

20 Years of TIMSS:

International Trends in Mathematics and Science Achievement, Curriculum, and Instruction

Ina V.S. Mullis and Michael O. Martin

Keynote Address

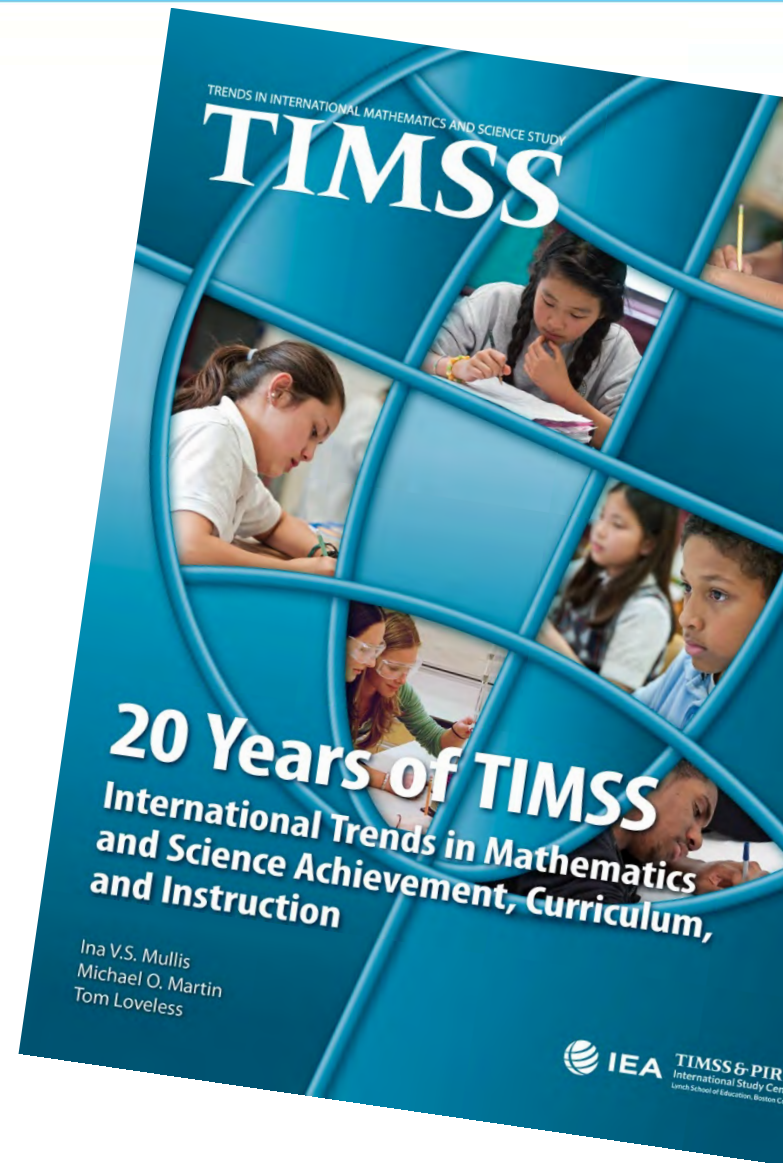
7th IEA International Research Conference

Prague, Czech Republic

June 28-30, 2017



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A TIMSS Walk Down Memory Lane

From our perspective...



TIMSS 1995—Study of enormous scope



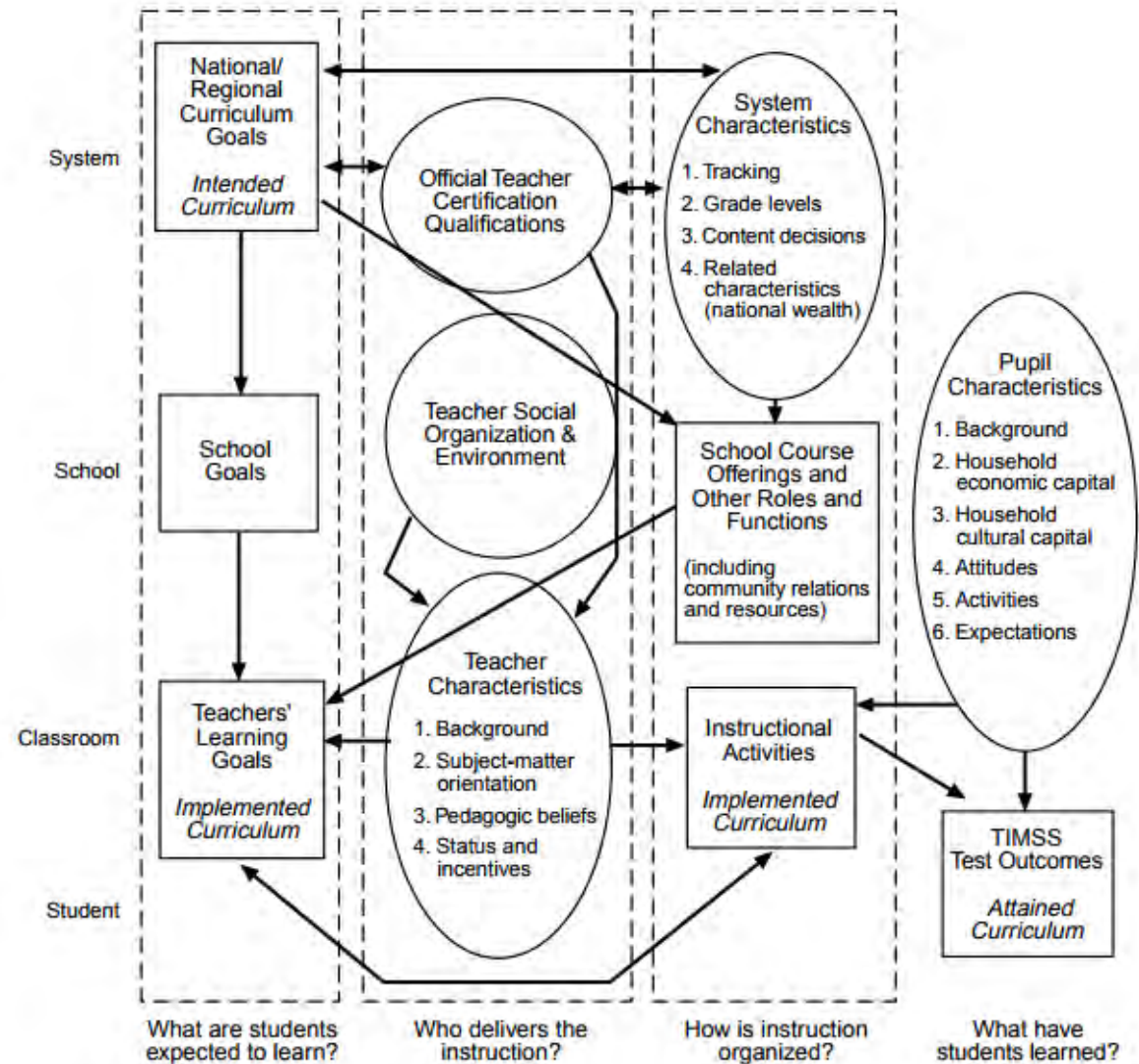
Begins modern era of interest in International Assessments

