Chapter 2

Performance at International Benchmarks

How Do Countries Compare with International Benchmarks of Mathematics Achievement?

The TIMSS mathematics achievement scale summarizes student performance on test items designed to measure a wide range of student knowledge and proficiency. In order to provide meaningful descriptions of what performance on the scale could mean in terms of the mathematics that students know and can do, TIMSS identified four points on the scale for use as international benchmarks. Selected to represent the range of performance shown by students internationally, the advanced benchmark is 625, the high benchmark is 550, the intermediate benchmark is 475, and the low benchmark is 400. TIMSS worked with the Science and Mathematics Item Review Committee to conduct an ambitious scale-anchoring exercise to describe performance at these benchmarks.

Exhibit 2.1 summarizes what eighth- and fourth-grade students scoring at these benchmarks typically know and can do. At the eighth grade, performance ranged from using relatively complex algebraic and geometric concepts and relationships at the advanced

benchmark to having some basic mathematical knowledge at the low benchmark. At the fourth grade, students at the advanced benchmark showed the ability to solve a variety of problems whereas those at the low benchmark demonstrated an understanding of whole numbers, the properties of basic geometric shapes, and how to read simple bar graphs. More detailed descriptions appear in the remaining sections of the chapter, together with example test items illustrating performance at each benchmark.

Exhibit 2.2 displays the percentage of students in each participating country that reached each international benchmark. Both the eighth- and fourth-grade results are presented in decreasing order by percentage reaching the advanced benchmark. In general, the high-performing countries had greater percentages of students reaching each benchmark, and the low-performing countries had lesser percentages. Among the high performers at the eighth grade, for example, Singapore, Chinese Taipei, Korea, and Hong Kong SAR had about one-third or more of their students reaching the advanced benchmark, about two-thirds to three-fourths reaching the high benchmark, around 90 percent reaching the intermediate benchmark, and almost all (96 to 99 percent) reaching the low benchmark. In contrast, low-performing countries had almost no students reaching the advanced benchmark, from 0 to 4 percent reaching the high benchmark, less than 20 percent reaching the intermediate benchmark, and about half or fewer reaching the low benchmark. At the fourth grade, 38 percent of the Singaporean students performed at or above the advanced benchmark, followed by about one-fifth of the students from Hong Kong, SAR and Japan. In all three of these top-performing countries, nearly all fourth-grade students, from 97 to 99 percent, reached the low benchmark. For the lowest-performing countries, Tunisia and Morocco, very few, if any, fourth-grade students reached the advanced benchmark, about 1 percent reached the high benchmark, 8 to 9 percent the intermediate benchmark, and 28 to 29 percent the low benchmark.

Although Exhibit 2.2 is organized to draw particular attention to the percentage of high-achieving students in each country, it conveys information about the distribution of middle and low performers also. For example, even though the Netherlands does not have the highest percentages at the advanced benchmark (10 percent at eighth grade and 5 percent at fourth grade), it appears to do an excellent job of educating all of its students, since 97 percent of the eighth-grade students and 99 percent of the fourth-grade students reached the low benchmarks at their respective grades. It should be noted that at the eighth grade, a number of countries, as well as three of the benchmarking participants, have less than 6 percent of their eighth-grade students reaching the advanced benchmark but have 90 percent or more reaching the low benchmark.

Exhibits 2.3 and 2.4, for the eighth and fourth grades, respectively, provide information on the changes in student performance between the previous assessments and TIMSS 2003. The exhibits show the percentage of students reaching each international benchmark (advanced-625, high-550, intermediate-475, and low-400) in each of the years. In general, the patterns in overall achievement are reflected in the benchmarks. For example, at the eighth grade the decrease in performance in the Slovak Republic or in Bulgaria is also apparent at all four benchmarks, implying a decrease (at most levels) of the proficiency distribution. In Japan, however, the decrease is reflected at the three top benchmarks but not at the low benchmark. In contrast, the increase for Korea appears mainly at the two middle benchmarks, and for the Philippines at the two lower benchmarks. At the fourth grade, the general improvements between 1995 and 2003 also are reflected generally at the benchmarks. However, the pattern across the countries indicates more improvement at the lower parts of the distributions than at the advanced benchmark.

To help interpret the achievement results, the remaining sections of the chapter first describe eighth-grade mathematics achievement at each of the international benchmarks together with examples of the types of items typically answered correctly by students performing at the benchmark. It then describes fourth-grade achievement at each of the international benchmarks together with examples of the types of items typically answered correctly by students performing at the benchmark.

At both the eighth and fourth grades, the analysis of performance at these benchmarks in mathematics suggests that three primary factors appeared to differentiate performance among the four levels:

- The mathematical operation required;
- The complexity of the numbers or number system;
- The nature of the problem situation.

For example, there is evidence that students performing at the lower end of the scale could add, subtract, and multiply whole numbers. In contrast, students performing at the higher end of the scale solved non-routine problems involving relationships among fractions, decimals, and percents; various geometric properties; and algebraic rules.

How Were the Benchmark Descriptions Developed?

To develop descriptions of achievement at the TIMSS 2003 international benchmarks, the TIMSS International Study Center used the scale-anchoring method. Scale anchoring is a way of describing students' performance at different points on the TIMSS 2003 achievement scales at eighth and fourth grades in terms of the types of items students at those grades, respectively, 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 2003 countries were pooled, so that the benchmark descriptions refer to all students achieving at that level. (That is, it does not matter which country the students are from, only how they performed on the test.) Criteria were applied to the TIMSS 2003 achievement scale results at the eighth grade to identify the sets of items that eighth-grade students reaching each international benchmark were likely to answer correctly and that those at the next lower benchmark were unlikely to answer correctly.[1] Similarly, criteria were applied to the TIMSS 2003 achievement scale results at the fourth grade to identify the sets of items that fourth-grade students reaching each international benchmark were likely to answer correctly and that those at the next lower benchmark were unlikely to answer correctly.

The sets of items produced by the analysis represented the accomplishments of students reaching each successively higher benchmark, and were used by a panel of subject-matter experts from the TIMSS countries to develop the benchmark descriptions.[2] The work of the panel involved developing a short description for each item of the mathematical understandings demonstrated by students answering it correctly, summarizing students' knowledge and understanding across the set of items for each benchmark to provide more general statements of achievement, and selecting example items illustrating the descriptions.

How Should the Descriptions Be Interpreted?

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

1 For example, for the advanced 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 high benchmark answered it correctly. Similarly, for the high 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 intermediate benchmark answered it correctly.

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

great majority of eighth- or fourth-grade students could be expected to perform when responding to the item.

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 2003 items. Since those items were developed in particular to sample the mathematics domains prescribed for this study, neither the set of items nor the descriptions based on them purport to be comprehensive. There are undoubtedly other mathematics curriculum elements on which students at the various benchmarks would have been successful if they had been included in the assessment.

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

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

Several example items are included for each benchmark to complement the descriptions by giving a more concrete notion of the abilities students were able to demonstrate. Each example item is accompanied by the percentage of correct responses for each country as well as the international average. In general, at each grade, the five or six countries scoring highest on the overall test also scored highest on each of the items used to illustrate benchmarks. Likewise, the five or six countries with the lowest mean achievement also tended to have consistently low percentages of correct responses on the illustrative items.

Not surprisingly, this was true for items assessing a range of cognitive skills – recall, ability to carry out routine procedures, and ability to solve routine and non-routine problems. The TIMSS 2003 results support the premise that successful problem solving is grounded in mastery of more fundamental knowledge and skills.

Item Examples and Student Performance

Beginning with the eighth grade and then for the fourth grade, the remainder of this chapter describes each benchmark and presents two example items illustrating what students know and can do at that level. For each example item, the percent correct for each of the TIMSS 2003 countries is displayed, as well as the international average. The correct answer is circled for multiple-choice items. For open-ended items, the answers shown exemplify the types of student responses that were given full credit. The example items are ones that students reaching each benchmark were likely to answer correctly, and they represent the types of items used to develop the description of achievement at that benchmark.[3]

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

Exhibit 2.1: **TIMSS 2003 International Benchmarks of Mathematics Achievement**

MATHEMATICS Grade 8

Advanced International Benchmark – 625

Students can organize information, make generalizations, solve non-routine problems, and draw and justify conclusions from data. They can compute percent change and apply their knowledge of numeric and algebraic concepts and relationships to solve problems. Students can solve simultaneous linear equations and model simple situations algebraically. They can apply their knowledge of measurement and geometry in complex problem situations. They can interpret data from a variety of tables and graphs, including interpolation and extrapolation.

High International Benchmark – 550

Students can apply their understanding and knowledge in a wide variety of relatively complex situations. They can order, relate, and compute with fractions and decimals to solve word problems, operate with negative integers, and solve multi-step word problems involving proportions with whole numbers. Students can solve simple algebraic problems including evaluating expressions, solving simultaneous linear equations, and using a formula to determine the value of a variable. Students can find areas and volumes of simple geometric shapes and use knowledge of geometric properties to solve problems. They can solve probability problems and interpret data in a variety of graphs and tables.

Intermediate International Benchmark – 475

Students can apply basic mathematical knowledge in straightforward situations. They can add, subtract, or multiply to solve one-step word problems involving whole numbers and decimals. They can identify representations of common fractions and relative sizes of fractions. They understand simple algebraic relationships and solve linear equations with one variable. They demonstrate understanding of properties of triangles and basic geometric concepts including symmetry and rotation. They recognize basic notions of probability. They can read and interpret graphs, tables, maps, and scales.

Low International Benchmark – 400

Students have some basic mathematical knowledge.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.1: **TIMSS 2003 International Benchmarks of Mathematics Achievement**

MATHEMATICS Grade 4

Advanced International Benchmark – 625

Students can apply their understanding and knowledge in a wide variety of relatively complex situations. They demonstrate a developing understanding of fractions and decimals and the relationship between them. They can select appropriate information to solve multi-step word problems involving proportions. They can formulate or select a rule for a relationship. They show understanding of area and can use measurement concepts to solve a variety of problems. They show some understanding of rotation. They can organize, interpret, and represent data to solve problems.

High International Benchmark – 550

Student can apply their knowledge and understanding to solve problems. Student can solve multi-step word problems involving addition, multiplication, and division. They can use their understanding of place value and simple fractions to solve problems. They can identify a number sentence that represents situations. Students show understanding of three-dimensional objects, how shapes can make other shapes, and simple transformation in a plane. They demonstrate a variety of measurement skills and can interpret and use data in tables and graphs to solve problems.

Intermediate International Benchmark – 475

Students can apply basic mathematical knowledge in straightforward situations. They can read, interpret, and use different representations of numbers. They can perform operations with three- and four-digit numbers and decimals. They can extend simple patterns. They are familiar with a range of two-dimensional shapes and read and interpret different representations of the same data.

Low International Benchmark – 400

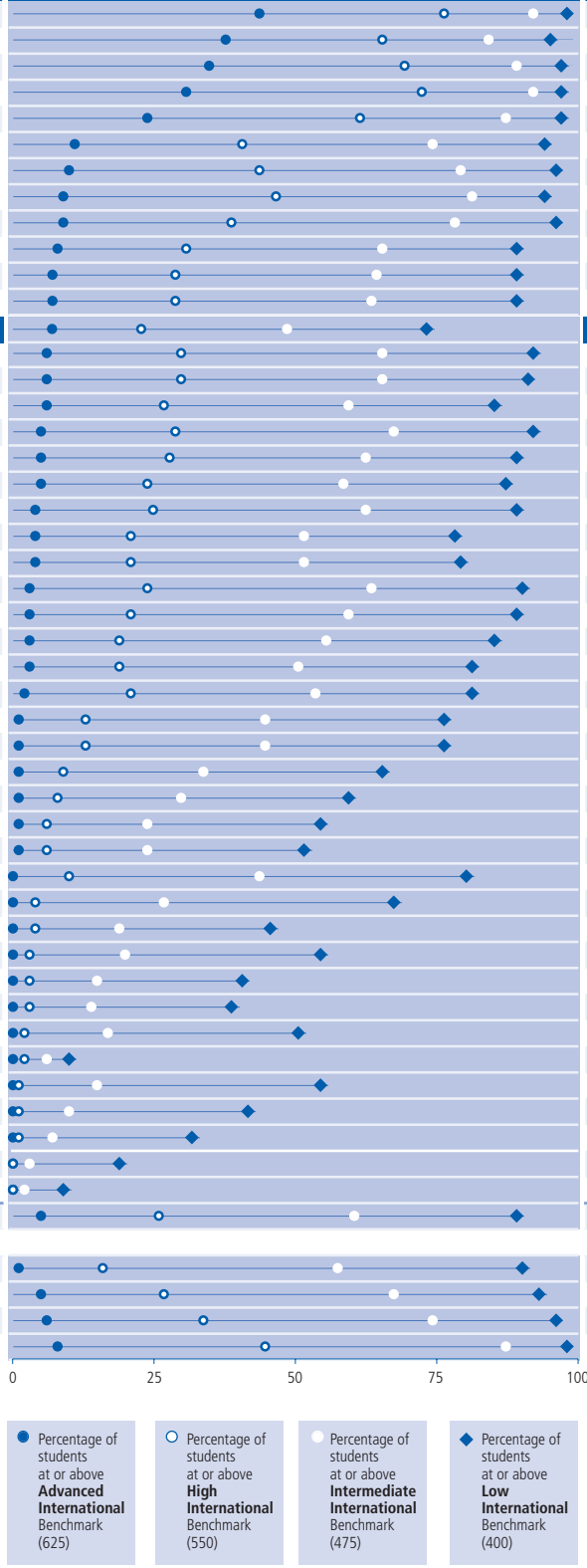
Students have some basic mathematical knowledge. Students demonstrate an understanding of whole numbers and can do simple computations with them. They demonstrate familiarity with the basic properties of triangles and rectangles. They can read information from simple bar graphs.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.2: Percentages of Students Reaching TIMSS 2003 International Benchmarks of Mathematics Achievement

