

# TIMSS in Perspective

## Lessons Learned from IEA's Four Decades of International Mathematics Assessment

Ina V.S. Mullis and Michael O. Martin

Co-Directors, TIMSS & PIRLS International Study Center

Lynch School of Education, Boston College

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**TIMSS**

Trends in International Mathematics and Science Study



**TIMSS & PIRLS**  
International Study Center  
Lynch School of Education, Boston College

# Overview of Presentation

- Conducting International Assessments
  - FIMS, SIMS, TIMSS, TIMSS-Trends
- International Comparisons in Mathematics Achievement
  - Distributions, Benchmarks, Trends
- Contexts for Learning Mathematics
  - Curriculum, Teacher Preparation, Instruction, Home Support, Student Attitudes

# FIMS – The First International Mathematics Study

- Pioneering international assessment – IEA's first study
- Expanding education systems – need for effective measure of output in terms of student achievement
- Applying psychometric techniques
- The world as an educational laboratory

# FIMS – The First International Mathematics Study (cont.)

## Why mathematics?

- Fundamental to improving mathematics and science
- Elements of curriculum and instruction common to many countries
- Widespread acceptance of symbols and notation, translation should be less problematic

# FIMS – The First International Mathematics Study (cont.)

FIMS conducted 1961-65 in 12 countries

- Two grades targeted (grade with most 13-year-olds; final grade for students studying advanced mathematics)
- Mathematics achievement in relation to school organization, mathematics curriculum and teaching, and student attitudes and backgrounds

Showed that international comparisons of student achievement were feasible, and could provide reliable data for policy makers

# SIMS – The Second International Mathematics Study

- Major emphasis on curriculum and instruction
- SIMS mathematics curriculum model
  - Intended curriculum (curricular goals and intentions)
  - Implemented curriculum (what is taught in the classroom)
  - Achieved curriculum (what mathematics students have learned)

# SIMS – The Second International Mathematics Study (cont.)

SIMS conducted 1980-82 in 20 countries

- Extensive curriculum analysis
  - Intended curriculum through expert reports
  - Implemented curriculum through “Opportunity to Learn” questionnaires
- Longitudinal study of classroom processes in 8 countries

# SIMS – The Second International Mathematics Study (cont.)

Student achievement in mathematics content areas (the achieved curriculum)

- Arithmetic, algebra, geometry and measurement, and descriptive statistics for grade with most 13-year-olds
- Algebra, geometry, and elementary functions and calculus for final-year students having advanced preparation in mathematics

# TIMSS – Third International Mathematics and Science Study

- Conducted in 1994-95, first to include both mathematics and science
- Launch of TIMSS coincided with an upsurge of interest in international studies – almost 50 countries participated
- Ambitious scope
  - Wide-ranging assessment of student achievement
  - Comprehensive curriculum analysis
  - Video study of instructional practices

# TIMSS – Third International Mathematics and Science Study (cont.)

Assessment of student achievement in mathematics and science

- Grades three and four (end of primary schooling)
- Grades seven and eight (lower secondary)
- Grade twelve (or final year)
  - Mathematics and science literacy for all students
  - Advanced mathematics and physics for students with preparation in these subjects

# TIMSS – Third International Mathematics and Science Study (cont.)

## Major methodological contributions

- Advanced psychometric scaling for analysis and reporting of student achievement
- Systematic emphasis on data quality and data comparability

# TIMSS – Third International Mathematics and Science Study (cont.)

- Ambitious curriculum frameworks for mathematics and science
- To be valid, assessment required
  - Wide range of mathematics and science content
  - Variety of cognitive skills
  - Items of different types
- Matrix-sampling design the solution
  - Each student administered a subset of the item pool

# TIMSS – Third International Mathematics and Science Study (cont.)

How to report student achievement?

- IRT (Item Response Theory) scaling with conditioning and multiple imputation
  - Developed for NAEP in the United States
  - Combines information from items administered and student background to derive scores on the entire assessment
- Great flexibility for assessment designers

# TIMSS – Third International Mathematics and Science Study (cont.)

## Comparative Validity

- Curriculum coverage comparable?
- Target populations comparable?
- Populations sampled correctly?
- Instrument translations comparable?
- Assessment administered appropriately?
- Items scored in the same way?
- Resulting data comparable?