- 46 countries around the world
- Mathematics & science 5 grades – 7 assessments
 - 2 grades most 13-year-olds (7th and 8th)
 - 2 grades most 9-year-olds (3rd and 4th)
 - Final year secondary school (literacy and advanced)
- “Hands-on” performance assessment

Contexts for Teaching and Learning - TIMSS Tangle



Figure 5.4 TIMSS Conceptual Framework: The Educational Experience Opportunity



TIMSS 1995—Array of Questionnaires

Contexts for teaching and learning

- Students
- Teachers
- School principals
- Curriculum experts

1st TIMSS Encyclopedia



TIMSS 1995—Questions About Data Quality

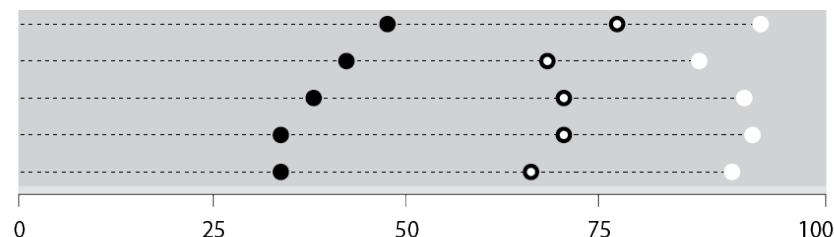
- Sampling?
- Translation?
- Plausible values?
- “Below the line”

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TIMSS 1999—TIMSS Repeat U.S. Initiative

- Repeat of TIMSS at 8th Grade
 - 4th grade would do better?
- 38 Countries
 - 26 Trend Countries
- U.S. benchmarking effort
 - 13 states;
14 school districts/
consortia



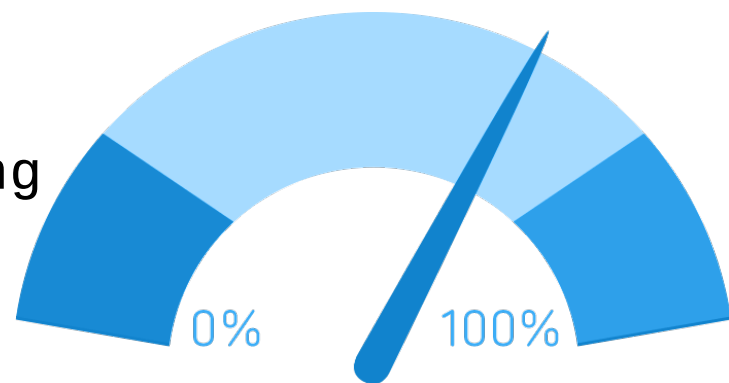
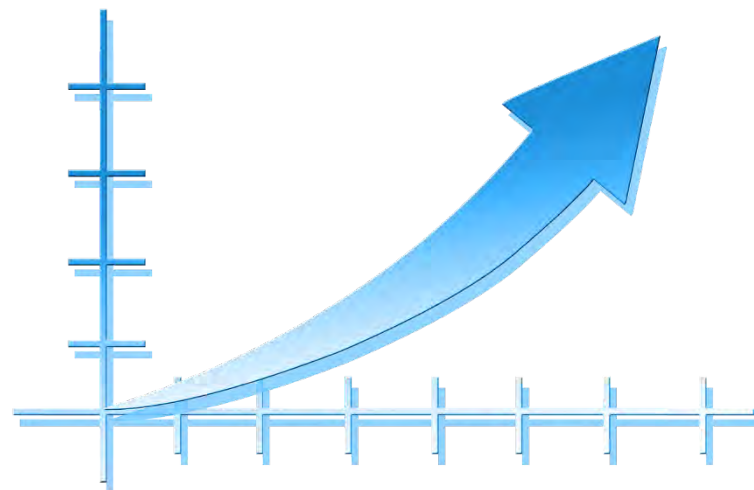
PIRLS 2001—Innovative Reading Assessment

- Replicate 1991 Reading Literacy Study
 - 9 countries
- More desire up-to-date methods
 - Longer, authentic passages
 - Constructed-response questions
- The “PIRLS Reader” in color
- The 1st PIRLS Encyclopedia
- 35 countries



