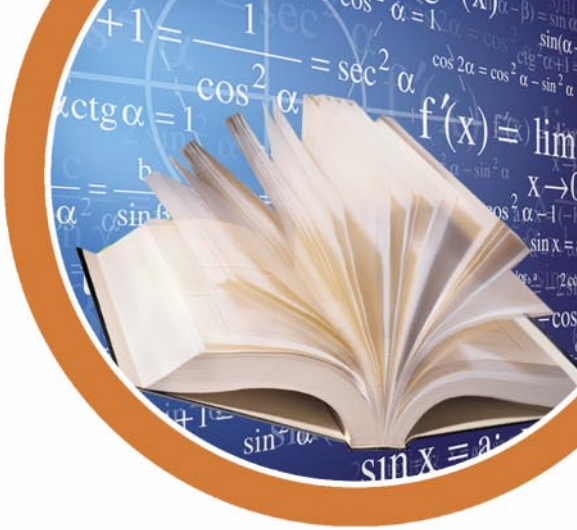

TIMSS 2019

Highlights of Western Cape Province Grade 9 Results in Mathematics and Science

Building Achievement and Bridging Achievement Gaps

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SECTION A: THE TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

Since 1995, the Human Sciences Research Council (HSRC) has conducted the Trends in International Mathematics and Science Study in South Africa. The country participated, at Grade 8, in the 1995, 1999 and 2003 cycles and, at Grade 9, in the 2003, 2011, 2015 and 2019 cycles. Since 2015, South Africa also participated in TIMSS at Grade 5.

Usually, the national data (a sample of around 300 schools) is disaggregated to provide provincial estimates (provincial sample of around 30 schools). The smaller provincial samples lead to achievement estimates with high standard errors. Two provinces, Western Cape and Gauteng, sought a more precise provincial achievement estimate. The TIMSS 2019 sample size in these two provinces was increased to 150 schools, and Western Cape and Gauteng provinces in addition to being part of the national sample, participated as self-standing entities called "benchmarking participants."

This report presents the Highlights of TIMSS 2019 results for Western Cape. It should be read together with the national highlights report titled *TIMSS 2019: Highlights of South African Grade 9 Results in Mathematics and Science.*

About TIMSS

TIMSS is an assessment of the mathematics and science knowledge and ability of fourth and eighth grade learners around the world. A few countries, including South Africa, assess fifth and ninth grade learners. The International Association for the Evaluation of Educational Achievement (IEA) designed the TIMSS assessment to allow participating nations to compare their learners' educational achievement across borders (website https://www.iea.nl/studies).

TIMSS was first administered in 1995 and subsequently every four years, with the latest assessment being TIMSS 2019. One of the key benefits of TIMSS is that it provides a series of trend measures, allowing participants to measure and monitor the health of their education systems over time.

TIMSS is designed to align broadly with the mathematics and science curricula of the participating countries. The achievement results provide a measure of the mathematics and science concepts and skills learnt in school. TIMSS also collects information from participating learners, their families, educators, and schools to allow cross-national comparison of educational contexts that may be related to learner achievement.

TIMSS uses the curriculum as the organising principle of how educational opportunities are provided to learners. The curriculum model consists of three aspects: (i) the intended curriculum, (ii) the implemented curriculum, and (iii) the attained curriculum (see Mullis & Martin, 2017 for details).

TIMSS 2019 and Western Cape as a Benchmarking Participant

Western Cape and Gauteng are two most economically affluent South African provinces and, among the nine, ranked as number one or two in past TIMSS cycles. Western Cape had a Gross Domestic Product (GDP) per capita of R97 664 in comparison to the South African GDP R81 875 in 2017[1]. At 21% the province has a substantially lower unemployment rate than the national average standing at 30% in 2020 [2]and the second lowest provincial poverty rate of 37%[3]. Western Cape's Human Development Index is the highest in South Africa at 0.74, compared to the South African average of 0.70 in 2018. Although indicators of socioeconomic status are higher than the national averages, the

[1] Statistics South Africa (2017). *Four factors about our provincial economies.* Statistics South Africa: Pretoria.

[2] Statistics South Africa. (2020). *Quarterly Labour Force Survey, Quarter 1: 2020.* Statistics South Africa: Pretoria.

[3] Statistics South Africa. (2015). *Poverty Trends in South Africa: An Examination of Absolute Poverty Between 2006 and 2015.* Statistics South Africa: Pretoria

economy of Western Cape in South Africa is dominated by the city of Cape Town, as one travels out of the City, indicators such as unemployment and poverty increase. It is a province of contrasts as 16% of the population live in informal dwellings- the highest proportion in the country. The majority of the population speak one of three languages at home: Afrikaans (47%), IsiXhosa (31%) and English (20%). This provincial context provides insight in the context in which learners live and learn.

