●
Thailand	30 (1.9) ●
Iran, Islamic Rep.	30 (2.4) ●
Cyprus	30 (2.6) ●
Romania	29 (2.3) ●
Korea, Rep. of	29 (1.7) ▼
Belgium (Flemish) †	29 (2.2) ▼
Philippines	27 (2.0) ▼
Israel 2	26 (2.4) ▼
Italy	25 (2.3) ▼
Hong Kong, SAR †	24 (1.6) ▼
Latvia (LSS) 1	24 (2.2) ▼
Chile	23 (1.6) ▼
Turkey	22 (1.5) ▼
Malaysia	21 (1.9) ▼
Macedonia, Rep. of	19 (2.3) ▼
Tunisia	19 (1.5) ▼
Morocco	17 (2.0) ▼
South Africa	15 (1.4) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year. Internationally comparable data are unavailable for Indonesia.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

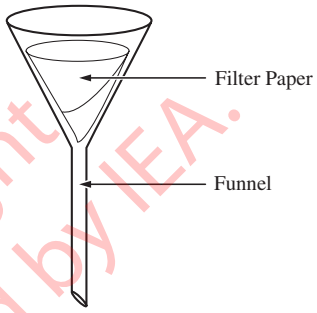
Exhibit 2.5 Top 10% TIMSS International Benchmark – Example Item 4

An Item That Students Reaching the Top 10% International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Chemistry

Description: Applies knowledge of the process of filtration and the difference between solutions and mixtures to identify a separable mixture.



Filtration using the equipment shown above can be used to separate which materials?

A. A mixture of salt and pepper

B. A mixture of pepper and water

C. A mixture of oxygen and water

D. A solution of silver nitrate in water

E. A solution of sugar in water

	Overall Percent Correct
Czech Republic	64 (3.3) ▲
Slovak Republic	62 (2.6) ▲
Lithuania 1‡	54 (3.0) ▲
Finland	54 (3.2) ▲
Latvia (LSS) 1	53 (2.7) ▲
Hungary	52 (2.7) ▲
Korea, Rep. of	51 (1.8) ▲
Russian Federation	50 (2.7) ▲
Canada	50 (1.9) ▲
Singapore	50 (2.6) ▲
Slovenia	48 (2.7) ▲
Netherlands †	48 (3.7) ●
Chinese Taipei	46 (2.0) ▲
Romania	42 (3.3) ●
Japan	42 (2.0) ●
Malaysia	42 (2.1) ●
Australia	41 (2.9) ●
New Zealand	39 (2.2) ●
International Avg.	39 (0.4)
United States	39 (2.1) ●
Cyprus	39 (3.2) ●
Hong Kong, SAR †	38 (2.3) ●
Bulgaria	37 (3.9) ●
Moldova	34 (2.5) ●
England †	34 (2.6) ●
Tunisia	34 (2.0) ●
Belgium (Flemish) †	33 (2.0) ●
Israel 2	32 (1.9) ▼
Italy	30 (2.1) ▼
Thailand	30 (2.1) ▼
Philippines	29 (1.7) ▼
Turkey	28 (1.7) ▼
Macedonia, Rep. of	27 (2.8) ▼
South Africa	27 (1.8) ▼
Jordan	24 (2.2) ▼
Chile	21 (1.6) ▼
Iran, Islamic Rep.	19 (1.7) ▼
Indonesia	15 (1.2) ▼
Morocco	12 (1.3) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.6 Top 10% TIMSS International Benchmark – Example Item 5

An Item That Students Reaching the Top 10% International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Environmental and Resource Issues

Description: Recognizes that rising ocean levels could result from global warming.

What is predicted to be a result of global warming?

A. Rising ocean level

B. More severe earthquakes

C. Larger volcanic eruptions

D. Thinning ozone layer

	Overall Percent Correct
Japan	67 (2.0) ▲
Hong Kong, SAR †	59 (2.3) ▲
Chinese Taipei	58 (2.2) ▲
Lithuania 1‡	57 (3.1) ▲
Singapore	56 (3.1) ▲
Australia	52 (3.6) ▲
Bulgaria	49 (3.5) ▲
Italy	48 (2.5) ▲
Korea, Rep. of	47 (2.1) ▲
Hungary	44 (2.6) ▲
New Zealand	43 (2.9) ▲
Cyprus	42 (2.4) ▲
Slovak Republic	42 (3.0) ●
Russian Federation	38 (3.2) ●
South Africa	37 (2.0) ●
Latvia (LSS) 1	35 (3.1) ●
International Avg.	**33 (0.4)**
England †	33 (2.7) ●
Belgium (Flemish) †	33 (2.7) ●
Netherlands †	33 (3.5) ●
Czech Republic	32 (3.4) ●
Canada	31 (2.9) ●
Finland	31 (2.8) ●
United States	30 (2.1) ●
Moldova	29 (2.4) ●
Slovenia	28 (2.7) ●
Macedonia, Rep. of	25 (2.3) ▼
Israel 2	23 (2.3) ▼
Romania	22 (2.6) ▼
Morocco	22 (2.1) ▼
Jordan	20 (1.9) ▼
Malaysia	18 (1.5) ▼
Chile	16 (1.7) ▼
Philippines	16 (1.5) ▼
Turkey	15 (1.3) ▼
Thailand	13 (1.5) ▼
Tunisia	11 (1.3) ▼
Indonesia	10 (1.3) ▼
Iran, Islamic Rep.	9 (1.1) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

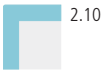
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Achievement at the Upper Quarter Benchmark

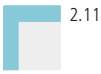
As shown in Exhibit 2.7, students performing at the Upper Quarter Benchmark typically showed a developing understanding of biological systems. Example Item 6 (see Exhibit 2.8) required students to apply knowledge of energy flow to complete a food web diagram. Internationally, 55 percent of students indicated the correct order of energy flow from the providers to the consumers. At least 84 percent of the students in Chinese Taipei, Singapore, Korea, and Malaysia responded correctly to this item.

Even though students at the lower benchmarks demonstrated practical knowledge of rusting and burning, only at the Upper Quarter Benchmark did students typically recognize these as chemical reactions. As shown in Example Item 7 in Exhibit 2.9, 55 percent of students internationally recognized that burning releases energy. However, there was a substantial range in performance across countries, from about one-fifth correct in South Africa and Morocco to about four-fifths correct in Chinese Taipei.

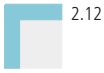
In Example Item 8 (see Exhibit 2.10), students were required to identify rusting as a chemical reaction from a list of chemical and physical changes. On average, slightly less than half of students internationally (49 percent) selected the correct response, compared with 87 percent in top-performing Chinese Taipei. A common misconception demonstrated by students in many countries was that the dissolving of sugar is a chemical reaction (option B).



Example Item 9 in Exhibit 2.11 required some knowledge of insect populations, natural selection, and the effect of human control on the environment. Students at the Upper Quarter Benchmark recognized that insecticides become less effective over time because some insects pass their resistance to their offspring. Internationally, slightly less than half of students (48 percent) chose the correct response, while in 10 countries 60 percent or more (up to 76 percent) of students did so. Many students internationally selected option C, which is a true statement related to the effect of insecticides on the environment, but not the correct explanation for the stated problem.



