CHAPTER 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 entities 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.

To provide an idea of the science understandings and skills displayed by students performing at different levels on the TIMSS science achievement scale, TIMSS described performance at four 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 TIMSS 1999 study. (The benchmarks were set at the 90th, 75th, 50th, and 25th percentiles, respectively.)

As states and school districts spend time and energy on improving students' science achievement, 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 range of achievement results for the TIMSS 1999 Benchmarking participants presented in Chapter 1, this chapter describes eighth-grade science achievement at each of the TIMSS 1999 international benchmarks, explaining the types of science understandings and skills typically displayed by students performing at the benchmarks. The benchmark descriptions are presented together with examples of the types of science test questions typically answered correctly by students reaching the benchmark. Appendix D contains the descriptions of the understandings and skills assessed by each item in the TIMSS 1999 assessment at each benchmark.[1]

For each of the example test questions, the percentages of correct responses are provided for selected countries as well as for the jurisdictions participating in the TIMSS 1999 Benchmarking project. The countries and Benchmarking jurisdictions are presented in descending order, with those performing highest shown first. The countries included for purposes of comparison are the United States as well as a dozen European and Asian countries of interest. These include several high-performing European countries (Belgium (Flemish), the Czech Republic, the Netherlands, and the Russian Federation), countries that are major economic trading partners of the United States (Canada, England, and Italy), and the top-scoring Asian countries of Chinese Taipei, Hong Kong, Japan, Korea, and Singapore.

Presented previously in Chapter 1, Exhibit 1.4 shows the percentages of students in each participating entity reaching each international benchmark – Top 10%, Upper Quarter, Median, and Lower Quarter. If an entity had high average achievement in science and a large percentage of its students at or above the upper benchmarks, this indicates that the students are concentrated among the highest-achieving students internationally. For example, top-performing Singapore had nearly

[1] For a detailed description of the items and benchmarks for TIMSS 1995 at fourth and eighth grades and how they compare to the National Research Council's National Science Education Standards, see Smith, T.A., Martin, M.O., Mullis, I.V.S., and Kelly, D.L. (2000), *Profiles of Student Achievement in Science at the TIMSS International Benchmarks: U.S. Performance and Standards in an International Context,* Chestnut Hill, MA: Boston College.

one-third (32 percent) of its students reaching the Top 10% Benchmark and more than half (56 percent) reaching the Upper Quarter Benchmark – the point on the scale that typically only 25 percent of the students would be expected to reach if achievement were distributed equally from country to country. Four-fifths of the Singaporean students (80 percent) reached the Median Benchmark. Performance in the United States was a little better than might be expected if achievement were distributed the same from country to country: 15 percent of the students reached the Top 10% Benchmark, 34 percent reached the Upper Quarter Benchmark, and 62 percent reached the Median Benchmark.

The analysis of performance at these benchmarks in science suggests that six primary factors appeared to differentiate performance at 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
- 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 answered 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.) Certain 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 those at the next lower benchmark were unlikely to answer correctly.[2] The sets of items thus produced represented the accomplishments of students reaching each benchmark and were used by a panel of subject matter experts from the TIMSS countries to develop the benchmark descriptions.[3] 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 understandings 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 to 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 one 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.

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.

2 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.

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

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

Finally, it must be emphasized that the descriptions of the international benchmarks are 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 participating entity.

Several example items are included for each benchmark to complement the descriptions by giving a more concrete notion of the abilities students demonstrated. Each example item is accompanied by the percentage of correct responses for each TIMSS 1999 Benchmarking participant. Percentages are also provided for selected countries, as is the international average for all 38 countries that participated in TIMSS 1999. In general, the several entities scoring highest on the overall test also scored highest on many of the example 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. 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.[4]

[4] 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 three lower benchmarks.

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 while the tree increased in height. Internationally on average, 41 percent of the eighth-grade students correctly explained that trees grow in height from the tips of their stems or branches. In Belgium (Flemish), the comparison country with most success on this item, nearly two-thirds of the students gave a correct response. Among the Benchmarking participants, eighth graders in the Naperville School District did as well as their counterparts in Belgium, with 63 percent answering correctly. In Michigan, Oregon, and Montgomery County, also, the percentage of students answering correctly was significantly greater than the international average. Generally, students in the United States – in the country as a whole and in the Benchmarking jurisdictions – performed at about the international average on this item. Miami-Dade was the only Benchmarking participant where the students performed significantly below the international average.

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 were asked to 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 the two machines pumped with the same amount of gasoline. Only in the Netherlands, Korea, and Belgium (Flemish) did a majority of the students give a fully correct response. Among Benchmarking participants, students in Naperville and the Michigan Invitational Group performed significantly above the international average, and students in Maryland, North and South Carolina, Chicago, Miami-Dade, and Rochester performed below it.

• 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.

Students at the Top 10% Benchmark also demonstrated an understanding of gravitational force (see in Example Item 3 in Exhibit 2.4). On average across countries, 36 percent of students recognized that gravity acts on a rocket while it is on the launch pad, while it ascends under power, and while it parachutes back to earth. This was quite a difficult question internationally, with only three of the comparison countries performing significantly above the international average (the Czech Republic, Singapore, and Chinese Taipei), and four performing below it (Korea, Belgium (Flemish), Italy, and Hong Kong). Nearly one-third of students across countries selected option A, indicating their misconception that gravity acts on the rocket only when it is falling back to earth. Students in the United States and in many of the Benchmarking entities performed relatively well on this question, with 15 entities having above-average performance. Only the public school systems of Miami-Dade and Chicago had below-average performance.

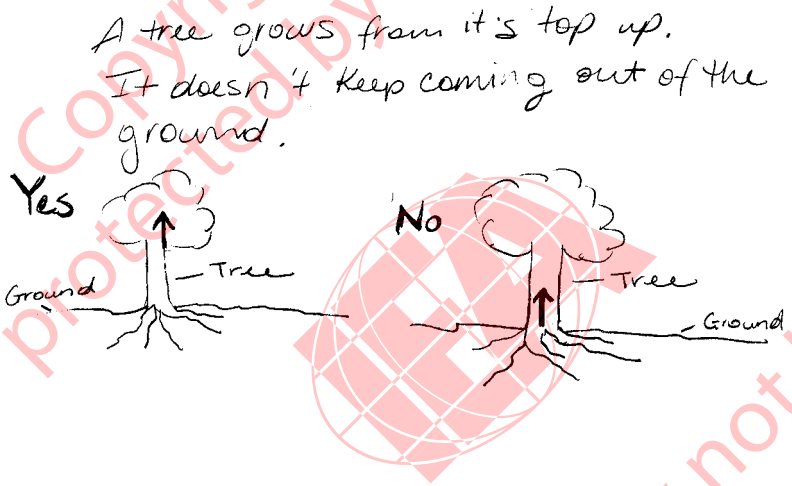
At the Top 10% Benchmark, students typically demonstrated knowledge of most of the chemical concepts covered by the TIMSS 1999 science test, including the structure of matter as well as chemical and physical changes. As shown in Example Item 4 in Exhibit 2.5, students could apply knowledge of the process of filtration and of 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 had the highest performance, with 64 percent of its students responding correctly. Performance of the United States and the Benchmarking jurisdictions on this item generally was around the international average. Only in Naperville, the First in the World Consortium, and the Academy School District was performance significantly above the international average, and only in the Rochester City School District was it significantly below.

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, more than half the students in Japan, Hong Kong, Chinese Taipei, and Singapore did so. Among Benchmarking participants, Naperville alone had above-average performance. Six of the participants had performance significantly below the international average: Pennsylvania, South Carolina, Project SMART, Rochester, North Carolina, and Jersey City. Many students incorrectly identified the thinning ozone layer (option D) as a result of global warming.