MATHEMATICS Grade 8

Countries	Percentages of Students Reaching International Benchmarks	Advanced International Benchmark (625)	High International Benchmark (550)	Intermediate International Benchmark (475)	Low International Benchmark (400)
Singapore		44 (2.0)	77 (2.0)	93 (1.0)	99 (0.2)
Chinese Taipei		38 (2.0)	66 (1.8)	85 (1.2)	96 (0.6)
◆◆ Korea, Rep. of		35 (1.3)	70 (1.0)	90 (0.5)	98 (0.3)
† Hong Kong, SAR		31 (1.6)	73 (1.8)	93 (1.3)	98 (0.6)
Japan		24 (1.0)	62 (1.2)	88 (0.6)	98 (0.2)
Hungary		11 (1.0)	41 (1.9)	75 (1.6)	95 (0.8)
† Netherlands		10 (1.5)	44 (2.5)	80 (2.0)	97 (0.8)
Belgium (Flemish)		9 (0.9)	47 (1.9)	82 (1.2)	95 (0.9)
Estonia		9 (0.8)	39 (1.9)	79 (1.4)	97 (0.5)
Slovak Republic		8 (0.8)	31 (1.7)	66 (1.7)	90 (1.1)
Australia		7 (1.1)	29 (2.4)	65 (2.3)	90 (1.4)
‡ United States		7 (0.7)	29 (1.6)	64 (1.6)	90 (1.0)
International Avg.		7 (0.1)	23 (0.2)	49 (0.2)	74 (0.2)
Malaysia		6 (1.0)	30 (2.4)	66 (2.1)	93 (0.9)
Russian Federation		6 (0.8)	30 (1.8)	66 (1.8)	92 (0.9)
2 Israel		6 (0.6)	27 (1.5)	60 (1.8)	86 (1.2)
Latvia		5 (0.7)	29 (1.5)	68 (1.7)	93 (0.8)
1 Lithuania		5 (0.6)	28 (1.2)	63 (1.4)	90 (0.8)
New Zealand		5 (1.3)	24 (2.7)	59 (2.5)	88 (1.7)
† Scotland		4 (0.6)	25 (2.1)	63 (2.4)	90 (1.1)
Romania		4 (0.6)	21 (1.8)	52 (2.2)	79 (1.7)
1 Serbia		4 (0.4)	21 (1.1)	52 (1.4)	80 (0.9)
Sweden		3 (0.5)	24 (1.2)	64 (1.5)	91 (1.0)
Slovenia		3 (0.5)	21 (1.0)	60 (1.3)	90 (0.9)
Italy		3 (0.6)	19 (1.5)	56 (1.7)	86 (1.2)
Bulgaria		3 (0.7)	19 (1.8)	51 (2.1)	82 (1.6)
Armenia		2 (0.3)	21 (1.3)	54 (1.5)	82 (1.0)
Cyprus		1 (0.2)	13 (0.7)	45 (1.0)	77 (1.0)
Moldova, Rep. of		1 (0.3)	13 (1.2)	45 (2.1)	77 (1.7)
2 Macedonia, Rep. of		1 (0.2)	9 (1.0)	34 (1.7)	66 (1.7)
Jordan		1 (0.2)	8 (1.0)	30 (1.9)	60 (1.9)
1 Indonesia		1 (0.2)	6 (0.7)	24 (1.7)	55 (2.4)
Egypt		1 (0.2)	6 (0.5)	24 (1.2)	52 (1.7)
Norway		0 (0.2)	10 (0.6)	44 (1.6)	81 (1.2)
Lebanon		0 (0.1)	4 (0.6)	27 (1.8)	68 (1.9)
Palestinian Nat'l Auth.		0 (0.1)	4 (0.4)	19 (1.2)	46 (1.5)
Iran, Islamic Rep. of		0 (0.2)	3 (0.4)	20 (1.1)	55 (1.4)
Chile		0 (0.1)	3 (0.4)	15 (1.2)	41 (1.8)
Philippines		0 (0.1)	3 (0.6)	14 (1.7)	39 (2.7)
Bahrain		0 (0.0)	2 (0.2)	17 (0.7)	51 (1.1)
South Africa		0 (0.1)	2 (0.6)	6 (1.3)	10 (1.8)
Tunisia		0 (0.0)	1 (0.3)	15 (1.1)	55 (1.6)
1 ‡ Morocco		0 (0.0)	1 (0.2)	10 (0.9)	42 (1.6)
Botswana		0 (0.0)	1 (0.2)	7 (0.7)	32 (1.5)
Saudi Arabia		0 (0.1)	0 (0.1)	3 (0.6)	19 (1.7)
Ghana		0 (0.0)	0 (0.0)	2 (0.5)	9 (1.3)
‡ England		5 (1.0)	26 (2.8)	61 (2.9)	90 (1.5)
Benchmarking Participants					
Basque Country, Spain		1 (0.3)	16 (1.5)	58 (2.2)	91 (1.0)
Indiana State, US		5 (1.5)	27 (3.2)	68 (2.5)	94 (1.0)
Ontario Province, Can.		6 (0.7)	34 (1.8)	75 (1.7)	97 (0.5)
Quebec Province, Can.		8 (1.4)	45 (2.2)	88 (1.1)	99 (0.2)



† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

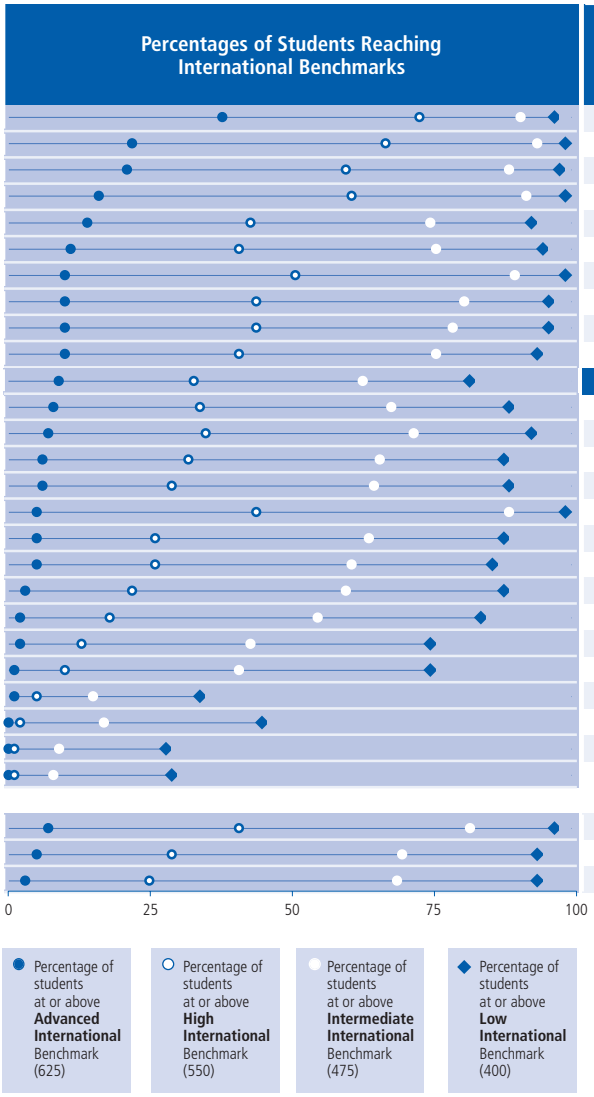
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number,

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.2: Percentages of Students Reaching TIMSS 2003 International Benchmarks of Mathematics Achievement

MATHEMATICS Grade 4

Countries	Advanced International Benchmark (625)	High International Benchmark (550)	Intermediate International Benchmark (475)	Low International Benchmark (400)
Singapore	38 (2.9)	73 (2.4)	91 (1.3)	97 (0.6)
† Hong Kong, SAR	22 (1.7)	67 (2.0)	94 (0.7)	99 (0.2)
Japan	21 (0.8)	60 (1.0)	89 (0.7)	98 (0.3)
Chinese Taipei	16 (0.9)	61 (1.1)	92 (0.7)	99 (0.2)
† England	14 (1.4)	43 (1.8)	75 (1.6)	93 (0.8)
Russian Federation	11 (1.6)	41 (2.6)	76 (2.0)	95 (0.8)
Belgium (Flemish)	10 (0.6)	51 (1.3)	90 (0.8)	99 (0.3)
Latvia	10 (0.9)	44 (1.9)	81 (1.3)	96 (0.7)
1 Lithuania	10 (1.1)	44 (1.7)	79 (1.3)	96 (0.7)
Hungary	10 (1.0)	41 (1.6)	76 (1.6)	94 (0.8)
International Avg.	9 (0.2)	33 (0.3)	63 (0.3)	82 (0.2)
Cyprus	8 (0.7)	34 (1.2)	68 (1.2)	89 (0.7)
† United States	7 (0.7)	35 (1.3)	72 (1.2)	93 (0.5)
Moldova, Rep. of	6 (1.0)	32 (2.1)	66 (2.1)	88 (1.5)
Italy	6 (1.0)	29 (1.8)	65 (1.7)	89 (1.1)
† Netherlands	5 (0.8)	44 (1.5)	89 (1.2)	99 (0.4)
† Australia	5 (0.7)	26 (1.7)	64 (1.9)	88 (1.3)
New Zealand	5 (0.5)	26 (1.2)	61 (1.3)	86 (1.0)
† Scotland	3 (0.4)	22 (1.4)	60 (1.6)	88 (1.2)
Slovenia	2 (0.4)	18 (1.0)	55 (1.5)	84 (1.0)
Armenia	2 (0.3)	13 (1.2)	43 (1.7)	75 (1.5)
Norway	1 (0.2)	10 (1.0)	41 (1.3)	75 (1.2)
Philippines	1 (0.7)	5 (2.1)	15 (2.7)	34 (2.6)
Iran, Islamic Rep. of	0 (0.1)	2 (0.3)	17 (1.3)	45 (2.2)
Tunisia	0 (0.1)	1 (0.3)	9 (1.0)	28 (1.7)
Morocco	0 (0.0)	1 (0.2)	8 (0.8)	29 (2.2)
Benchmarking Participants				
Indiana State, US	7 (1.2)	41 (1.6)	82 (1.5)	97 (0.6)
Ontario Province, Can.	5 (1.1)	29 (2.2)	70 (1.7)	94 (0.9)
Quebec Province, Can.	3 (0.4)	25 (1.5)	69 (1.4)	94 (0.8)



SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Exhibit 2.3: Trends in Percentages of Students Reaching the TIMSS 2003 International Benchmarks of Mathematics Achievement in 1995, 1999, and 2003