The Western Cape TIMSS 2019 school sample was selected from the 2018 Department of Basic Education (DBE) List of Schools that offered Grade 9 classes. Statistics Canada selected the South African sample and Western Cape provincial sample of 150 schools based on school type (public, independent) as explicit stratification variables and school poverty ranking as the implicit stratification variable. The realised Western Cape sample was 149 schools, 149 principals, 162 science educators, 170 mathematics educators and 5 350 learners.

The key research questions framing the analysis of the TIMSS 2019 Western Cape data are:

- What are the mathematics and science achievements and achievement gaps in TIMSS 2019?
- What are the mathematics and science achievement trends from 2011 to 2019?
- What influences mathematics and science achievement in Western Cape?

Structure of the Highlights of Grade 9 Western Cape Results Report

This TIMSS 2019 Western Cape Highlights of Results Report used information from the TIMSS 2019 International Results in Mathematics and Science Report (Mullis, et al 2020) as well as analyses conducted by the Human Sciences Research Council.

Section A provides the brief outline of TIMSS to orient the reader.

Section B reports the TIMSS 2019 mathematics and science achievements for Western Cape. We report on achievement patterns at three levels: (i) International, (ii) Western Cape only and in relation to other provinces, and (iii) Local (fee-status of schools and gender). We then describe the achievement trends from TIMSS 2011 to TIMSS 2019.

Section C signals possible predictors of mathematics and science achievement. From our bivariate analysis, we identified the home, school and classroom factors (using scales constructed by the IEA designed for the group of international participants, but which could provide South Africa with aspirational targets) that showed an association with mathematics and science achievement.

Section D presents the key findings and recommendations emerging from this analysis.

This Western Cape Highlights of TIMSS Results Report will be followed by a comprehensive TIMSS 2019 Western Cape Report (to be published by June 2021).

SECTION B: ACHIEVEMENTS AND ACHIEVEMENT GAPS

1. INTERNATIONAL MATHEMATICS AND SCIENCE ACHIEVEMENT

Table 1: Mathematics Achievement

Country	Mathematics Mean (SE)
Singapore	616 (4.0)
Chinese Taipei	612 (2.7)
Korea, Rep. of	607 (2.8)
Japan	594 (2.7)
Hong Kong SAR	578 (4.1)
Russian Federation	543 (4.5)
Ireland	524 (2.6)
Lithuania	520 (2.9)
Israel	519 (4.3)
Australia	517 (3.8)
Hungary	517 (2.9)
United States	515 (4.8)
England	515 (5.3)
Finland	509 (2.6)
Norway (9)	503 (2.4)
Sweden	503 (2.5)
Cyprus	501 (1.6)
Portugal	500 (3.2)
TIMSS Scale Centrepoint	**500**
Italy	497 (2.7)
Turkey	496 (4.3)
Kazakhstan	488 (3.3)
France	483 (2.5)
New Zealand	482 (3.4)
Bahrain	481 (1.7)
Romania	479 (4.3)
United Arab Emirates	473 (1.9)
Georgia	461 (4.3)
Malaysia	461 (3.2)
Iran, Islamic Rep. of	446 (3.7)
Qatar	443 (4.0)
Chile	441 (2.8)
Western Cape (9)	441 (4.4)
Lebanon	429 (2.9)
Gauteng (9)	421 (3.0)
Jordan	420 (4.3)
Egypt	413 (5.2)
Oman	411 (2.8)
Kuwait	403 (5.0)
Saudi Arabia	394 (2.5)
South Africa (9)	389 (2.3)
Morocco	388 (2.3)

Thirty-nine countries and seven regional entities (called bench marking participants) participated in the eighth-grade assessments (Norway, South Africa, Western Cape and Gauteng Provinces participated at the ninth grade). Tables 1 and 2 describe the TIMSS mathematics and science scale scores and standard errors for participating countries. The TIMSS achievement scale has been set with a Centrepoint of 500 and a standard deviation of 100. Achievement scores are presented with the standard error of the mean (SE) in brackets which describes how precise the mean estimate is and the level of variation within the achievement distribution.

For mathematics the top five ranked countries were from East Asia, Singapore, Chinese Taipei, the Republic of Korea, Japan and Hong Kong SAR. The five lowest performing countries were Oman, Kuwait, Saudi Arabia, South Africa and Morocco.