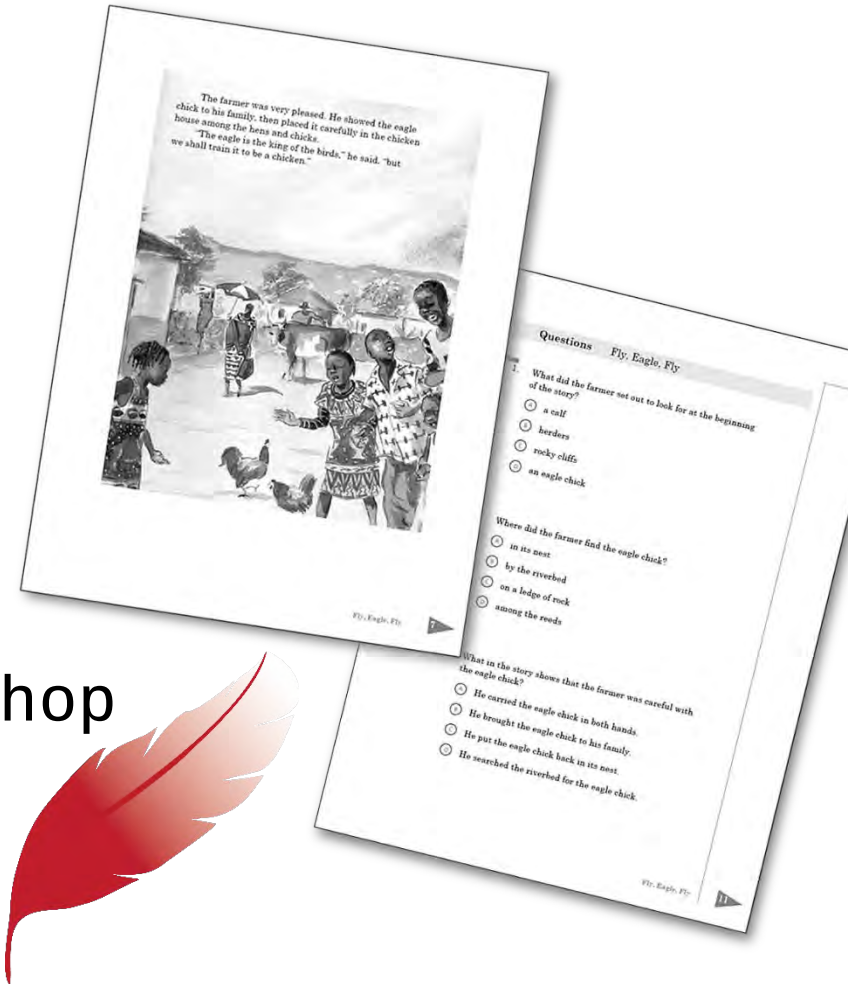
TIMSS 2003—Cemented TIMSS Trends

- New design for trend
 - 4 years; Grades 4 and 8
- 49 Countries
- TIMSS Framework (NSF)
- Cognitive Domains
 - Knowing, applying, reasoning
- Benchmarking Option



PIRLS 2006—First Trends

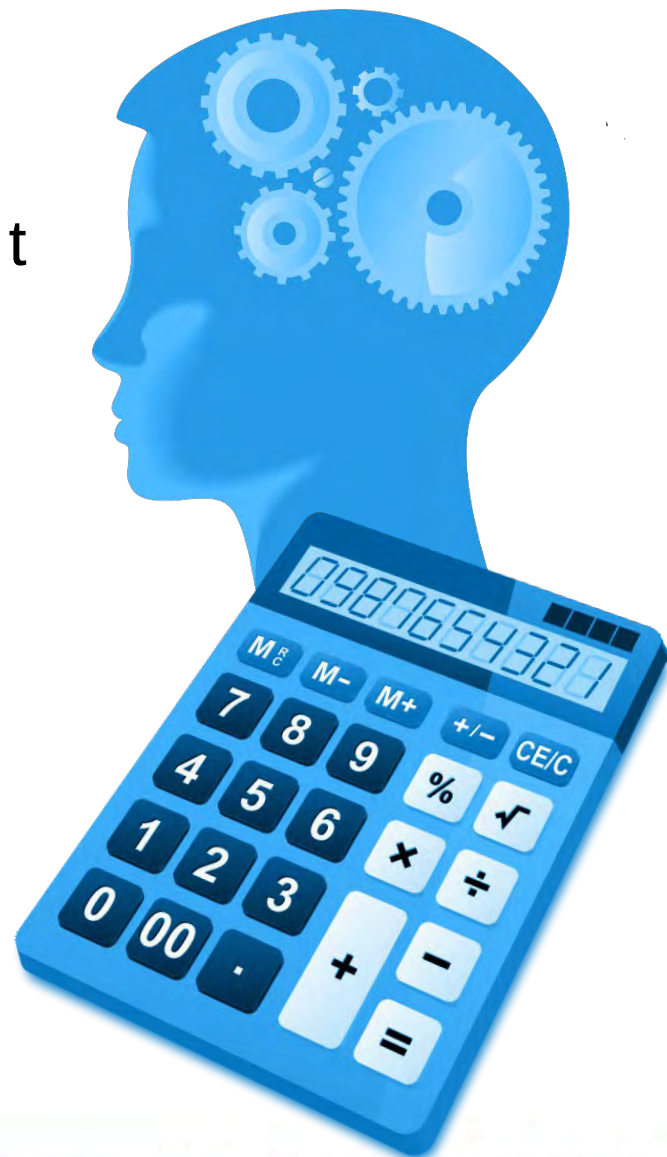
- 5-year trend cycle
- Added Comprehension Processes
 - Increased passages and items
- 40 countries
- First Item-writing workshop
 - Popular innovation – increased NRC involvement



TIMSS 2007

Continued TIMSS development and expansion

- Better framework alignment
 - Grades 4 and 8
- Cognitive Domain Scales
 - Knowing, Applying, Reasoning
- Calculators at 8th grade
- TIMSS Encyclopedia (re-imagined)



TIMSS Advanced 2008—Norwegian Initiative

- Trends to 1995
 - Advanced mathematics and physics
- TIMSS Advanced Framework
- Item development effort



TIMSS and PIRLS in 2011—Historic Event

- 4 & 5-year cycles into alignment
- 70 countries in total
- 40 countries assessed TIMSS and PIRLS at fourth grade
 - 34 same students
- Context Questionnaire Scales
- 2 Encyclopedias
- Relationships Report



TIMSS and TIMSS Advanced 2015 —20 Years of Trends

- Biggest TIMSS to date
- 7 TIMSS Assessments for Item Development
- Trends in Context Questionnaire Scales
- Home Questionnaire
- Online Reports
- 57 TIMSS Countries
- 9 TIMSS Advanced
- 600,000 students



TOUCHING THE LIVES OF MILLIONS— 500 million!