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) ▲
Naperville Sch. Dist. #203, IL	63 (4.2) ▲
Canada	59 (1.9) ▲
First in the World Consort., IL	58 (6.4) ●
Japan	57 (1.9) ▲
Netherlands †	56 (3.6) ▲
England †	55 (2.9) ▲
Academy School Dist. #20, CO	54 (4.7) ●
Michigan	54 (3.6) ▲
Chinese Taipei	53 (2.0) ▲
Oregon	53 (3.3) ▲
Montgomery County, MD 2	52 (3.5) ▲
Project SMART Consortium, OH	51 (4.3) ●
SW Math/Sci. Collaborative, PA	50 (4.4) ●
Michigan Invitational Group, MI	50 (4.6) ●
Massachusetts	50 (4.0) ●
Singapore	49 (2.8) ●
Indiana †	49 (5.0) ●
Czech Republic	48 (3.1) ●
Russian Federation	48 (2.7) ●
Pennsylvania	47 (3.3) ●
Illinois	46 (3.9) ●
Idaho	46 (4.2) ●
Connecticut	45 (4.0) ●
United States	45 (2.2) ●
Maryland	45 (3.4) ●
Missouri	44 (2.0) ●
Italy	43 (2.7) ●
North Carolina	42 (2.9) ●
South Carolina	40 (2.7) ●
Hong Kong, SAR †	40 (2.1) ●
Fremont/Lincoln/WestSide PS, NE	39 (5.9) ●
Guilford County, NC 2	39 (5.3) ●
Delaware Science Coalition, DE	37 (4.8) ●
Texas	35 (3.7) ●
Korea, Rep. of	33 (1.9) ▼
Chicago Public Schools, IL	31 (5.2) ●
Rochester City Sch. Dist., NY	28 (6.0) ●
Jersey City Public Schools, NJ	28 (4.6) ●
Miami-Dade County PS, FL	25 (3.2) ▼
International Avg. (All Countries)	41 (0.4)

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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.

	Overall Percent Correct
Netherlands †	58 (3.9) ▲
Korea, Rep. of	52 (1.8) ▲
Belgium (Flemish) †	51 (3.5) ▲
Naperville Sch. Dist. #203, IL	51 (3.9) ▲
Singapore	49 (3.2) ▲
Michigan Invitational Group, MI	47 (3.7) ▲
Japan	46 (2.1) ▲
First in the World Consort., IL	45 (4.9) ●
Chinese Taipei	44 (2.1) ▲
Canada	43 (1.9) ▲
England †	42 (3.0) ▲
Academy School Dist. #20, CO	41 (4.3) ●
Oregon	38 (3.4) ●
Montgomery County, MD [2]	38 (4.4) ●
Michigan	37 (3.7) ●
Massachusetts	34 (3.2) ●
Illinois	33 (4.0) ●
Project SMART Consortium, OH	33 (5.0) ●
Russian Federation	33 (2.6) ●
SW Math/Sci. Collaborative, PA	32 (4.5) ●
Hong Kong, SAR †	32 (2.0) ●
Czech Republic	30 (2.6) ●
United States	30 (1.9) ●
Connecticut	29 (3.2) ●
Guilford County, NC [2]	29 (4.6) ●
Pennsylvania	28 (3.5) ●
Indiana †	26 (3.9) ●
Texas	25 (3.4) ●
Delaware Science Coalition, DE	23 (3.2) ●
Italy	23 (2.3) ●
Maryland	22 (1.8) ▼
Missouri	22 (3.2) ●
Idaho	22 (3.4) ●
South Carolina	22 (2.9) ▼
Jersey City Public Schools, NJ	21 (4.3) ●
Fremont/Lincoln/WestSide PS, NE	20 (5.7) ●
North Carolina	19 (3.0) ▼
Chicago Public Schools, IL	16 (4.4) ▼
Miami-Dade County PS, FL	12 (2.9) ▼
Rochester City Sch. Dist., NY	10 (3.4) ▼
International Avg. (All Countries)	31 (0.4)

▲ Participant average significantly higher than international average
● No statistically significant difference between participant average and international average
▼ Participant 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.

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

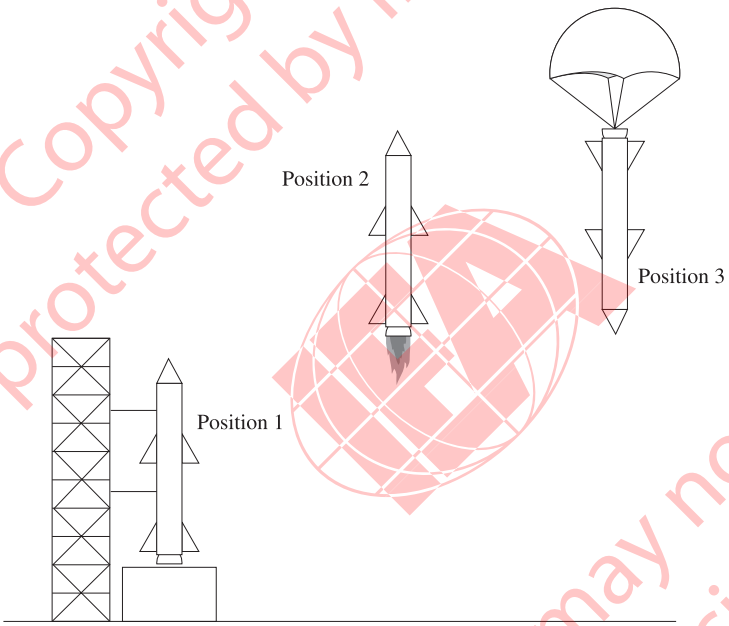
[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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
Michigan Invitational Group, MI	65 (4.1) ▲
Czech Republic	65 (3.1) ▲
Naperville Sch. Dist. #203, IL	64 (4.0) ▲
Academy School Dist. #20, CO	63 (3.6) ▲
Michigan	62 (3.4) ▲
First in the World Consort., IL	60 (4.7) ▲
Idaho	59 (4.7) ▲
Project SMART Consortium, OH	56 (4.3) ▲
SW Math/Sci. Collaborative, PA	56 (4.1) ▲
Massachusetts	55 (4.2) ▲
Fremont/Lincoln/WestSide PS, NE	54 (5.0) ▲
Oregon	53 (4.1) ▲
Guilford County, NC [2]	52 (4.2) ▲
Indiana †	50 (3.4) ▲
South Carolina	49 (3.6) ▲
Singapore	49 (2.8) ▲
Chinese Taipei	48 (2.3) ▲
Missouri	48 (2.7) ▲
Pennsylvania	47 (4.0) ●
Maryland	46 (3.5) ●
United States	46 (2.3) ▲
Russian Federation	46 (3.4) ●
Canada	45 (3.3) ●
Illinois	44 (3.2) ●
England †	43 (3.0) ●
North Carolina	41 (2.9) ●
Connecticut	41 (3.6) ●
Japan	40 (2.0) ●
Montgomery County, MD [2]	40 (3.3) ●
Netherlands †	39 (5.3) ●
Delaware Science Coalition, DE	39 (5.6) ●
Texas	36 (3.3) ●
Rochester City Sch. Dist., NY	34 (4.4) ●
Korea, Rep. of	29 (1.7) ▼
Belgium (Flemish) †	29 (2.2) ▼
Miami-Dade County PS, FL	26 (2.6) ▼
Jersey City Public Schools, NJ	25 (4.4) ●
Italy	25 (2.3) ▼
Hong Kong, SAR †	24 (1.6) ▼
Chicago Public Schools, IL	24 (3.7) ▼
International Avg. (All Countries)	36 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

