Mathematics and Science Achievements and Achievement Gaps in South Africa

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Presentation to SAARMSTE 2021

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South African Mathematics and Science Achievement

- South African mathematics and science achievement, though improving, is still low and socially graded. Achievement gaps confirm the story that advantage begets advantage and home disadvantage continues to school.

- Periodic measurement of learning achievements is key to understand the health of our education system.

- Measurement of achievement occurs through school-based assessments, national and provincial systemic studies, regional (SACMEQ) and international studies (TIMSS and PIRLS).

Trends in International Mathematics and Science Study

- TIMSS is a cross-national and trend assessment of the mathematics and science knowledge of 4/5th Grade and 8/9th Grade learners.
- TIMSS assessments align broadly with countries mathematics and science curricula of countries. 1/3rd of TIMSS items assess knowledge and 2/3rd assess applying and reasoning skills.
- TIMSS dataset consists of achievement data and demographic and contextual information to explain achievement.
- **South Africa and TIMSS:**

➢ Grade 8 in 1995, 1999 & 2003 and Grade 9 in 2003, 2011, 2015 and 2019 cycles. Only 25-year achievement dataset

➢ Grade 5 in 2015 and 2019

TIMSS Methodology

- Statistics Canada selects a representative sample of schools (learners representative of the population), with province as the explicit stratification variable.
- TIMSS uses a matrix design to construct 14 achievement booklets. High coverage of assessment topics
- TIMSS uses Rasch analysis, item response theory and imputations to generate five plausible achievement estimates

- **Details of methodology:** TIMSS-SA, TIMSS & PIRLS Study Centre in Boston College and International Association for the Evaluation of Education Achievement.

Who participated in TIMSS 2019?

Grade 4/5

- 64 countries and entities
- **Realised sample:** 297 schools, 294 Mathematics & science teachers; 11 903 learners and 11 720 parents/guardians.
- Data was collected in Sept 2018.

Grade 8/9

- 46 countries and entities
- **Realised sample:** 519 schools; 543 Mathematics & Science teachers; 20 829 learners.
- Data collected in September 2019.

Three Stories:
Building Achievement, Bridging Achievement Gaps

1. The Achievement Story

2. The Achievement Gaps

3. Evaluation of the Changes

1. TIMSS Achievement Story

- Mathematics and Science Achievement, 2019, described through scale (IRT) score estimates and standard error

- Achievement Trends from 1995/2003 to 2019

- Mathematics and Science **Abilities in 2019 –** interpreting abilities or skills that learners demonstrate at different achievement points, called international benchmark points.

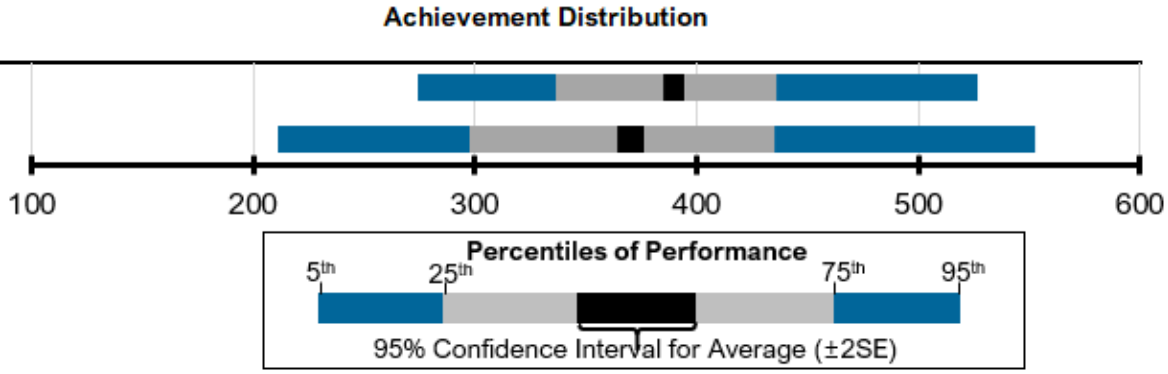
1.1. Average mathematics and science achievement and score distributions, 2019

Grade 5

	Average Scale Score (SE)
Mathematics	374 (3.6)
Science	324 (4.9)

Grade 9

	Average Scale Score (SE)
Mathematics	389 (2.3)
Science	370 (3.1)