MATHEMATICS Grade 8

Countries	Advanced International Benchmark (625)			High International Benchmark (550)		
	2003 Percent of Students	1999 Percent of Students	1995 Percent of Students	2003 Percent of Students	1999 Percent of Students	1995 Percent of Students
Singapore	44 (2.0)	42 (3.5)	40 (2.9)	77 (2.0)	77 (2.6)	84 (1.8) ▼
Chinese Taipei	38 (2.0)	37 (1.6)	✧ ✧	66 (1.8)	67 (1.5)	✧ ✧
Korea, Rep. of	35 (1.3)	32 (0.9)	31 (1.1) ▲	70 (1.0)	70 (1.0)	67 (1.0)
Hong Kong, SAR	31 (1.6)	28 (2.1)	23 (2.4) ▲	73 (1.8)	70 (2.3)	65 (3.2) ▲
Japan	24 (1.0)	29 (0.9) ▼	29 (1.0) ▼	62 (1.2)	66 (1.0) ▼	67 (0.8) ▼
Hungary	11 (1.0)	13 (1.2)	10 (0.8)	41 (1.9)	43 (1.9)	40 (1.6)
Netherlands	10 (1.5)	11 (2.0)	9 (1.9)	44 (2.5)	47 (4.1)	41 (3.1)
Belgium (Flemish)	9 (0.9)	19 (1.5) ▼	15 (1.5) ▼	47 (1.9)	57 (1.7) ▼	54 (3.0) ▼
Slovak Republic	8 (0.8)	11 (1.2) ▼	11 (1.2) ▼	31 (1.7)	42 (2.3) ▼	43 (1.6) ▼
Australia	7 (1.1)	– –	7 (1.0)	29 (2.4)	– –	33 (1.8)
United States	7 (0.7)	7 (1.0)	4 (0.7) ▲	29 (1.6)	30 (1.6)	26 (2.0)
Russian Federation	6 (0.8)	12 (1.6) ▼	9 (1.2) ▼	30 (1.8)	39 (2.8) ▼	38 (3.1) ▼
Israel	6 (0.6)	4 (0.5) ▲	– –	27 (1.5)	19 (1.3) ▲	– –
Malaysia	6 (1.0)	10 (1.2) ▼	✧ ✧	30 (2.4)	36 (2.4)	✧ ✧
Lithuania	5 (0.6)	3 (0.6) ▲	2 (0.5) ▲	28 (1.2)	18 (2.0) ▲	17 (1.5) ▲
New Zealand	5 (1.3)	6 (1.1)	6 (1.0)	24 (2.7)	26 (2.4)	28 (2.2)
Latvia (LSS)	5 (0.9)	6 (0.8)	4 (0.7)	27 (1.7)	28 (1.8)	22 (1.4) ▲
Romania	4 (0.6)	4 (0.9)	4 (0.6)	21 (1.8)	20 (2.0)	21 (1.6)
Scotland	4 (0.6)	✧ ✧	5 (1.4)	25 (2.1)	✧ ✧	24 (2.7)
Bulgaria	3 (0.7)	9 (2.1) ▼	17 (2.0) ▼	19 (1.8)	32 (3.0) ▼	40 (2.8) ▼
Sweden	3 (0.5)	✧ ✧	12 (1.1) ▼	24 (1.2)	✧ ✧	46 (2.4) ▼
Slovenia	3 (0.5)	– –	4 (0.7)	21 (1.0)	– –	22 (1.3)
Italy	3 (0.6)	4 (0.6)	– –	19 (1.5)	21 (1.5)	– –
Cyprus	1 (0.2)	2 (0.4) ▼	3 (0.4) ▼	13 (0.7)	19 (0.9) ▼	19 (1.0) ▼
Moldova, Rep. of	1 (0.3)	3 (0.6) ▼	✧ ✧	13 (1.2)	18 (1.6) ▼	✧ ✧
Macedonia, Rep. of	1 (0.2)	2 (0.4) ▼	✧ ✧	9 (1.0)	13 (1.0) ▼	✧ ✧
Jordan	1 (0.2)	3 (0.5) ▼	✧ ✧	8 (1.0)	12 (1.0) ▼	✧ ✧
Indonesia	1 (0.2)	2 (0.3) ▼	✧ ✧	6 (0.7)	8 (0.9)	✧ ✧
Norway	0 (0.2)	✧ ✧	4 (0.4) ▼	10 (0.6)	✧ ✧	26 (1.3) ▼
Iran, Islamic Rep. of	0 (0.2)	1 (0.2)	0 (0.2)	3 (0.4)	6 (0.9) ▼	4 (0.6)
Chile	0 (0.1)	1 (0.4)	✧ ✧	3 (0.4)	4 (1.1)	✧ ✧
South Africa	0 (0.1)	0 (0.1)	– –	2 (0.6)	1 (0.5)	– –
Philippines	0 (0.1)	0 (0.1)	✧ ✧	3 (0.6)	1 (0.6)	✧ ✧
Tunisia	0 (0.0)	0 (0.1)	✧ ✧	1 (0.3)	5 (0.5) ▼	✧ ✧
‡ England	5 (1.0)	6 (0.8)	6 (1.0)	26 (2.8)	25 (2.0)	27 (1.5)
International Avg.	8 (0.2)	10 (0.2) ▼	11 (0.3) ▼	28 (0.3)	31 (0.3) ▼	37 (0.4) ▼
Benchmarking Participants						
Indiana State, US	5 (1.5)	7 (1.6)	✧ ✧	27 (3.2)	32 (3.9)	✧ ✧
Ontario Province, Can.	6 (0.7)	6 (0.8)	3 (0.4) ▲	34 (1.8)	32 (1.8)	26 (1.7) ▲
Quebec Province, Can.	8 (1.4)	18 (4.4) ▼	14 (2.8)	45 (2.2)	60 (3.5) ▼	54 (4.2)

▲ 2003 significantly higher

▼ 2003 significantly lower

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

Trend notes: Because of differences in population coverage, 1999 data are not shown for Australia and Slovenia, and 1995 data are not shown for Israel, Italy, and South Africa. Korea tested later in 2003 than in 1999 and 1995, at the beginning of the next school year. Similarly, Lithuania tested later in 1999 than in 2003 and 1995. Data for Latvia in this exhibit include Latvian-speaking schools only.

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

A dash (–) indicates comparable data are not available.

A diamond (✧) indicates the country did not participate in the assessment.

Exhibit 2.3: Trends in Percentages of Students Reaching the TIMSS 2003 International Benchmarks of Mathematics Achievement in 1995, 1999, and 2003

MATHEMATICS Grade 8

Countries	Intermediate International Benchmark (475)				Low International Benchmark (400)			
	2003 Percent of Students	1999 Percent of Students		1995 Percent of Students	2003 Percent of Students	1999 Percent of Students		1995 Percent of Students
Singapore	93 (1.0)	94 (1.2)		98 (0.4) ▼	99 (0.2)	99 (0.3)		100 (0.0) ▼
Chinese Taipei	85 (1.2)	85 (1.0)		✧ ✧	96 (0.6)	95 (0.5)		✧ ✧
Korea, Rep. of	90 (0.5)	91 (0.5)		89 (0.7) ▲	98 (0.3)	99 (0.2)		97 (0.4)
Hong Kong, SAR	93 (1.3)	92 (1.3)		88 (2.1)	98 (0.6)	98 (0.6)		96 (1.1)
Japan	88 (0.6)	90 (0.5)	▼	91 (0.5) ▼	98 (0.2)	98 (0.2)		98 (0.2)
Hungary	75 (1.6)	75 (1.5)		74 (1.6)	95 (0.8)	93 (1.0)		94 (0.9)
Netherlands	80 (2.0)	82 (3.4)		78 (2.9)	97 (0.8)	96 (1.5)		95 (1.6)
Belgium (Flemish)	82 (1.2)	86 (1.2)	▼	85 (2.7)	95 (0.9)	97 (0.6)	▼	96 (1.2)
Slovak Republic	66 (1.7)	79 (1.7)	▼	79 (1.3) ▼	90 (1.1)	96 (0.6)	▼	96 (0.6) ▼
Australia	65 (2.3)	– –		68 (1.7)	90 (1.4)	– –		90 (1.0)
United States	64 (1.6)	62 (1.8)		61 (2.4)	90 (1.0)	87 (1.1)	▲	86 (1.5) ▲
Russian Federation	66 (1.8)	73 (2.7)	▼	73 (2.4) ▼	92 (0.9)	93 (1.4)		93 (1.1)
Israel	60 (1.8)	49 (1.9)	▲	– –	86 (1.2)	76 (2.0)	▲	– –
Malaysia	66 (2.1)	70 (2.1)		✧ ✧	93 (0.9)	93 (0.9)		✧ ✧
Lithuania	63 (1.4)	53 (2.3)	▲	50 (2.3) ▲	90 (0.8)	85 (1.8)	▲	81 (1.7) ▲
New Zealand	59 (2.5)	57 (2.5)		64 (2.2)	88 (1.7)	84 (1.5)		89 (1.4)
Latvia (LSS)	66 (2.2)	65 (1.9)		57 (1.8) ▲	92 (1.1)	91 (0.9)		87 (1.4) ▲
Romania	52 (2.2)	51 (2.6)		52 (2.2)	79 (1.7)	79 (2.1)		79 (1.6)
Scotland	63 (2.4)	✧ ✧		60 (2.6)	90 (1.1)	✧ ✧		87 (1.4)
Bulgaria	51 (2.1)	67 (2.5)	▼	69 (2.4) ▼	82 (1.6)	90 (1.2)	▼	90 (1.1) ▼
Sweden	64 (1.5)	✧ ✧		81 (1.8) ▼	91 (1.0)	✧ ✧		96 (0.8) ▼
Slovenia	60 (1.3)	– –		60 (1.8)	90 (0.9)	– –		90 (0.9)
Italy	56 (1.7)	53 (2.1)		– –	86 (1.2)	82 (1.6)		– –
Cyprus	45 (1.0)	53 (1.2)	▼	51 (1.3) ▼	77 (1.0)	82 (0.9)	▼	77 (1.0)
Moldova, Rep. of	45 (2.1)	47 (2.1)		✧ ✧	77 (1.7)	79 (1.7)		✧ ✧
Macedonia, Rep. of	34 (1.7)	40 (1.9)	▼	✧ ✧	66 (1.7)	70 (1.8)		✧ ✧
Jordan	30 (1.9)	33 (1.6)		✧ ✧	60 (1.9)	61 (1.4)		✧ ✧
Indonesia	24 (1.7)	23 (1.4)		✧ ✧	55 (2.4)	50 (2.1)		✧ ✧
Norway	44 (1.6)	✧ ✧		64 (1.3) ▼	81 (1.2)	✧ ✧		90 (0.9) ▼
Iran, Islamic Rep. of	20 (1.1)	26 (1.9)	▼	24 (1.9) ▼	55 (1.4)	61 (1.6)	▼	59 (1.8) ▼
Chile	15 (1.2)	16 (1.9)		✧ ✧	41 (1.8)	46 (1.9)		✧ ✧
South Africa	6 (1.3)	6 (1.1)		– –	10 (1.8)	13 (2.0)		– –
Philippines	14 (1.7)	9 (1.5)	▲	✧ ✧	39 (2.7)	29 (2.5)	▲	✧ ✧
Tunisia	15 (1.1)	34 (1.5)	▼	✧ ✧	55 (1.6)	78 (1.2)	▼	✧ ✧
‡ England	61 (2.9)	60 (2.2)		61 (1.5)	90 (1.5)	88 (1.2)		87 (1.0)
International Avg.	56 (0.3)	57 (0.3)	▼	69 (0.4) ▼	80 (0.3)	80 (0.2)		89 (0.3) ▼
Benchmarking Participants								
Indiana State, US	68 (2.5)	71 (3.5)		✧ ✧	94 (1.0)	93 (1.4)		✧ ✧
Ontario Province, Can.	75 (1.7)	72 (1.6)		65 (1.7) ▲	97 (0.5)	96 (0.6)		91 (1.0) ▲
Quebec Province, Can.	88 (1.1)	93 (1.1)	▼	90 (2.6)	99 (0.2)	99 (0.4)		99 (0.5)

▲ 2003 significantly higher

▼ 2003 significantly lower

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

Trend notes: Because of differences in population coverage, 1999 data are not shown for Australia and Slovenia, and 1995 data are not shown for Israel, Italy, and South Africa. Korea tested later in 2003 than in 1999 and 1995, at the beginning of the next school year. Similarly, Lithuania tested later in 1999 than in 2003 and 1995. Data for Latvia in this exhibit include Latvian-speaking schools only.

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

A dash (–) indicates comparable data are not available.

A diamond (✧) indicates the country did not participate in the assessment.

Exhibit 2.4: Trends in Percentages of Students Reaching the TIMSS 2003 International Benchmarks of Mathematics Achievement in 1995 and 2003

MATHEMATICS Grade 4

Countries	Advanced International Benchmark (625)			High International Benchmark (550)			Intermediate International Benchmark (475)			Low International Benchmark (400)		
	2003 Percent of Students	1995 Percent of Students		2003 Percent of Students	1995 Percent of Students		2003 Percent of Students	1995 Percent of Students		2003 Percent of Students	1995 Percent of Students	
Singapore	38 (2.9)	38 (2.2)		73 (2.4)	70 (1.6)		91 (1.3)	89 (1.0)		97 (0.6)	96 (0.4)	▲
Hong Kong, SAR	22 (1.7)	17 (1.7)		67 (2.0)	56 (2.2)	▲	94 (0.7)	87 (1.3)	▲	99 (0.2)	97 (0.6)	▲
Japan	21 (0.8)	22 (1.0)		60 (1.0)	61 (1.1)		89 (0.7)	89 (0.7)		98 (0.3)	98 (0.2)	
England	14 (1.4)	7 (0.8)	▲	43 (1.8)	24 (1.5)	▲	75 (1.6)	54 (1.6)	▲	93 (0.8)	82 (1.1)	▲
Hungary	10 (1.0)	11 (1.0)		41 (1.6)	38 (1.8)		76 (1.6)	72 (1.5)	▲	94 (0.8)	91 (0.9)	▲
Latvia (LSS)	9 (0.9)	6 (1.3)		43 (2.1)	27 (2.1)	▲	80 (1.4)	61 (1.9)	▲	96 (0.8)	88 (1.1)	▲
Cyprus	8 (0.7)	5 (0.6)	▲	34 (1.2)	21 (1.3)	▲	68 (1.2)	52 (1.5)	▲	89 (0.7)	79 (1.3)	▲
United States	7 (0.7)	9 (0.9)		35 (1.3)	37 (1.6)		72 (1.2)	71 (1.3)		93 (0.5)	92 (0.7)	
Netherlands	5 (0.8)	12 (1.1)	▼	44 (1.5)	50 (1.9)	▼	89 (1.2)	87 (1.4)		99 (0.4)	99 (0.4)	
Australia	5 (0.7)	6 (0.6)		26 (1.7)	27 (1.4)		64 (1.9)	61 (1.6)		88 (1.3)	86 (1.1)	
New Zealand	5 (0.5)	4 (0.6)		27 (1.2)	19 (1.4)	▲	62 (1.3)	51 (1.9)	▲	86 (1.0)	78 (1.7)	▲
Scotland	3 (0.4)	7 (0.9)	▼	22 (1.4)	27 (1.7)	▼	60 (1.6)	60 (1.9)		88 (1.2)	85 (1.2)	
Slovenia	2 (0.4)	2 (0.4)		18 (1.0)	14 (1.1)	▲	55 (1.5)	45 (2.0)	▲	84 (1.0)	77 (1.4)	▲
Norway	1 (0.2)	2 (0.4)	▼	10 (1.0)	16 (1.2)	▼	41 (1.3)	53 (2.0)	▼	75 (1.2)	84 (1.2)	▼
Iran, Islamic Rep. of	0 (0.1)	0 (0.2)		2 (0.3)	3 (0.7)		17 (1.3)	15 (1.9)		45 (2.2)	44 (2.5)	
International Avg.	10 (0.3)	10 (0.3)		36 (0.4)	33 (0.4)	▲	69 (0.4)	63 (0.4)	▲	88 (0.3)	85 (0.3)	▲
Benchmarking Participants												
Ontario Province, Can.	5 (1.1)	4 (0.5)		29 (2.2)	22 (1.5)	▲	70 (1.7)	59 (1.9)	▲	94 (0.9)	86 (1.3)	▲
Quebec Province, Can.	3 (0.4)	13 (1.9)	▼	25 (1.5)	50 (3.4)	▼	69 (1.4)	87 (1.7)	▼	94 (0.8)	98 (0.7)	▼

▲ 2003 significantly higher

▼ 2003 significantly lower

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Trend notes: Because of differences between 1995 and 2003 in population coverage, 1995 data are not shown for Italy. Data for Latvia in this exhibit include Latvian-speaking schools only. To be comparable with 1995, 2003 data for New Zealand in this exhibit include students in English medium instruction only (98% of the estimated population).