Students performing at the Upper Quarter Benchmark demonstrated basic scientific inquiry skills such as recognizing the variables to be controlled in an experiment and drawing conclusions from a set of observations. In Example Item 10 (see Exhibit 2.12), students identified the correct conclusion that can be drawn from observing the evaporation



of two different liquids. Internationally, less than half the students (48 percent) chose the correct response. In comparison, more than 70 percent of students in five countries did so – England, Singapore, the Netherlands, the United States, and Australia.

Exhibit 2.7 Description of Upper Quarter TIMSS International Benchmark of Science Achievement

TIMSS 1999 8th grade Science

• Upper Quarter Benchmark

Summary

Students demonstrate conceptual understanding of some science cycles, systems, and principles. They have some understanding of the earth's processes, biological systems and populations, chemical reactions, and composition of matter. They solve physics problems related to light, speed, heat, and temperature and demonstrate basic knowledge of major environmental concerns. They demonstrate some scientific inquiry skills. They can combine information to draw conclusions; interpret information in diagrams, graphs and tables to solve problems; and provide short explanations conveying scientific knowledge in the life sciences.

Students have some understanding of earth's processes. They can recognize a definition of sedimentary rock and that fossil fuels are formed from the remains of living things. They demonstrate some understanding of the water cycle and can recognize how a river changes as it flows from a mountain to a plain. Students recognize some features of the solar system, including the definition of an earth year and the relative distances of the Sun and Moon from the earth.

Students show a developing understanding of biological systems and populations. They interpret a diagram depicting the exchange of gases in a forest ecosystem and apply knowledge of energy flow in an ecosystem to complete a food web diagram. In addition, students recognize that the main function of chlorophyll in plants is to absorb light energy and that plants can extract minerals from natural fertilizers. They recognize that preventing sperm production will reduce the insect population and that insects pass on their resistance to insecticides. They also can identify distinguishing features of insects and determine characteristics used to sort animals into classification groups. Students also demonstrate understanding of some elements of the human circulatory and immune systems and are able to describe how the human body temperature is controlled.

Students can solve some basic problems related to light, heat, and temperature. For example, they can relate shadow size to distance from a light source and draw the image of an object reflected in a mirror. Students recognize that metal conducts heat faster than glass, wood, or plastic and why the height of an alcohol column in a thermometer rises with increasing temperature. Students also can determine speed from distance and time and complete a table showing a proportional relation between voltage and current.

Students have some understanding of chemical reactions and the composition of matter. They can identify burning and rusting as chemical reactions, recognize that burning releases energy, and that most of the chemical energy from burning gasoline in a car engine is wasted as heat. Students can explain which candle will be extinguished first based on the amount of oxygen available. They recognize that sugar is a compound composed of molecules made up of atoms and recognize that nothing remains of an object if all of its atoms are removed.

Students demonstrate basic knowledge of major environmental issues. They can explain why the depletion of the ozone layer may be harmful to people, recognize that increased carbon dioxide in the atmosphere may lead to global warming, and can identify coal as a non-renewable resource. Students can state two reasons why some people do not have enough water to drink.

Students demonstrate basic scientific inquiry skills. In an experimental situation, they recognize which variables to control, draw a conclusion from a set of observations, and distinguish an observation from other types of scientific statements.

Students can combine information to draw conclusions; interpret information in diagrams, graphs and tables to solve problems; and provide short explanations conveying scientific knowledge, particularly in the life sciences.

75th Percentile: 558

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

Exhibit 2.8 Upper Quarter TIMSS International Benchmark – Example Item 6

An Item That Students Reaching the Upper Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Life Science

Description: Applies knowledge of energy flow to complete a food web diagram.

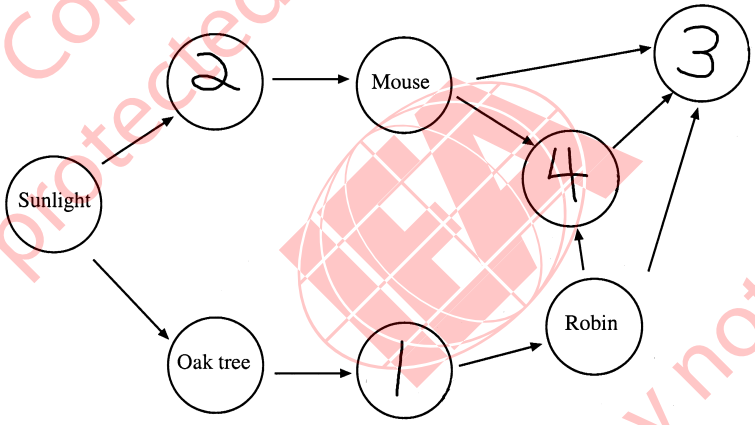
An incomplete food web has been drawn for you. Complete it by filling in each of the empty circles with the number of the correct animal or plant from the list. Remember that the arrows represent energy flow and go from the provider to the user.

1) Caterpillar

2) Corn

3) Hawk

4) Snake



The answer shown illustrates the type of student response that was given credit.

	Overall Percent Correct	
Chinese Taipei	89 (1.4)	▲
Singapore	89 (1.5)	▲
Korea, Rep. of	85 (1.2)	▲
Malaysia	84 (1.8)	▲
England †	75 (2.6)	▲
Bulgaria	70 (2.9)	▲
Hungary	70 (2.6)	▲
Japan	68 (2.0)	▲
Russian Federation	67 (3.2)	▲
Indonesia	66 (2.3)	▲
Romania	65 (3.5)	●
Hong Kong, SAR †	64 (2.3)	▲
Canada	63 (2.7)	●
Belgium (Flemish) †	62 (2.6)	●
Czech Republic	60 (2.9)	●
Australia	60 (2.7)	●
Netherlands †	58 (3.1)	●
Thailand	58 (2.5)	●
Finland	57 (2.9)	●
Moldova	56 (2.7)	●
United States	56 (1.7)	●
International Avg.	55 (0.4)	
Slovak Republic	54 (3.5)	●
Jordan	51 (2.2)	●
Latvia (LSS) 1	50 (2.6)	●
Macedonia, Rep. of	48 (2.7)	●
Slovenia	48 (3.1)	●
Italy	48 (2.3)	●
New Zealand	48 (2.9)	●
Philippines	39 (2.2)	▼
Lithuania 1‡	37 (3.1)	▼
Cyprus	37 (2.8)	▼
Turkey	36 (2.3)	▼
Tunisia	36 (2.3)	▼
Israel 2	35 (2.6)	▼
Iran, Islamic Rep.	35 (1.9)	▼
Chile	28 (1.8)	▼
Morocco	16 (2.0)	▼
South Africa	12 (1.6)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.9 Upper Quarter TIMSS International Benchmark – Example Item 7

An Item That Students Reaching the Upper Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Chemistry

Description: Recognizes that burning wood releases energy.

