TIMSS 1999 international benchmarks delineate performance of the top 10 percent, top quarter, top half, and lower quarter of students in the entities

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.

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

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.

Ethan hammered a nail into the trunk of a yo

* 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.

B

1000 ÷ 1.25 = 800
500 ÷ .5 = 1000

* 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.

* 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).

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

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( ) 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 rising ocean levels could result from global warming.

Participant average significantly higher than international average ▲

Participant average significantly lower than international average

* 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

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.

An incomplete food web

* 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.

I

* 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.

* 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

Ins

* 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.

Two open

* 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

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.

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.

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)	

▲ 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.

Chinese Taipei	▲
Singapore	▲
Academy School Dist. #20, CO	▲
Hong Kong, SAR †	▲
Netherlands †	▲
Korea, Rep. of	▲
Project SMART Consortium, OH	▲
Naperville Sch. Dist. #203, IL	▲
Michigan Invitational Group, MI	▲
Russian Federation	▲
Japan	▲
SW Math/Sci. Collaborative, PA	▲
England †	▲
Michigan	▲
Missouri	▲
Idaho	▲
Massachusetts	▲
Canada	▲
Indiana †	●
Oregon	▲
Guilford County, NC 2	▲
Fremont/Lincoln/WestSide PS, NE	●
Montgomery County, MD 2	▲
North Carolina	●
First in the World Consort., IL	●
Pennsylvania	●
Czech Republic	●
South Carolina	▲
Connecticut	●
International Avg. (All Countries)	

▲ 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 interna-

* 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).

* 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).

* 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.

* 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).

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.