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

Grade 8: Achievement at the Advanced International Benchmark

Exhibit 2.5 describes performance at the advanced international benchmark. Eighth-grade students reaching this benchmark demonstrated the ability to organize information in problem-solving situations, make generalizations, solve non-routine problems, and draw and justify conclusions from data. They typically demonstrated success on the knowledge and skills represented by this benchmark, as well as those demonstrated at the high, intermediate, and low benchmarks.

Example Item 1 in Exhibit 2.6 illustrates the type of algebra problem an eighth-grade student performing at the advanced benchmark generally answered correctly. The eighth-grade students reaching the advanced benchmark typically were able to apply a generalization in order to solve a sequence problem like the one shown in Exhibit 2.6. More specifically, they were asked to generalize from the first of several terms of a sequence growing in two dimensions to find a specified term. The problem was presented in three parts, A, B, and C. For parts A and B, students were given a geometric pattern and then asked to indicate how many triangles would be in the 3rd, 4th, and 7th figures, respectively, if the pattern were extended. In part C, students were asked to explain a way to find the number of triangles in the 50th figure that did not involve drawing or counting it. The achievement results are shown for part C.

To receive full credit for Part C, students had to show or explain how their answer was obtained by providing a general expression or an equation and by calculating the correct number of triangles for the 50th figure. Internationally, this was among the most difficult items in the assessment. On average, 14 percent of the students received full credit for their responses.

Unlike students performing at lower benchmarks, students reaching the advanced benchmark typically could correctly answer multi-step word problems. Example Item 2 from the data content area presented in Exhibit 2.7 requires students to select relevant infor-

mation from a table, calculate which of the two phone plans would be less expensive for Betty, and justify their answer in terms of the monthly fee and free minutes. With an international average of 21 percent correct (for full credit), this item was a challenge for many of the eighth-grade students participating in TIMSS 2003. In no country did the majority of eighth-grade students answer the item correctly, although Japan came very close with 49 percent. In Australia, Estonia, Korea and Singapore, from 40 to 44 percent of the eighth-grade students answered the item correctly.

Exhibit 2.5: **Description of TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement**

MATHEMATICS Grade 8

Advanced International Benchmark – 625

Summary

Students can organize information, make generalizations, solve non-routine problems, and draw and justify conclusions from data. They can compute percent change and apply their knowledge of numeric and algebraic concepts and relationships to solve problems. Students can solve simultaneous linear equations and model simple situations algebraically. They can apply their knowledge of measurement and geometry in complex problem situations. They can interpret data from a variety of tables and graphs, including interpolation and extrapolation.

Students can organize information, make generalizations, and solve non-routine problems. Students can solve multi-step problems involving computations with whole numbers, decimals, and rounding. They can use the distributive property of the product to identify different representations of a number. They can compute with integers using order of operations.

Students can solve problems involving operations with proper and improper fractions, including fractions with unlike denominators. Given two points on a number line representing unspecified fractions, students can identify the point that represents their product. They can convert mixed numbers to decimal fractions. They can solve word problems involving inverse operations, decimal place value, and a fraction of a whole number of currency units. They can order integers, decimals, and common fractions.

Given a number and the ratio of two of its parts, students can find the value of one part. They can, given the dimensions of two rectangles, express the ratio of their areas. They can identify equivalent ratios and determine the ratio of two parts of a whole. They can find the percent change, given the original and final quantities, and, given the original and reduced prices, determine the percent reduction. They also can solve a multi-step non-routine problem involving percents.

Students can extend number patterns to identify the numbers common to two different arithmetic sequences and identify the row in a table whose entries are used to solve a problem. Students can make generalizations to find terms in number patterns and can explain the process used to find those terms.

They can add three simple rational expressions with unlike numerical denominators, identify the sum of three consecutive whole numbers given the middle number in general terms, and evaluate an algebraic equation by using an equivalent form and substituting given values. They can identify algebraic expressions that model situations, a diagram that models an addition of two like algebraic terms, and what the variable represents in an equation for a given situation. They can solve a pair of linear, simultaneous equations, and given a linear equation in which y is expressed in terms of x, they can solve for x.

Students can apply their knowledge of measurement in complex problem situations. They can solve area problems in which they have to find the length of a side, the perimeter of a figure, the area between two rectangles when one is inside the other, and the area of a trapezoid inscribed in a rectangle. They can draw a new rectangle based on a given rectangle and find its area. They can use their knowledge of the area of a circle and of average rate to solve a problem. They can apply their knowledge of number of milliliters in a liter to solve a word problem and solve a problem that involves filling a rectangular prism with spheres. Students can combine information about lengths of segments on a line to solve a distance problem. They can solve multi-step problems involving time, distance, and speed, and can relate different units of time to solve a problem. They can use knowledge of time, clocks, and angles to solve a problem.

Students can combine knowledge of geometric figures to solve problems that involve more than one step. This knowledge involves congruent triangles, the sum of angles in a triangle, interior and exterior angles, angle bisectors, and regular hexagons. They recognize that arcs of equal radii generate an equilateral triangle. Students can select coordinates on a line in a plane given the coordinates of two other points on the line. Students can justify that a triangle is a right triangle using the Pythagorean relationship.

Students can predict outcomes from data and use their understanding of probability to draw a spinner that could have produced the data in a given table. Students can interpret data from a variety of tables and graphs, including interpolation and extrapolation. They can derive information from given timetables to complete a table for a specified journey and check that it meets given conditions. They can draw and justify conclusions based on data.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.6: TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 1 (Part C)

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

MATHEMATICS Grade 8

Content Area: Algebra

Description: Part C–Generalizing from the first several terms of a sequence growing in two dimensions, explains a way to find a specified term, e.g. the 50th.

The three figures below are divided into small congruent triangles.

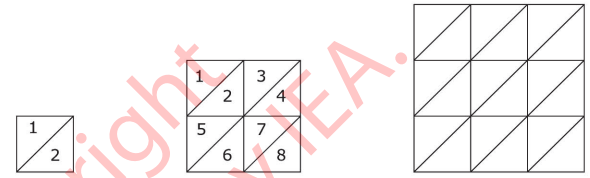


Figure 1 Figure 2 Figure 3

A. Complete the table below. First, fill in how many small triangles make up Figure 3. Then, find the number of small triangles that would be needed for the 4th figure if the sequence of figures is extended.

Figure	Number of Small Triangles
1	2
2	8
3	18
4	32

B. The sequence of figures is extended to the 7th figure. How many small triangles would be needed for Figure 7?

Answer: 98

$7^2 \times 2$

49×2

C. The sequence of figures is extended to the 50th figure. Explain a way to find the number of small triangles in the 50th figure that does not involve drawing it and counting the number of triangles.

$50^2 \times 2$

2500×2

5000

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

Country	Percent Full Credit
Chinese Taipei	49 (2.0) ▲
◆◆ Korea, Rep. of	48 (1.8) ▲
† Hong Kong, SAR	45 (2.0) ▲
Singapore	44 (2.0) ▲
Japan	44 (2.1) ▲
† Netherlands	36 (2.4) ▲
Australia	26 (2.7) ▲
Hungary	24 (2.1) ▲
† Scotland	22 (2.2) ▲
Belgium (Flemish)	21 (1.3) ▲
‡ United States	19 (1.5) ▲
Sweden	17 (1.6)
New Zealand	16 (2.1)
Estonia	15 (1.3)
Slovak Republic	14 (1.5)
International Avg.	14 (0.2)
Italy	14 (1.5)
Latvia	13 (1.5)
Slovenia	13 (1.6)
1 Serbia	11 (1.2) ▼
1 Lithuania	11 (1.3) ▼
Romania	11 (1.6) ▼
Malaysia	10 (1.0) ▼
2 Israel	10 (1.3) ▼
Cyprus	10 (1.1) ▼
Norway	9 (1.3) ▼
Russian Federation	9 (1.2) ▼
Armenia	8 (1.2) ▼
1 Indonesia	7 (0.9) ▼
Chile	6 (0.8) ▼
Jordan	5 (0.9) ▼
Egypt	5 (0.8) ▼
Palestinian Nat'l Auth.	5 (0.7) ▼
2 Macedonia, Rep. of	4 (0.9) ▼
Philippines	4 (0.9) ▼
Bulgaria	4 (0.8) ▼
Bahrain	4 (0.8) ▼
Iran, Islamic Rep. of	3 (0.6) ▼
1 ‡ Morocco	2 (0.8) ▼
Botswana	2 (0.5) ▼
South Africa	1 (0.5) ▼
Tunisia	1 (0.3) ▼
Lebanon	1 (0.3) ▼
Ghana	1 (0.3) ▼
Saudi Arabia	0 (0.1) ▼
Moldova, Rep. of	0 (0.1) ▼
‡ England	20 (2.0) ▲
Benchmarking Participants	
Basque Country, Spain	16 (2.0)
Indiana State, US	16 (1.9)
Ontario Province, Can.	26 (2.3) ▲
Quebec Province, Can.	28 (2.7) ▲

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Exhibit 2.7: TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 2

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

MATHEMATICS Grade 8

Content Area: Data

Description: Interpret data from a table, draws and justifies conclusions.

Betty, Frank, and Darlene have just moved to Zedland. They each need to get phone service. They received the following information from the telephone company about the two different phone plans it offers.

They must pay a set fee each month and there are different rates for each minute they talk. These rates depend on the time of the day or night they use the phone, and on which payment plan they choose. Both plans include time for which phone calls are free. Details of the two plans are shown in the table below.

Plan	Monthly Fee	Rate per minute		Free minutes per month
		Day (8 am – 6 pm)	Night (6 pm – 8 am)	
Plan A	20 zeds	3 zeds	1 zed	180
Plan B	15 zeds	2 zeds	2 zeds	120

Betty talks for less than 2 hours per month. Which plan would be less expensive for her?

Less expensive plan Plan B

Explain your answer in terms of both the monthly fee and free minutes.

she talks for less than 2 hours and Plan B has less monthly fees

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

Country	Percent Full Credit
Japan	49 (2.2) ▲
Australia	44 (2.2) ▲
Estonia	44 (2.1) ▲
◆◆ Korea, Rep. of	40 (1.7) ▲
Singapore	40 (1.7) ▲
Hungary	39 (2.2) ▲
Belgium (Flemish)	38 (1.9) ▲
1 Lithuania	37 (1.7) ▲
‡ United States	37 (1.7) ▲
† Scotland	36 (2.7) ▲
2 Israel	33 (2.1) ▲
New Zealand	30 (2.4) ▲
† Netherlands	28 (2.5) ▲
† Hong Kong, SAR	28 (2.0) ▲
Slovenia	27 (2.2) ▲
Sweden	27 (1.9) ▲
Malaysia	27 (1.7) ▲
Chinese Taipei	27 (1.8) ▲
Slovak Republic	26 (2.0) ▲
Italy	23 (1.8)
Latvia	22 (1.8)
International Avg.	21 (0.3)
Jordan	20 (1.8)
Bahrain	18 (1.4) ▼
Norway	18 (1.4) ▼
Romania	16 (1.8) ▼
Russian Federation	15 (2.0) ▼
Egypt	14 (1.2) ▼
Cyprus	13 (1.4) ▼
1 Indonesia	12 (1.4) ▼
1 Serbia	12 (1.3) ▼
Chile	12 (1.1) ▼
Bulgaria	12 (1.7) ▼
Lebanon	11 (1.4) ▼
Philippines	11 (1.2) ▼
2 Macedonia, Rep. of	10 (1.5) ▼
Saudi Arabia	8 (1.8) ▼
1 ‡ Morocco	7 (1.2) ▼
South Africa	6 (1.2) ▼
Palestinian Nat'l Auth.	5 (0.7) ▼
Iran, Islamic Rep. of	4 (0.7) ▼
Tunisia	4 (0.6) ▼
Ghana	3 (1.0) ▼
Botswana	2 (0.8) ▼
Armenia	2 (0.6) ▼
Moldova, Rep. of	1 (0.5) ▼
‡ England	45 (2.5) ▲
Benchmarking Participants	
Basque Country, Spain	19 (2.1)
Indiana State, US	34 (3.3) ▲
Ontario Province, Can.	36 (2.4) ▲
Quebec Province, Can.	24 (2.1)

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Grade 8: Achievement at the High International Benchmark

Exhibit 2.8 describes performance at the high benchmark. Eighth-grade students performing at this level applied their mathematical knowledge and understanding in a wide variety of relatively complex situations. For example, they demonstrated facility with fractions in a variety of formats, as illustrated by Example Item 3 shown in Exhibit 2.9. This item required students to divide or reason with a unit fraction to solve a one-step word problem. Internationally, 38 percent of the students, on average, were able to provide a correct response. About three-fourths or more of the students in Singapore, Hong Kong SAR, Chinese Taipei, and the Netherlands answered the question correctly.

