Chapter 2

Mathematics Achievement in the Cognitive Domains at the Fourth and Eighth Grades

This chapter of the report presents the TIMSS 2003 mathematics achievement results for each of the three cognitive domains. Following the presentation of the results, for each domain in turn – knowing, applying, and reasoning – there is an overview of performance across domains.

Knowing Facts, Procedures, and Concepts

The first page of Exhibit 2.1 presents the distribution of students' mathematics achievement in the cognitive domain of knowing facts, procedures, and concepts for the 46 countries and four benchmarking entities that participated in TIMSS 2003 at the eighth grade, and the second page presents the distribution of student achievement for the 25 countries and three benchmarking entities that participated at the fourth grade. Countries are shown in decreasing order of average (mean) scale score, together with an indication of whether the country average is significantly higher or lower than the interna-

At the fourth grade, the difference was also large between the highest-performing country Singapore (626) and the lowest-performing country Tunisia (338). Thirteen countries and the three benchmarking entities performed above the international average and eight countries performed below the international average. The four countries performing about at the international average were Australia, Moldova, Cyprus, and New Zealand.

For both the eighth and fourth grades, Exhibit 2.1 illustrates the broad range of achievement both within and across the countries assessed. It provides a graphical representation of student performance within each country. The bar graph for each country shows the 5th, 25th, 75th, and 95th percentiles[1] as well as the 95% confidence for the mean. Each percentile point indicates the percentage of students below that point on the scale. For most TIMSS 2003 participants at the eighth grade, there was an enormous range within each country between the highest and lowest scores, often as much as 400 scale-score points. This range was as large or larger than the difference in mean achievement between the highest and lowest performing country. For the eighth grade knowing scale, the range for most students in the higher-achiev

Exhibit 2.2: Multiple Comparisons of Average Mathematics Achievement for Knowing Cognitive Domain

MATHEMATICS Grade 8

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

Exhibit 2.2: Multiple Comparisons of Average Mathematics Achievement for Knowing Cognitive Domain

MATHEMATICS Grade 4

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

Exhibit 2.3: Distribution of Mathematics Achievement for Applying Cognitive Domain