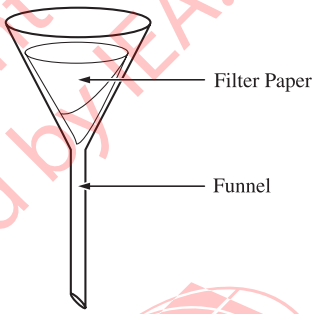
† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
Naperville Sch. Dist. #203, IL	60 (3.0) ▲
First in the World Consort., IL	57 (5.4) ▲
Academy School Dist. #20, CO	55 (4.5) ▲
Korea, Rep. of	51 (1.8) ▲
Russian Federation	50 (2.7) ▲
Canada	50 (1.9) ▲
Singapore	50 (2.6) ▲
Michigan Invitational Group, MI	50 (4.4) ●
Netherlands †	48 (3.7) ●
Oregon	48 (4.0) ●
Chinese Taipei	46 (2.0) ▲
Idaho	46 (4.2) ●
Michigan	45 (3.9) ●
SW Math/Sci. Collaborative, PA	44 (3.8) ●
Pennsylvania	43 (3.3) ●
Japan	42 (2.0) ●
Connecticut	42 (3.5) ●
Montgomery County, MD [2]	42 (5.9) ●
Project SMART Consortium, OH	41 (4.1) ●
Massachusetts	41 (2.8) ●
South Carolina	40 (3.5) ●
Illinois	40 (3.0) ●
United States	39 (2.1) ●
Maryland	39 (2.9) ●
Texas	39 (3.6) ●
Hong Kong, SAR †	38 (2.3) ●
Guilford County, NC [2]	38 (4.5) ●
Indiana †	37 (3.6) ●
Fremont/Lincoln/WestSide PS, NE	36 (6.4) ●
Missouri	34 (2.6) ●
England †	34 (2.6) ●
Belgium (Flemish) †	33 (2.0) ●
North Carolina	32 (3.7) ●
Miami-Dade County PS, FL	31 (3.6) ●
Italy	30 (2.1) ▼
Delaware Science Coalition, DE	29 (3.9) ●
Chicago Public Schools, IL	27 (4.4) ●
Jersey City Public Schools, NJ	26 (4.7) ●
Rochester City Sch. Dist., NY	18 (4.1) ▼
International Avg. (All Countries)	39 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

Top 10% TIMSS International Benchmark – Example Item 5

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

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) ▲
Singapore	56 (3.1) ▲
Naperville Sch. Dist. #203, IL	48 (4.4) ▲
Italy	48 (2.5) ▲
Korea, Rep. of	47 (2.1) ▲
Academy School Dist. #20, CO	44 (3.8) ●
Massachusetts	40 (3.8) ●
Russian Federation	38 (3.2) ●
Montgomery County, MD [2]	37 (3.2) ●
Idaho	36 (3.2) ●
Missouri	36 (3.4) ●
First in the World Consort., IL	35 (6.3) ●
England †	33 (2.7) ●
Belgium (Flemish) †	33 (2.7) ●
Netherlands †	33 (3.5) ●
SW Math/Sci. Collaborative, PA	32 (3.9) ●
Delaware Science Coalition, DE	32 (4.3) ●
Czech Republic	32 (3.4) ●
Canada	31 (2.9) ●
Indiana †	31 (4.0) ●
United States	30 (2.1) ●
Connecticut	30 (4.1) ●
Fremont/Lincoln/WestSide PS, NE	30 (4.6) ●
Guilford County, NC [2]	30 (4.3) ●
Maryland	30 (2.9) ●
Michigan	29 (3.0) ●
Oregon	28 (3.7) ●
Michigan Invitational Group, MI	27 (7.4) ●
Illinois	27 (2.7) ●
Texas	26 (3.5) ●
Pennsylvania	25 (2.3) ▼
South Carolina	25 (2.5) ▼
Project SMART Consortium, OH	24 (3.0) ▼
Rochester City Sch. Dist., NY	23 (2.9) ▼
Miami-Dade County PS, FL	22 (3.9) ●
North Carolina	22 (2.5) ▼
Chicago Public Schools, IL	21 (5.3) ●
Jersey City Public Schools, NJ	20 (4.2) ▼
International Avg. (All Countries)	33 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

( ) 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 may be seen 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. Among the comparison countries, performance on this item was best in Chinese Taipei, Singapore, and Korea, with least at 85 percent of the students responding correctly. Students in Naperville performed about as well as students in those three countries. Other Benchmarking entities with performance significantly above the international average were the Academy School District, the Michigan Invitational Group, the Project SMART Consortium, and the state of Michigan. Those with significantly below-average performance were the public school systems of Jersey City, Chicago, Rochester, and Miami-Dade.

Even though students at the lower benchmarks demonstrated practical knowledge of rusting and burning, only at the Upper Quarter Benchmark did they 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. Performance in the United States (64 percent correct) and many Benchmarking jurisdictions was significantly above the international average. Miami-Dade was the only Benchmarking participant with below-average performance.

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 the 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). Performance in the United States overall was near the international average, although in six of the Benchmarking entities – the First in the World Consortium, the Academy School District, Michigan, Guilford County, Idaho, and Oregon – performance was significantly above average.

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. While internationally slightly less

than half the students (48 percent) chose the correct response, performance in the United States as a whole (62 percent) and in many of the Benchmarking jurisdictions was significantly above the international average. First in the World and Naperville had particularly good performance on this item, comparable to that in Chinese Taipei. Internationally, many students selected option C, which is a true statement on the effect of insecticides on the environment, but is 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. Although internationally less than half the students (48 percent) chose the correct response, students in the United States performed very well (76 percent correct). All of the Benchmarking participants had significantly above-average performance on this question, with 17 of them performing comparably to or better than the two highest-performing countries, England and Singapore.

• 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

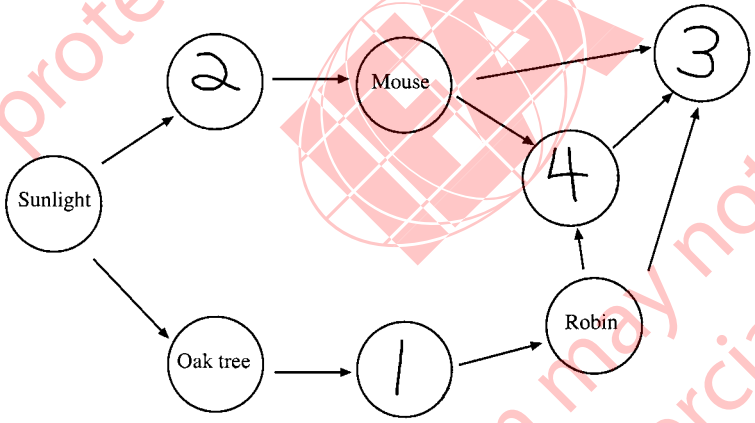
SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999.