Eighth-grade students reaching the high benchmark generally were able to apply knowledge of geometric properties. In Example Item 4 in Exhibit 2.10, students needed to use their knowledge of the properties of congruent triangles to find the measure of an angle. About four-fifths or more of the students in Korea, Hong Kong SAR, Japan, and Singapore answered the item correctly. Internationally, however, just under half the eighth-grade students (46 percent, on average) did so.

Exhibit 2.8: **Description of TIMSS 2003 High International Benchmark (550) of Mathematics Achievement**

MATHEMATICS Grade 8

High International Benchmark – 550

Summary

Students can apply their understanding and knowledge in a wide variety of relatively complex situations. They can order, relate, and compute with fractions and decimals to solve word problems, operate with negative integers, and solve multi-step word problems involving proportions with whole numbers. Students can solve simple algebraic problems including evaluating expressions, solving simultaneous linear equations, and using a formula to determine the value of a variable. Students can find areas and volumes of simple geometric shapes and use knowledge of geometric properties to solve problems. They can solve probability problems and interpret data in a variety of graphs and tables.

Students can apply their understanding and knowledge in a wide variety of relatively complex situations. Students can solve word problems by determining a number between two given numbers that is divisible by only one of two other numbers, and by estimating the product of whole numbers. They can identify the prime factorization of a given number. Students can solve word problems by using the patterns in a two-column table to determine the number in the second column that corresponds to a number midway between two entries in the first column. They demonstrate understanding of the effects of operations involving negative integers by identifying the largest number produced. They can identify the number that gives a specified result when divided by a given negative integer.

Students demonstrate some facility with fractions and decimals through computation, ordering, rounding, and use in word problems. They can identify the fraction of an hour representing a given time interval and three fractions with denominators less than 10. Students can solve one-step word problems involving division of a whole number by a unit fraction and multi-step word problems involving multiplication of whole numbers by fractions. They can select a fraction representing the comparison of parts to a whole, given each of two parts, and identify the percent equivalent of a given fraction with a denominator that is a factor of 100. They can round four-place decimals to the nearest hundredth. They can multiply two-place decimal numbers by three-place decimal numbers without calculators.

Students can identify one proportional share of an amount divided into three unequal parts. They can solve word problems by finding the missing term in a proportion. They can select the statement that describes the effect of adding the same amount to both terms of a ratio, and can determine the simplified ratio of the shaded to unshaded parts of a shape. They can calculate the new price of an item given the percent increase in price.

Given the first several terms of a sequence in numeric and pictorial form, students can extend the sequence to find specified terms. Students can solve simple algebraic problems. They can simplify an algebraic expression by combining like terms, and can find the value of an expression involving multiplication of negative integers. Students can identify an algebraic expression that corresponds to a situation, subtract algebraic expressions with the same numeric denominators, and recognize the product of two algebraic expressions in one variable that involves exponents.

Students can solve a linear equation with parentheses, solve simple, simultaneous linear equations, and identify the quantity that satisfies two inequalities represented using a balance. They can identify the linear equation that describes the relationship between the first and second terms in a set of ordered pairs. They can use a formula to determine the value of one variable given the value of the other.

Students can compare volumes by visualizing and counting cubes, find the number of cubes needed to a fill a hole in a given shape, and calculate the volume of a rectangular prism given its net. Students can solve a variety of problems involving area. For example, they can find the perimeter of a square given its area, find the area of a rectangle enclosing two touching circles with a given radius, find the area of an irregular figure formed by rectangles, and find the area of a triangle, on the same base and with the same height as a square, when the length of a side of the square is known. From a set of times expressed variously in days, hours, minutes, and seconds, students can determine which is least. Given the start time and the duration of an event expressed as a fraction of an hour, students can determine the end time. They can solve word problems involving average speed, distance, and time.

Students can use properties of lines and angles to solve routine problems that involve supplementary, adjacent, and vertical angles and measures of angles. They can use properties of triangles to find the measure of an angle. Students can produce a drawing that meets specific angle specifications. They can identify a pair of similar triangles given the length of their sides and identify a false statement about congruent triangles. They show understanding of transformations (rotations and reflections) in a plane. They can select a center of rotation when given a figure and its image. Students can visualize a figure cut from a folded piece of paper.

Students understand elementary concepts of probability, including estimating outcomes from sample data. They can solve simple problems involving the relationship between successful and unsuccessful outcomes and probabilities. They also recognize that when outcomes are expressed as fractions of a whole, the least likely outcome corresponds to a smallest fraction. They can read and interpret data in pie graphs, line graphs, and frequency tables to solve problems. They can compare and integrate several sets of data to determine which meet given conditions.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.9: TIMSS 2003 High International Benchmark (550) of Mathematics Achievement – Example Item 3

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

MATHEMATICS Grade 8

Content Area: Number

Description: Solves a one-step word problem involving division of a whole number by a unit fraction.

A scoop holds $\frac{1}{5}$ kg of flour. How many scoops of flour are needed to fill a bag with 6 kg of flour?

Answer: $6 \div \frac{1}{5}$

6×5

30 scoops

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

Country	Percent Full Credit	
Singapore	79 (1.9)	▲
† Hong Kong, SAR	76 (1.8)	▲
Chinese Taipei	75 (1.9)	▲
† Netherlands	74 (2.1)	▲
◆◆ Korea, Rep. of	68 (1.5)	▲
Japan	62 (1.8)	▲
Belgium (Flemish)	62 (2.2)	▲
Sweden	60 (1.9)	▲
Australia	53 (2.6)	▲
‡ United States	52 (1.7)	▲
† Scotland	51 (2.7)	▲
Estonia	51 (2.0)	▲
Latvia	51 (2.7)	▲
Hungary	51 (2.1)	▲
Russian Federation	49 (2.7)	▲
2 Israel	48 (2.3)	▲
Malaysia	47 (2.2)	▲
New Zealand	46 (3.2)	▲
Slovenia	46 (2.1)	▲
Armenia	45 (2.2)	▲
1 Lithuania	43 (2.3)	▲
Slovak Republic	43 (2.0)	▲
Norway	39 (2.1)	
Romania	39 (2.8)	
International Avg.	38 (0.3)	
1 Serbia	38 (2.0)	
Bulgaria	38 (3.0)	
Cyprus	37 (1.8)	
Moldova, Rep. of	37 (2.7)	
Italy	34 (2.1)	▼
1 Indonesia	26 (1.5)	▼
2 Macedonia, Rep. of	22 (2.0)	▼
Iran, Islamic Rep. of	20 (1.9)	▼
Tunisia	18 (1.4)	▼
Egypt	17 (1.4)	▼
Jordan	16 (1.5)	▼
Lebanon	15 (1.4)	▼
Chile	13 (1.1)	▼
Philippines	13 (1.3)	▼
Bahrain	11 (1.3)	▼
Botswana	11 (1.1)	▼
Palestinian Nat'l Auth.	10 (1.2)	▼
1 ‡ Morocco	8 (1.5)	▼
South Africa	7 (1.3)	▼
Saudi Arabia	7 (1.9)	▼
Ghana	6 (1.0)	▼
‡ England	50 (3.1)	▲
Benchmarking Participants		
Basque Country, Spain	42 (2.5)	
Indiana State, US	56 (4.0)	▲
Ontario Province, Can.	53 (2.2)	▲
Quebec Province, Can.	61 (2.9)	▲

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Exhibit 2.10: TIMSS 2003 High International Benchmark (550) of Mathematics Achievement – Example Item 4

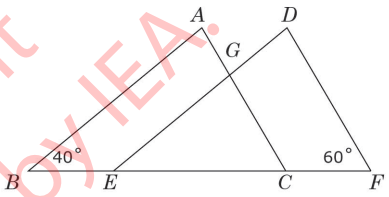
An Item That Students Reaching the High International Benchmark Are Likely to Answer Correctly*

MATHEMATICS Grade 8

Content Area: Geometry

Description: Uses properties of congruent triangles to find the measure of an angle.

In this figure, triangles ABC and DEF are congruent with $BC = EF$.



What is the measure of angle EGC ?

Ⓐ 20°
Ⓑ 40°
Ⓒ 60°
● 80°
Ⓔ 100°

Country	Percent Full Credit	
⧓ Korea, Rep. of	84 (1.4)	▲
† Hong Kong, SAR	81 (1.6)	▲
Japan	80 (1.4)	▲
Singapore	79 (1.6)	▲
Chinese Taipei	73 (1.9)	▲
Estonia	67 (2.0)	▲
Belgium (Flemish)	66 (1.7)	▲
Latvia	63 (2.2)	▲
Bulgaria	60 (2.6)	▲
2 Israel	57 (2.7)	▲
Russian Federation	55 (2.7)	▲
Lebanon	55 (2.2)	▲
† Scotland	54 (2.7)	▲
Slovak Republic	54 (2.5)	▲
1 Lithuania	51 (2.3)	▲
Hungary	50 (2.4)	
Australia	47 (2.1)	
Egypt	47 (1.7)	
Malaysia	47 (2.4)	
International Avg.	46 (0.3)	
Armenia	45 (2.4)	
Moldova, Rep. of	45 (3.0)	
Cyprus	44 (2.2)	
† Netherlands	44 (2.5)	
1 Serbia	43 (1.9)	
New Zealand	42 (3.6)	
Jordan	42 (1.8)	▼
Italy	42 (2.3)	
Tunisia	41 (1.6)	▼
Bahrain	41 (2.4)	▼
Sweden	40 (2.1)	▼
Palestinian Nat'l Auth.	39 (1.7)	▼
Iran, Islamic Rep. of	37 (2.1)	▼
Slovenia	37 (2.5)	▼
‡ United States	36 (1.7)	▼
2 Macedonia, Rep. of	33 (2.4)	▼
Norway	32 (2.1)	▼
1 Indonesia	31 (1.7)	▼
1 ‡ Morocco	31 (2.2)	▼
Chile	30 (1.8)	▼
Saudi Arabia	26 (2.5)	▼
South Africa	21 (1.5)	▼
Ghana	20 (1.6)	▼
Botswana	20 (1.5)	▼
Romania	18 (1.7)	▼
Philippines	15 (1.3)	▼
‡ England	47 (2.8)	
Benchmarking Participants		
Basque Country, Spain	32 (2.5)	▼
Indiana State, US	30 (2.6)	▼
Ontario Province, Can.	50 (2.6)	
Quebec Province, Can.	69 (1.8)	▲

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

⧓ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Grade 8: Achievement at the Intermediate International Benchmark

Eighth-grade students at the intermediate benchmark demonstrated the ability to apply basic mathematical knowledge in straightforward situations (see Exhibit 2.11). For example, as shown by Example Item 5 in Exhibit 2.12, students showed that they could subtract a two-place decimal number from another. The international average percent correct for this item was 61 percent. Singapore and Korea outperformed other countries with 87 to 88 percent correct.

Example Item 6 shown in Exhibit 2.13 illustrates students' emerging familiarity with algebraic representation. Internationally, on average, nearly two-thirds of the eighth-grade students were able to solve the equation for a missing number in a proportion. About three-fourths or more of the students were able to do so in 13 countries up to and including 93 percent in Singapore.

Exhibit 2.11: **TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement**

Intermediate International Benchmark – 475

Summary

Students can apply basic mathematical knowledge in straightforward situations. They can add, subtract, or multiply to solve one-step word problems involving whole numbers and decimals. They can identify representations of common fractions and relative sizes of fractions. They understand simple algebraic relationships and solve linear equations with one variable. They demonstrate understanding of properties of triangles and basic geometric concepts including symmetry and rotation. They recognize basic notions of probability. They can read and interpret graphs, tables, maps, and scales.