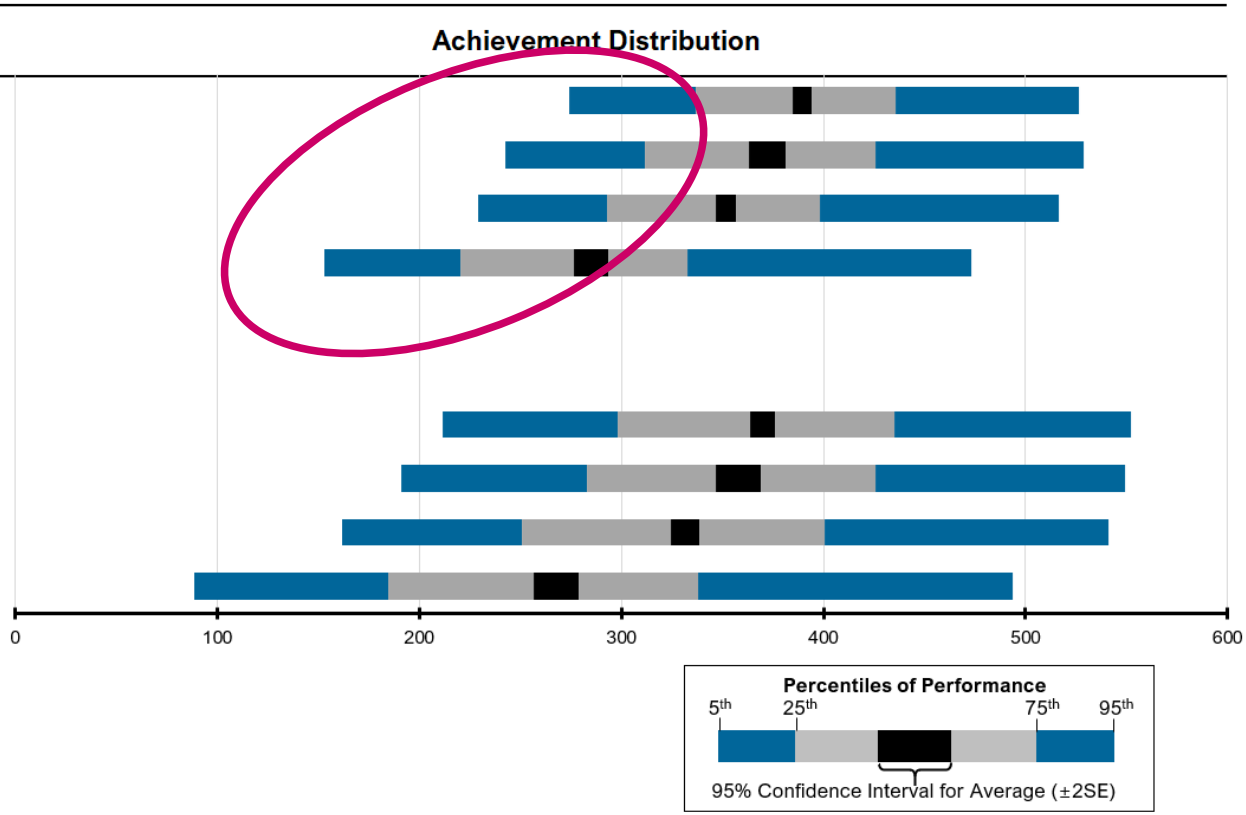
Science has wider distribution and starts at much lower scores than mathematics. Science needs attention.

1.2. Change in Grade 9 mathematics and science achievement, 2003 to 2019

Over 25 years, achievement improved by one standard deviation (100 points)

Mathematics	Average Scale Score (SE)
TIMSS 2019	389 (2.3)
TIMSS 2015	372 (4.5)
TIMSS 2011	352 (2.5)
TIMSS 2003	285 (4.2)

Science	Average Scale Score (SE)
TIMSS 2019	370 (3.1)
TIMSS 2015	358 (5.6)
TIMSS 2011	332 (3.6)
TIMSS 2003	268 (5.5)



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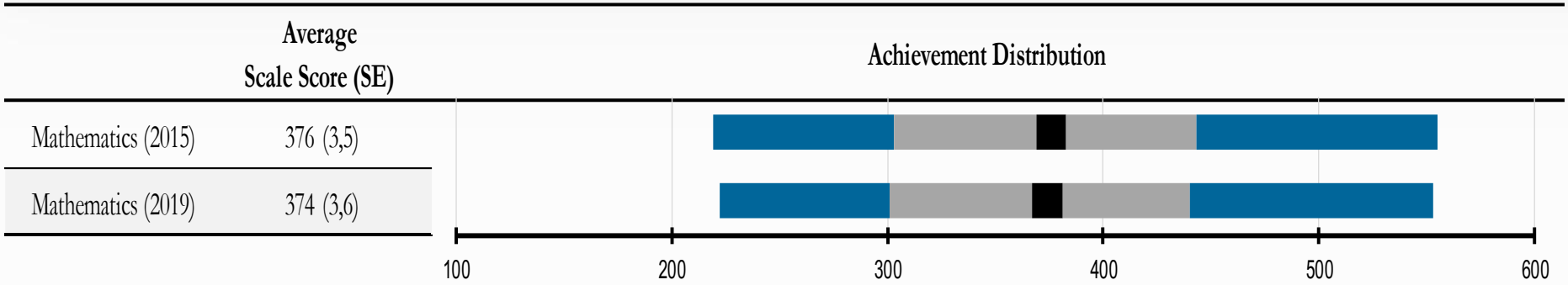
Change in Grade 5 South African achievement: 2015 - 2019



No mathematics achievement change from 2015 to 2019

- Need to look for reasons of no changes outside TIMSS data.
- Different patterns in primary and secondary schools?

1.3. Grade 9 performance by ability level, 2019

Mathematics				Science
Apply and reason in a variety of problems situations and make generalisations.	1%	Advanced benchmark (625)	1%	Communicate understanding of concepts related to biology, physical, and earth sciences in a variety of contexts.
Apply knowledge and understanding in complex situations.	3%	High benchmark (550)	5%	Apply knowledge and understanding of concepts from biology, physical, and earth sciences.
Show and apply basic mathematical knowledge in a variety of situations.	13%	Intermediate benchmark (475)	15%	Have and apply basic knowledge of biology, physical, and earth sciences.
Show some knowledge of whole numbers and basic graphs.	41%	Low benchmark (400)	36%	Have some knowledge of biology, physical, and earth sciences.