If you are burning wood, the reaction will

(A.) release energy

B. absorb energy

C. neither absorb nor release energy

D. sometimes release and sometimes absorb energy, depending on the kind of wood

	Overall Percent Correct	
Chinese Taipei	82 (1.0)	▲
Hungary	77 (1.3)	▲
Finland	75 (1.5)	▲
Macedonia, Rep. of	74 (1.5)	▲
Hong Kong, SAR †	70 (1.3)	▲
England †	68 (1.5)	▲
Singapore	68 (2.1)	▲
Iran, Islamic Rep.	66 (1.3)	▲
Canada	66 (1.2)	▲
Korea, Rep. of	65 (1.0)	▲
Russian Federation	65 (2.6)	▲
Malaysia	65 (1.5)	▲
United States	64 (1.5)	▲
Netherlands †	64 (2.9)	●
Bulgaria	63 (2.1)	▲
Belgium (Flemish) †	61 (1.6)	▲
Lithuania †‡	61 (1.9)	●
Japan	59 (1.2)	●
Israel 2	58 (1.9)	●
Australia	58 (1.8)	●
Turkey	58 (1.1)	●
New Zealand	58 (1.6)	●
Slovenia	57 (1.9)	●
International Avg.	**55 (0.3)**	
Italy	54 (1.7)	●
Cyprus	54 (1.6)	●
Slovak Republic	54 (2.2)	●
Moldova	53 (2.0)	●
Jordan	51 (1.7)	●
Czech Republic	47 (1.9)	▼
Romania	46 (2.0)	▼
Thailand	43 (1.4)	▼
Latvia (LSS) 1	40 (2.1)	▼
Indonesia	36 (1.3)	▼
Chile	33 (1.4)	▼
Philippines	30 (1.6)	▼
Tunisia	25 (1.0)	▼
South Africa	20 (1.3)	▼
Morocco	17 (1.0)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.10 Upper Quarter TIMSS International Benchmark – Example Item 8

An Item That Students Reaching the Upper Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Chemistry

Description: From a list of chemical and physical changes, identifies rusting as a chemical reaction.

Which is an example of a chemical reaction?

A. Water boiling

B. Sugar dissolving

C. Nails rusting

D. Wax melting

	Overall Percent Correct
Chinese Taipei	87 (1.1) ▲
Japan	76 (1.9) ▲
Hong Kong, SAR †	72 (2.2) ▲
England †	66 (3.1) ▲
Singapore	64 (2.8) ▲
Netherlands †	64 (2.7) ▲
Russian Federation	60 (2.7) ▲
Korea, Rep. of	59 (1.7) ▲
Iran, Islamic Rep.	58 (2.2) ▲
Malaysia	57 (2.1) ▲
Finland	56 (3.2) ●
Hungary	56 (2.6) ●
Canada	55 (3.2) ●
Bulgaria	54 (3.6) ●
Jordan	54 (2.6) ●
Slovenia	54 (2.8) ●
Australia	53 (2.7) ●
Romania	52 (3.4) ●
United States	52 (1.7) ●
International Avg.	**49 (0.4)**
Belgium (Flemish) †	49 (3.1) ●
Thailand	49 (2.2) ●
Italy	48 (2.5) ●
Latvia (LSS) 1	47 (3.1) ●
Czech Republic	47 (3.5) ●
Slovak Republic	47 (3.3) ●
New Zealand	42 (2.6) ●
Macedonia, Rep. of	40 (2.8) ▼
Cyprus	40 (2.3) ▼
Chile	37 (1.9) ▼
Lithuania 1‡	37 (3.1) ▼
Indonesia	35 (2.0) ▼
Moldova	34 (2.7) ▼
Turkey	32 (1.8) ▼
Israel 2	31 (2.3) ▼
Philippines	30 (1.9) ▼
Morocco	30 (2.0) ▼
Tunisia	23 (1.8) ▼
South Africa	18 (1.6) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.11 Upper Quarter TIMSS International Benchmark – Example Item 9

An Item That Students Reaching the Upper Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Environmental and Resource Issues

Description: Recognizes that insecticides become less effective over time because certain insects pass their resistance to the insecticide to their offspring.

Insecticides are used to control insect populations so that they do not destroy crops. Over time, some insecticides become less effective at killing insects, and new insecticides must be developed. What is the most likely reason insecticides become less effective over time?

A. Surviving insects have learned to include insecticides as a food source.

B. Surviving insects pass their resistance to insecticides to their offspring.

C. Insecticides build up in the soil.

D. Insecticides are concentrated at the bottom of the food chain.

	Overall Percent Correct	
Chinese Taipei	76 (1.7)	▲
Hong Kong, SAR †	74 (2.2)	▲
Hungary	70 (2.8)	▲
Singapore	69 (2.2)	▲
Japan	68 (1.7)	▲
Australia	66 (2.5)	▲
United States	62 (1.8)	▲
Netherlands †	61 (3.5)	▲
Canada	60 (3.0)	▲
Russian Federation	60 (3.6)	●
Finland	57 (3.0)	●
Slovenia	57 (3.1)	●
Czech Republic	57 (3.3)	●
England †	56 (2.6)	●
New Zealand	56 (2.5)	●
Belgium (Flemish) †	53 (2.7)	●
Lithuania 1‡	51 (2.9)	●
Israel 2	51 (2.5)	●
Bulgaria	50 (3.3)	●
Italy	50 (2.3)	●
Thailand	49 (2.4)	●
International Avg.	48 (0.4)	
Romania	48 (2.8)	●
Korea, Rep. of	47 (2.0)	●
Slovak Republic	45 (2.9)	●
Turkey	43 (2.2)	●
Moldova	42 (2.8)	●
Iran, Islamic Rep.	38 (2.3)	▼
Chile	38 (1.9)	▼
Latvia (LSS) 1	38 (2.9)	▼
Macedonia, Rep. of	37 (2.8)	▼
Philippines	33 (1.8)	▼
Jordan	32 (2.1)	▼
Cyprus	31 (2.4)	▼
Indonesia	27 (2.0)	▼
South Africa	25 (1.5)	▼
Malaysia	24 (1.3)	▼
Tunisia	21 (1.6)	▼
Morocco	20 (1.9)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.12 Upper Quarter TIMSS International Benchmark – Example Item 10

An Item That Students Reaching the Upper Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Scientific Inquiry and the Nature of Science

Description: Identifies an appropriate conclusion from observations of evaporating liquids.

Two open bottles, one filled with vinegar and the other with olive oil, were left on a window sill in the Sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation?

A. Vinegar evaporates faster than olive oil.

B. Olive oil evaporates faster than vinegar.

C. Both vinegar and olive oil evaporate.

D. Only liquids containing water evaporate.

E. Direct sunlight is needed for evaporation.

	Overall Percent Correct
England †	78 (2.6) ▲
Singapore	78 (1.9) ▲
Netherlands †	76 (2.8) ▲
United States	76 (1.4) ▲
Australia	70 (2.2) ▲
Israel 2	67 (2.3) ▲
New Zealand	67 (2.6) ▲
Hungary	64 (2.1) ▲
Canada	64 (2.6) ▲
Korea, Rep. of	59 (2.0) ▲
Japan	50 (2.1) ●
Italy	49 (2.9) ●
Jordan	49 (2.2) ●
Belgium (Flemish) †	49 (2.0) ●
Hong Kong, SAR †	49 (2.1) ●
Czech Republic	49 (3.4) ●
International Avg.	**48 (0.4)**
Malaysia	46 (2.3) ●
Bulgaria	45 (3.9) ●
Finland	45 (2.5) ●
Macedonia, Rep. of	44 (2.5) ●
Chinese Taipei	44 (2.0) ●
Indonesia	42 (2.0) ●
Iran, Islamic Rep.	42 (2.4) ●
Turkey	41 (2.0) ▼
Latvia (LSS) 1	41 (2.7) ●
Slovak Republic	40 (3.3) ●
Lithuania 1‡	39 (3.0) ●
Slovenia	39 (2.3) ▼
Morocco	38 (2.2) ▼
Philippines	38 (2.0) ▼
Chile	38 (2.2) ▼
Cyprus	36 (2.6) ▼
Romania	30 (2.5) ▼
South Africa	29 (2.1) ▼
Russian Federation	29 (2.3) ▼
Thailand	28 (2.5) ▼
Tunisia	27 (1.7) ▼
Moldova	19 (1.6) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.8).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Achievement at the Median Benchmark

Exhibit 2.13 describes performance at the Median Benchmark. Students at this benchmark could recognize and communicate basic scientific knowledge across a range of topics. Internationally on average, 66 percent of students extracted relevant information from the data table of planetary conditions to describe why a condition would be hostile to human life (see Example Item 11 in Exhibit 2.14). The majority said that there was too little oxygen in the atmosphere to breathe on Proto. Other common responses that received credit referred to low temperatures due to the greater distance from the sun, and lack of an ozone layer to protect human beings from the sun's radiation.