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)	▲
Naperville Sch. Dist. #203, IL	84 (2.6)	▲
England †	75 (2.6)	▲
Academy School Dist. #20, CO	75 (3.8)	▲
Michigan Invitational Group, MI	73 (4.2)	▲
Project SMART Consortium, OH	73 (4.1)	▲
Michigan	70 (2.2)	▲
Japan	68 (2.0)	▲
Russian Federation	67 (3.2)	▲
Hong Kong, SAR †	64 (2.3)	▲
First in the World Consort., IL	64 (5.9)	●
Canada	63 (2.7)	●
Belgium (Flemish) †	62 (2.6)	●
Oregon	62 (3.1)	●
Texas	62 (4.2)	●
Idaho	62 (3.6)	●
Indiana †	61 (4.7)	●
Czech Republic	60 (2.9)	●
Missouri	60 (3.3)	●
South Carolina	59 (3.6)	●
Netherlands †	58 (3.1)	●
Illinois	57 (3.4)	●
Massachusetts	56 (4.4)	●
United States	56 (1.7)	●
Connecticut	56 (4.4)	●
Pennsylvania	56 (3.1)	●
SW Math/Sci. Collaborative, PA	55 (5.2)	●
Montgomery County, MD 2	55 (4.2)	●
Maryland	53 (3.5)	●
Guilford County, NC 2	53 (6.1)	●
Delaware Science Coalition, DE	50 (4.7)	●
Fremont/Lincoln/WestSide PS, NE	48 (6.5)	●
Italy	48 (2.3)	●
North Carolina	44 (3.8)	●
Jersey City Public Schools, NJ	37 (5.4)	▼
Chicago Public Schools, IL	35 (3.7)	▼
Rochester City Sch. Dist., NY	34 (4.8)	▼
Miami-Dade County PS, FL	31 (5.6)	▼
International Avg. (All Countries)	55 (0.4)	

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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	
Naperville Sch. Dist. #203, IL	82 (2.1)	▲
Chinese Taipei	82 (1.0)	▲
Academy School Dist. #20, CO	78 (2.0)	▲
First in the World Consort., IL	77 (2.4)	▲
Project SMART Consortium, OH	77 (2.8)	▲
Michigan Invitational Group, MI	75 (2.2)	▲
Guilford County, NC [2]	72 (2.4)	▲
Michigan	72 (2.8)	▲
Connecticut	70 (3.5)	▲
Indiana †	70 (2.7)	▲
Hong Kong, SAR †	70 (1.3)	▲
England †	68 (1.5)	▲
Singapore	68 (2.1)	▲
SW Math/Sci. Collaborative, PA	68 (3.2)	▲
Oregon	67 (2.4)	▲
Montgomery County, MD [2]	66 (2.4)	▲
Canada	66 (1.2)	▲
Pennsylvania	66 (2.7)	▲
Korea, Rep. of	65 (1.0)	▲
Russian Federation	65 (2.6)	▲
Idaho	65 (2.6)	▲
Missouri	65 (2.4)	▲
Illinois	65 (2.6)	▲
United States	64 (1.5)	▲
Netherlands †	64 (2.9)	●
Texas	63 (2.9)	●
Massachusetts	62 (2.3)	●
North Carolina	61 (2.3)	●
Belgium (Flemish) †	61 (1.6)	▲
Maryland	61 (2.0)	●
South Carolina	60 (3.1)	●
Japan	59 (1.2)	●
Delaware Science Coalition, DE	58 (3.2)	●
Fremont/Lincoln/WestSide PS, NE	56 (3.1)	●
Italy	54 (1.7)	●
Rochester City Sch. Dist., NY	51 (3.3)	●
Jersey City Public Schools, NJ	48 (3.8)	●
Chicago Public Schools, IL	47 (3.8)	●
Czech Republic	47 (1.9)	▼
Miami-Dade County PS, FL	41 (4.1)	▼
International Avg. (All Countries)	55 (0.3)	

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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)	▲
First in the World Consort., IL	65 (3.8)	▲
Singapore	64 (2.8)	▲
Netherlands †	64 (2.7)	▲
Academy School Dist. #20, CO	63 (3.6)	▲
Michigan	62 (3.1)	▲
Michigan Invitational Group, MI	62 (4.5)	●
Guilford County, NC [2]	62 (3.3)	▲
Idaho	61 (2.6)	▲
Russian Federation	60 (2.7)	▲
Project SMART Consortium, OH	60 (6.3)	●
Korea, Rep. of	59 (1.7)	▲
Missouri	59 (4.6)	●
Oregon	58 (2.6)	▲
Naperville Sch. Dist. #203, IL	57 (3.3)	●
Massachusetts	56 (3.0)	●
Canada	55 (3.2)	●
Pennsylvania	54 (3.3)	●
Montgomery County, MD [2]	53 (4.6)	●
SW Math/Sci. Collaborative, PA	52 (4.4)	●
Texas	52 (4.5)	●
United States	52 (1.7)	●
Indiana †	51 (3.8)	●
Fremont/Lincoln/WestSide PS, NE	49 (6.3)	●
Belgium (Flemish) †	49 (3.1)	●
North Carolina	48 (3.7)	●
Italy	48 (2.5)	●
Czech Republic	47 (3.5)	●
Illinois	46 (3.8)	●
South Carolina	45 (3.3)	●
Connecticut	45 (4.3)	●
Delaware Science Coalition, DE	42 (5.6)	●
Maryland	42 (3.2)	●
Miami-Dade County PS, FL	39 (4.1)	●
Rochester City Sch. Dist., NY	35 (6.5)	●
Chicago Public Schools, IL	34 (4.8)	▼
Jersey City Public Schools, NJ	32 (3.5)	▼
International Avg. (All Countries)	49 (0.4)	

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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	
First in the World Consort., IL	78 (4.5)	▲
Naperville Sch. Dist. #203, IL	78 (3.3)	▲
Chinese Taipei	76 (1.7)	▲
Michigan Invitational Group, MI	75 (3.1)	▲
Hong Kong, SAR †	74 (2.2)	▲
Project SMART Consortium, OH	73 (3.7)	▲
Michigan	73 (2.9)	▲
Idaho	73 (3.6)	▲
Academy School Dist. #20, CO	72 (4.4)	▲
Montgomery County, MD 2	71 (3.4)	▲
SW Math/Sci. Collaborative, PA	70 (3.1)	▲
Oregon	69 (3.4)	▲
Singapore	69 (2.2)	▲
Connecticut	69 (3.8)	▲
Japan	68 (1.7)	▲
South Carolina	67 (3.3)	▲
Massachusetts	66 (3.4)	▲
Indiana †	66 (5.0)	▲
Guilford County, NC 2	65 (5.6)	●
Texas	64 (4.1)	▲
Pennsylvania	63 (3.6)	▲
Missouri	63 (2.9)	▲
United States	62 (1.8)	▲
Netherlands †	61 (3.5)	▲
Maryland	61 (2.5)	▲
Canada	60 (3.0)	▲
Russian Federation	60 (3.6)	●
Fremont/Lincoln/WestSide PS, NE	59 (5.6)	●
North Carolina	58 (3.6)	●
Illinois	58 (2.7)	▲
Delaware Science Coalition, DE	57 (5.4)	●
Czech Republic	57 (3.3)	●
England †	56 (2.6)	●
Belgium (Flemish) †	53 (2.7)	●
Chicago Public Schools, IL	51 (6.3)	●
Italy	50 (2.3)	●
Korea, Rep. of	47 (2.0)	●
Miami-Dade County PS, FL	46 (4.5)	●
Jersey City Public Schools, NJ	44 (3.9)	●
Rochester City Sch. Dist., NY	37 (4.5)	●
International Avg. (All Countries)	48 (0.4)	