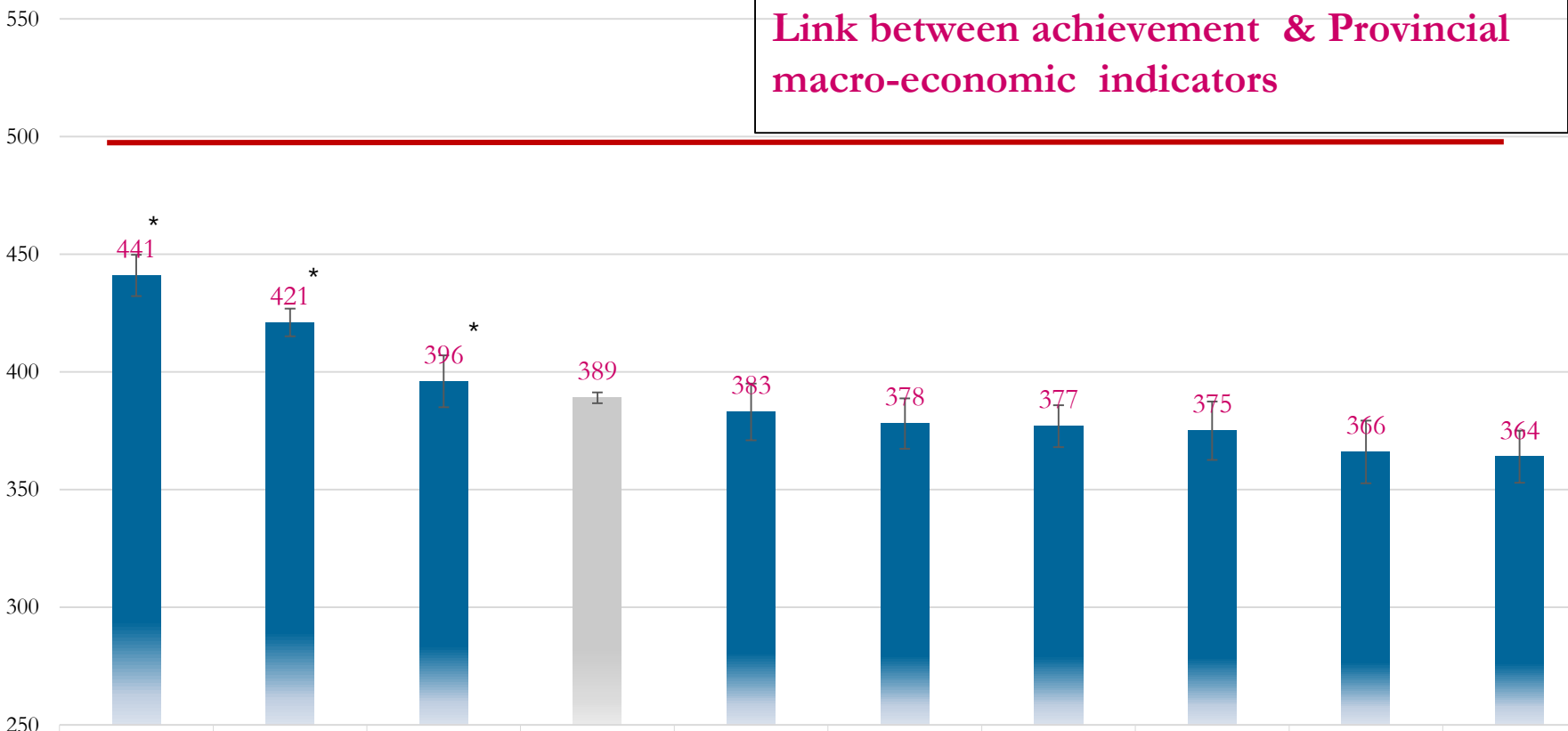
2. Achievement Gaps

Achievement gaps refers to any **significant and persistent** disparity in educational attainment between different groups of students.

- Province
- Poverty index and fee status of schools
- Gender
- Science vs Mathematics Achievement
- Language of home and instruction
- Writing Skills

Provincial Achievement and Gaps, Grade 9, 2019

Link between achievement & Provincial macro-economic indicators



	WC	GT	FS	National	NW	KZN	NC	MP	EC	LP
Mathematics	441	421	396	389	383	378	377	375	366	364
GDP per capita (R000's)	98	111	80	82	77	66	80	78	55	59
Poverty Rate (%)	37.1	33.3	54.9	55.5	64.3	68.1	59.0	59.3	72.9	72.4

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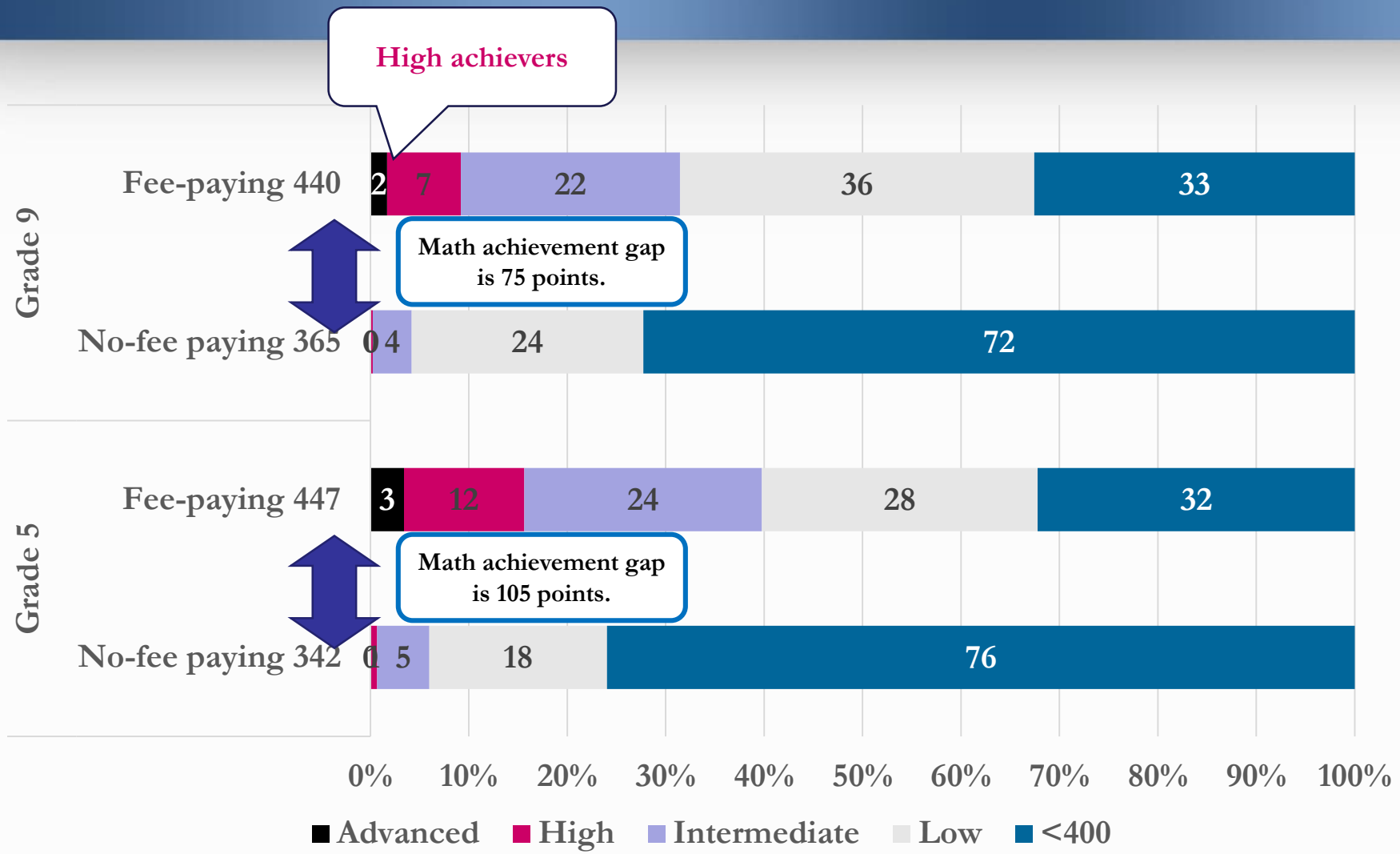
Mathematics Achievement by School fee-status & Gap