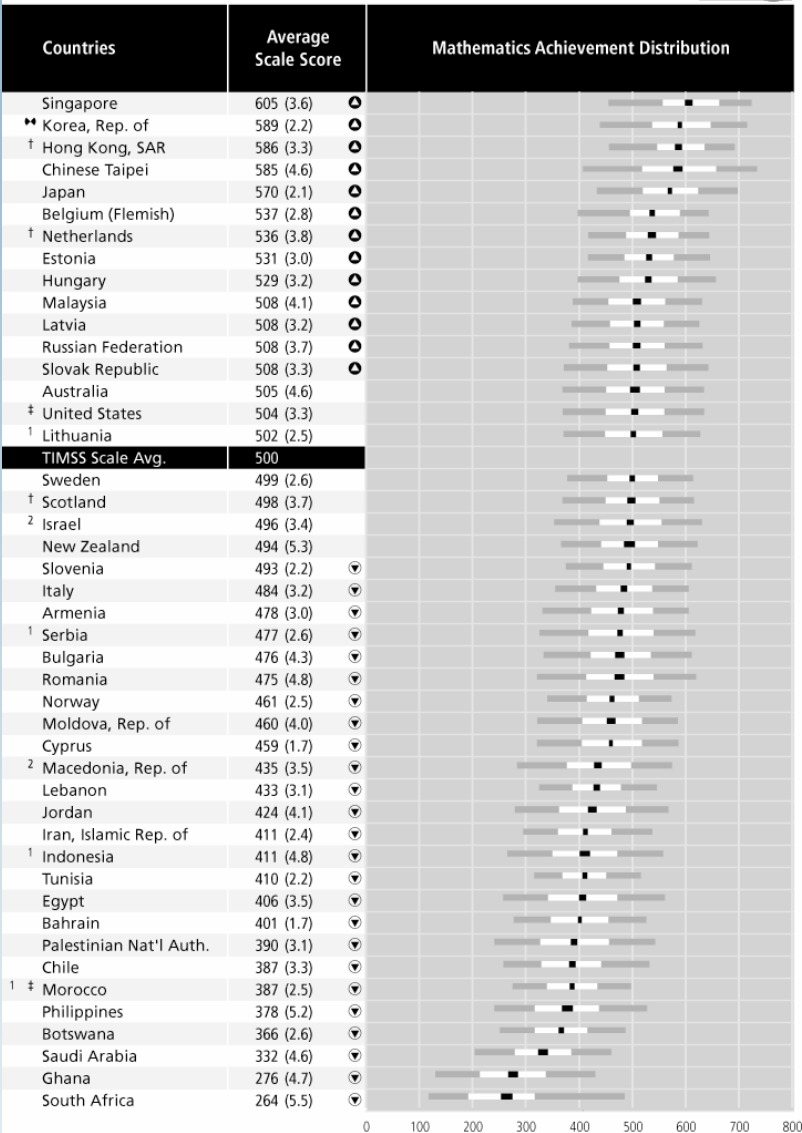
# TIMSS – *Trends in* International Mathematics and Science Study

- TIMSS 1995 – Focus on 4<sup>th</sup> and 8<sup>th</sup> grades
- TIMSS 1999 – 8<sup>th</sup> grade only
- TIMSS 2003 – 4<sup>th</sup> and 8<sup>th</sup> grades
- TIMSS 2007 – 4<sup>th</sup> and 8<sup>th</sup> grades

# TIMSS – Trends in International Mathematics and Science Study (cont.)

## TIMSS Advanced 2008

- First administered as part of TIMSS 1995 Final Year assessment
- Assesses students with advanced preparation in
  - Advanced mathematics
  - Physics