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Student Achievement in Mathematics and Science

- **Average Achievement in Mathematics and Science**
- **Achievement at the International Benchmarks**



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Trends at Fourth Grade Show Increases in Mathematics Achievement Around the World

Trends 2005-2015: 47 Countries

14 Countries Higher Average Achievement



Australia, Cyprus, Finland, Croatia,
French Republic, Georgia,
Hong Kong SAR, Ireland,
Japan, Korea, New Zealand,
Norway, Portugal, Singapore,
Slovenia, the United States,
Russian Federation, Singapore,
Slovenia, Spain, Sweden, Turkey,
United Arab Emirates

15 Countries Same Average Achievement



Austria, Belgium (Flemish),
Chile, Denmark, England,
Iran, Italy, Korea, Lithuania,
New Zealand, Northern Ireland,
Norway, Serbia, Slovak Republic,
the United States

2 Countries Lower Average Achievement



Czech Republic,
Netherlands,
Saudi Arabia



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Trends at Eighth Grade Show Increases in Mathematics Achievement Around the World

Trends 1995-2015: 36 Countries

9 Countries Higher Average Achievement



Bahrain, Chile, Georgia, Iran, England, Hong Kong SAR, Japan, Kazakhstan, Lithuania, Iran, Korea, Lithuania, Malaysia, Morocco, Norway, Russian Federation, Singapore, Oman, Qatar, Singapore, Slovenia, the United States, Slovenia, South Africa, Sweden, United Arab Emirates, the United States

4 Countries Same Average Achievement



Australia, Botswana, England, Hong Kong SAR, Hungary, Japan, New Zealand, Israel, Italy, Korea, Lebanon, New Zealand, Russian Federation, Thailand, Turkey

3 Countries Lower Average Achievement



Hungary, Norway, Jordan, Saudi Arabia, Sweden



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Trends at Fourth Grade Show Increases in Science Achievement Around the World

Trends 2005-2015: 47 Countries

17 Countries Higher Average Achievement



Cyprus, England, Australia, Bahrain, Croatia, Hong Kong SAR, Hungary, Iran, Ireland, Japan, Kazakhstan, Lithuania, Morocco, Korea, Portugal, New Zealand, Oman, Qatar, Singapore, Slovenia, Russian Federation, Spain, Turkey, United Arab Emirates

16 Countries Same Average Achievement



Australia, Belgium (Flemish), Chile, Czech Republic, Chinese Taipei, Czech Republic, Denmark, England, New Zealand, the United States, Georgia, Germany, Hungary, Korea, Northern Ireland, Norway, Serbia, Singapore, Sweden, the United States

3 Countries Lower Average Achievement



Netherlands, Finland, Iran, Italy, Norway, Netherlands, Kuwait, Portugal, Saudi Arabia, Slovak Republic



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Trends at Eighth Grade Show Increases in Science Achievement Around the World

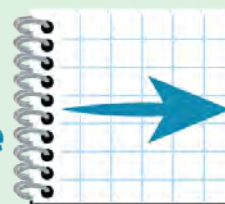
Trends 1995-2015: 36 Countries

9 Countries Higher Average Achievement



Belgium, Hong Kong SAR, Ireland,
Japan, Korea SAR, Lithuania,
Russia, Kazakhstan, Singapore,
Malaysia, the United States,
Qatar, Slovenia, South Africa,
Sweden, Turkey,
United Arab Emirates

4 Countries Same Average Achievement



Australia, Chile, Chinese Taipei,
England, Hungary, Israel,
New Zealand, Lebanon,
New Zealand, Norway,
Russian Federation,
Singapore, Thailand,
the United States

2 Countries Lower Average Achievement



Bolivia, Iran,
Jordan,
Saudi Arabia



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400 – Low International Benchmark

4th Grade Mathematics

Students have some basic mathematical knowledge

- Add and subtract whole numbers
- Some understanding of multiplication by one-digit numbers
- Solve simple word problems
- Have some knowledge of simple fractions, geometric shapes, and measurement
- Read and complete simple bar graphs and tables

625 – Advanced International Benchmark 4th Grade Mathematics

Students can apply their understanding and knowledge in a variety of relatively complex situations and explain their reasoning.

- Solve a variety of multi-step word problems involving whole numbers
- Show an increasing understanding of fractions and decimals
- Apply knowledge of a range of two- and three-dimensional shapes in a variety of situations
- Interpret and represent data to solve multi-step problems



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Gender Differences in Mathematics and Science

- **Gender differences in 1995 and 2015**
- **Changes in gender differences in 20-year trend countries**

Gender Differences in Mathematics and Science Achievement

TIMSS 1995:

- In mathematics, generally small or negligible differences in at both 4th and 8th grades
 - Where differences, always boys higher
- In science, boys outperformed girls...
 - In half the countries at 4th grade
 - In almost all the countries at 8th grade

Gender Differences in Mathematics and Science Achievement

TIMSS 2015:

- Gender equity in about half the countries
 - Both mathematics and science
- Fewer countries with boys performing better
- Quite a few countries with girls performing better

Gender Differences in Mathematics and Science Achievement

TIMSS 2015: Average achievement- all countries

- Mathematics
 - 4th grade – no difference
 - 8th grade – girls 3 points higher
- Science
 - 4th grade – girls 4 points higher
 - 8th grade – girls 10 points higher