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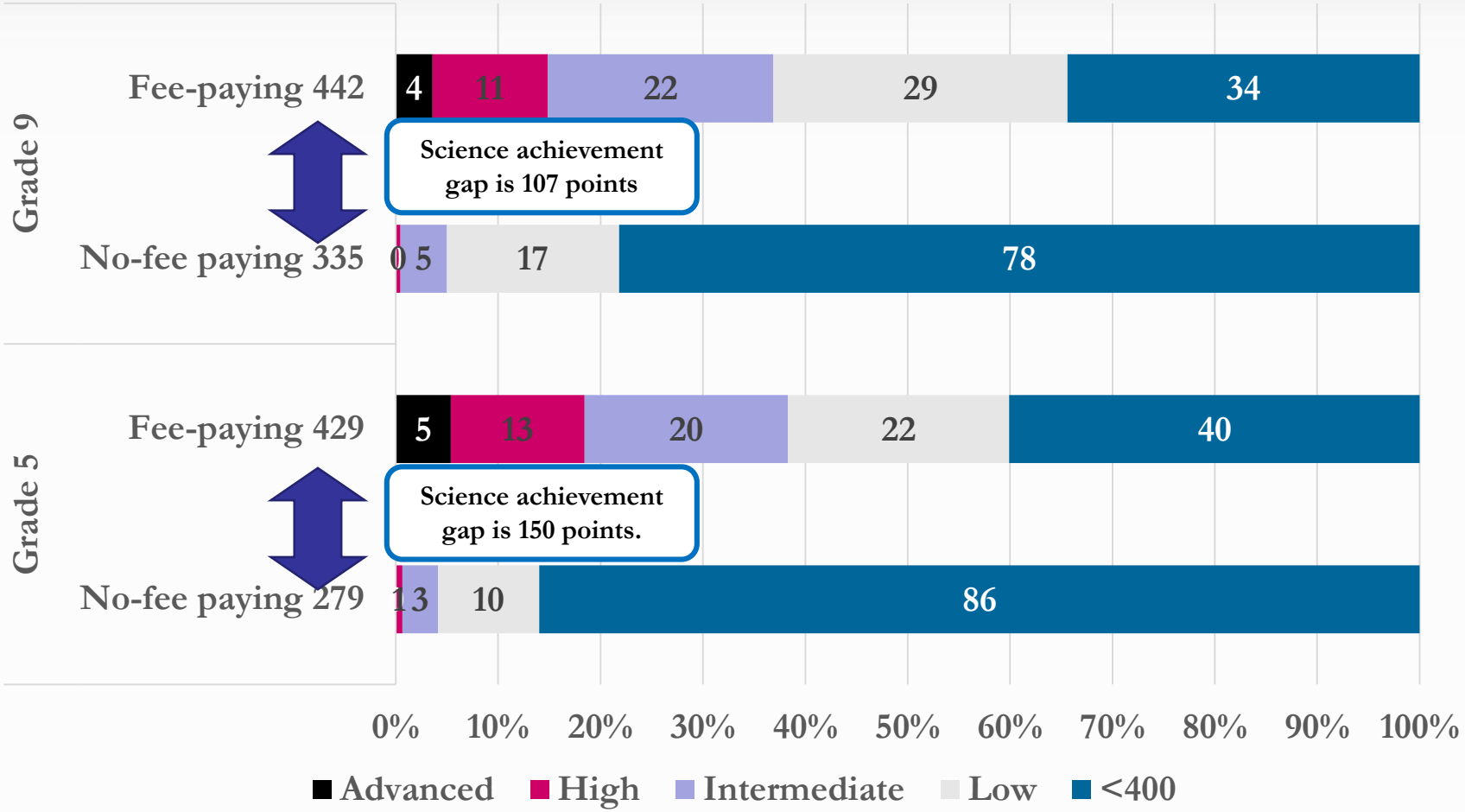
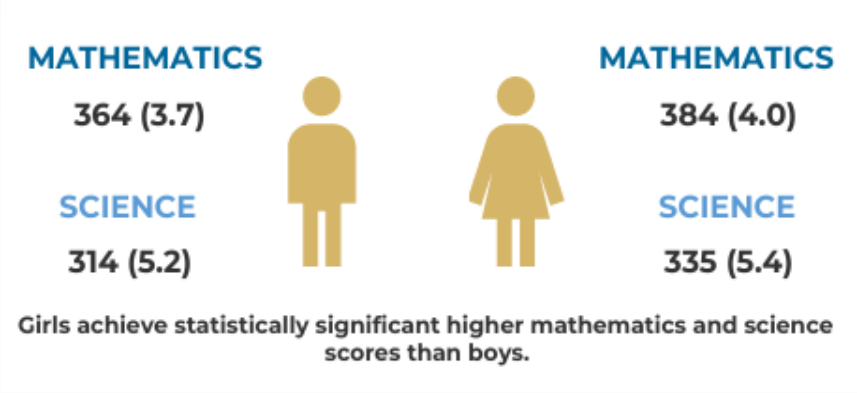
Science Achievement Gap, School Fee Status