Western Cape scored an average of 441 TIMSS points in mathematics. This score was not significantly different from Chile, Qatar, Abu Dhabi and Iran, but different from all other countries.

Singapore had the highest science achievement, followed by Chinese Taipei, Japan, Korea and Russian Federation. The five lowest performing countries are Saudi Arabia, Morocco, Egypt, Lebanon and South Africa.

Table 2: Science Achievement

Country	Science Mean (SE)
Singapore	608 (3.9)
Chinese Taipei	574 (1.9)
Japan	570 (2.1)
Korea, Rep. of	561 (2.1)
Russian Federation	543 (4.2)
Finland	543 (4.2)
Lithuania	534 (3.0)
Hungary	530 (2.6)
Australia	528 (3.2)
Ireland	523 (2.9)
United States	522 (4.7)
Sweden	521 (3.2)
Portugal	519 (2.9)
England	517 (4.8)
Turkey	515 (3.7)
Israel	513 (4.2)
Hong Kong SAR	504 (5.2)
Italy	500 (2.6)
TIMSS Scale Centrepoint	**500**
New Zealand	499 (3.5)
Norway (9)	495 (3.5)
France	489 (2.7)
Bahrain	486 (1.9)
Cyprus	484 (1.9)
Kazakhstan	478 (3.1)
Qatar	475 (4.4)
United Arab Emirates	473 (2.2)
Romania	470 (4.2)
Chile	462 (2.9)
Malaysia	460 (3.5)
Oman	457 (2.9)
Jordan	452 (4.7)
Iran, Islamic Rep.	449 (3.6)
Georgia	447 (3.9)
Kuwait	444 (5.7)
Western Cape (9)	439 (5.1)
Saudi Arabia	431 (2.6)
Gauteng (9)	422 (3.9)
Morocco	394 (2.7)
Egypt	389 (5.4)
Lebanon	377 (4.6)
South Africa (9)	370 (3.1)

The science average for Western Cape of 439 points is not significantly different from Saudi Arabia, Kuwait, Georgia, Iran and Jordan but different from all other countries.

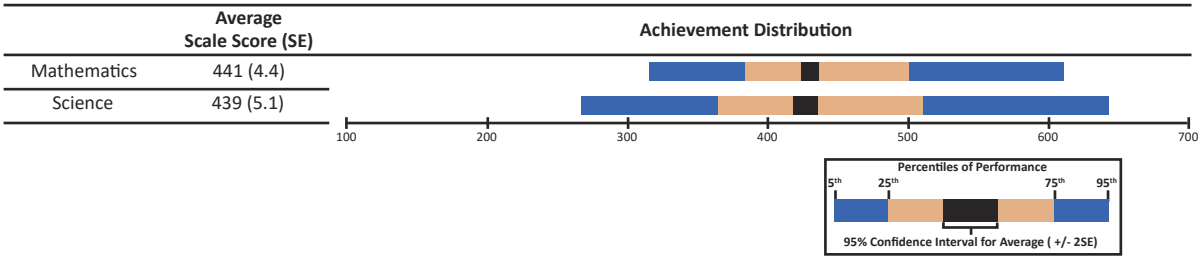
2. Western Cape Mathematics and Science Performance

The TIMSS 2019 mathematics assessment comprised 211 assessment items in total, but each learner responded to part of the assessment. In order to provide comparable scores for each learner, TIMSS uses item response theory (IRT) scaling methods to create a set of plausible achievement estimates for each learner. This is used to calculate the scale score achievement estimates. TIMSS also describes mathematics and science performance in a second way: TIMSS translates the achievement scale scores to describe the abilities learners demonstrate at particular points on the achievement scale, called International Benchmarks.

2.1 Western Cape Mathematics and Science Scale Score Achievement, 2019

The 39 participating countries (and seven benchmarking entities) include highly industrialised, middle- and low-income countries from all continents. The three countries from the African continent are South Africa, Egypt, and Morocco. Figure 1 presents the average achievement, at Grade 9, for the Western Cape province together with the scale score distribution. The length of each of the bars on the graph is indicative of variation in achievement. The shorter the distribution the less the variation in achievement and hence the more homogeneous and vice versa.