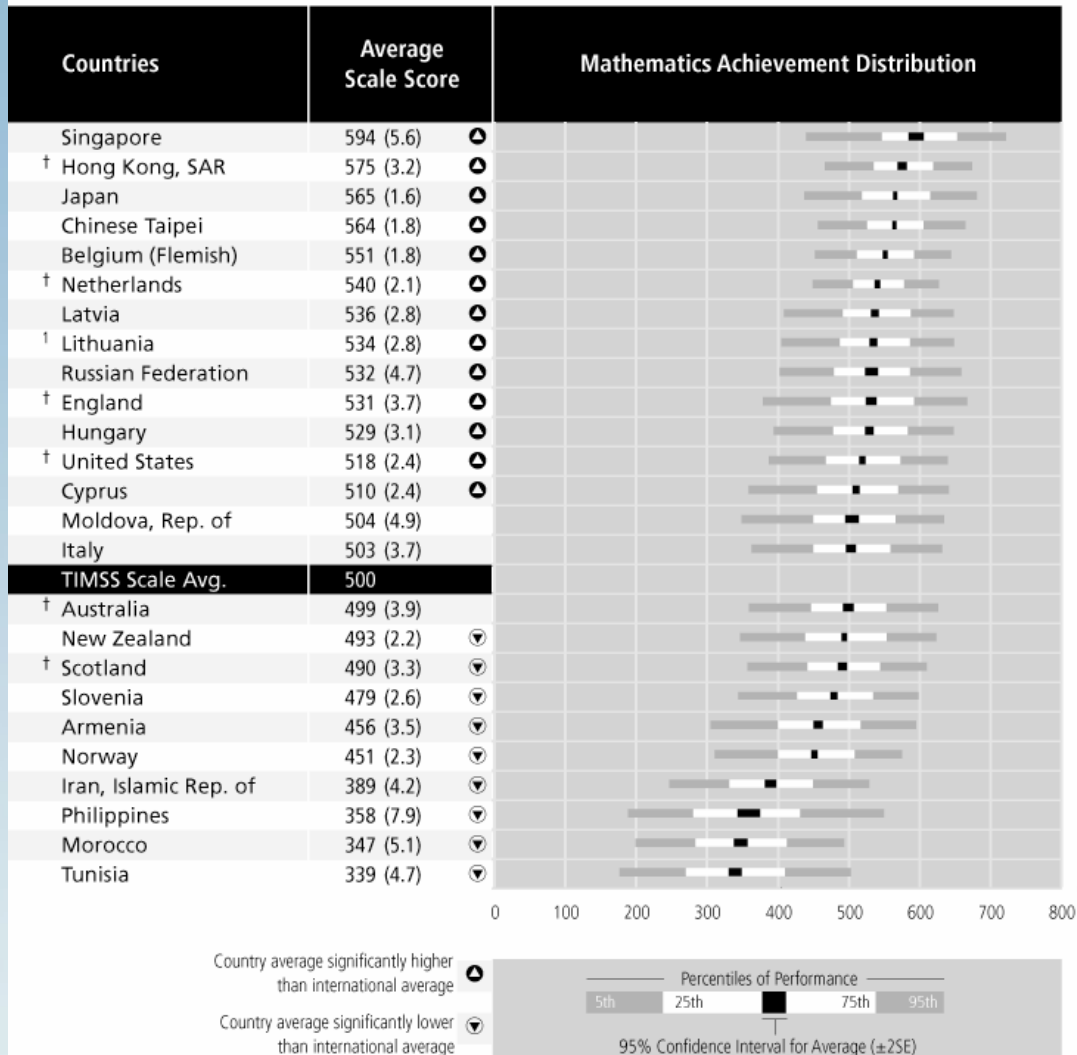


SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2003

- 13 above average
- 7 about average, U.S.
- 25 below average
- Wide range of achievement – across and within countries
- Range between 5<sup>th</sup> and 95<sup>th</sup> percentiles approximately 270-300
- Average in Singapore same as 95<sup>th</sup> percentile in lowest countries

Exhibit 1: Distribution of Mathematics Achievement (2)

TIMSS2003

MATHEMATICS  
Grade 4

- 13 above average, U.S.
- 3 about average
- 9 below average
- Wide range of achievement – across and within countries

Countries	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)
<b>International Avg.</b>	<b>7 (0.1)</b>	<b>23 (0.2)</b>	<b>49 (0.2)</b>	<b>74 (0.2)</b>
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)
<sup>2</sup> 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)
<sup>1</sup> 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)
<sup>1</sup> 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)
<sup>2</sup> 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)
<sup>1</sup> 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)
‡ 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)

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

## Advanced (625)

Can organize information, make generalizations, solve non-routine problems

## High (550)

Apply understanding in wide variety of complex situations

## Intermediate (475)

Apply basic knowledge in straightforward situations

## Low (400)

Some basic mathematical knowledge

Exhibit 2: Percentages of Students Reaching TIMSS 2003 International Benchmarks of Mathematics Achievement (2)

TIMSS2003  
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)
† 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)
<b>International Avg.</b>	<b>9 (0.2)</b>	<b>33 (0.3)</b>	<b>63 (0.3)</b>	<b>82 (0.2)</b>
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)