Students can apply basic mathematical knowledge in straightforward situations. They can arrange four given digits in descending and ascending order to form the largest and smallest possible numbers, and find the difference between those two numbers. They can solve word problems involving addition and multiplication of two-digit whole numbers. Students can approximate the quantity remaining after an amount is reduced by a given percent. They can select the statement that describes the effect of adding the same amount to both terms of a ratio. They can use knowledge of exponent notation to select approximations to two squared whole numbers.

Students show some understanding of decimals and fractions. They can solve word problems involving addition of numbers with up to three decimal places, and subtraction with up to two decimal places. They can select a two-place decimal closest to a given whole number and round two-place decimals to whole numbers. Students can identify the decimal number that is equivalent to the sum of two fractions whose denominators are powers of 10. They can select the smallest fraction from a set of commonly used fractions and can also write a fraction less than a given fraction. They can identify a circular model of a fraction that best approximates a given rectangular model of the same fraction.

Students at this level know the meaning of simple algebraic expressions involving multiplication and addition and can identify the expression that represents a situation. They can solve linear equations with one variable. Using the properties of a balance, they can reason to find an unknown weight. Students are able to recognize and extend number patterns. Given two straight line graphs, they can select the one that models a situation described in words, and interpret the graphs and use their intersection to solve a problem.

Students can identify a value of unlabeled marks on circular and linear scales. They can solve problems by comparing distances on a map drawn to scale.

Students can use knowledge of basic geometric properties to identify corresponding parts of congruent figures and to divide an isosceles triangle into congruent triangles. They can use properties of triangles to locate points on a grid. They can relate two-dimensional representations to three-dimensional objects and identify a three-dimensional figure after a rotation. Students can use the concept of line symmetry to complete geometric patterns and they can locate points in the Cartesian plane.

Students can locate and interpret data presented in bar graphs, pie graphs, and line graphs. They can construct a pie chart representing given data. Given a table of values for two variables, they can select the graph that represents the given data. They can calculate and compare averages, and have some understanding of the likelihood of an event.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.12: TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 5

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

MATHEMATICS Grade 8

Content Area: Number

Description: Solves a word problem involving subtraction of a two-place decimal number from another.

Alice ran a race in 49.86 seconds. Betty ran the same race in 52.30 seconds. How much longer did it take Betty to run the race than Alice?

● 2.44 seconds

Ⓑ 2.54 seconds

Ⓒ 3.56 seconds

Ⓓ 3.76 seconds

Country	Percent Full Credit	
Singapore	88 (1.0)	▲
◆◆ Korea, Rep. of	87 (1.1)	▲
Malaysia	81 (1.4)	▲
† Netherlands	81 (2.0)	▲
Hungary	80 (1.9)	▲
Chinese Taipei	80 (1.6)	▲
Japan	78 (1.6)	▲
Russian Federation	76 (1.8)	▲
† Hong Kong, SAR	75 (1.6)	▲
Slovak Republic	74 (2.1)	▲
‡ United States	74 (1.7)	▲
Slovenia	73 (2.3)	▲
Estonia	72 (1.8)	▲
Belgium (Flemish)	71 (1.8)	▲
† Scotland	71 (2.0)	▲
Moldova, Rep. of	69 (2.3)	▲
1 Serbia	68 (2.1)	▲
Latvia	67 (2.4)	▲
Bulgaria	66 (2.5)	
1 Lithuania	65 (2.3)	
Romania	64 (2.4)	
Tunisia	63 (2.0)	
Australia	63 (2.4)	
Sweden	63 (2.0)	
Italy	62 (2.1)	
Botswana	61 (1.7)	
International Avg.	61 (0.3)	
Lebanon	61 (2.3)	
Armenia	60 (2.2)	
2 Macedonia, Rep. of	59 (2.1)	
Cyprus	59 (1.8)	
Egypt	58 (1.7)	
2 Israel	58 (1.9)	
1 Indonesia	55 (2.0)	▼
New Zealand	53 (2.4)	▼
Jordan	46 (2.2)	▼
Norway	46 (2.5)	▼
Philippines	45 (2.2)	▼
1 ‡ Morocco	45 (2.6)	▼
Bahrain	45 (2.0)	▼
Iran, Islamic Rep. of	44 (1.9)	▼
Chile	42 (1.8)	▼
Palestinian Nat'l Auth.	37 (1.7)	▼
Ghana	32 (2.0)	▼
South Africa	29 (1.8)	▼
Saudi Arabia	19 (2.3)	▼
‡ England	54 (2.5)	▼
Benchmarking Participants		
Basque Country, Spain	64 (3.0)	
Indiana State, US	77 (2.2)	▲
Ontario Province, Can.	73 (2.4)	▲
Quebec Province, Can.	76 (1.9)	▲

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Exhibit 2.13: TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 6

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

MATHEMATICS Grade 8

Content Area: Algebra

Description: Solves equation for missing number in a proportion.

If $\frac{12}{n} = \frac{36}{21}$, then n equals

(A) 3

● 7

(C) 36

(D) 63

Country	Percent Full Credit	
Singapore	93 (0.7)	▲
◆◆ Korea, Rep. of	89 (0.9)	▲
† Hong Kong, SAR	88 (1.2)	▲
Belgium (Flemish)	86 (1.4)	▲
† Netherlands	85 (1.8)	▲
Malaysia	83 (1.5)	▲
Chinese Taipei	83 (1.5)	▲
‡ United States	80 (1.1)	▲
Japan	79 (1.6)	▲
Hungary	79 (1.7)	▲
† Scotland	79 (1.9)	▲
Australia	76 (1.9)	▲
Slovak Republic	74 (2.0)	▲
Slovenia	72 (2.3)	▲
2 Israel	72 (2.0)	▲
Lebanon	71 (2.6)	▲
Russian Federation	71 (1.9)	▲
Estonia	71 (2.2)	▲
Latvia	70 (2.1)	▲
New Zealand	68 (2.3)	
Sweden	66 (2.1)	
Iran, Islamic Rep. of	66 (1.7)	
Italy	65 (2.1)	
Cyprus	65 (1.8)	
International Avg.	65 (0.3)	
Tunisia	64 (1.7)	
1 Lithuania	64 (2.1)	
1 Serbia	63 (2.1)	
Moldova, Rep. of	61 (2.5)	
Romania	61 (2.2)	▼
Bulgaria	59 (2.0)	▼
Norway	59 (2.1)	▼
1 Indonesia	58 (1.9)	▼
Egypt	58 (2.2)	▼
Armenia	54 (2.6)	▼
1 ‡ Morocco	54 (3.0)	▼
Jordan	53 (1.9)	▼
Palestinian Nat'l Auth.	52 (1.6)	▼
Philippines	52 (2.1)	▼
2 Macedonia, Rep. of	50 (2.3)	▼
Bahrain	44 (2.2)	▼
Chile	44 (2.0)	▼
Botswana	41 (1.7)	▼
Saudi Arabia	30 (2.2)	▼
Ghana	28 (1.6)	▼
South Africa	26 (1.5)	▼
‡ England	74 (2.6)	▲
Benchmarking Participants		
Basque Country, Spain	77 (2.3)	▲
Indiana State, US	83 (1.7)	▲
Ontario Province, Can.	86 (1.8)	▲
Quebec Province, Can.	88 (1.4)	▲

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Grade 8: Achievement at the Low International Benchmark

As shown in Exhibit 2.14, the very few items anchoring at the low benchmark provided evidence that students performing at this level have some basic mathematical knowledge. Essentially, however, students performing at the 400 level or lower had considerable difficulty with many of the TIMSS 2003 items. The one example item that is available for public release is presented in Exhibit 2.15. Students answering Example Item 7 demonstrated some understanding of decimal place values, by correctly selecting 9.99 as the two-place decimal closest to 10. The international average was 77 percent correct, and 15 countries as well as three benchmarking participants had 90 percent or more of their students choosing the correct answer. In five countries – the Netherlands, Sweden, Estonia, Singapore, and Lithuania – 95 percent or more of the students gave the correct response.

Exhibit 2.14: **Description of TIMSS 2003 Low International Benchmark (400) of Mathematics Achievement**

MATHEMATICS Grade 8

Low International Benchmark – 400

Summary

Students have some basic mathematical knowledge.

The few items at this level provide some evidence that students can do basic computations with whole numbers without a calculator. They can select the two-place decimal closest to a whole number. They can multiply two-place decimal numbers by three-place decimal numbers with calculators available. They recognize some basic terminology and read information from a line on a graph.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.15: TIMSS 2003 Low International Benchmark (400) of Mathematics Achievement – Example Item 7

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

MATHEMATICS Grade 8

Content Area: Number

Description: Selects two-place decimal closest to a given whole number.

Which of these numbers is closest to 10?

Ⓐ 0.10

● 9.99

Ⓒ 10.10

Ⓓ 10.90

Country	Percent Full Credit	
† Netherlands	97 (1.0)	▲
Sweden	96 (1.1)	▲
Estonia	96 (1.2)	▲
Singapore	95 (1.1)	▲
1 Lithuania	95 (1.0)	▲
Belgium (Flemish)	94 (1.4)	▲
◆◆ Korea, Rep. of	94 (1.2)	▲
Malaysia	93 (1.4)	▲
Japan	92 (1.4)	▲
1 Serbia	91 (1.6)	▲
Norway	91 (1.3)	▲
Russian Federation	91 (1.2)	▲
Latvia	90 (1.9)	▲
Slovak Republic	90 (2.0)	▲
Italy	90 (1.9)	▲
† Hong Kong, SAR	89 (1.6)	▲
† Scotland	89 (2.0)	▲
Chinese Taipei	89 (1.5)	▲
Cyprus	88 (2.0)	▲
Hungary	88 (2.0)	▲
Australia	88 (1.8)	▲
‡ United States	87 (1.1)	▲
Slovenia	87 (2.2)	▲
New Zealand	86 (2.0)	▲
Bulgaria	85 (2.7)	▲
Moldova, Rep. of	82 (2.5)	
2 Israel	81 (2.3)	
Romania	79 (2.5)	
2 Macedonia, Rep. of	78 (2.7)	
International Avg.	77 (0.3)	
Tunisia	76 (2.3)	
1 ‡ Morocco	75 (3.1)	
1 Indonesia	74 (2.7)	
Iran, Islamic Rep. of	69 (2.4)	▼
Chile	67 (1.9)	▼
Lebanon	67 (2.7)	▼
Armenia	66 (2.6)	▼
Jordan	55 (2.7)	▼
Palestinian Nat'l Auth.	50 (2.7)	▼
Bahrain	49 (3.2)	▼
Egypt	48 (2.5)	▼
Philippines	42 (2.8)	▼
Botswana	40 (2.6)	▼
Saudi Arabia	35 (2.6)	▼
South Africa	30 (2.7)	▼
Ghana	24 (2.4)	▼
‡ England	82 (2.5)	▲
Benchmarking Participants		
Basque Country, Spain	92 (2.0)	▲
Indiana State, US	84 (3.2)	▲
Ontario Province, Can.	91 (1.8)	▲
Quebec Province, Can.	91 (1.8)	▲

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

‡ Did not satisfy guidelines for sample participation rates (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

2 National Defined Population covers less than 90% of National Desired Population (see Exhibit A.6).

◆◆ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year.

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

Grade 4: Achievement at the Advanced International Benchmark

At the fourth grade, students reaching the advanced benchmark demonstrated that they could apply their understanding and knowledge in a wide variety of relatively complex situations (see Exhibit 2.16). In the content area of number, fourth-grade students reaching the advanced level exhibited a developing understanding of fractions and decimals and the relationship between them. For example, as illustrated by Example Item 1 in Exhibit 2.17, students at this level were able to identify "0.7" as the decimal representation for a fraction with a denominator of 10. Internationally, on average, 43 percent of the fourth-grade students answered this item correctly. By far the best performance was in Singapore, where 95 percent of the students answered correctly. The next highest achievement was in Hong Kong, SAR with 78 percent answering correctly.

In measurement, fourth-grade students reaching the advanced level were able to determine the area of a figure composed of squares and half squares (see Example Item 2 in Exhibit 2.18). Further, the students had to draw the irregular figure on a grid so that it had the correct area. This was relatively difficult for the fourth-grade students in TIMSS 2003, with 29 percent answering correctly, on average, internationally. About two-thirds of the fourth-grade students in Japan and Chinese Taipei responded correctly.

Exhibit 2.16: **Description of TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement**

Advanced International Benchmark – 625

Summary

Students can apply their understanding and knowledge in a wide variety of relatively complex situations. They demonstrate a developing understanding of fractions and decimals and the relationship between them. They can select appropriate information to solve multi-step word problems involving proportions. They can formulate or select a rule for a relationship. They show understanding of area and can use measurement concepts to solve a variety of problems. They show some understanding of rotation. They can organize, interpret, and represent data to solve problems.

Students at this level demonstrate a developing understanding of fractions and decimals and the relationship between them. They can determine the fraction of a figure that is shaded. Given a fraction, they can identify a larger fraction with a different denominator. They can use tiles to represent one half. They can identify the decimal representation of fractions with denominators of 10 and subtract a one-place decimal from a two-place decimal. They can solve simple ratio problems and problems that involve halving whole numbers and fractions. They can select appropriate information to solve multi-step word problems involving proportions.