Gender Differences in Achievement in 2015

	4th Grade		8th Grade	
	Mathematics	Science	Mathematics	Science
Countries with BOYS higher	18	11	6	5
Avg. Difference	9 Points	8 Points	9 Points	11 Points
Countries with no difference	23	25	26	20
Countries with GIRLS higher	8	11	7	14
Avg. Difference	18 Points	24 Points	17 Points	28 Points
Number of Countries	49	47	39	39

Countries Where Girls Had Higher Achievement Than Boys in 2015

4th Grade

Mathematics

Bahrain
Finland
Indonesia
Jordan
Kuwait
Oman
Saudi Arabia
South Africa

Science

Bahrain
Bulgaria
Finland
Kazakhstan
Kuwait
Morocco
Oman
Qatar
Saudi Arabia
Sweden
United Arab Emirates

8th Grade

Mathematics

Bahrain
Botswana
Jordan
Malaysia
Oman
Singapore
Thailand

Science

Bahrain
Botswana
Jordan
Kuwait
Lebanon
Malaysia
Malta
Morocco
Oman
Qatar
Thailand
Turkey
Saudi Arabia
United Arab Emirates

Gender Differences in 20-Year Trend Countries

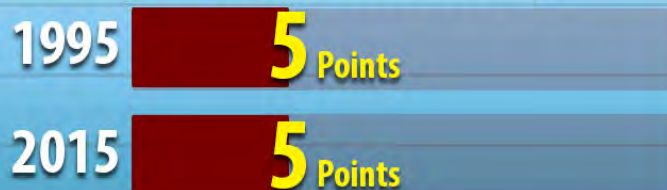
- Across 20-years of trends, gender differences in 2015 look different from 1995
 - Fewer countries with boys doing better, more with girls doing better
- More, and more diverse, countries in 2015
 - Change in composition of countries a factor?
 - Focus on 20-year trend countries (17 at 4th grade, 16 at 8th grade)

Gender Gaps Have Narrowed

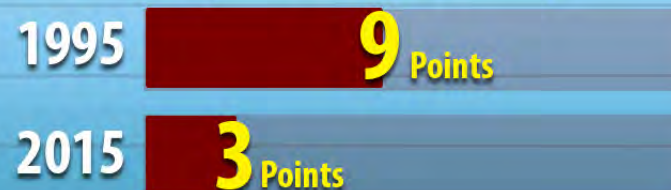
Size of Average Gender Achievement Gaps Favoring Boys, 1995 -2015

4th Grade

Mathematics

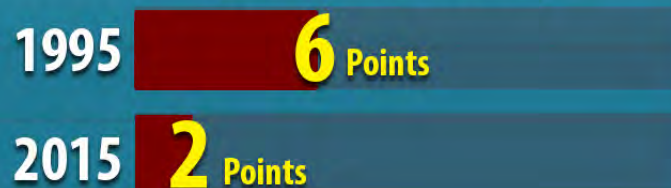


Science



8th Grade

Mathematics



Science



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Gender Differences in TIMSS Advanced

TIMSS 1995:

- More males than females in advanced courses
 - Especially in physics
- Higher achievement for males

Attracting Women to STEM Education Remains a Challenge

More **Males** than **Females** were enrolled in Advanced Mathematics programs in **6** countries.



More
Males
enrolled

6 Countries
France, Sweden,
Norway, Italy, Lebanon,
the United States

2 Countries
Slovenia,
Portugal



More
Females
enrolled

Males had higher achievement
than **Females** in **6** countries.



Males
higher
achievement

6 Countries
Russian Federation,
Norway, Sweden, France,
Slovenia, the United States

0 Countries
Females
higher
achievement



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Attracting Women to STEM Education Remains a Challenge

More **Males** than **Females** were enrolled in physics programs in all countries.

More
Males
enrolled

9

Countries

France, Italy, Russian Federation, Sweden, the United States, Lebanon, Slovenia, Norway, Portugal

0

Countries

More
Females
enrolled

Males had higher achievement than **Females** in **8** countries.

Males
higher
achievement

8

Countries

France, Italy, Russian Federation, Sweden, the United States, Slovenia, Norway, Portugal

0

Countries

Females
higher
achievement



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Changes in Gender Differences in TIMSS Advanced

TIMSS 2015 (6 trend countries):

- Advanced mathematics
 - More equity in enrolment (54/47% vs 58/42%)
 - No change in achievement difference (20 pt. male advantage)
- Physics
 - Enrolment difference little changed (62/38%)
 - Achievement gap reduced – from 53 to 28 points

Home Environment



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Curriculum and Teacher Education



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Curriculum Has Changed in Mathematics and Science

- **Continually evolving curriculum content**
During the 20 years of TIMSS, nearly all countries have implemented periodic curriculum reforms, ranging from updates to full scale
- **More challenging at primary levels**
Topics have moved down in grades



Teachers Are More Highly Educated



- **Increased requirements for becoming a teacher**
University degrees
- **Teacher education programs more selective**
Interviews and minimum GPAs
- **Additional certification requirements**
Oral and written exams

Trends in Instructional Time, 1995 - 2015

4th Grade

MATHEMATICS Yearly Hours

1995 **165**

2015 **151**

SCIENCE Yearly Hours

1995 **73**

2015 **69**

8th Grade

1995 **127**

2015 **130**

1995 **101**

2015 **116**

School Climate



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Trends in School Emphasis on Academic Success, 2007 - 2015