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

**Advanced (625)**  
Apply understanding in wide variety of complex situations

**High (550)**  
Apply understanding to solve problems

**Intermediate (475)**  
Apply knowledge in straightforward situations

**Low (400)**  
Some basic knowledge

# The TIMSS Advanced International Benchmark (625)

Percentage of eighth-grade students reaching the advanced benchmark in 2003

Singapore	44%
Chinese Taipei	38%
Korea, Rep. of	35%
Hong Kong SAR	35%
Japan	24%
United States	7%

# The TIMSS Intermediate International Benchmark (475)

Percentage of eighth-grade students reaching the international benchmark in 2003

Singapore	93%
Hong Kong SAR	93%
Korea, Rep. of	90%
Japan	88%
Chinese Taipei	85%
United States	64%

Exhibit 3: Trends in Average Mathematics Achievement

TIMSS2003  
MATHEMATICS  
Grade 8

Countries	2003 Average Scale Score	1999 to 2003 Difference	1995 to 2003 Difference
Australia	505 (4.6)	- -	-4 (6.0)
Belgium (Flemish)	537 (2.8)	-21 (4.3) ▼	-13 (6.5) ▼
Bulgaria	476 (4.3)	-34 (7.3) ▼	-51 (7.2) ▼
Chile	387 (3.3)	-6 (5.5)	◇ ◇
Chinese Taipei	585 (4.6)	0 (6.1)	◇ ◇
Cyprus	459 (1.7)	-17 (2.4) ▼	-8 (2.8) ▼
Hong Kong, SAR	586 (3.3)	4 (5.4)	17 (7.0) ▲
Hungary	529 (3.2)	-2 (4.9)	3 (4.5)
Indonesia	411 (4.8)	8 (6.9)	◇ ◇
Iran, Islamic Rep. of	411 (2.4)	-11 (4.1) ▼	-7 (4.5)
Israel	496 (3.4)	29 (5.2) ▲	- -
Italy	484 (3.2)	4 (5.0)	- -
Japan	570 (2.1)	-9 (2.7) ▼	-11 (2.6) ▼
Jordan	424 (4.1)	-3 (5.4)	◇ ◇
Korea, Rep. of	589 (2.2)	2 (2.9)	8 (2.9) ▲
Latvia (LSS)	505 (3.8)	0 (5.1)	17 (5.2) ▲
Lithuania	502 (2.5)	20 (4.9) ▲	30 (4.8) ▲
Macedonia, Rep. of	435 (3.5)	-12 (5.5) ▼	◇ ◇
Malaysia	508 (4.1)	-11 (6.0)	◇ ◇
Moldova, Rep. of	460 (4.0)	-9 (5.6)	◇ ◇
Netherlands	536 (3.8)	-4 (8.1)	7 (7.2)
New Zealand	494 (5.3)	3 (7.4)	-7 (7.1)
Norway	461 (2.5)	◇ ◇	-37 (3.3) ▼
Philippines	378 (5.2)	33 (7.9) ▲	◇ ◇
Romania	475 (4.8)	3 (7.5)	2 (6.6)
Russian Federation	508 (3.7)	-18 (7.0) ▼	-16 (6.5) ▼
Scotland	498 (3.7)	◇ ◇	4 (6.8)
Singapore	605 (3.6)	1 (7.2)	-3 (5.4)
Slovak Republic	508 (3.3)	-26 (5.2) ▼	-26 (4.5) ▼
Slovenia	493 (2.2)	- -	-2 (3.7)
South Africa	264 (5.5)	-11 (8.8)	- -
Sweden	499 (2.6)	◇ ◇	-41 (5.0) ▼
Tunisia	410 (2.2)	-38 (3.3) ▼	◇ ◇
United States	504 (3.3)	3 (5.2)	12 (5.8) ▲
TIMSS Scale Avg.	500		

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

- 17 three-cycle trends

34 two-cycle trends

- 5 had improvement 1995-2003, U.S.

Hong Kong SAR and Korea  
Latvia and Lithuania

Exhibit 3: Trends in Average Mathematics Achievement (2)

Countries	2003 Average Scale Score	1995 to 2003 Difference
Australia	499 (3.9)	4 (5.2)
Cyprus	510 (2.4)	35 (4.0) ▲
England	531 (3.7)	47 (5.0) ▲
Hong Kong, SAR	575 (3.2)	18 (5.1) ▲
Hungary	529 (3.1)	7 (4.8)
Iran, Islamic Rep. of	389 (4.2)	2 (6.5)
Japan	565 (1.6)	-3 (2.4)
Latvia (LSS)	533 (3.1)	34 (5.5) ▲
Netherlands	540 (2.1)	-9 (3.6) ▼
New Zealand	496 (2.1)	26 (4.9) ▲
Norway	451 (2.3)	-25 (3.8) ▼
Scotland	490 (3.3)	-3 (5.3)
Singapore	594 (5.6)	4 (7.2)
Slovenia	479 (2.6)	17 (4.1) ▲
United States	518 (2.4)	0 (3.8)
<b>TIMSS Scale Avg.</b>	<b>500</b>	