Students can identify the number that satisfies a number sentence with two terms on each side involving addition or division. They can identify a two-step rule for a linear relationship between the first and second numbers in a set of ordered pairs and between adjacent terms in a sequence of numbers. They can formulate a rule for a multiplicative relationship between the first and second numbers in a set of ordered pairs.

Students can use their knowledge of measurement to solve problems including conversion of metric units for capacity and time units. They can solve simple problems involving distance, time, and speed and problems involving two operations. They can estimate the length of a curved line next to the middle of a ruler. Students can use maps drawn to scale to solve problems, including locating a point between two specified points and estimating distance. Students show an understanding of area in that they can determine the area of a figure composed of squares and half squares. Students also can complete an irregular figure on a grid so that it has a given area, and recognize that area does not change when a figure is cut into parts and rearranged.

Student can draw angles greater than 90 degrees. They show some understanding of rotation in a plane and in space. For example, they can identify the position of a shape after a half-turn rotation in a plane and recognize the equivalent three-dimensional figure after rotation.

Students can organize, interpret, and represent data to solve problems. They can organize data and complete a tally chart to represent the data. They can solve problems that involve relating and interpreting values from two sets of data from a graph.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.17: TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 1

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

MATHEMATICS Grade 4

Content Area: Number

Description: Identifies the decimal representation for a fraction with a denominator of 10.

Which of these means $\frac{7}{10}$?

Ⓐ 70

Ⓑ 7

● 0.7

Ⓓ 0.07

Country	Percent Full Credit
Singapore	95 (0.8) ▲
† Hong Kong, SAR	78 (1.8) ▲
Chinese Taipei	74 (1.8) ▲
Belgium (Flemish)	73 (2.4) ▲
Cyprus	65 (2.2) ▲
† United States	62 (1.8) ▲
Japan	60 (2.2) ▲
Italy	58 (2.4) ▲
Moldova, Rep. of	52 (2.6) ▲
Philippines	49 (2.7) ▲
1 Lithuania	48 (2.6) ▲
† England	46 (2.5)
International Avg.	43 (0.4)
† Australia	42 (3.0)
Armenia	42 (2.5)
Russian Federation	39 (2.7)
New Zealand	37 (2.0) ▼
† Netherlands	29 (2.0) ▼
Morocco	23 (2.2) ▼
† Scotland	22 (2.1) ▼
Norway	17 (1.6) ▼
Hungary	17 (1.6) ▼
Iran, Islamic Rep. of	16 (1.6) ▼
Tunisia	15 (1.5) ▼
Latvia	12 (1.6) ▼
Slovenia	8 (1.8) ▼
Benchmarking Participants	
Indiana State, US	59 (3.6) ▲
Ontario Province, Can.	47 (3.3)
Quebec Province, Can.	26 (2.6) ▼

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

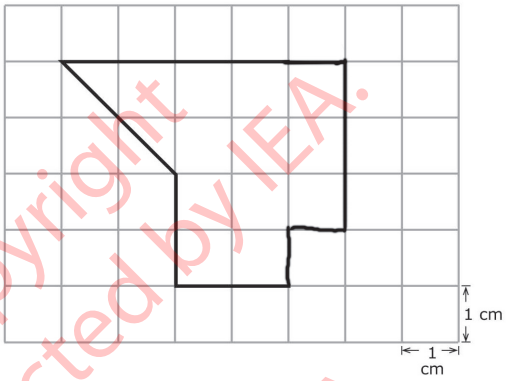
Exhibit 2.18: TIMSS 2003 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 2

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

MATHEMATICS Grade 4

Content Area: Measurement

Description: Completes an irregular figure on a grid so that it has a given area.



The squares in the grid above have areas of 1 square centimeter. Draw lines to complete the figure so that it has an area of 13 square centimeters.

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

Country	Percent Full Credit	
Japan	68 (2.1)	▲
Chinese Taipei	66 (1.8)	▲
† Hong Kong, SAR	52 (2.8)	▲
Singapore	43 (2.2)	▲
Latvia	43 (2.9)	▲
1 Lithuania	40 (2.5)	▲
† Netherlands	37 (2.6)	▲
Moldova, Rep. of	35 (2.3)	▲
Cyprus	34 (2.3)	▲
Russian Federation	30 (2.4)	
International Avg.	**29 (0.4)**	
† Scotland	29 (2.4)	
† England	29 (2.3)	
† Australia	29 (2.2)	
Belgium (Flemish)	28 (2.2)	
Hungary	26 (2.0)	
Armenia	25 (2.3)	
† United States	24 (1.7)	▼
Italy	22 (2.0)	▼
New Zealand	15 (1.6)	▼
Iran, Islamic Rep. of	11 (1.6)	▼
Slovenia	11 (1.7)	▼
Norway	10 (1.6)	▼
Morocco	9 (1.9)	▼
Tunisia	9 (1.2)	▼
Philippines	5 (1.5)	▼
Benchmarking Participants		
Indiana State, US	17 (2.2)	▼
Ontario Province, Can.	38 (2.6)	▲
Quebec Province, Can.	35 (2.6)	▲

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Grade 4: Achievement at the High International Benchmark

As detailed in Exhibit 2.19, fourth-grade students reaching the high benchmark were able to apply their knowledge and understanding to solve problems. For example, Exhibit 2.20 containing Example Item 3 shows that these fourth-grade students were able to select the expression that represented the situation in a word problem involving multiplication. The international average was 58 percent, with Singaporean students having the highest achievement (86%) followed by Chinese Taipei (81%).

In geometry, students used the simple properties of triangles and rectangles to solve problems. Example Item 4 presented in Exhibit 2.21 shows that students can compose triangles to make other shapes, including a larger triangle and a square. Students were given square tiles divided diagonally into one white and one black triangle and ask to use the tiles in answering a set a of questions. In part A, students were asked to make a large triangle and in part B to make a black square. The achievement results are presented for part B. Forty-two percent of the fourth-grade students, on average, internationally performed this task correctly. Japan had the best performance, with 71 percent correct. The next highest performance was in the Netherlands with 60 percent correct.

Exhibit 2.19: **Description of TIMSS 2003 High International Benchmark (550) of Mathematics Achievement**

High International Benchmark – 550

Summary

Student can apply their knowledge and understanding to solve problems. Student can solve multi-step word problems involving addition, multiplication, and division. They can use their understanding of place value and simple fractions to solve problems. They can identify a number sentence that represents situations. Students show understanding of three-dimensional objects, how shapes can make other shapes, and simple transformation in a plane. They demonstrate a variety of measurement skills and can interpret and use data in tables and graphs to solve problems.

Students at this level can solve multi-step word problems involving addition, multiplication, and division. They can solve word problem involving division of three-digit by one-digit whole numbers. They can use their understanding of place value to solve problems. For example, they can arrange single digits to create the largest and smallest possible numbers and to create sums and differences of numbers that meet specified criteria (i.e., sum closest to a given value, largest sum, and largest difference). They can round three-digit whole numbers to the nearest hundred, select the two-place decimal closest to a given whole number, and estimate the product of two two-digit numbers.

Students can solve problems involving 1/2 and 3/4 and by finding a fractional part of a set of objects. They can recognize the figure illustrating a simple ratio and select appropriate information to solve a simple proportional problem.

Students can extend entries in a table according to numeric rules described in a situation. They can select an expression that represents a situation involving multiplication. They can identify a number sentence that represents a situation involving division and can identify a number that satisfies such a number sentence. Students can identify the result of a specified sequence of operations on a given number and identify the missing number in a square whose rows and columns have the same sum.

Students can calculate the volume of a rectangular solid given the volume of one layer and the number of layers. Students can locate a point on a map drawn to scale between two given distances and can read scales when the interval scale represents more than one unit (e.g., 5 units). Students can solve multi-step problems involving time and temperature. They can solve a word problem involving conversion between hours and minutes and read a thermometer to solve problems involving change in temperatures. Students can select an appropriate type of metric unit to measure weight (mass).

Students can use simple properties of triangles and rectangles to solve problems. They can compose and decompose shapes to make other simple shapes. They can identify two triangles that have the same shape but different sizes in a complex figure. Students have basic knowledge of transformations in a plane. For example, they can draw the reflection of a figure on a grid and identify a figure in which a line of symmetry is shown. Students demonstrate some familiarity with three-dimensional objects. They can identify a solid with curved and flat surfaces and recognize a net of a triangular prism.

Students can interpret and use data in tables and graphs to solve problems. They can use data from bar graphs, tally charts, and tables. They can compare data from two tables to draw conclusions. They can identify the label for a bar graph based on data in a tally chart.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.20: TIMSS 2003 High International Benchmark (550) of Mathematics Achievement – Example Item 3

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

MATHEMATICS Grade 4

Content Area: Patterns and Relationships

Description: Selects the expression that represents a situation involving multiplication.

☐ represents the number of magazines that Lina reads each week.
Which of these represents the total number of magazines that Lina reads in 6 weeks?

Ⓐ $6 + \square$

● $6 \times \square$

Ⓒ $\square + 6$

Ⓓ $(\square + \square) \times 6$

Country	Percent Full Credit	
Singapore	86 (1.4)	▲
Chinese Taipei	81 (1.5)	▲
† Hong Kong, SAR	76 (1.9)	▲
† United States	72 (1.2)	▲
† Netherlands	72 (2.7)	▲
Belgium (Flemish)	67 (1.6)	▲
Japan	67 (2.0)	▲
Russian Federation	66 (2.6)	▲
Latvia	66 (2.3)	▲
† England	66 (2.5)	▲
Cyprus	65 (2.0)	▲
Moldova, Rep. of	64 (2.4)	▲
1 Lithuania	62 (2.3)	
Hungary	61 (2.2)	
Slovenia	60 (2.2)	
† Scotland	60 (2.2)	
International Avg.	58 (0.4)	
† Australia	56 (2.3)	
New Zealand	54 (1.7)	▼
Italy	50 (2.3)	▼
Armenia	46 (2.4)	▼
Philippines	38 (2.3)	▼
Norway	37 (2.1)	▼
Iran, Islamic Rep. of	34 (2.3)	▼
Morocco	29 (2.2)	▼
Tunisia	20 (2.0)	▼
Benchmarking Participants		
Indiana State, US	74 (2.0)	▲
Ontario Province, Can.	61 (2.5)	
Quebec Province, Can.	60 (2.4)	

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Exhibit 2.21: TIMSS 2003 High International Benchmark (550) of Mathematics Achievement – Example Item 4 (Part B)

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

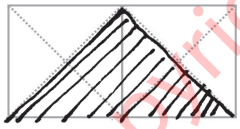
MATHEMATICS Grade 4

Content Area: Geometry

Description: Part B–Makes and draws one square from four triangle tiles (square tiles divided diagonally into one white and one black triangle).

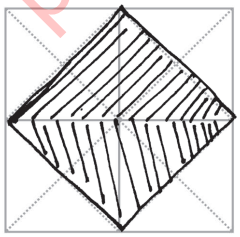
A. Use 2 of the triangle tiles to make one large black triangle. Then show what you did with your tiles by shading in your triangle below.

Shade in Your Triangle Here



B. Use all 4 triangle tiles to make a black square. Then show what you did with your tiles by shading in your square below.

Shade in Your Square Here



C. What fraction of the figure is shaded in part B above?

Answer: 1/2

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

Country	Percent Full Credit	
Japan	71 (2.0)	▲
† Netherlands	60 (3.2)	▲
Russian Federation	57 (2.3)	▲
1 Lithuania	57 (2.3)	▲
Belgium (Flemish)	55 (2.0)	▲
Chinese Taipei	54 (1.5)	▲
† England	54 (2.4)	▲
† Australia	52 (3.0)	▲
New Zealand	52 (2.3)	▲
Italy	51 (2.9)	▲
† Scotland	48 (2.9)	▲
Norway	47 (3.1)	
Cyprus	47 (2.3)	▲
† Hong Kong, SAR	46 (2.0)	▲
Singapore	45 (2.3)	
Hungary	45 (2.1)	
Slovenia	44 (2.6)	
† United States	42 (1.7)	
International Avg.	42 (0.5)	
Moldova, Rep. of	37 (2.9)	
Latvia	33 (2.2)	▼
Tunisia	15 (1.5)	▼
Iran, Islamic Rep. of	13 (2.0)	▼
Armenia	10 (1.3)	▼
Philippines	7 (1.0)	▼
Morocco	5 (1.7)	▼
Benchmarking Participants		
Indiana State, US	42 (3.4)	
Ontario Province, Can.	49 (2.4)	▲
Quebec Province, Can.	49 (2.9)	▲

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Grade 4: Achievement at the Intermediate International Benchmark

Exhibit 2.22 presents the description of student achievement at the intermediate benchmark. At the intermediate benchmark, fourth-grade students could apply basic mathematical knowledge in straightforward situations. In comparison to the high benchmark, the mathematics and the problem situations were less complex.

In the number content area, students demonstrated the ability to recognize and translate between different representations of whole numbers, including number line, pictorial representations, and expanded notation. As illustrated by Example Item 5 in Exhibit 2.23, fourth-grade students reaching the intermediate benchmark recognized which figure had two-thirds shaded parts. Fifty-seven percent of the fourth-grade students, on average, internationally answered the question correctly. In Singapore, 93 percent answered correctly followed by 86 percent in Hong Kong, SAR.