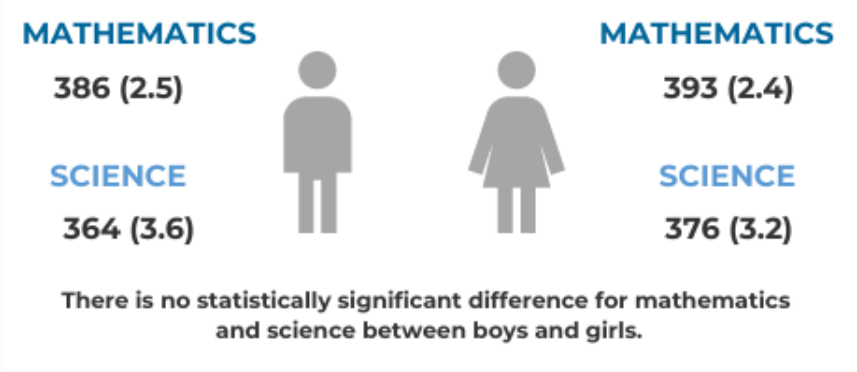
Achievement by Gender and Gaps 2019

Grade 5



Girls achieve statistically significant higher mathematics and science scores than boys.

Grade 9

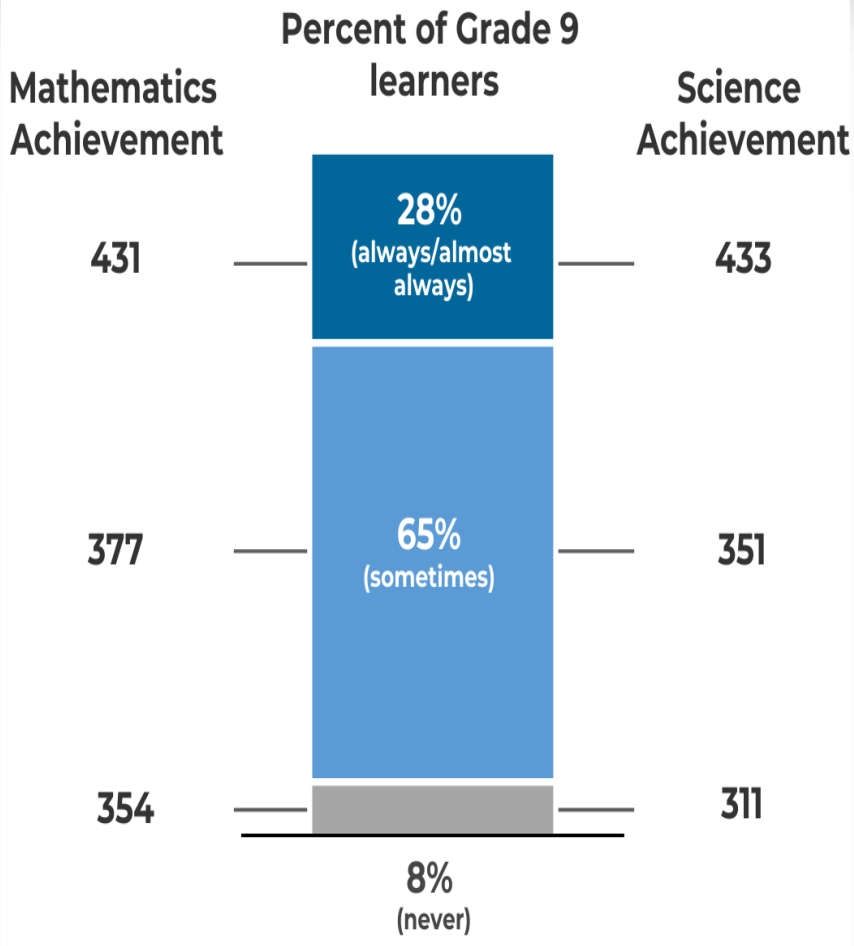


There is no statistically significant difference for mathematics and science between boys and girls.