2.13

2.14

At the Median Benchmark students typically demonstrated some knowledge of the characteristics of animals and plants. In Example 12 (Exhibit 2.15), 70 percent of students on average across countries recognized feeding milk to their young as a characteristic of mammals. In several countries, including Bulgaria, Chinese Taipei, Cyprus, Hong Kong, Iran, Japan, Latvia (LSS), Slovak Republic, and Slovenia, 80 percent or more of students responded correctly.

2.15

Students at the Median Benchmark typically were familiar with some aspects of force and motion. As shown in Example Item 13 in Exhibit 2.16, students could identify the diagram showing forces that would result in rotation. Performance on this item ranged from 36 percent correct in South Africa to 76 percent correct in Japan, with an international average of 62 percent.

2.16

In Example Item 14 (see Exhibit 2.17), students applied knowledge of the concept of electrical circuits and the electrical conductivity of various materials to identify the diagrams that show a complete circuit. Internationally, 64 percent of students on average correctly identified the circuits connected to metallic materials. In Hong Kong, the top-performing country on this item, 84 percent of the students responded correctly.

2.17

At the Median Benchmark, students were able to apply basic knowledge about the role of oxygen or air in rusting and burning. In Example Item 15 (see Exhibit 2.18), 67 percent of students internationally and more than 90 percent of those in top-performing Chinese Taipei recognized that painting iron surfaces inhibits rust by preventing exposure to oxygen and moisture.

2.18

2.19

Students at the Median Benchmark showed some elementary knowledge of the human impact on the environment, as illustrated by Example Item 16 in Exhibit 2.19. Over two-thirds (68 percent) of students on average internationally, and 92 percent of students in Chinese Taipei, recognized that soil erosion is more likely in barren sloping areas.

Exhibit 2.13 Description of Median TIMSS International Benchmark of Science Achievement

TIMSS 1999 8th grade Science

• Median Benchmark

Summary

Students can recognize and communicate basic scientific knowledge across a range of topics. They recognize some characteristics of the solar system, ecosystems, animals and plants, energy sources, force and motion, light reflection and radiation, sound, electrical circuits, and human impact on the environment. They can apply and briefly communicate practical knowledge, extract tabular information, extrapolate from data presented in a simple linear graph, and interpret representational diagrams.

Students demonstrate some familiarity with the solar system. They can identify a planetary condition that would be hostile to human life and explain the effect of relative distance on the apparent size of the planets. Students also recognize that the Sun is the source of energy for earth's water cycle. In addition, they can select the best description of how long the plates making up the earth's surface have been moving.

Students have a basic understanding of ecosystems. They can describe one role of the Sun in ecosystems and can suggest a negative consequence of the introduction of a new species. They have some knowledge of the characteristics of animals and plants. They recognize that mammals feed milk to their young, wolves use their scent to mark their territories, and that seedlings growing in a forest have large leaves to gather light for photosynthesis. They also can identify some functions of blood.

In physics, students are acquainted with some aspects of energy and motion. They recognize examples of fossil fuels, that a compressed spring has stored energy, and that a given sequence of energy changes applies to gasoline burning to power a car. They recognize that an object will move in a straight line when released from a circular path. They can apply practical knowledge of levers to identify the best way to balance two objects of unequal weight and can identify forces resulting in rotation. Students demonstrate some knowledge of light reflection and radiation. They can identify the apparent position of a reflected image in a mirror, recognize that ultraviolet radiation from the sun causes sunburn and that a person feels cooler wearing light-colored clothes because they reflect more radiation. Students also recognize that sound needs to travel through some medium. They can identify a substance based on whether it is attracted to a magnet and apply knowledge of conductors to identify a complete electrical circuit.

In chemistry, students can apply basic knowledge about the role of air in rusting and burning. They recognize that painting iron prevents exposure to oxygen and moisture and that candles burning in closed containers will be extinguished due to a lack of air.

Students demonstrate elementary knowledge of human impact on the environment. They recognize that soil erosion is more likely in barren sloping areas and in areas subject to overgrazing. Students describe a positive effect on farming of a dam located upriver. Also, they provide one reason for the occurrence of famine.

Students can extract information from a table to draw conclusions and interpret representational diagrams. They also can extrapolate from data presented in a simple linear graph. Students can apply knowledge to practical situations and communicate their practical knowledge through brief descriptive responses.

50th Percentile: 488

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

Exhibit 2.14 Median TIMSS International Benchmark – Example Item 11

An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Earth Science

Description: Extracts information from a table of planetary conditions to describe a condition hostile to human life.

Diana and Mario were discussing what it might be like on other planets. Their science teacher gave them data about Earth and an imaginary planet Proto. The table shows these data.

	Earth	Proto
Distance from a star like the Sun	148 640 000 km	902 546 000 km
Atmospheric pressure at surface of planet	101 325 Pa	100 Pa
Atmospheric conditions		
• gas components	21% oxygen 0.03% carbon dioxide 78% nitrogen	5% oxygen 5% carbon dioxide 90% nitrogen
• ozone layer	yes	no
• cloud cover	yes	no

Write down one important reason why it would be difficult for humans to live on Proto if it existed. Explain your answer.

It would be near impossible to breath on Proto because there is too little oxygen in the atmosphere.

The answer shown illustrates the type of student response that was given credit.

	Overall Percent Correct
Slovak Republic	89 (1.4) ▲
Singapore	86 (1.7) ▲
Australia	83 (2.0) ▲
Hungary	83 (1.9) ▲
Canada	82 (2.4) ▲
England †	82 (2.4) ▲
Netherlands †	81 (2.6) ▲
Latvia (LSS) † 1	80 (2.4) ▲
New Zealand	80 (1.9) ▲
Finland	80 (2.6) ▲
Chinese Taipei	79 (1.5) ▲
Slovenia	78 (2.6) ▲
United States	78 (1.6) ●
Belgium (Flemish) †	77 (2.7) ●
Korea, Rep. of	77 (1.5) ●
Czech Republic	75 (3.0) ●
Russian Federation	73 (2.1) ●
Italy	70 (2.4) ●
Hong Kong, SAR †	70 (2.2) ●
Japan	69 (1.7) ●
Lithuania ‡	67 (3.3) ●
Malaysia	67 (2.1) ●
International Avg.	**66 (0.4)**
Bulgaria	65 (2.9) ●
Tunisia	64 (2.2) ▼
Thailand	62 (2.6) ▼
Israel 2	62 (2.8) ▼
Jordan	59 (2.4) ▼
Indonesia	59 (2.5) ▼
Macedonia, Rep. of	58 (2.8) ▼
Chile	57 (2.4) ▼
Cyprus	51 (3.0) ▼
Moldova	51 (2.8) ▼
Romania	48 (3.2) ▼
Turkey	47 (2.0) ▼
Iran, Islamic Rep.	45 (2.3) ▼
Philippines	26 (2.3) ▼
Morocco	25 (2.1) ▼
South Africa	21 (2.4) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.15: Median TIMSS International Benchmark – Example Item 12

An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Life Science

Description: Recognizes that feeding milk to its young is a defining characteristic of mammals.