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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
Naperville Sch. Dist. #203, IL	90 (2.0) ▲
Project SMART Consortium, OH	86 (4.3) ▲
First in the World Consort., IL	85 (3.0) ▲
Indiana †	85 (2.5) ▲
SW Math/Sci. Collaborative, PA	85 (3.0) ▲
Guilford County, NC 2	84 (3.3) ▲
South Carolina	83 (2.6) ▲
Michigan Invitational Group, MI	82 (3.8) ▲
Missouri	82 (2.6) ▲
Academy School Dist. #20, CO	81 (3.9) ▲
Pennsylvania	81 (2.3) ▲
Oregon	80 (3.3) ▲
Illinois	79 (3.6) ▲
Massachusetts	79 (1.6) ▲
Montgomery County, MD 2	79 (1.7) ▲
Connecticut	79 (3.9) ▲
Michigan	78 (3.0) ▲
England †	78 (2.6) ▲
Singapore	78 (1.9) ▲
North Carolina	77 (2.4) ▲
Netherlands †	76 (2.8) ▲
United States	76 (1.4) ▲
Rochester City Sch. Dist., NY	76 (4.4) ▲
Idaho	76 (3.4) ▲
Texas	74 (3.6) ▲
Maryland	72 (3.2) ▲
Delaware Science Coalition, DE	72 (3.7) ▲
Fremont/Lincoln/WestSide PS, NE	69 (4.8) ▲
Chicago Public Schools, IL	69 (5.6) ▲
Miami-Dade County PS, FL	67 (4.0) ▲
Canada	64 (2.6) ▲
Jersey City Public Schools, NJ	64 (4.8) ▲
Korea, Rep. of	59 (2.0) ▲
Japan	50 (2.1) ●
Italy	49 (2.9) ●
Belgium (Flemish) †	49 (2.0) ●
Hong Kong, SAR †	49 (2.1) ●
Czech Republic	49 (3.4) ●
Chinese Taipei	44 (2.0) ●
Russian Federation	29 (2.3) ▼
International Avg. (All Countries)	48 (0.4)

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant 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.

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

( ) 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 on Proto to breathe. 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. On this item, also, the United States and many of the Benchmarking jurisdictions had relatively good performance. The United States as a whole and 16 of the jurisdictions had performance significantly above the international average, and none had below-average performance.

At the Median Benchmark, students typically demonstrated some knowledge of the characteristics of animals and plants. In Example 12 (see Exhibit 2.15), 70 percent of students on average across countries recognized feeding milk to their young as a characteristic of mammals. This was not an area of strength in the United States, where performance was significantly below the international average. Only students in the Academy School District and the Michigan Invitational Group performed significantly above the international average, whereas students in Maryland, North Carolina, and the public school systems in Rochester, Miami-Dade, Chicago, and Jersey City performed below average.

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 scoring at this level could identify the diagram showing forces that would result in rotation. Performance on this item was at the international average (62 percent correct) for the United States and for all Benchmarking participants except Chicago and Miami-Dade, which had below-average performance.

In Example Item 14 (see Exhibit 2.17), students had to apply an understanding 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. On this item, also, performance in the United States was at about the

international average. Although seven of the comparison countries – Hong Kong, the Russian Federation, Belgium (Flemish), Chinese Taipei, Singapore, Korea, and the Netherlands – had above-average performance, only in Missouri and Naperville was performance significantly above the international average.

At the Median Benchmark, students were able to apply basic knowledge of 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. The United States and all but the four lowest-performing Benchmarking participants had average performance on this item.

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 recognized that soil erosion is more likely in barren sloping areas. Although the United States overall had about average performance on this item, 13 of the Benchmarking participants performed significantly above the international average, including the Academy School District, which had performance comparable to high-scoring Chinese Taipei, Singapore, and Hong Kong.

• 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.

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
First in the World Consort., IL	91 (3.4) ▲
Michigan Invitational Group, MI	87 (3.4) ▲
Guilford County, NC [2]	86 (3.1) ▲
Singapore	86 (1.7) ▲
SW Math/Sci. Collaborative, PA	85 (4.1) ▲
Indiana †	84 (2.7) ▲
North Carolina	82 (2.4) ▲
Canada	82 (2.4) ▲
Pennsylvania	82 (2.2) ▲
England †	82 (2.4) ▲
Netherlands †	81 (2.6) ▲
Naperville Sch. Dist. #203, IL	80 (4.0) ▲
Massachusetts	80 (2.7) ▲
Michigan	80 (2.9) ▲
Project SMART Consortium, OH	80 (3.5) ▲
Oregon	80 (2.8) ▲
Chinese Taipei	79 (1.5) ▲
Delaware Science Coalition, DE	79 (3.3) ▲
Idaho	78 (3.6) ▲
Academy School Dist. #20, CO	78 (3.3) ▲
Illinois	78 (2.2) ▲
United States	78 (1.6) ▲
South Carolina	78 (3.8) ●
Belgium (Flemish) †	77 (2.7) ▲
Korea, Rep. of	77 (1.5) ▲
Connecticut	77 (4.1) ●
Czech Republic	75 (3.0) ●
Montgomery County, MD [2]	74 (3.6) ●
Jersey City Public Schools, NJ	74 (4.1) ●
Chicago Public Schools, IL	74 (3.0) ●
Missouri	73 (3.0) ●
Russian Federation	73 (2.1) ▲
Texas	73 (4.6) ●
Maryland	73 (2.4) ●
Italy	70 (2.4) ●
Hong Kong, SAR †	70 (2.2) ●
Japan	69 (1.7) ●
Fremont/Lincoln/WestSide PS, NE	68 (5.8) ●
Rochester City Sch. Dist., NY	67 (3.6) ●
Miami-Dade County PS, FL	63 (5.4) ●
International Avg. (All Countries)	66 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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
Japan	86 (0.8) ▲
Hong Kong, SAR †	83 (1.2) ▲
Academy School Dist. #20, CO	81 (1.7) ▲
Chinese Taipei	80 (1.1) ▲
Czech Republic	79 (1.9) ▲
Korea, Rep. of	77 (1.1) ▲
Michigan Invitational Group, MI	77 (2.0) ▲
Singapore	77 (1.8) ▲
Russian Federation	76 (2.1) ●
Belgium (Flemish) †	70 (1.7) ●
Michigan	70 (2.0) ●
Italy	70 (1.6) ●
First in the World Consort., IL	68 (2.2) ●
Idaho	68 (3.0) ●
South Carolina	68 (2.2) ●
Connecticut	68 (2.8) ●
Oregon	67 (2.2) ●
Montgomery County, MD [2]	67 (2.9) ●
Canada	66 (1.0) ▼
Naperville Sch. Dist. #203, IL	66 (2.6) ●
Guilford County, NC [2]	65 (3.2) ●
SW Math/Sci. Collaborative, PA	65 (2.0) ●
Texas	65 (3.6) ●
United States	65 (1.6) ▼
Indiana †	64 (2.1) ●
Missouri	64 (2.6) ●
Pennsylvania	64 (2.8) ●
Massachusetts	63 (2.3) ●
Netherlands †	62 (1.8) ▼
Project SMART Consortium, OH	61 (3.2) ●
Illinois	60 (3.0) ●
Maryland	60 (2.6) ▼
Delaware Science Coalition, DE	60 (3.7) ●
Fremont/Lincoln/WestSide PS, NE	60 (4.2) ●
North Carolina	58 (2.2) ▼
Rochester City Sch. Dist., NY	53 (2.9) ▼
England †	52 (2.0) ▼
Miami-Dade County PS, FL	51 (3.1) ▼
Chicago Public Schools, IL	51 (3.9) ▼
Jersey City Public Schools, NJ	44 (3.5) ▼
International Avg. (All Countries)	70 (0.2)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

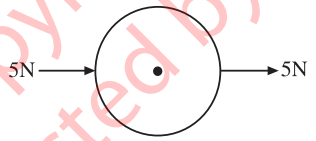
2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

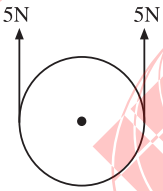
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

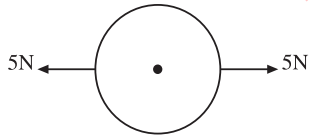
Content Area: Physics

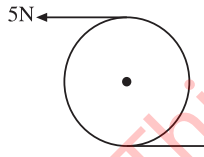
Description: Identifies the diagram that shows the forces acting on a wheel that will result in rotation.