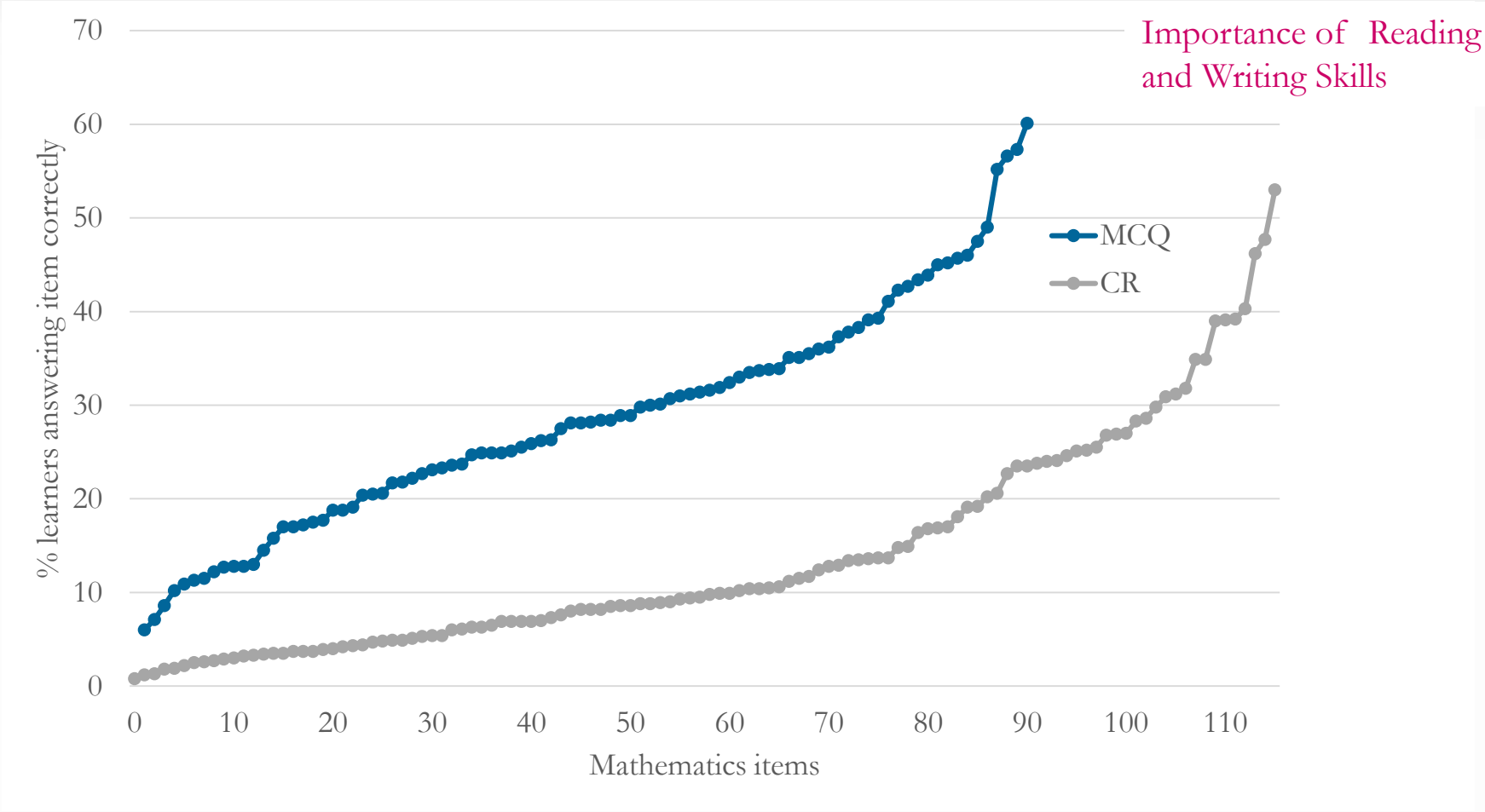
Science Achievement Gap

- Science achievement is lower than mathematics and the variance is higher
- Learners at lower end of achievement distribution score lower in science than in mathematics.
- Science gaps are higher than mathematics gaps
- More challenges (language of instruction, resources for science teaching, educator knowledge) in the teaching and learning of science than mathematics
- National and provincial departments of education must also focus on science subjects

Language of Learning and Teaching (LoLT)



Writing Gaps: Learners answering Selected and Constructed Response correctly



3. Evaluating our improvement?

- Rank order: We are the bottom end of 39 participating countries (world total is 202).
- Rate of mathematics achievement change.
- Will we meet our developmental targets?

Mathematics Performance Internationally, 2019

Grade 5

Country	Score (SE)
Singapore	625 (3,9)
Hong Kong SAR	602 (3,3)
Korea, Rep. of	600 (2,2)
Chinese Taipei	599 (1,9)
Japan	593 (1,8)
Serbia	508 (3,2)
Spain	502 (2,1)
TIMSS Scale Centrepoint	**500**
Armenia	498 (2,5)
Albania	494 (3,4)
New Zealand	487 (2,6)
Morocco	383 (4,3)
Kuwait	383 (4,7)
South Africa	374 (3,6)
Pakistan	328 (12)
Philippines	297 (6,4)

Grade 9

Country	Score (SE)
Singapore	616 (4)
Chinese Taipei	612 (2,7)
Korea, Rep. of	607 (2,8)
Japan	594 (2,7)
Hong Kong SAR	578 (4,1)
Cyprus	501 (1,6)
Portugal	500 (3,2)
TIMSS Scale Centerpoint	**500**
Italy	497 (2,7)
Turkey	496 (4,3)
Kazakhstan	488 (3,3)
Oman	411 (2,8)
Kuwait	403 (5)
Saudi Arabia	394 (2,5)
South Africa (9)	389 (2,3)
Morocco	388 (2,3)