Figure 1: Average mathematics and science achievement and scale score distributions, 2019

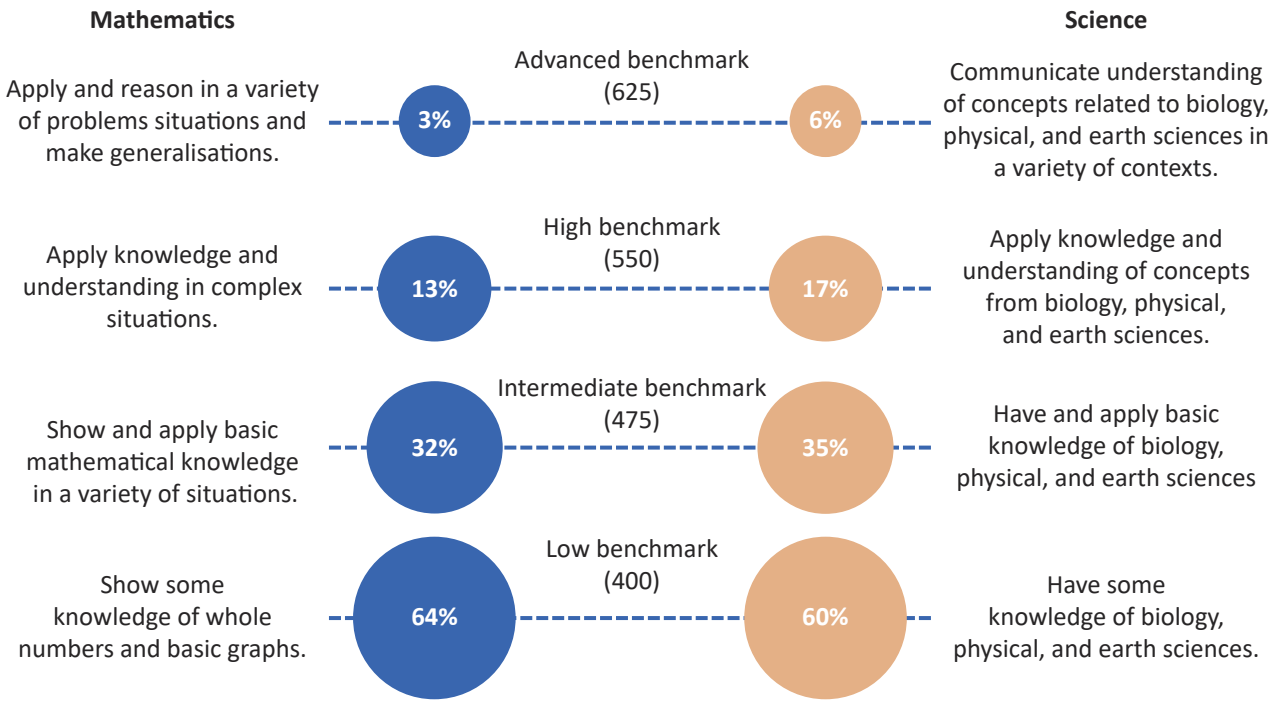


The Western Cape average scale score for **mathematics is 441 (4.4)** and for **science is 439 (5.1)**. This score is higher than the South African national average of 389 (2.3) for mathematics and 370 (3.1) for science. The length of the bars points to a wider achievement distribution for science than mathematics, a reflection of higher variation in science learner ability. The achievement distribution (difference between achievements at 95th and 5th percentile) for science at 366 points is wider than for mathematics at 295 points. The science achievements at the bottom end of the distribution are lower than the corresponding mathematics scores and at the top end are higher than the corresponding mathematics scores, indicating higher inequalities for science than for mathematics.

2.2 Mathematics and Science Abilities at International Benchmarks

In order to interpret the TIMSS achievement scales, TIMSS describes four points on the scale called International Benchmarks, in terms of mathematical and science abilities (skills or knowledge). The four points (and the achievement score range) are the Advanced International Benchmark (greater than 625), High International Benchmark (550 to 625), Intermediate International Benchmark (475 to 550) and Low International Benchmark (400 to 475). The Western Cape mathematics and science ability profile is presented in Figure 2.

Figure 2: Percentage of learners reaching international benchmarks for mathematics and science, 2019