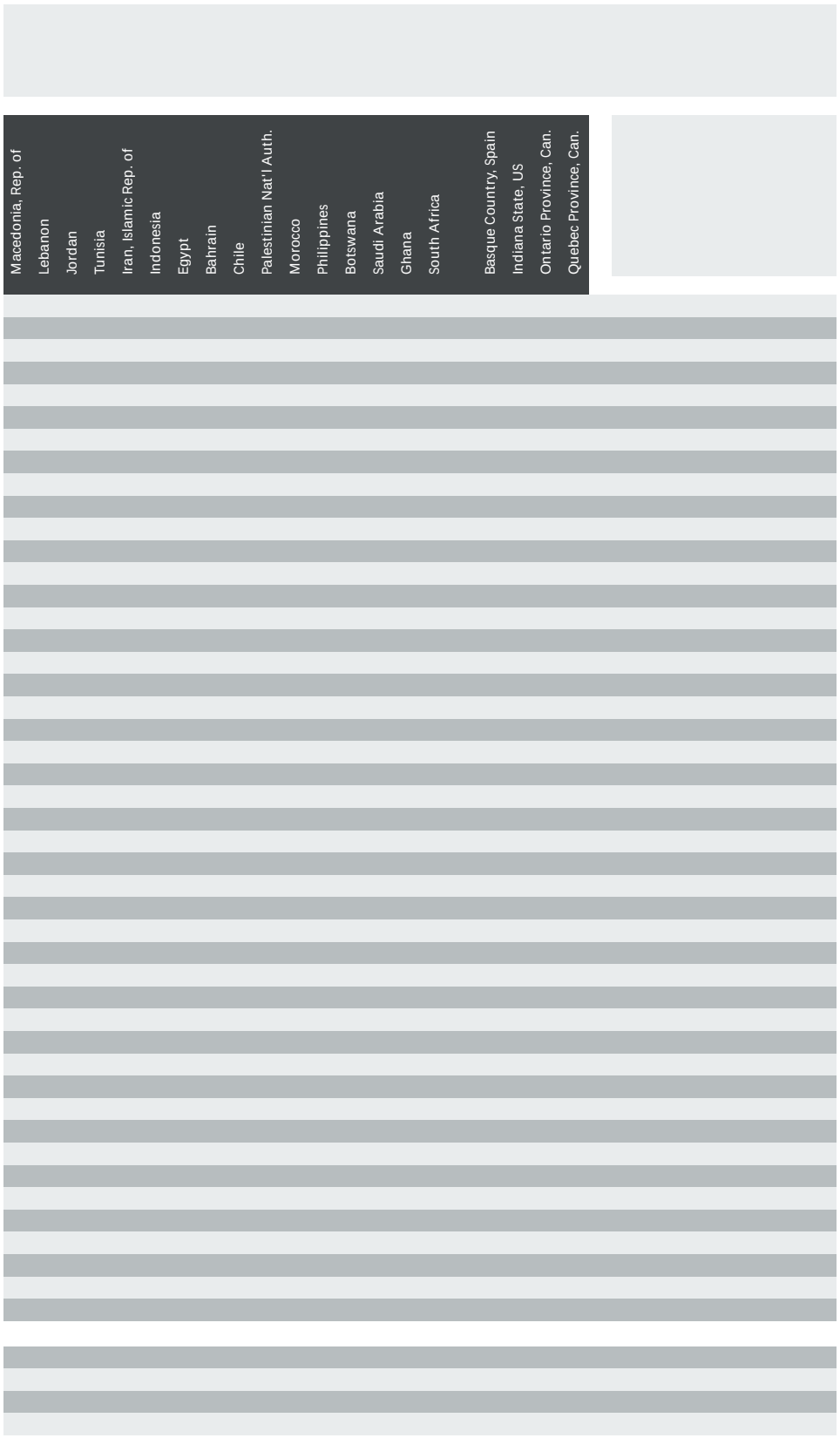
MATHEMATICS Grade 4

Countries	Years of Schooling*	Average Age	Mathematics Achievement Distribution		Human Development Index**
Singapore	4	10.3		595 (5.9) ▲	0.884
† Hong Kong, SAR	4	10.2		577 (3.3) ▲	0.889
Japan	4	10.4		566 (2.1) ▲	0.932
Chinese Taipei	4	10.2		561 (1.9) ▲	–
Belgium (Flemish)	4	10.0		546 (2.1) ▲	0.937
Latvia	4	11.1		545 (3.3) ▲	0.811
Russian Federation	3 or 4	10.6		542 (4.7) ▲	0.779
† Lithuania	4	10.9		542 (2.9) ▲	0.824
† Netherlands	4	10.2		541 (2.6) ▲	0.938
Hungary	4	10.5		530 (3.4) ▲	0.837
† England	5	10.3		526 (4.1) ▲	0.930
Cyprus	4	9.9		510 (2.8) ▲	0.891
Moldova, Rep. of	4	11.0		507 (4.8) ▲	0.700
† United States	4	10.2		505 (2.6) ▲	0.937
International Avg.	4	10.3		495 (0.7)	–
Italy	4	9.8		494 (3.6)	0.916
† Australia	4 or 5	9.9		490 (3.8)	0.939
† Scotland	5	9.7		487 (3.5) ▼	0.930
New Zealand	4.5 - 5.5	10.0		486 (2.3) ▼	0.917
Slovenia	3 or 4	9.8		477 (2.8) ▼	0.881
Armenia	4	10.9		462 (3.2) ▼	0.729
ø Norway	4	9.8		446 (2.2) ▼	0.944
Iran, Islamic Rep. of	4	10.4		391 (3.8) ▼	0.719
Philippines	4	10.8		364 (7.5) ▼	0.751
Morocco	4	11.0		349 (4.5) ▼	0.606
Tunisia	4	10.4		348 (4.6) ▼	0.740
Benchmarking Participants					
Indiana State, US	4	10.5	¾ · (4.5)	523(0.93	

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

Exhibit 2.4: Multiple Comparisons of Average Mathematics Achievement for Applying Cognitive Domain

MATHEMATICS Grade 8



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

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

Exhibit 2.6: Multiple Comparisons of Average Mathematics Achievement for Reasoning Cognitive Domain

MATHEMATICS Grade 8

Countries	Singapore	Korea, Rep. of	Chinese Taipei	Japan	Hong Kong, SAR	Netherlands	Belgium (Flemish)	Hungary	Estonia	Australia	Scotland

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

Exhibit 2.6: Multiple Comparisons of Average Mathematics Achievement for Reasoning Cognitive Domain

MATHEMATICS Grade 4

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

country's average mathematics achievement in the reasoning domain compares to achievement in the other participating countries.