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Rate of Achievement Change

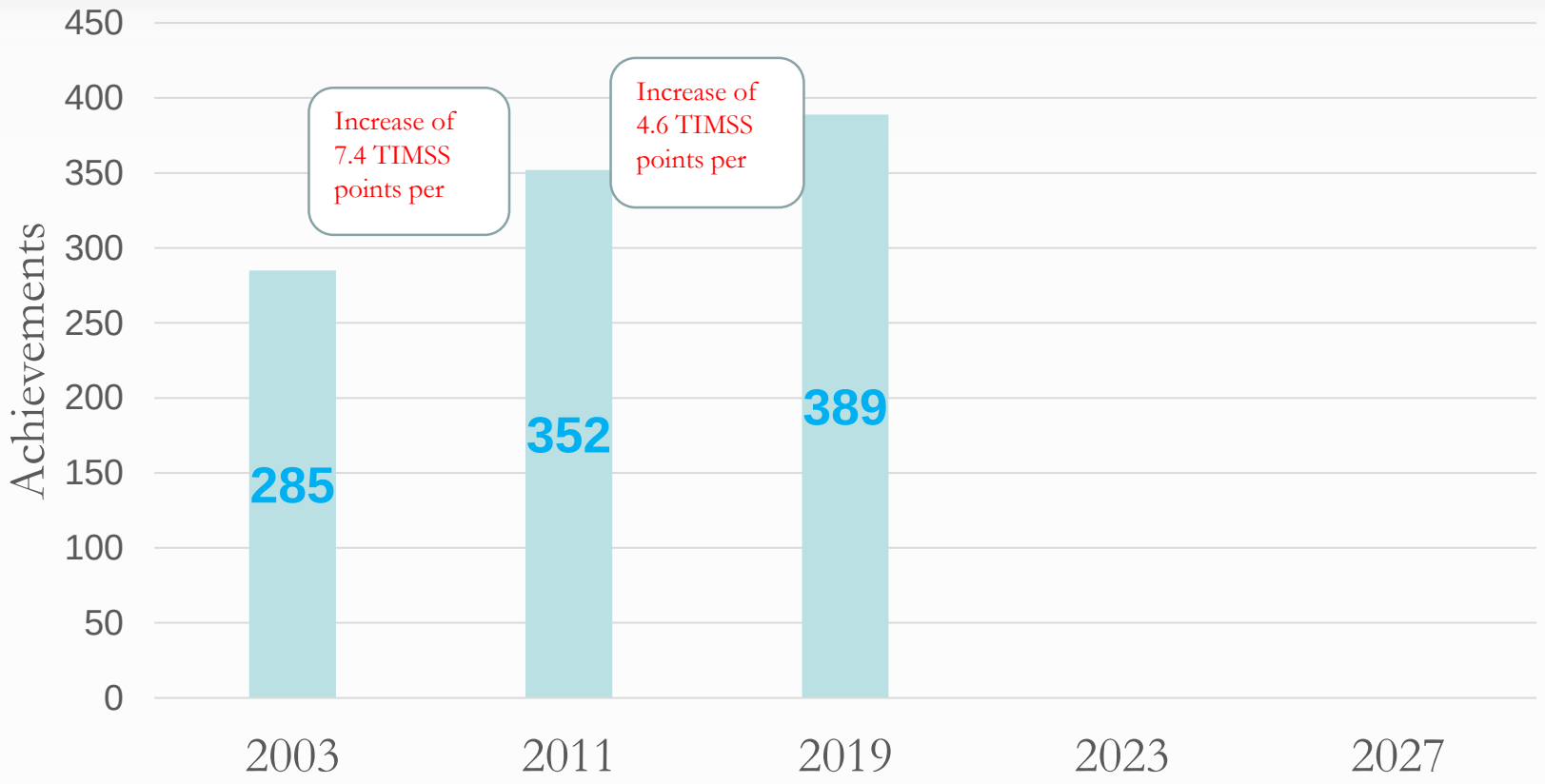
- **Grade 9:** Annual (Mathematics) achievement improvement rate from **2003 to 2011 was 7.4** points and

  from **2011 to 2019 was 4.6 points**.

  Rate of achievement change is slowing down.

Meeting the Developmental Target?

MSTF target is mathematics score of 420 in TIMSS 2023



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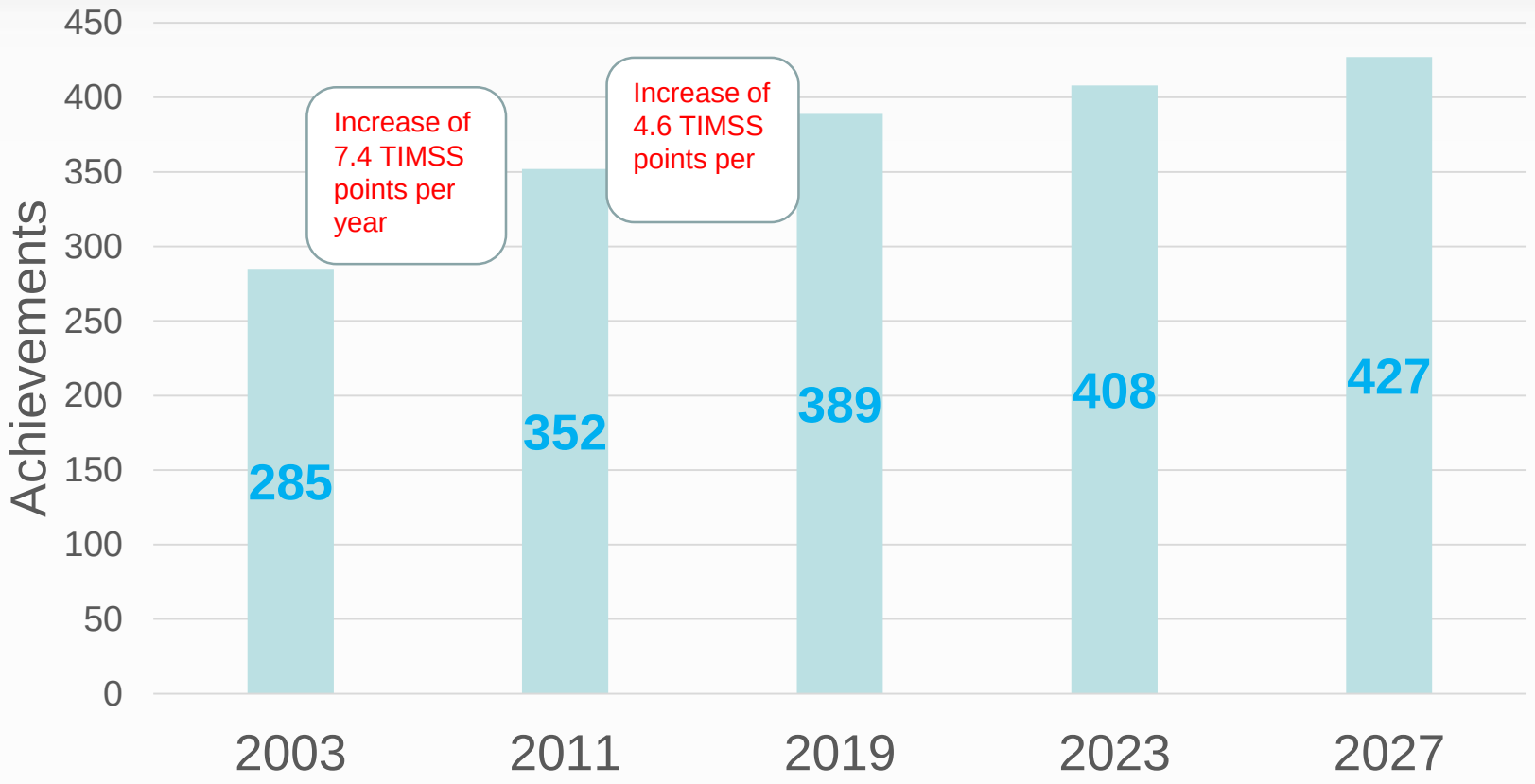