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

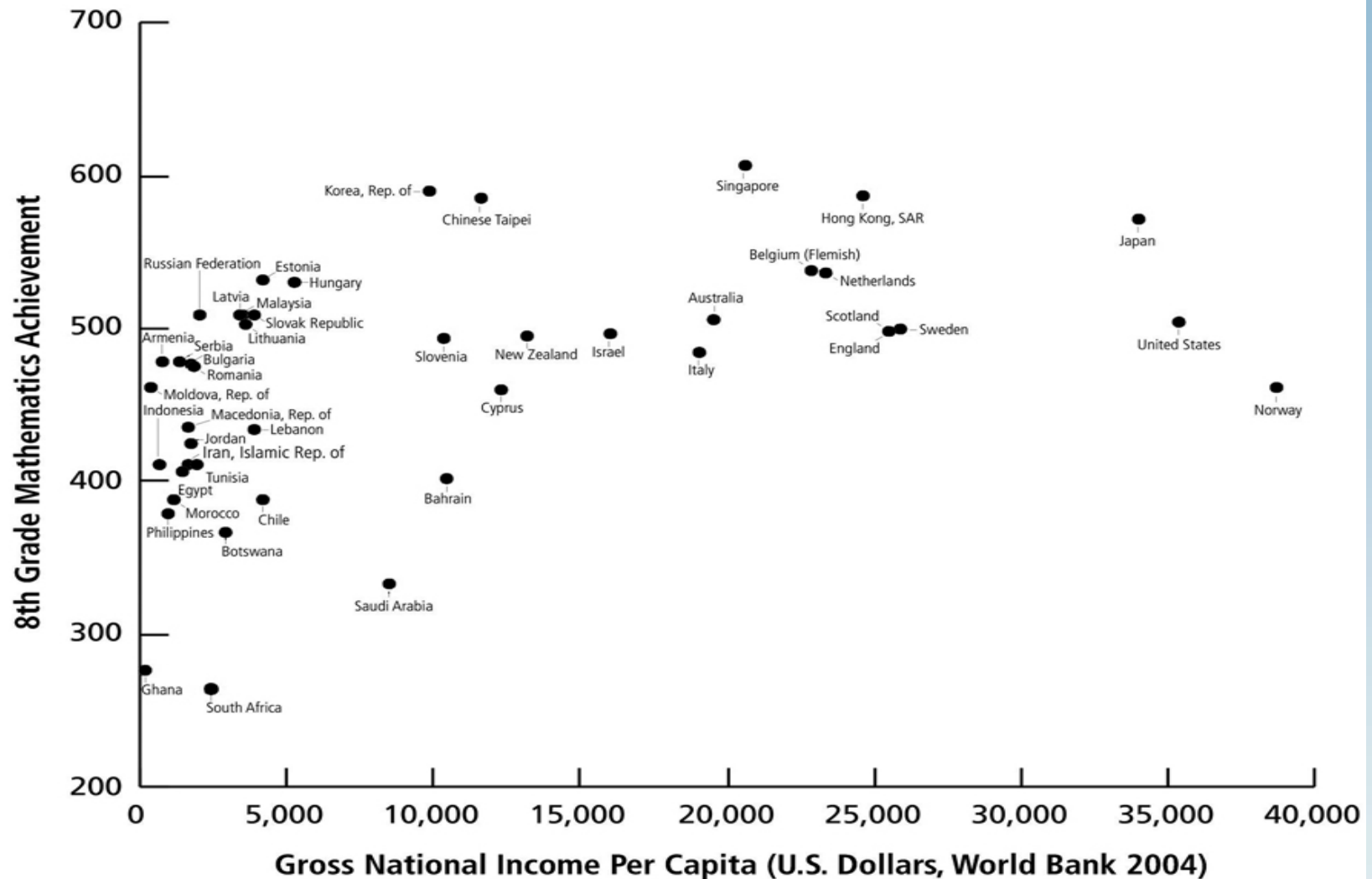
2003 Country average significantly higher ▲