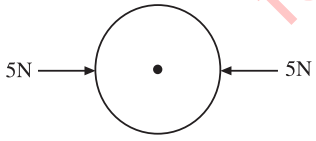
A uniform wheel is free to rotate on its axle at its center. It is acted on by two forces in the same plane. Each force has the same size, equal to 5N (Newtons). In which case will the wheel rotate?

A. 

B. 

C. 

D. 

E. 

	Overall Percent Correct
Japan	76 (1.6) ▲
Czech Republic	69 (2.4) ●
Netherlands †	69 (3.3) ●
Russian Federation	68 (2.7) ●
Academy School Dist. #20, CO	68 (3.2) ●
First in the World Consort., IL	67 (5.5) ●
Idaho	66 (4.3) ●
Italy	66 (2.7) ●
Canada	66 (2.6) ●
Massachusetts	65 (3.7) ●
Oregon	65 (3.6) ●
SW Math/Sci. Collaborative, PA	65 (3.8) ●
Michigan Invitational Group, MI	64 (4.5) ●
Belgium (Flemish) †	64 (2.3) ●
Korea, Rep. of	63 (1.7) ●
Michigan	63 (2.9) ●
United States	62 (1.7) ●
Missouri	62 (3.6) ●
Hong Kong, SAR †	62 (1.9) ●
Connecticut	61 (3.8) ●
England †	61 (2.6) ●
Texas	60 (2.6) ●
Singapore	60 (2.3) ●
Montgomery County, MD [2]	60 (4.3) ●
Indiana †	59 (4.5) ●
Fremont/Lincoln/WestSide PS, NE	58 (7.5) ●
Guilford County, NC [2]	58 (4.8) ●
Chinese Taipei	58 (2.2) ●
Jersey City Public Schools, NJ	57 (5.2) ●
Delaware Science Coalition, DE	57 (5.1) ●
Pennsylvania	56 (5.7) ●
Illinois	56 (3.4) ●
Maryland	55 (2.5) ●
South Carolina	55 (3.1) ●
Naperville Sch. Dist. #203, IL	55 (4.4) ●
North Carolina	54 (3.3) ●
Project SMART Consortium, OH	53 (4.9) ●
Chicago Public Schools, IL	48 (4.3) ▼
Rochester City Sch. Dist., NY	42 (4.3) ▼
Miami-Dade County PS, FL	38 (3.7) ▼
International Avg. (All Countries)	62 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

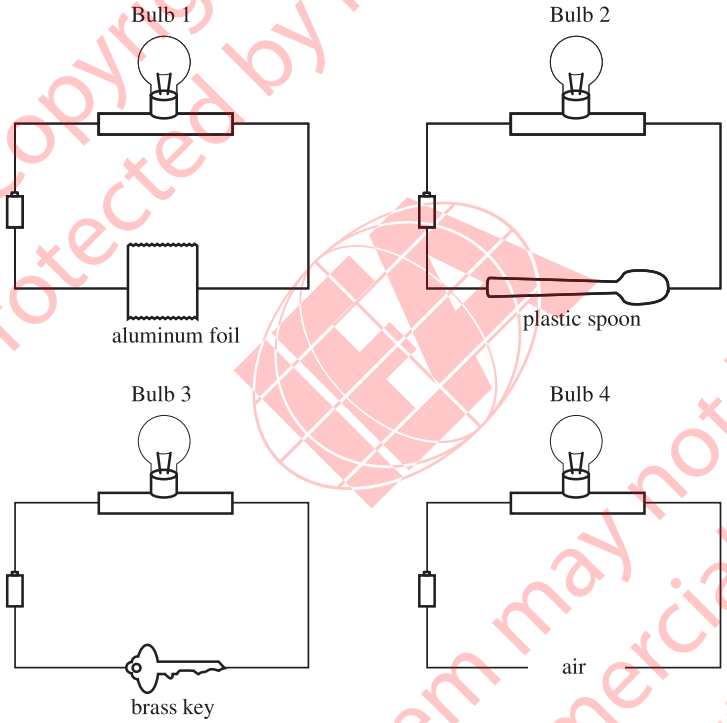
2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
Korea, Rep. of	78 (1.7) ▲
Netherlands †	78 (2.7) ▲
First in the World Consort., IL	75 (4.9) ●
Missouri	74 (2.2) ▲
Naperville Sch. Dist. #203, IL	73 (2.7) ▲
Academy School Dist. #20, CO	73 (3.5) ●
Illinois	72 (2.9) ●
Czech Republic	72 (2.7) ●
Massachusetts	72 (2.5) ●
Indiana †	71 (3.1) ●
SW Math/Sci. Collaborative, PA	70 (4.0) ●
Montgomery County, MD 2	70 (3.3) ●
Michigan	69 (2.9) ●
Fremont/Lincoln/WestSide PS, NE	69 (7.2) ●
Japan	68 (1.9) ●
Michigan Invitational Group, MI	68 (4.6) ●
Connecticut	67 (3.0) ●
Pennsylvania	67 (3.1) ●
Project SMART Consortium, OH	65 (4.5) ●
Idaho	65 (3.3) ●
England †	65 (2.6) ●
Maryland	65 (2.6) ●
Oregon	65 (3.2) ●
United States	64 (1.7) ●
Guilford County, NC 2	64 (3.6) ●
South Carolina	64 (2.5) ●
Texas	64 (4.3) ●
North Carolina	64 (3.2) ●
Delaware Science Coalition, DE	61 (3.7) ●
Canada	60 (2.2) ●
Jersey City Public Schools, NJ	58 (4.1) ●
Miami-Dade County PS, FL	57 (1.9) ▼
Rochester City Sch. Dist., NY	57 (4.9) ●
Italy	56 (2.3) ▼
Chicago Public Schools, IL	55 (4.8) ●
International Avg. (All Countries)	64 (0.4)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
Russian Federation	81 (1.3) ▲
Singapore	81 (1.8) ▲
Netherlands †	80 (2.2) ▲
Hong Kong, SAR †	79 (1.4) ▲
England †	76 (1.6) ▲
Michigan Invitational Group, MI	74 (2.4) ●
Korea, Rep. of	73 (1.1) ▲
Connecticut	72 (2.6) ●
Naperville Sch. Dist. #203, IL	72 (2.0) ●
Canada	72 (1.6) ●
Michigan	72 (2.7) ●
SW Math/Sci. Collaborative, PA	72 (2.9) ●
Czech Republic	72 (1.8) ●
Massachusetts	71 (2.4) ●
Academy School Dist. #20, CO	71 (2.2) ●
Project SMART Consortium, OH	70 (1.9) ●
Oregon	70 (2.0) ●
Japan	70 (1.3) ●
Belgium (Flemish) †	70 (1.6) ●
Idaho	69 (2.1) ●
Pennsylvania	69 (2.0) ●
First in the World Consort., IL	68 (2.8) ●
Guilford County, NC [2]	68 (2.3) ●
Texas	68 (2.6) ●
Indiana †	67 (1.9) ●
Missouri	67 (2.3) ●
Illinois	66 (2.6) ●
United States	66 (1.4) ●
Italy	65 (1.6) ●
Montgomery County, MD [2]	64 (2.3) ●
North Carolina	64 (2.1) ●
South Carolina	63 (3.1) ●
Maryland	63 (2.7) ●
Fremont/Lincoln/WestSide PS, NE	62 (3.1) ●
Delaware Science Coalition, DE	60 (3.1) ●
Jersey City Public Schools, NJ	53 (2.6) ▼
Rochester City Sch. Dist., NY	50 (3.4) ▼
Chicago Public Schools, IL	49 (3.1) ▼
Miami-Dade County PS, FL	45 (3.3) ▼
International Avg. (All Countries)	67 (0.2)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
Academy School Dist. #20, CO	85 (1.7) ▲
Hong Kong, SAR †	85 (1.1) ▲
Netherlands †	83 (2.9) ▲
Korea, Rep. of	83 (0.9) ▲
Project SMART Consortium, OH	82 (3.3) ▲
Naperville Sch. Dist. #203, IL	81 (1.6) ▲
Michigan Invitational Group, MI	80 (1.6) ▲
Russian Federation	80 (1.3) ▲
Japan	79 (1.0) ▲
SW Math/Sci. Collaborative, PA	79 (2.0) ▲
England †	78 (1.4) ▲
Michigan	78 (2.0) ▲
Missouri	78 (2.0) ▲
Idaho	78 (2.2) ▲
Massachusetts	76 (2.2) ▲
Canada	76 (1.3) ▲
Indiana †	76 (2.6) ●
Oregon	75 (2.3) ▲
Guilford County, NC [2]	75 (2.2) ▲
Fremont/Lincoln/WestSide PS, NE	75 (2.9) ●
Montgomery County, MD [2]	74 (2.1) ▲
North Carolina	74 (2.2) ●
First in the World Consort., IL	74 (3.5) ●
Pennsylvania	74 (2.0) ●
Czech Republic	73 (1.8) ●
South Carolina	73 (1.5) ▲
Connecticut	73 (2.7) ●
United States	73 (1.6) ●
Maryland	72 (2.5) ●
Illinois	70 (1.5) ●
Delaware Science Coalition, DE	70 (4.0) ●
Texas	69 (3.1) ●
Belgium (Flemish) †	68 (1.3) ●
Italy	59 (1.8) ▼
Jersey City Public Schools, NJ	55 (3.1) ▼
Rochester City Sch. Dist., NY	50 (3.1) ▼
Chicago Public Schools, IL	49 (3.3) ▼
Miami-Dade County PS, FL	44 (4.9) ▼
International Avg. (All Countries)	68 (0.2)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in italics did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