At the eighth grade, average achievement in the reasoning domain ranged from 583 in Singapore to 287 in South Africa. Twenty-four countries and the four benchmarking participants performed significantly above the international average, three countries (Bulgaria, Armenia, and Serbia) performed comparably to the international average, and 19 countries performed significantly below the average.

At the eighth grade, looking at both Exhibits 2.5 and 2.6, it can be seen that the rank ordering of significant differences in achievement is rather complicated for the reasoning domain. Singapore and the Republic of Korea had the highest average achievement in the reasoning domain, nearly identical (583 and 582), but Singapore had a larger standard error (3.5 to 1.7). Thus, the Republic of Korea had significantly higher achievement than every participating country except Singapore and Chinese Taipei whereas Singapore (with the larger standard error) had higher average achievement than every participating country except the Republic of Korea, Chinese Taipei, and Japan. Chinese Taipei and Japan had the same average score (576) followed by Hong Kong SAR. Chinese Taipei (also with a relatively larger standard error of 4.2) did not perform statistically differently than the other three Asian countries, whereas a difference was found between the Republic of Korea and Japan due to their small standard errors. Hong Kong SAR was outperformed only by Singapore and the Republic of Korea. The Netherlands and Belgium (Flemish) only were outperformed by the five top-scoring Asian countries.

At the fourth grade, performance ranged from 574 for Singapore to 340 for Tunisia. Fifteen countries and the three benchmarking participants performed significantly above the international average, three countries (Italy, Scotland, and Moldova) performed essentially at the international average, and seven countries performed significantly below the international average. Singapore had the highest achievement, outperforming all countries except Hong Kong SAR and

Chinese Taipei. Hong Kong, Chinese Taipei and Japan had similar achievement followed by Belgium (Flemish), England, and the Netherlands (all with similar average achievement and only outperformed by the four highest-achieving Asian countries).

Overview Across Domains

At both the eighth and fourth grades, the countries with the highest achievement in each of the three cognitive domains also tended to be the highest-scoring countries (though not always in the same rank order) on the overall mathematics assessment. At the eighth grade (see Exhibit 1.1), the four countries with the highest overall mathematics achievement were Singapore followed by the Republic of Korea, Hong Kong SAR, and Chinese Taipei (only outperformed by Singapore). Japan had the next highest achievement outperforming all the rest of the participating countries except the previous four countries. Belgium (Flemish), the Netherlands, Estonia, Hungary, and the Canadian province of Quebec also performed well (at least as well or better than all other participants except the five Asian countries listed above).

- In reasoning, Singapore and the Republic of Korea performed very similarly followed by Chinese Taipei and Japan and then Hong Kong SAR (see Exhibits 2.5 and 2.6). The Netherlands, Belgium (Flemish), and the Canadian province of Quebec also had relatively high achievement, only being outperformed by the five Asian countries.

At the fourth grade, Singapore was the highest-performing country in overall mathematics followed by Hong Kong SAR, and then by Japan and Chinese Taipei who performed similarly (see Exhibit 1.1). Belgium (Flemish) had higher achievement than all countries except these four Asian countries.

- In knowing, the pattern at the fourth grade was the same as for overall mathematics (see Exhibits 2.1 and 2.2). The four Asian countries had the best achievement (Singapore followed by Hong Kong SAR, and then by Chinese Taipei and Japan) with Belgium (Flemish) having higher achievement than all countries except the four best-achieving Asian countries.
- In applying, the pattern for the four high-achieving Asian countries was the same as for overall mathematics (see Exhibits 2.3 and 2.4). However, Belgium (Flemish), Latvia, the Russian Federation, Lithuania, and the Netherlands all followed, performing similarly to each other with lower achievement than the four Asian countries, but higher achievement than the rest of the participating countries.
- In reasoning, Singapore, Hong Kong SAR, and Chinese Taipei had the highest achievement (see Exhibits 2.5 and 2.6). Japan had achievement similar to Hong Kong SAR and Chinese Taipei, but was outperformed by Singapore. Belgium (Flemish), England, and the Netherlands had achievement equal to or higher than all participants except the four top-achieving Asian countries.

Just as countries with high achievement on the mathematics assessment as a whole had high achievement in the three cognitive dti

(e.g., South Africa, Ghana, and Saudi Arabia at the eighth grade and the Philippines, Morocco, and Tunisia at the fourth grade) also