Percentages of Students in Schools Where Teachers Emphasized Academic Success

4th Grade

Very High
Emphasis

2007 **5%**

2015 **7%**

High
Emphasis

2007 **55%**

2015 **65%**

Medium
Emphasis

2007 **40%**

2015 **28%**

8th Grade

2007 **4%**

2015 **7%**

2007 **43%**

2015 **58%**

2007 **53%**

2015 **35%**

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School Safety



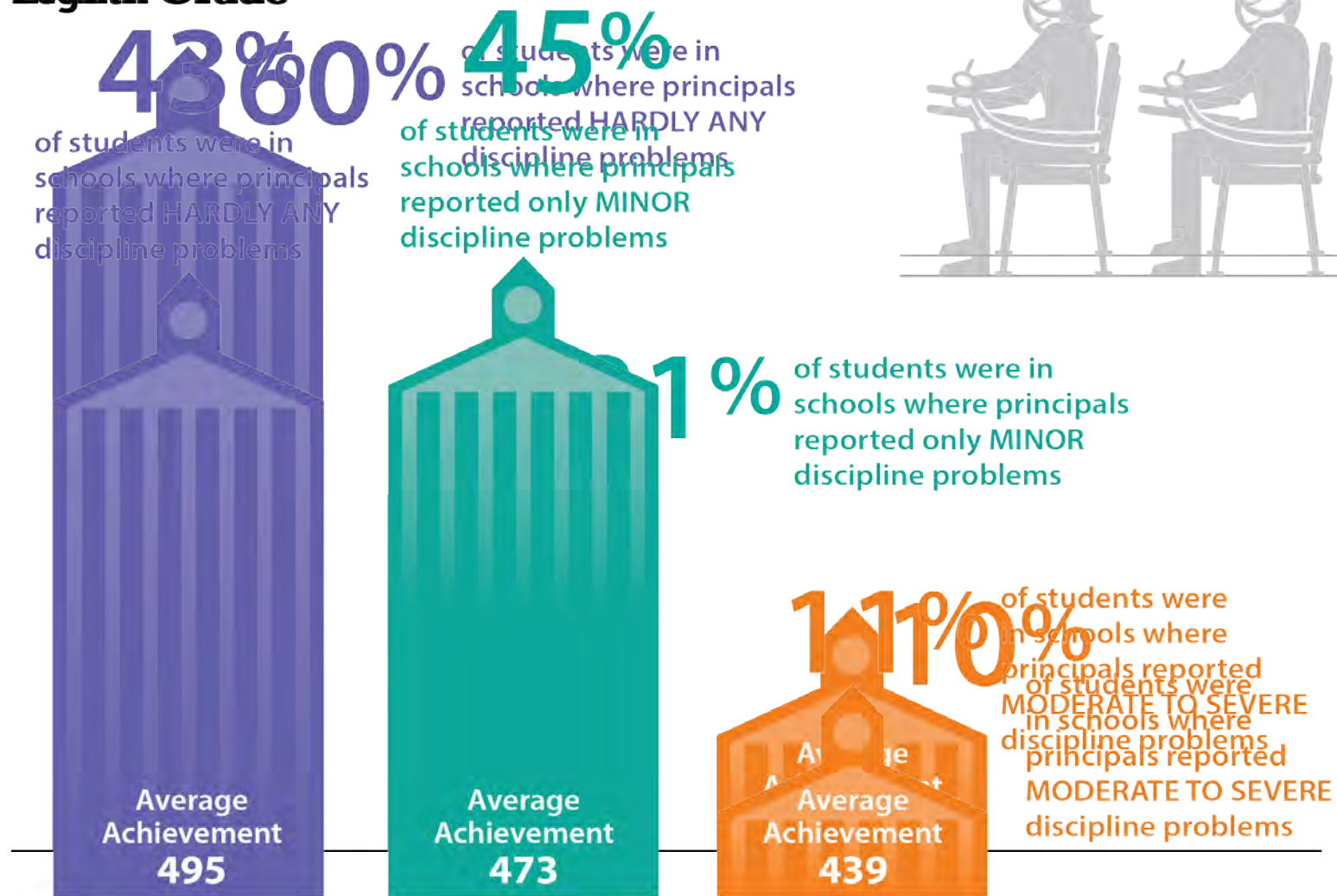
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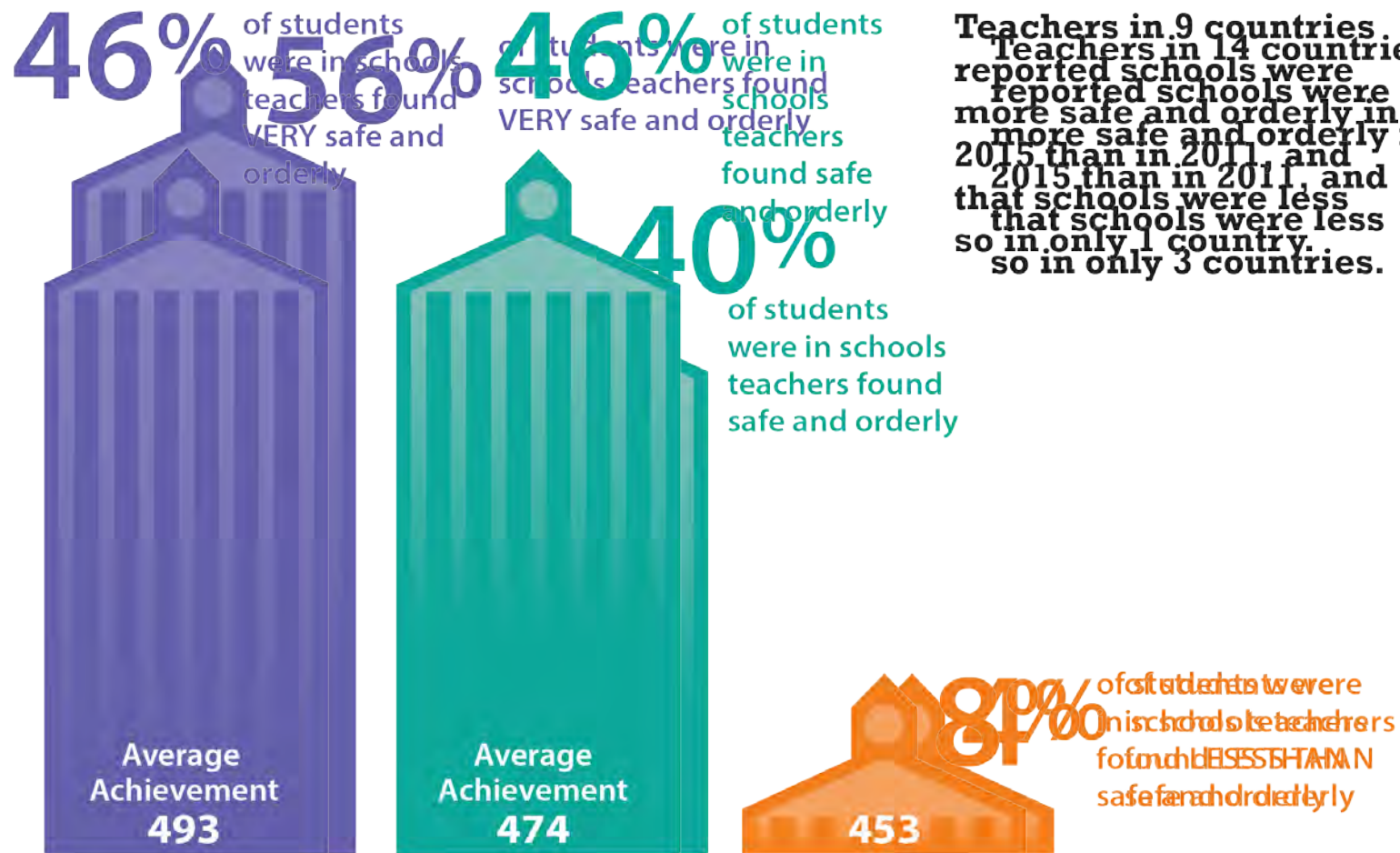
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Principals' Reports of Discipline Problems— Eighth Grade