A small animal called the duckbilled platypus lives in Australia. Which characteristic of this animal shows that it is a mammal?

A. It eats other animals.

B. It feeds its young milk.

C. It makes a nest and lays eggs.

D. It has webbed feet.

	Overall Percent Correct
Slovenia	89 (1.0) ▲
Japan	86 (0.8) ▲
Bulgaria	85 (1.6) ▲
Iran, Islamic Rep.	84 (1.1) ▲
Hong Kong, SAR †	83 (1.2) ▲
Slovak Republic	81 (1.3) ▲
Chinese Taipei	80 (1.1) ▲
Latvia (LSS) 1	80 (1.4) ▲
Cyprus	80 (1.1) ▲
Czech Republic	79 (1.9) ▲
Malaysia	78 (1.4) ▲
Hungary	78 (1.5) ▲
Korea, Rep. of	77 (1.1) ▲
Singapore	77 (1.8) ▲
Russian Federation	76 (2.1) ●
Romania	73 (2.1) ●
Thailand	71 (1.4) ●
Finland	71 (1.5) ●
Belgium (Flemish) †	70 (1.7) ●
Lithuania 1‡	70 (1.8) ●
Macedonia, Rep. of	70 (1.6) ●
International Avg.	**70 (0.2)**
Italy	70 (1.6) ●
Chile	68 (1.0) ●
Moldova	68 (2.0) ●
Tunisia	67 (1.2) ●
Canada	66 (1.0) ▼
Turkey	65 (1.1) ▼
United States	65 (1.6) ▼
Indonesia	64 (1.5) ▼
Jordan	63 (1.3) ▼
Australia	63 (1.7) ▼
Netherlands †	62 (1.8) ▼
Israel 2	60 (1.7) ▼
New Zealand	54 (1.8) ▼
England †	52 (2.0) ▼
South Africa	46 (1.5) ▼
Morocco	45 (1.3) ▼
Philippines	30 (1.5) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.16 Median TIMSS International Benchmark – Example Item 13

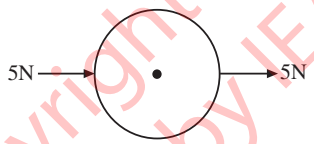
An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

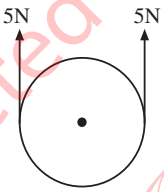
TIMSS 1999 8th grade Science

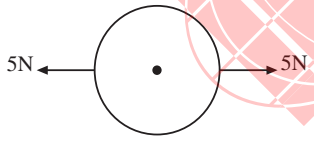
Content Area: Physics

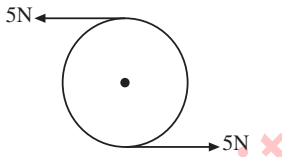
Description: Identifies the diagram that shows the forces acting on a wheel that will result in rotation.

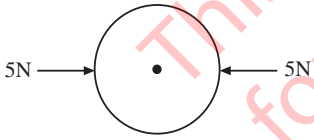
A uniform wheel is free to rotate on its axle at its center. It is acted on by two forces in the same plane. Each force has the same size, equal to 5N (Newtons). In which case will the wheel rotate?

A.


B.


C.


D.


E.


	Overall Percent Correct
Japan	76 (1.6) ▲
Hungary	74 (2.3) ▲
Lithuania ‡	72 (2.8) ▲
Latvia (LSS) 1	72 (2.6) ▲
Czech Republic	69 (2.4) ●
Netherlands †	69 (3.3) ●
Finland	69 (2.2) ▲
Slovenia	69 (2.4) ●
Russian Federation	68 (2.7) ●
Thailand	67 (1.9) ●
Bulgaria	67 (3.2) ●
Italy	66 (2.7) ●
Canada	66 (2.6) ●
Slovak Republic	66 (2.5) ●
Belgium (Flemish) †	64 (2.3) ●
Korea, Rep. of	63 (1.7) ●
Romania	63 (3.2) ●
United States	62 (1.7) ●
Moldova	62 (3.3) ●
International Avg.	62 (0.4)
Hong Kong, SAR †	62 (1.9) ●
England †	61 (2.6) ●
Chile	60 (2.1) ●
Australia	60 (2.1) ●
Singapore	60 (2.3) ●
Jordan	60 (2.4) ●
New Zealand	59 (2.2) ●
Tunisia	58 (2.0) ●
Malaysia	58 (1.9) ●
Chinese Taipei	58 (2.2) ●
Cyprus	57 (2.7) ●
Turkey	57 (2.1) ●
Israel 2	57 (2.1) ●
Morocco	55 (2.3) ●
Iran, Islamic Rep.	54 (1.9) ▼
Macedonia, Rep. of	54 (2.9) ●
Indonesia	52 (2.5) ▼
Philippines	49 (2.0) ▼
South Africa	36 (1.9) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.17 Median TIMSS International Benchmark – Example Item 14

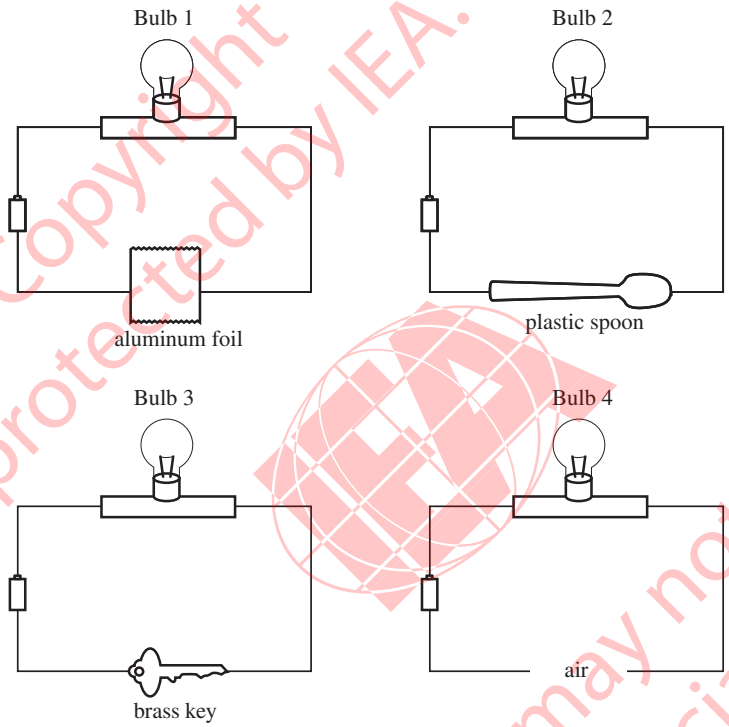
An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Physics

Description: Applies concept of electrical circuits and knowledge of conductors to identify diagrams that show a complete circuit.

The following diagrams show a battery and a bulb connected by wires to various materials.



Which of the bulbs will light?