In the data content area, the fourth-grade students completed a bar graph based on the solution of a word problem (see Example Item 6 in Exhibit 2.24). Indeed fourth-grade students in many of the participating countries performed this task successfully. In 15 countries and three benchmarking participants, 80 percent or more of the students answered correctly.

Exhibit 2.22: **Description of TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement**

Intermediate International Benchmark – 475

Summary

Students can apply basic mathematical knowledge in straightforward situations. They can read, interpret, and use different representations of numbers. They can perform operations with three- and four-digit numbers and decimals. They can extend simple patterns. They are familiar with a range of two-dimensional shapes and read and interpret different representations of the same data.

Students at this level demonstrate an understanding of and can order and operate with whole numbers. They can recognize and translate between different representations of whole numbers, including number line, pictorial representations, and expanded notation. They can identify the appropriate operations to solve multiplication and division problems. They can solve problems that involve the addition of four-digit numbers, multiplication of a three-digit by a one-digit whole number, multiplication of two two-digit numbers, and division of a three-digit by a one-digit whole number. Students can add and subtract two-place decimals. They can recognize the fractional part of a set of objects or a region, can identify the fraction that represents a given part-whole situation, and select information to solve a simple proportion problem.

Students show understanding of patterns. They can generalize from the first several terms of a numeric sequence to select another number (e.g., the tenth) that is also in the sequence. They can extend sequences based on geometric patterns or patterns involving time. They can identify the next terms in an alternating number pattern involving counting forward and backward by ones. Students can identify an expression that represents a situation involving multiplication and a number sentence that represents a situation involving subtraction.

Students have some basic knowledge of area. For example, they recognize that area does not change when parts of a figure are rearranged and the inverse relationship between the size and number of units needed to cover an area. They can read a one-month calendar and use the fact that a week has seven days to solve a problem. They can select a reasonable weight, given in metric units, for an adult.

Students are familiar with a range of two-dimensional shapes. They can draw a line to divide a rectangle into two triangles and can name common geometrical shapes in a picture. They also can identify a three-dimensional object given the pictorial representation of its faces. They can locate position on a grid and describe the movement from one position to another. Students can draw a line parallel to an oblique line on a grid, and identify a pattern generated by a quarter-turn clockwise.

Students can read and interpret different representations of the same data. For example, they can match data in pie charts to tables and bar graphs. Given verbal descriptions of data or problem situations, they can use that information to complete bar graphs and a two-by-two table. They can also use information to identify the number of symbols needed to complete a pictograph when the symbol represents more than one unit.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.23: TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 5

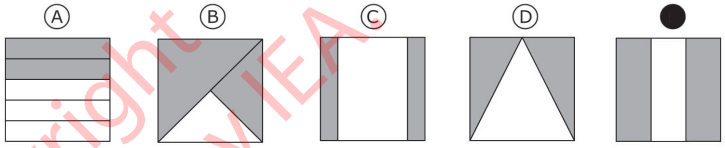
An Item That Students Reaching the Intermediate International Benchmark Are Likely to Answer Correctly*

MATHEMATICS Grade 4

Content Area: Number

Description: Recognizes a familiar fraction represented by a figure with shaded parts (region model).

Which shows $\frac{2}{3}$ of the square shaded?



Country	Percent Full Credit	
Singapore	93 (1.0)	▲
† Hong Kong, SAR	86 (1.7)	▲
† United States	82 (1.1)	▲
Chinese Taipei	81 (1.5)	▲
Belgium (Flemish)	79 (1.8)	▲
Japan	76 (1.5)	▲
Cyprus	75 (1.8)	▲
† Netherlands	73 (2.1)	▲
† England	67 (2.2)	▲
† Australia	62 (2.2)	▲
Latvia	60 (2.8)	
New Zealand	59 (2.2)	
International Avg.	57 (0.4)	
Hungary	56 (2.7)	
1 Lithuania	56 (2.2)	
Italy	55 (2.4)	
† Scotland	52 (2.2)	▼
Philippines	50 (2.3)	▼
Russian Federation	49 (2.8)	▼
Iran, Islamic Rep. of	47 (2.7)	▼
Moldova, Rep. of	43 (2.7)	▼
Slovenia	34 (2.5)	▼
Armenia	29 (2.2)	▼
Norway	29 (2.0)	▼
Morocco	13 (1.7)	▼
Tunisia	12 (1.6)	▼
Benchmarking Participants		
Indiana State, US	89 (2.2)	▲
Ontario Province, Can.	69 (2.8)	▲
Quebec Province, Can.	67 (2.6)	▲

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Exhibit 2.24: TIMSS 2003 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 6

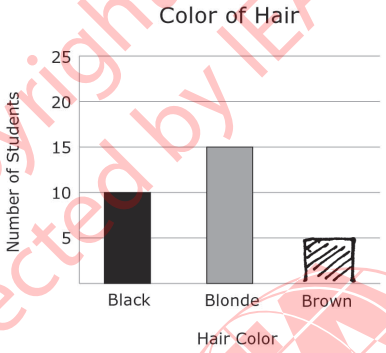
An Item That Students Reaching the Intermediate International Benchmark Are Likely to Answer Correctly*

MATHEMATICS Grade 4

Content Area: Data

Description: Completes a bar graph based on the solution of a word problem.

In a class of 30 students, 10 have black hair, 15 have blonde hair, and the rest have brown hair. Complete the graph below to show the number of students with brown hair.



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

Country	Percent Full Credit	
Belgium (Flemish)	93 (1.1)	▲
† Netherlands	93 (1.1)	▲
† Hong Kong, SAR	92 (1.0)	▲
Chinese Taipei	92 (1.1)	▲
Singapore	90 (1.2)	▲
Japan	90 (1.3)	▲
Latvia	88 (1.4)	▲
1 Lithuania	87 (1.8)	▲
† England	86 (1.7)	▲
Hungary	84 (1.7)	▲
† Scotland	83 (1.8)	▲
Russian Federation	82 (2.4)	▲
† United States	82 (1.3)	▲
Cyprus	80 (1.3)	▲
New Zealand	80 (1.7)	▲
Slovenia	79 (2.3)	▲
† Australia	76 (2.1)	
Norway	75 (1.9)	
International Avg.	73 (0.4)	
Italy	71 (1.8)	
Moldova, Rep. of	67 (2.2)	▼
Armenia	50 (2.2)	▼
Philippines	29 (2.5)	▼
Iran, Islamic Rep. of	28 (2.3)	▼
Morocco	24 (3.1)	▼
Tunisia	21 (2.1)	▼
Benchmarking Participants		
Indiana State, US	84 (1.7)	▲
Ontario Province, Can.	85 (2.0)	▲
Quebec Province, Can.	83 (1.8)	▲

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Grade 4: Achievement at the Low International Benchmark

As can be seen from the description presented in Exhibit 2.25, fourth-grade students reaching the low benchmark have some basic mathematical knowledge. For example, they demonstrate an understanding of computation with whole numbers as shown in Exhibit 2.26. In Example Item 7, fourth-grade students were asked to multiply a two-digit whole number (15) by a one-digit whole number (9). Students in many of the participating countries and benchmarking entities answered this open-ended question correctly. The international average was 72 percent, and 90 percent or more of the fourth-graders answered correctly in Chinese Taipei, Singapore, Hong Kong SAR, and the Russian Federation.

Exhibit 2.27 contains Example Item 8 asking the fourth-grade students to draw a triangle on a grid such that the line AB is the base and the two new sides are the same length as each other. Two-thirds of the fourth-grade students, on average, internationally completed this task correctly. Ninety-five percent of the students in Hong Kong, SAR did so, as did 80 to 84 percent of the fourth-graders in Latvia, Japan, and New Zealand.

Exhibit 2.25: **Description of TIMSS 2003 Low International Benchmark (400) of Mathematics Achievement**

MATHEMATICS Grade 4

Low International Benchmark – 400

Summary

Students have some basic mathematical knowledge. Students demonstrate an understanding of whole numbers and can do simple computations with them. They demonstrate familiarity with the basic properties of triangles and rectangles. They can read information from simple bar graphs.

Students at this level demonstrate an understanding of whole numbers. They are familiar with numbers into the thousands They demonstrate understanding of place value and can translate between representations of whole numbers. They can add a four-digit and a three-digit whole number, multiply a two-digit by a one-digit whole number, and subtract two fractions with the same denominator. They can solve problems involving addition. Students can find the missing number in a number sentence involving multiplication by a one-digit whole number.

Students can compare areas by counting squares, identify two figures with the same shape, and draw a line to divide a rectangle into two rectangles. Students demonstrate familiarity with triangles. For example, they can identify two triangles with the same size and shape in a complex figure, recognize triangles in a set of polygons, and identify that a triangle has three sides. Given the base on a grid, students can draw a triangle whose other two sides are each the same length. Students can read information from simple bar graphs.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

Exhibit 2.26: TIMSS 2003 Low International Benchmark (400) of Mathematics Achievement – Example Item 7

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

MATHEMATICS Grade 4

Content Area: Number

Description: Multiply a two-digit by a one-digit whole number.

$15 \times 9 =$

Answer: 135

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

Country	Percent Full Credit	
Chinese Taipei	94 (1.0)	▲
Singapore	93 (1.0)	▲
† Hong Kong, SAR	91 (1.0)	▲
Russian Federation	90 (1.3)	▲
Moldova, Rep. of	88 (1.2)	▲
1 Lithuania	87 (1.7)	▲
Japan	86 (1.6)	▲
† Netherlands	86 (1.5)	▲
Latvia	86 (1.9)	▲
Hungary	85 (1.6)	▲
Armenia	85 (1.4)	▲
Belgium (Flemish)	84 (1.4)	▲
Cyprus	76 (1.6)	▲
Italy	75 (2.0)	
† United States	73 (1.2)	
International Avg.	72 (0.4)	
Tunisia	68 (2.0)	
Slovenia	67 (2.6)	
Iran, Islamic Rep. of	61 (2.5)	▼
† England	59 (2.7)	▼
Philippines	59 (2.5)	▼
† Scotland	54 (2.2)	▼
† Australia	45 (2.4)	▼
New Zealand	41 (2.0)	▼
Morocco	36 (3.1)	▼
Norway	30 (1.9)	▼
Benchmarking Participants		
Indiana State, US	78 (2.3)	▲
Ontario Province, Can.	54 (2.7)	▼
Quebec Province, Can.	66 (2.3)	▼

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

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

Exhibit 2.27: TIMSS 2003 Low International Benchmark (400) of Mathematics Achievement – Example Item 8

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

MATHEMATICS Grade 4

Content Area: Measurement

Description: Given the base draws a triangle on a grid with the other two sides the same length.

Draw a triangle in the grid so that the line *AB* is the base of the triangle and the two new sides are the same length as each other.

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

Country	Percent Full Credit	
† Hong Kong, SAR	95 (0.9)	▲
Latvia	84 (1.4)	▲
Japan	80 (1.8)	▲
New Zealand	80 (1.8)	▲
Singapore	77 (1.8)	▲
Russian Federation	77 (2.3)	▲
Belgium (Flemish)	77 (1.8)	▲
† Australia	77 (2.1)	▲
Italy	77 (1.9)	▲
1 Lithuania	74 (1.9)	▲
† England	73 (2.1)	▲
Hungary	72 (2.0)	▲
† Scotland	71 (2.2)	
Chinese Taipei	70 (1.5)	
Moldova, Rep. of	67 (2.8)	
International Avg.	67 (0.4)	
Slovenia	64 (2.7)	
† United States	63 (1.4)	▼
Norway	58 (2.3)	▼
Cyprus	57 (2.1)	▼
Armenia	56 (2.0)	▼
Iran, Islamic Rep. of	48 (2.7)	▼
Philippines	45 (2.7)	▼
Morocco	42 (2.6)	▼
Tunisia	28 (1.7)	▼
Benchmarking Participants		
Indiana State, US	64 (2.9)	
Ontario Province, Can.	76 (2.2)	▲
Quebec Province, Can.	68 (2.2)	

▲ Country average significantly higher than international average

▼ Country average significantly lower than international average

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

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

† Met guidelines for sample participation rates only after replacement schools were included (see Exhibit A.9).

1 National Desired Population does not cover all of International Desired Population (see Exhibit A.6).

( ) 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?

At both grades, the benchmark descriptions and example items strongly suggest a gradation in achievement, from the top-performing students' ability to generalize and solve non-routine or contextualized problems to the lower-performing students being able primarily to use routine, mainly numeric procedures. The fact that, even at the intermediate benchmark, students demonstrate only limited achievement in problem solving beyond straightforward one-step problems may suggest a need to reconsider the role, or priority, of problem solving in mathematics curricula.

In looking across the item-level results, it also is important to note the variation in performance across the topics covered. For example, on just the few items (15) presented in this chapter, there was a substantial range in performance for many countries. While some countries consistently registered high or low performance, and others had results consistently near the international average, a number of countries performed significantly above the international average on at least one item, and significantly below the international average on at least one item. Such results may reflect intended differences in emphasis in national curricula. It is likely, however, that such results may be unintended, and the findings will provide important information about strengths and weaknesses in intended or implemented curricula. At the very least, an in-depth examination of the TIMSS 2003 results may reveal aspects of curricula that merit further investigation.