Teachers' Reports of Safe and Orderly Schools—Eighth Grade



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Trends in Safe and Orderly Schools, 2007 - 2015

Percentages of Students in Schools that Teachers Judged Safe and Orderly

4th Grade

Very Safe and
Orderly

Somewhat Safe
and Orderly

Not Safe and
Orderly

2007 **47%**

2007 **49%**

2007 **4%**

2015 **69%**

2015 **28%**

2015 **2%**

8th Grade

2007 **39%**

2007 **54%**

2007 **7%**

2015 **63%**

2015 **33%**

2015 **3%**

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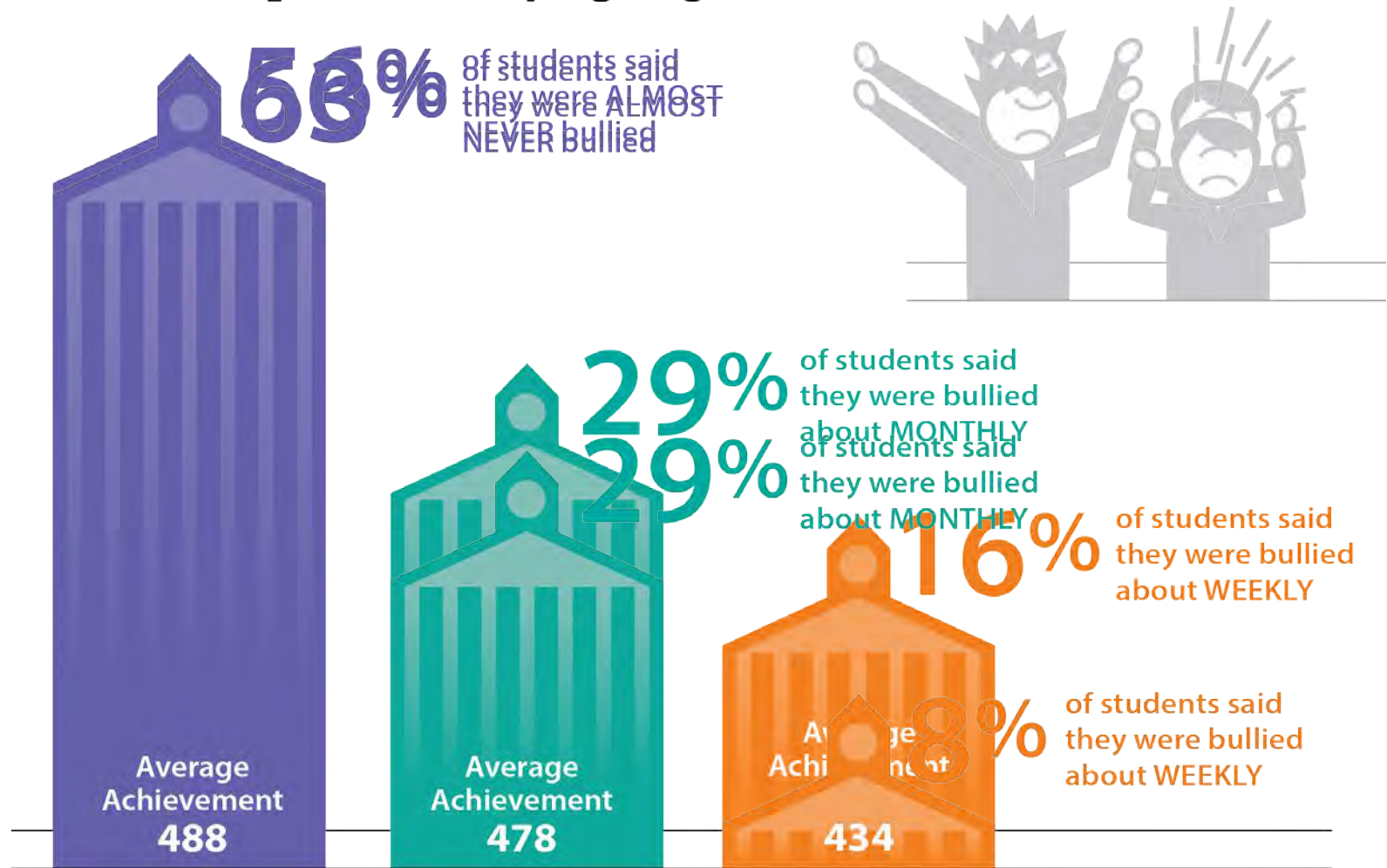
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Students' Reports of Bullying—Eighth Grade