A. 1 only

B. 2 and 3 only

C. 1 and 3 only

D. 1, 3 and 4 only

E. 1, 2 and 3 only

	Overall Percent Correct
Hong Kong, SAR †	84 (1.8) ▲
Russian Federation	82 (2.4) ▲
Belgium (Flemish) †	81 (1.9) ▲
Chinese Taipei	80 (1.6) ▲
Singapore	79 (2.1) ▲
Israel 2	79 (1.9) ▲
Korea, Rep. of	78 (1.7) ▲
Netherlands †	78 (2.7) ▲
Hungary	74 (2.3) ▲
Australia	73 (2.1) ▲
Malaysia	72 (1.8) ▲
Czech Republic	72 (2.7) ●
Slovak Republic	71 (2.5) ●
Jordan	70 (2.0) ●
Cyprus	69 (2.3) ●
Finland	68 (3.0) ●
Japan	68 (1.9) ●
Thailand	65 (2.1) ●
Slovenia	65 (2.7) ●
England †	65 (2.6) ●
Tunisia	65 (2.2) ●
United States	64 (1.7) ●
International Avg.	64 (0.4)
New Zealand	64 (2.6) ●
Lithuania 1‡	63 (2.6) ●
Canada	60 (2.2) ●
Bulgaria	57 (3.1) ●
Romania	57 (2.7) ●
Italy	56 (2.3) ▼
Morocco	56 (2.0) ▼
Latvia (LSS) 1	56 (3.5) ●
Indonesia	52 (2.4) ▼
Chile	50 (2.1) ▼
Moldova	48 (2.8) ▼
Macedonia, Rep. of	48 (2.7) ▼
Turkey	46 (2.2) ▼
Iran, Islamic Rep.	43 (1.9) ▼
Philippines	42 (1.9) ▼
South Africa	33 (2.0) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.18 Median TIMSS International Benchmark – Example Item 15

An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Chemistry

Description: Recognizes that painting iron prevents exposure to oxygen and moisture.

Paint applied to an iron surface prevents the iron from rusting. Which ONE of the following provides the best reason?

A. It prevents nitrogen from coming in contact with the iron.

B. It reacts chemically with the iron.

C. It prevents carbon dioxide from coming in contact with the iron.

D. It makes the surface of the iron smoother.

E. It prevents oxygen and moisture from coming in contact with the iron.

	Overall Percent Correct
Chinese Taipei	91 (0.7) ▲
Finland	83 (1.3) ▲
Russian Federation	81 (1.3) ▲
Hungary	81 (1.3) ▲
Singapore	81 (1.8) ▲
Netherlands †	80 (2.2) ▲
Hong Kong, SAR †	79 (1.4) ▲
Jordan	78 (1.2) ▲
England †	76 (1.6) ▲
Bulgaria	76 (1.7) ▲
Iran, Islamic Rep.	76 (1.3) ▲
Lithuania 1‡	74 (1.6) ▲
Slovak Republic	73 (1.5) ▲
Korea, Rep. of	73 (1.1) ▲
Canada	72 (1.6) ●
Australia	72 (1.7) ●
Czech Republic	72 (1.8) ●
Romania	71 (1.7) ●
Thailand	70 (1.2) ●
Slovenia	70 (1.6) ●
Japan	70 (1.3) ●
Belgium (Flemish) †	70 (1.6) ●
Latvia (LSS) 1	69 (1.7) ●
International Avg.	**67 (0.2)**
New Zealand	66 (1.7) ●
United States	66 (1.4) ●
Israel 2	66 (1.7) ●
Malaysia	66 (1.7) ●
Italy	65 (1.6) ●
Macedonia, Rep. of	65 (1.8) ●
Chile	64 (1.1) ●
Cyprus	62 (1.6) ▼
Turkey	58 (0.9) ▼
Philippines	48 (1.6) ▼
Moldova	47 (1.9) ▼
Indonesia	47 (1.5) ▼
Tunisia	44 (1.3) ▼
South Africa	26 (1.7) ▼
Morocco	24 (1.1) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998–1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8 for details).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.19 Median TIMSS International Benchmark – Example Item 16

An Item That Students Reaching the Median International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Environmental and Resource Issues

Description: Recognizes that soil erosion is more likely in barren sloping areas.

Rain and running water can wash away soil. From which area is soil most likely to be washed away?

A. A sloping area with bushes

B. A flat area with grasses

C. A flat area that is barren

D. A sloping area that is barren

	Overall Percent Correct	
Chinese Taipei	92 (0.7)	▲
Singapore	88 (1.2)	▲
Slovak Republic	85 (1.3)	▲
Hong Kong, SAR †	85 (1.1)	▲
Netherlands †	83 (2.9)	▲
Korea, Rep. of	83 (0.9)	▲
Malaysia	81 (1.1)	▲
Russian Federation	80 (1.3)	▲
Japan	79 (1.0)	▲
England †	78 (1.4)	▲
Australia	78 (1.3)	▲
Canada	76 (1.3)	▲
Cyprus	76 (1.3)	▲
Latvia (LSS) 1	75 (1.7)	▲
Slovenia	75 (1.5)	▲
Tunisia	74 (1.1)	▲
Czech Republic	73 (1.8)	●
Indonesia	73 (1.5)	▲
United States	73 (1.6)	●
New Zealand	71 (1.3)	●
Hungary	70 (1.2)	●
Thailand	69 (1.3)	●
Belgium (Flemish) †	68 (1.3)	●
Finland	68 (1.7)	●
International Avg.	68 (0.2)	
Lithuania 1‡	66 (1.7)	●
Jordan	65 (1.5)	●
Romania	65 (1.7)	●
Israel 2	63 (1.8)	●
Italy	59 (1.8)	▼
Macedonia, Rep. of	55 (1.7)	▼
Bulgaria	52 (2.0)	▼
Chile	52 (1.3)	▼
Moldova	50 (2.0)	▼
Turkey	49 (1.4)	▼
Iran, Islamic Rep.	44 (1.3)	▼
Morocco	42 (1.0)	▼
Philippines	39 (1.8)	▼
South Africa	26 (1.7)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8 for details).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Achievement at the Lower Quarter Benchmark

2.20 Exhibit 2.20 describes performance at the Lower Quarter Benchmark. At this level of performance, students typically demonstrated knowledge of some basic facts about the earth's physical features and could use information presented in simple diagrams. In Example Item 17 (see Exhibit 2.21), 82 percent of students internationally were able to interpret the pictorial diagram of the earth's layers and identify the center as the hottest layer. Ninety percent or more of students in 13 countries responded correctly.

2.21

In the life sciences, students at the Lower Quarter Benchmark showed some basic knowledge of human biology. A full 87 percent of students internationally recognized that exercise causes an increase in their breathing and pulse rates (see Example Item 18 in Exhibit 2.22). However, students did not relate this common knowledge to the function of the circulatory or respiratory system until the higher benchmarks.

2.22

At the Lower Quarter Benchmark, students recognized some facts about familiar physical phenomena. In Example Item 19 in Exhibit 2.23, they demonstrated basic knowledge of light reflection by recognizing that white surfaces reflect more light than colored surfaces, but without the further understanding of light properties shown by students at the higher benchmarks. Internationally, 82 percent of students on average and more than half of students in all countries answered this item correctly.