( ) 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

Exhibit 2.20 describes performance at the Lower Quarter Benchmark. At this level of performance, students typically could demonstrate 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. Among Benchmarking participants, almost all students (85 percent or more) gave the correct answer.

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). Performance on this item was even higher in the United States and most Benchmarking jurisdictions. Student performance exceeded the international average in the United States overall and in 19 of the Benchmarking entities, and was not significantly below the international average in any entity. However, typically only students scoring at higher benchmarks could relate the link between exercise and pulse and breathing rate to the function of the circulatory or respiratory system.

At the Lower Quarter Benchmark, students could recognize 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. Internationally and in the United States, more than 80 percent of students answered this item correctly. Among Benchmarking participants, only in Naperville, Michigan, and Montgomery County was the percentage of students choosing the correct answer significantly greater than the international average.

Students at the Lower Quarter Benchmark could also recognize that there is greater evaporation from a larger surface area, 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. Performance was at about the international average on this question in the United States and in many of the Benchmarking jurisdictions. However, performance in First in the World, the Academy School District, Project SMART, Naperville, and Michigan was significantly above the international average. In each of these entities, the item was answered correctly by more than 90 percent of the eighth-grade students.

• 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.

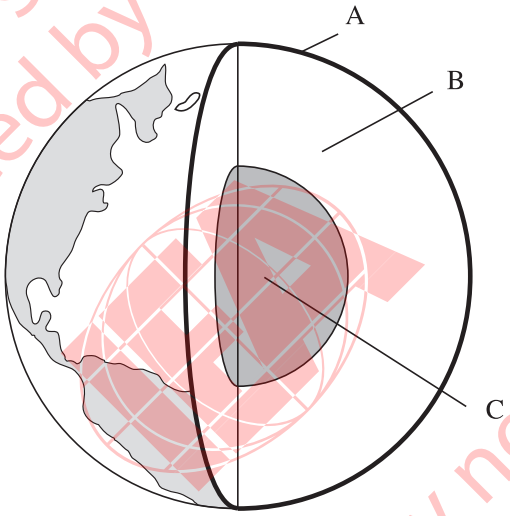
25th Percentile: 410

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

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
Naperville Sch. Dist. #203, IL	97 (0.8) ▲
Michigan Invitational Group, MI	96 (0.6) ▲
Academy School Dist. #20, CO	95 (1.0) ▲
Oregon	95 (0.6) ▲
First in the World Consort., IL	95 (1.6) ▲
Montgomery County, MD [2]	95 (1.2) ▲
SW Math/Sci. Collaborative, PA	95 (0.8) ▲
Michigan	95 (0.9) ▲
Project SMART Consortium, OH	94 (1.2) ▲
Fremont/Lincoln/WestSide PS, NE	94 (0.9) ▲
Massachusetts	94 (0.8) ▲
Canada	94 (0.5) ▲
South Carolina	94 (1.0) ▲
Guilford County, NC [2]	94 (1.5) ▲
Netherlands †	93 (2.3) ▲
Pennsylvania	93 (1.0) ▲
Connecticut	93 (1.3) ▲
North Carolina	93 (1.0) ▲
England †	93 (0.9) ▲
Maryland	93 (0.8) ▲
Texas	93 (1.1) ▲
Delaware Science Coalition, DE	92 (1.2) ▲
United States	92 (0.7) ▲
Idaho	92 (1.0) ▲
Missouri	92 (1.2) ▲
Illinois	92 (0.8) ▲
Indiana †	91 (0.9) ▲
Italy	91 (0.9) ▲
Rochester City Sch. Dist., NY	91 (1.5) ▲
Czech Republic	91 (1.3) ▲
Russian Federation	90 (1.1) ▲
Japan	89 (0.7) ▲
Belgium (Flemish) †	89 (1.6) ▲
Hong Kong, SAR †	88 (0.8) ▲
Chicago Public Schools, IL	87 (2.0) ●
Jersey City Public Schools, NJ	86 (1.7) ●
Miami-Dade County PS, FL	85 (1.6) ●
Korea, Rep. of	85 (0.8) ▲
Chinese Taipei	84 (0.8) ●
Singapore	84 (1.2) ●
International Avg. (All Countries)	82 (0.2)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
First in the World Consort., IL	97 (0.8) ▲
Naperville Sch. Dist. #203, IL	96 (0.8) ▲
Singapore	96 (0.6) ▲
Netherlands †	95 (1.2) ▲
Belgium (Flemish) †	95 (1.4) ▲
England †	95 (1.0) ▲
Korea, Rep. of	95 (0.4) ▲
SW Math/Sci. Collaborative, PA	95 (0.8) ▲
Indiana †	94 (0.9) ▲
Michigan Invitational Group, MI	94 (1.2) ▲
Guilford County, NC 2	94 (1.3) ▲
Canada	94 (0.6) ▲
Oregon	94 (0.9) ▲
Chinese Taipei	94 (0.5) ▲
Project SMART Consortium, OH	94 (1.2) ▲
Academy School Dist. #20, CO	94 (1.1) ▲
Czech Republic	94 (1.1) ▲
Missouri	94 (0.9) ▲
Connecticut	94 (1.2) ▲
Michigan	94 (1.1) ▲
Pennsylvania	93 (1.0) ▲
Montgomery County, MD 2	93 (0.9) ▲
Massachusetts	93 (1.0) ▲
Idaho	93 (1.3) ▲
Hong Kong, SAR †	93 (0.6) ▲
Illinois	93 (1.1) ▲
North Carolina	92 (1.1) ▲
Maryland	92 (1.0) ▲
United States	91 (0.5) ▲
Fremont/Lincoln/WestSide PS, NE	91 (2.0) ●
Texas	90 (2.0) ●
South Carolina	90 (1.5) ●
Delaware Science Coalition, DE	90 (1.7) ●
Russian Federation	89 (1.0) ●
Italy	89 (0.9) ●
Chicago Public Schools, IL	87 (1.3) ●
Rochester City Sch. Dist., NY	86 (2.3) ●
Jersey City Public Schools, NJ	84 (2.3) ●
Miami-Dade County PS, FL	81 (2.2) ●