Resources and Technology



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Technology Has Growing Presence in Mathematics and Science Education

- **About 90% of the TIMSS 2015 countries reported initiatives for integrating technology into mathematics and science classrooms**
 - Teachers reported increasing technology use more in fourth grade than eighth grade
 - More technology use reported in science—simulations, inquiry, and visualizing abstract concepts
 - Singapore introduced its fourth Masterplan in 2015, the latest in a series of technology policies



Trends in Adequacy of School Resources for Instruction, 2007 - 2015

Percentages of Students in Schools Where Instruction was Affected by Resource Shortages

4th Grade

Not
Affected

Affected
Somewhat

Affected
a Lot

2007 **53%**

2007 **43%**

2007 **4%**

2015 **50%**

2015 **45%**

2015 **6%**

8th Grade

2007 **46%**

2007 **48%**

2007 **6%**

2015 **44%**

2015 **42%**

2015 **15%**

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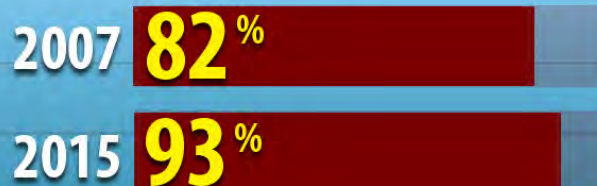
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Trends in Computer Access, 2007 - 2015

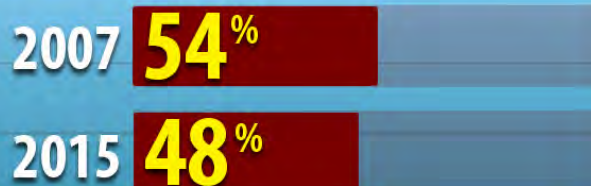
Percentages of Students

4th Grade

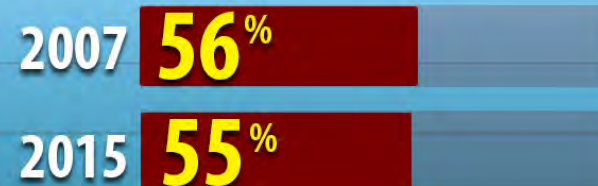
Computer in
Home



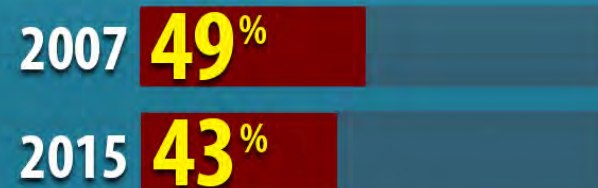
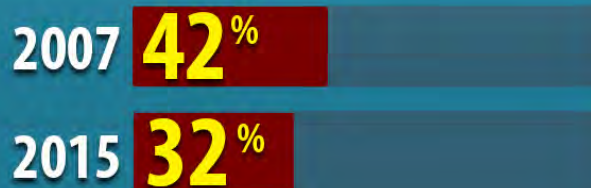
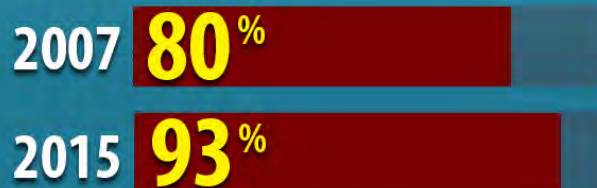
Computer Available for
Mathematics Lessons



Computer Available for
Science Lessons



8th Grade



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Student Attitudes



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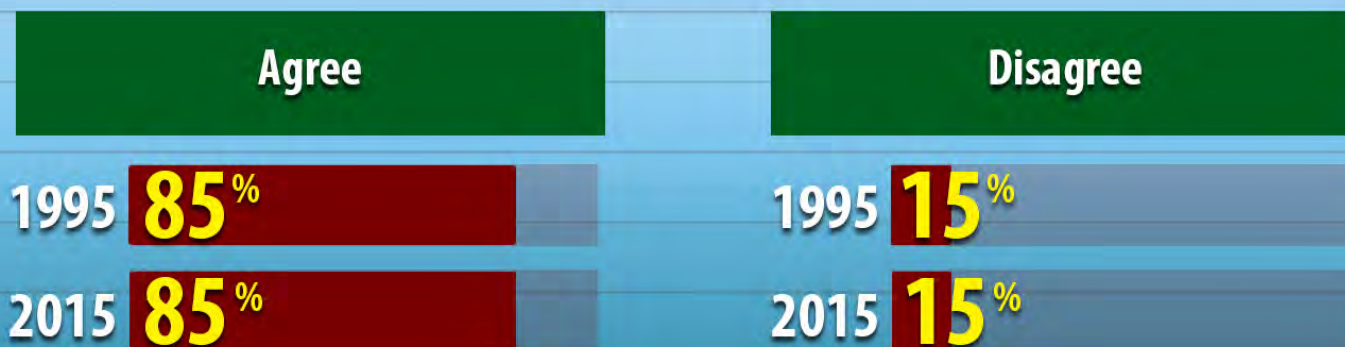
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Trends in "I Enjoy Learning Mathematics", 1995 - 2015

Percentages of Students Who Agreed with the Statement, "I Enjoy Learning Mathematics"

4th Grade



8th Grade





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Thank You!

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