2.23

Students at the Lower Quarter Benchmark also recognized the relationship between larger surface area and increased evaporation rate as shown in Example Item 20 in Exhibit 2.24. Internationally on average, 84 percent of students could interpret the pictorial diagrams showing liquid in containers of different shapes and identify the container with the largest surface area as the one from which the liquid would evaporate first. This item was answered correctly by at least 90 percent of students in nearly half of the countries.

2.24

Exhibit 2.20 Description of Lower Quarter TIMSS International Benchmark of Science Achievement

TIMSS 1999 8th grade Science

• Lower Quarter Benchmark

Summary

Students recognize some basic facts from the earth, life, and physical sciences presented using non-technical language. They can identify some of the earth's physical features, have some knowledge of the human body, and demonstrate familiarity with everyday physical phenomena. They can interpret and use information presented in simple diagrams.

Students know a few basic facts about the earth's physical features and solar system. For example, they can select the hottest of earth's layers, recognize that there is less oxygen at higher altitudes and know that the moon reflects sunlight.

Students demonstrate some basic knowledge of human biology and plant features. They recognize that nerves carry sensory messages to the brain, that traits are inherited from both parents and transferred through sperm and egg, that exercise leads to increased breathing and pulse rates, and that vitamins are necessary for human nutrition. They also recognize that seeds develop from flowers of a plant and can state one role of trees in a rainforest.

Students recognize some facts about familiar physical phenomena. They can recognize the correct arrangement of flashlight batteries, the container where evaporation would be greatest, and that fanning a fire makes it burn faster by supplying more oxygen. Students also know some basic facts about light reflection. They can identify the path of light reflected from a mirror, recognize that objects are visible because of reflected light and that white surfaces reflect more light than colored surfaces. They also recognize that a powder made up of both black and white specks is likely to be a mixture.

Students can interpret uncomplicated pictorial diagrams.

25th Percentile: 410

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

Exhibit 2.21 Lower Quarter TIMSS International Benchmark – Example Item 17

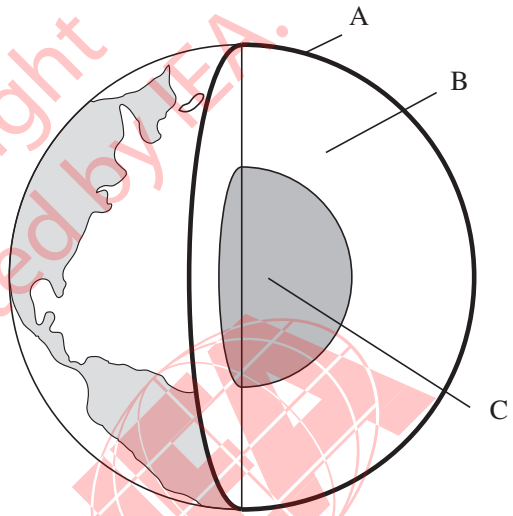
An Item That Students Reaching the Lower Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Earth Science

Description: Interprets a diagram of the Earth's layers and identifies the center as the hottest.

The picture shows the three main layers of the Earth.



Where is it the hottest?

A. Layer A

B. Layer B

C. Layer C

D. All three layers are the same temperature.

	Overall Percent Correct
Slovenia	96 (0.5) ▲
Slovak Republic	95 (0.6) ▲
Canada	94 (0.5) ▲
Bulgaria	94 (0.8) ▲
Netherlands †	93 (2.3) ▲
Finland	93 (0.9) ▲
England †	93 (0.9) ▲
United States	92 (0.7) ▲
Hungary	92 (0.9) ▲
Italy	91 (0.9) ▲
Czech Republic	91 (1.3) ▲
Russian Federation	90 (1.1) ▲
Australia	90 (1.0) ▲
New Zealand	89 (0.9) ▲
Japan	89 (0.7) ▲
Belgium (Flemish) †	89 (1.6) ▲
Hong Kong, SAR †	88 (0.8) ▲
Korea, Rep. of	85 (0.8) ▲
Chinese Taipei	84 (0.8) ●
Singapore	84 (1.2) ●
Lithuania †‡	83 (1.5) ●
Latvia (LSS) 1	83 (1.3) ●
International Avg.	**82 (0.2)**
Israel 2	80 (1.1) ●
Moldova	79 (1.5) ●
Jordan	79 (1.0) ▼
Malaysia	78 (1.1) ▼
Macedonia, Rep. of	77 (1.4) ▼
Cyprus	77 (1.1) ▼
Turkey	75 (1.1) ▼
Chile	74 (1.1) ▼
Iran, Islamic Rep.	72 (1.2) ▼
Thailand	72 (1.4) ▼
Romania	70 (1.5) ▼
Philippines	67 (1.5) ▼
Tunisia	67 (1.1) ▼
Indonesia	64 (1.1) ▼
South Africa	61 (1.0) ▼
Morocco	54 (1.0) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.22 Lower Quarter TIMSS International Benchmark – Example Item 18

An Item That Students Reaching the Lower Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Life Science

Description: Recognizes that exercise causes an increase in breathing and pulse rates.

Immediately before and after running a 50 meter race, your pulse and breathing rates are taken. What changes would you expect to find?

A. no change in pulse but a decrease in breathing rate

B. an increase in pulse but no change in breathing rate

C. an increase in pulse and breathing rate

D. a decrease in pulse and breathing rate

E. no change in either

	Overall Percent Correct	
Japan	98 (0.3)	▲
Hungary	97 (0.5)	▲
Singapore	96 (0.6)	▲
Netherlands †	95 (1.2)	▲
Belgium (Flemish) †	95 (1.4)	▲
England †	95 (1.0)	▲
Slovenia	95 (0.6)	▲
Korea, Rep. of	95 (0.4)	▲
Lithuania ‡	95 (0.8)	▲
Canada	94 (0.6)	▲
Chinese Taipei	94 (0.5)	▲
Finland	94 (0.6)	▲
Czech Republic	94 (1.1)	▲
Australia	94 (0.8)	▲
Hong Kong, SAR †	93 (0.6)	▲
Tunisia	92 (0.5)	▲
Slovak Republic	92 (1.0)	▲
Bulgaria	92 (1.2)	▲
Latvia (LSS) † 1	92 (0.9)	▲
United States	91 (0.5)	▲
New Zealand	90 (0.8)	▲
Malaysia	89 (0.9)	●
Russian Federation	89 (1.0)	●
Italy	89 (0.9)	●
Cyprus	88 (0.8)	●
International Avg.	87 (0.2)	
Thailand	87 (1.0)	●
Israel 2	86 (1.2)	●
Macedonia, Rep. of	86 (1.2)	●
Moldova	85 (1.2)	●
Romania	84 (1.3)	●
Chile	83 (0.8)	▼
Indonesia	83 (1.1)	▼
Jordan	83 (0.9)	▼
Turkey	79 (1.3)	▼
Iran, Islamic Rep.	79 (1.0)	▼
Philippines	59 (1.8)	▼
Morocco	58 (1.3)	▼
South Africa	36 (1.4)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.23 Lower Quarter TIMSS International Benchmark – Example Item 19

An Item That Students Reaching the Lower Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Physics

Description: Recognizes that white surfaces reflect more light than colored surfaces.

The walls of a building are to be painted to reflect as much light as possible. What color should they be painted?