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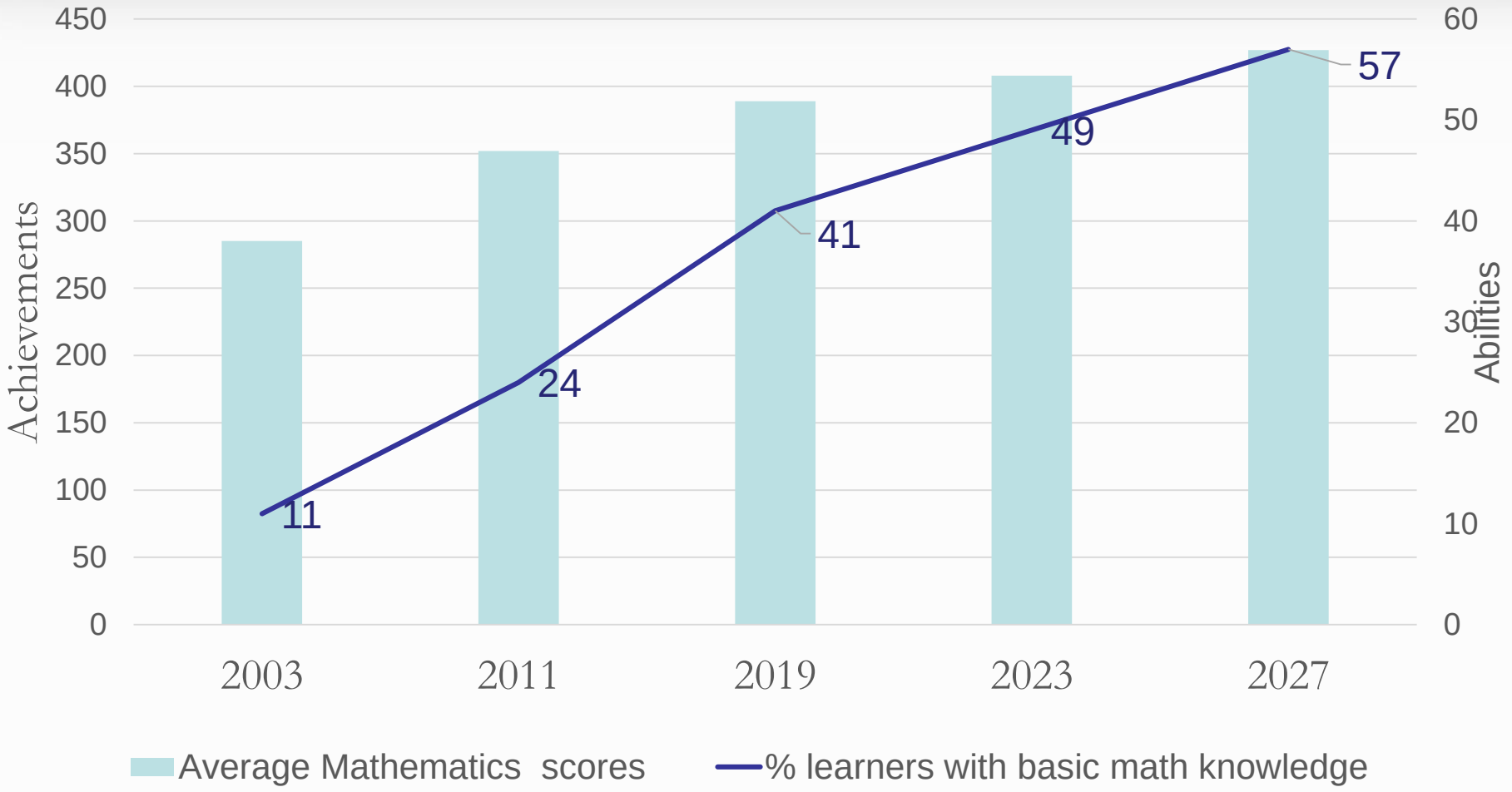
Change in mathematics achievement and basic abilities



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Concluding comments

- TIMSS 2023: e-TIMSS and group adaptive design
- What are the curriculum leverage points to improve achievements?
- What theoretical frameworks do we use to analyse achievement datasets?
- What complementary qualitative studies do we need?
- How do we build research competences to conduct large scale assessments and analyses large scale achievement datasets?