2003 Country average significantly lower ▼

TIMSS2003  
MATHEMATICS  
Grade 4

- 6 countries improved from 1995 to 2003
- 7 stayed the same, including U.S.
- 2 countries declined

**Exhibit 4: TIMSS 2003 8th Grade Mathematics Achievement by Gross National Income Per Capita**



# Organization of Schools

- Universal education through secondary school
  - Huge improvement since FIMS
  - But in 1995, still room for improvement (50% in South Africa, 35% in U.S., and 12-15% in Norway and France no longer in school by final year)
- Interesting to see what we find in 2008

## Organization of Schools (cont.)

- Percentages of students having taken advanced mathematics: 2% in Russian Federation to 75% in Slovenia, U.S. 14%
- Percentages of students having taken physics: 3% in Russian Federation to 44% in Austria and Slovenia, U.S. 14%

# Curriculum

- Intended curriculum – 8<sup>th</sup> and 4<sup>th</sup> grades
  - 38 and 21 same curriculum, no grouping
  - 9 and 5 same curriculum, with grouping
  - 4 and 0 different curriculum, different groups
- Substantial overlap with TIMSS topics
  - 76% and 68% on average
  - Higher-performing countries had greater levels of coverage
- Majority of countries undergoing curriculum revision – three-fourths and half

## Curriculum (cont.)

- Implemented curriculum – 8<sup>th</sup> and 4<sup>th</sup> grades
- According to teacher reports at both grades, 70-72% of students, on average, had been taught the TIMSS 2003 mathematics topics
- 8<sup>th</sup> grade: substantial agreement between topics in intended curriculum and topics taught
- 4<sup>th</sup> grade: less agreement

# Teacher Experience and Preparation

## TIMSS 2003

- Obtaining a university degree
- Supervised practical experience (practicum)
- Passing an examination
- Completion of a probationary period
- Completion of an induction program

Most countries required only two or three

# Teacher Experience and Preparation (cont.)

	Number of Countries	
	8 <sup>th</sup>	4 <sup>th</sup>
Degree	33	15
Practicum	33	19
Examination	28	14
Probation	23	16
Induction	11	8

# Teacher Experience and Preparation (cont.)

Percentages of students taught by teachers who studied

	8 <sup>th</sup>	4 <sup>th</sup>
Mathematics	70	
Math education (or both)	54	
Primary education		80
With math specialty		26

# Teacher Experience and Preparation (cont.)

Percentages of students taught by teachers who felt ready to teach topics

	8 <sup>th</sup>	4 <sup>th</sup>
Number	99	97
Algebra	97	97
Measurement	98	99
Geometry	98	90
Data	88	97

# Instruction

- Textbook foundation of instruction
  - Two-thirds 4<sup>th</sup> and 8<sup>th</sup> grade students
- Predominant activities – 60% of class time both grades
  - Teacher lecture
  - Teacher-guided student practice
  - Students working on problems on their own

# Instruction (cont.)

- Calculators
  - Permitted for all 8<sup>th</sup> grade students (98% or more) in both high-performing and low-performing countries
  - Not permitted for majority of 4<sup>th</sup> grade students – 57% on average
- Computers
  - Not available: 68% at 8<sup>th</sup> grade; 58% at 4<sup>th</sup> grade
  - Greatest use by Netherlands (31%) and Singapore (14%) in half the lessons for practicing skills and procedures

# Home Support for Learning

- Higher levels of parents' education are associated with higher 8<sup>th</sup> grade student achievement
- Students speaking the language of the test always or almost always had higher achievement at both grades
- More books in the home and having study aids were associated with higher achievement at both grades

# Attitudes and Values

TIMSS 2003 had two scales

- Higher self-confidence in learning mathematics is associated with higher achievement at both grades
- Placing a higher value on learning mathematics is associated with higher achievement at both grades

# Safe and Orderly Schools

- Students in schools that teachers characterize as safe had higher achievement at both grades
  - About three-fourths in schools characterized as safe
  - One-fifth in schools somewhat safe, 5% in unsafe schools
- According to students, 15% at 8<sup>th</sup> grade and 23% at 4<sup>th</sup> grade were in unsafe schools and had lower achievement

# Summary

- Many lessons learned since the pioneering days
- Different countries use different approaches but an effective educational system always requires enormous effort
  - High percentages of students in school through secondary school, and taking advanced courses
  - A rigorous and progressive curriculum
  - Well-prepared teachers
  - Economic resources, facilities, and materials
  - Students ready to learn and encouraged by society

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