International Avg. (All Countries)	87 (0.2)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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)	▲
Netherlands †	92 (1.3)	▲
Singapore	91 (0.9)	▲
Czech Republic	90 (1.0)	▲
Russian Federation	90 (1.1)	▲
Naperville Sch. Dist. #203, IL	89 (1.1)	▲
England †	89 (1.1)	▲
Chinese Taipei	89 (0.7)	▲
Michigan	87 (1.3)	▲
Montgomery County, MD [2]	87 (1.5)	▲
Japan	87 (0.9)	▲
Academy School Dist. #20, CO	87 (1.5)	●
Michigan Invitational Group, MI	87 (1.5)	●
Oregon	86 (1.5)	●
Guilford County, NC [2]	86 (1.9)	●
Missouri	86 (1.3)	●
Project SMART Consortium, OH	85 (2.1)	●
Hong Kong, SAR †	85 (0.8)	▲
SW Math/Sci. Collaborative, PA	85 (1.4)	●
First in the World Consort., IL	85 (2.1)	●
Idaho	85 (1.5)	●
Illinois	85 (1.3)	●
Indiana †	84 (1.3)	●
Connecticut	84 (1.7)	●
Massachusetts	83 (1.6)	●
Pennsylvania	83 (1.6)	●
Canada	83 (1.2)	●
United States	83 (0.8)	●
Texas	83 (2.0)	●
Fremont/Lincoln/WestSide PS, NE	82 (2.4)	●
Italy	82 (1.3)	●
North Carolina	82 (1.4)	●
Delaware Science Coalition, DE	81 (2.0)	●
Maryland	81 (1.7)	●
South Carolina	80 (1.7)	●
Korea, Rep. of	78 (0.9)	▼
Chicago Public Schools, IL	77 (2.5)	●
Rochester City Sch. Dist., NY	76 (1.9)	▼
Miami-Dade County PS, FL	74 (2.6)	▼
Jersey City Public Schools, NJ	71 (2.9)	▼
International Avg. (All Countries)	82 (0.2)	

▲ Participant average significantly higher than international average
● No statistically significant difference between participant average and international average
▼ Participant 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.

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

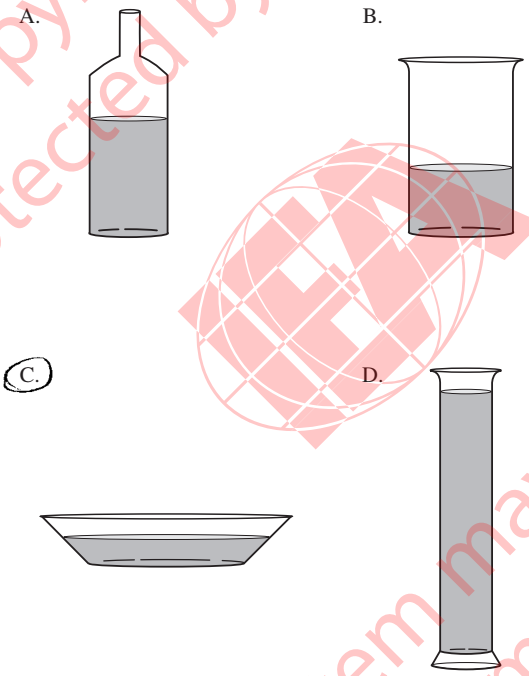
2 National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

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

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) ▲
First in the World Consort., IL	95 (2.0) ▲
Korea, Rep. of	95 (0.8) ▲
Russian Federation	95 (1.4) ▲
Czech Republic	94 (1.6) ▲
Japan	94 (1.2) ▲
Academy School Dist. #20, CO	94 (1.9) ▲
Hong Kong, SAR †	93 (1.2) ▲
Chinese Taipei	93 (0.9) ▲
Project SMART Consortium, OH	92 (2.3) ▲
Naperville Sch. Dist. #203, IL	92 (2.0) ▲
England †	92 (1.7) ▲
Canada	91 (1.2) ▲
Massachusetts	91 (2.2) ●
Michigan	91 (1.7) ▲
SW Math/Sci. Collaborative, PA	90 (2.2) ●
Guilford County, NC [2]	90 (2.6) ●
Netherlands †	89 (4.7) ●
Michigan Invitational Group, MI	89 (2.5) ●
Connecticut	88 (3.3) ●
Missouri	87 (2.2) ●
South Carolina	87 (2.1) ●
Montgomery County, MD [2]	87 (4.6) ●
North Carolina	87 (2.1) ●
Illinois	87 (2.5) ●
Idaho	86 (2.0) ●
Rochester City Sch. Dist., NY	86 (3.6) ●
Pennsylvania	86 (2.1) ●
Belgium (Flemish) †	84 (3.1) ●
United States	84 (1.3) ●
Delaware Science Coalition, DE	84 (3.5) ●
Maryland	83 (2.1) ●
Oregon	82 (3.1) ●
Texas	82 (3.7) ●
Indiana †	81 (2.3) ●
Jersey City Public Schools, NJ	79 (3.0) ●
Fremont/Lincoln/WestSide PS, NE	73 (3.4) ▼
Miami-Dade County PS, FL	72 (2.7) ▼
Chicago Public Schools, IL	71 (4.0) ▼
Italy	70 (2.3) ▼
International Avg. (All Countries)	84 (0.3)

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

▲ Participant average significantly higher than international average

● No statistically significant difference between participant average and international average

▼ Participant average significantly lower than international average

Significance tests adjusted for multiple comparisons

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

States in *italics* did not fully satisfy guidelines for sample participation rates (see Appendix A for details).

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.6).

[2] National Defined Population covers less than 90 percent of National Desired Population (see Exhibit A.3).

( ) 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 reevaluate the attention paid to chemistry in eighth-grade science curricula. In addition, knowledge of systems and cycles in the life and physical sciences was demonstrated mainly by students scoring at the upper benchmarks, indicating that more emphasis in these areas may be needed. Basic scientific inquiry skills also were more in evidence among students scoring at the upper benchmarks, indicating that science curricula in many countries may not be stressing scientific investigation by grade 8.

In reviewing the item-level results, it is also important to note the variation in performance across the topics covered. On the 20 items presented in this chapter, there was a substantial range in performance for many Benchmarking participants. In some cases, differences in performance may reflect intended differences in emphasis in the curriculum. 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.