A. White

B. Red

C. Black

D. Pink

	Overall Percent Correct	
Belgium (Flemish) †	94 (0.8)	▲
Hungary	94 (0.8)	▲
Slovak Republic	92 (0.8)	▲
Netherlands †	92 (1.3)	▲
Singapore	91 (0.9)	▲
Slovenia	91 (0.9)	▲
Czech Republic	90 (1.0)	▲
Russian Federation	90 (1.1)	▲
Australia	89 (0.9)	▲
England †	89 (1.1)	▲
Chinese Taipei	89 (0.7)	▲
Lithuania 1‡	88 (1.1)	▲
Malaysia	87 (0.8)	▲
Japan	87 (0.9)	▲
Bulgaria	86 (1.0)	▲
Romania	86 (1.3)	●
Latvia (LSS) 1	86 (1.0)	▲
Hong Kong, SAR †	85 (0.8)	▲
Finland	85 (1.1)	●
Israel 2	85 (0.8)	▲
Canada	83 (1.2)	●
United States	83 (0.8)	●
International Avg.	82 (0.2)	
Italy	82 (1.3)	●
New Zealand	81 (1.3)	●
Philippines	80 (1.0)	●
Korea, Rep. of	78 (0.9)	▼
Indonesia	78 (0.9)	▼
Macedonia, Rep. of	77 (1.2)	▼
Cyprus	76 (1.0)	▼
Moldova	75 (1.7)	▼
Turkey	75 (1.1)	▼
Chile	75 (1.0)	▼
Iran, Islamic Rep.	73 (1.1)	▼
Thailand	73 (1.2)	▼
Tunisia	73 (1.1)	▼
Jordan	70 (1.1)	▼
South Africa	69 (0.8)	▼
Morocco	56 (1.2)	▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

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( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 2.24 Lower Quarter TIMSS International Benchmark – Example Item 20

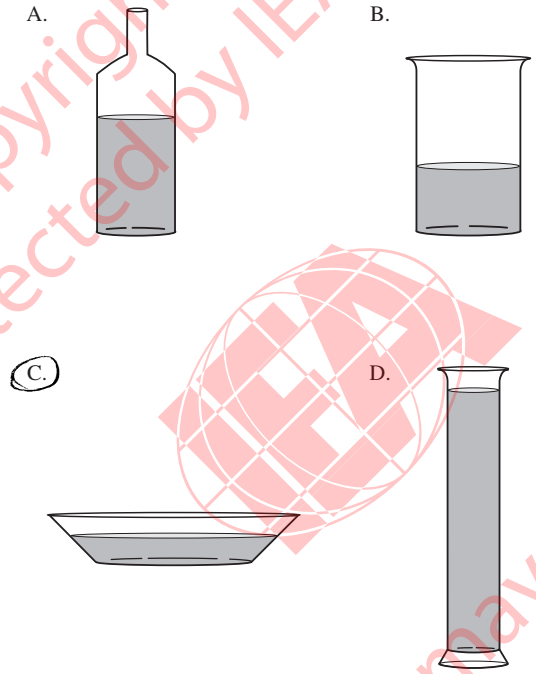
An Item That Students Reaching the Lower Quarter International Benchmark Are Likely to Answer Correctly*

TIMSS 1999 8th grade Science

Content Area: Physics

Description: Recognizes the relationship between surface area and evaporation rate.

A student put 100 mL of water in each of the open containers and let them stand in the sun for one day. Which container would probably lose the most water due to evaporation?



	Overall Percent Correct
Singapore	98 (0.8) ▲
Hungary	95 (1.1) ▲
Korea, Rep. of	95 (0.8) ▲
Russian Federation	95 (1.4) ▲
Czech Republic	94 (1.6) ▲
Japan	94 (1.2) ▲
Slovak Republic	94 (1.7) ▲
Hong Kong, SAR †	93 (1.2) ▲
Moldova	93 (1.5) ▲
Bulgaria	93 (1.4) ▲
Malaysia	93 (1.2) ▲
Chinese Taipei	93 (0.9) ▲
England †	92 (1.7) ▲
Canada	91 (1.2) ▲
Australia	90 (1.8) ▲
Latvia (LSS) 1	90 (1.5) ▲
Lithuania 1‡	90 (2.2) ●
Israel 2	89 (1.4) ▲
Netherlands †	89 (4.7) ●
Romania	88 (1.8) ●
Cyprus	88 (1.6) ●
New Zealand	88 (1.6) ●
Jordan	87 (1.6) ●
Finland	86 (2.0) ●
Thailand	85 (1.7) ●
International Avg.	84 (0.3)
Belgium (Flemish) †	84 (3.1) ●
United States	84 (1.3) ●
Slovenia	83 (2.0) ●
Macedonia, Rep. of	83 (2.2) ●
Indonesia	75 (1.5) ▼
Tunisia	75 (1.5) ▼
Turkey	74 (1.6) ▼
Chile	72 (1.7) ▼
Italy	70 (2.3) ▼
Iran, Islamic Rep.	69 (1.9) ▼
Philippines	60 (2.2) ▼
South Africa	53 (1.9) ▼
Morocco	45 (2.9) ▼

▲ Country average significantly higher than international average

● No statistically significant difference between country average and international average

▼ Country average significantly lower than international average

Significance tests adjusted for multiple comparisons

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

* The item was answered correctly by a majority of students reaching this benchmark.

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.8).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.5). Because coverage falls below 65%, Latvia is annotated LSS for Latvian-Speaking Schools only.

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.5).

‡ Lithuania tested the same cohort of students as other countries, but later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

What Issues Emerge from the Benchmark Descriptions?

The benchmark descriptions and example items reveal a gradation in achievement from the top-performing students' ability to grasp complex and abstract science concepts, apply knowledge to solve problems, and understand the fundamentals of scientific investigation, to the lower-performing students' recognition of basic facts and familiarity with everyday physical phenomena. The fact that even at the Median Benchmark students had only a very limited knowledge of chemical concepts suggests a need to increase the coverage of chemistry topics in science curricula. In addition, knowledge of systems and cycles in the life and physical sciences was not demonstrated until the upper benchmarks, indicating that more emphasis in these areas may be needed. Basic scientific inquiry skills also were not demonstrated until the upper benchmarks, revealing that science curricula in many countries may not be stressing scientific investigation by grade 8.

In reviewing the item-level results, it also is important to note the variation in performance across the topics covered. For example, on the 20 items presented in this chapter, there was a substantial range in performance for many countries. While some countries consistently ranked high or low in performance, and others had results consistently near the international average, 28 countries performed significantly above the international average on at least one item and significantly below the international average on at least one item (Australia, Belgium (Flemish), Bulgaria, Canada, Cyprus, the Czech Republic, England, Finland, Hong Kong, Indonesia, Iran, Israel, Italy, Jordan, Korea, Latvia (LSS), Lithuania, Macedonia, Malaysia, Moldova, the Netherlands, New Zealand, the Russian Federation, the Slovak Republic, Slovenia, Thailand, Tunisia, and the United States). For example, the Czech Republic had the highest percentage correct on the chemistry item requiring students to identify the heterogeneous mixture that can be separated by filtration (Exhibit 2.5), but performed significantly below the international average on the item requiring knowledge that a burning reaction releases energy (Exhibit 2.9). In some cases, differences of this sort may reflect intended differences in emphasis in national curricula. It is likely, however, that such results may be unintended, and the findings will provide important information about strengths and weaknesses in the intended or implemented curricula. At the very least, an in-depth examination of the TIMSS 1999 results may reveal aspects of curricula that merit further investigation.