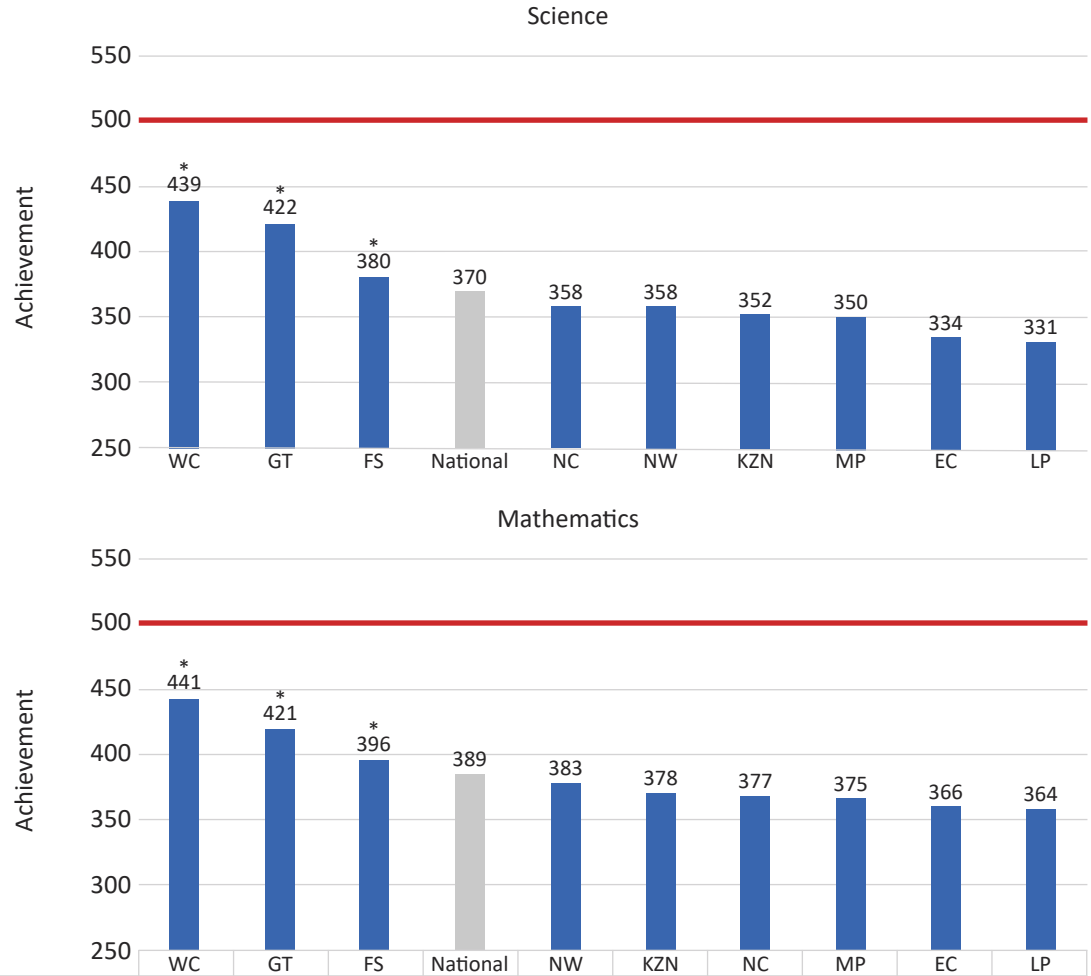


On the TIMSS scale learners who achieve above 400 TIMSS points are described as having acquired basic mathematical or science knowledge for that grade. Two thirds (64%) of learners demonstrated they acquired basic mathematical knowledge and 60 % acquired basic science knowledge. There are some highly talented learners in the Western Cape. Six percent of science learners (compared to the international average of 7%) and 3% of mathematics learners (compared to the international average of 5%) scored above the Advanced Benchmark of 625 TIMSS points. Higher achievement scores denote that learners possess abilities to apply knowledge in complex situations or to make generalisations based on prior knowledge.

2.3 Western Cape TIMSS Performance Relative to Other Provinces

Socioeconomic conditions differ from province to province. The provincial macro-indicators of economic affluence expressed through the Gross Domestic Product (GDP) and poverty rate, coupled with the size of provincial education departments measured using the number of learners in no-fee schools, paint the picture of an opportunity gradient amongst provinces. These macro-level statistics are presented in the table below the provincial achievement graphs in Figure 3. Clearly, there is a relationship between the macro socioeconomic indicators and the provincial mathematics and science achievements: Provinces with higher levels of economic affluence achieve higher mathematics and science achievements.

Figure 3: Provincial mathematics and science achievement, with confidence intervals, and provincial macro-level statistics, 2019



	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
School population (mil)	1.1	2.2	0.7	12.4	0.8	2.8	0.3	1.1	1.8	1.7

*Denotes significant difference from other provincial and national average scores

The top three performing provinces for both mathematics are Western Cape with an achievement score 441(4.4), Gauteng with 421(3) and Free State with 396(5.5) and similarly for science are Western Cape with 439 (5.1), Gauteng with 421(5.7) and Free State with 396 (7.4). The achievement scores of the three top provinces are significantly different from each other, as well as the other six provinces. None of the provinces are close to the Centrepoint score of 500 points (red line on the diagram).

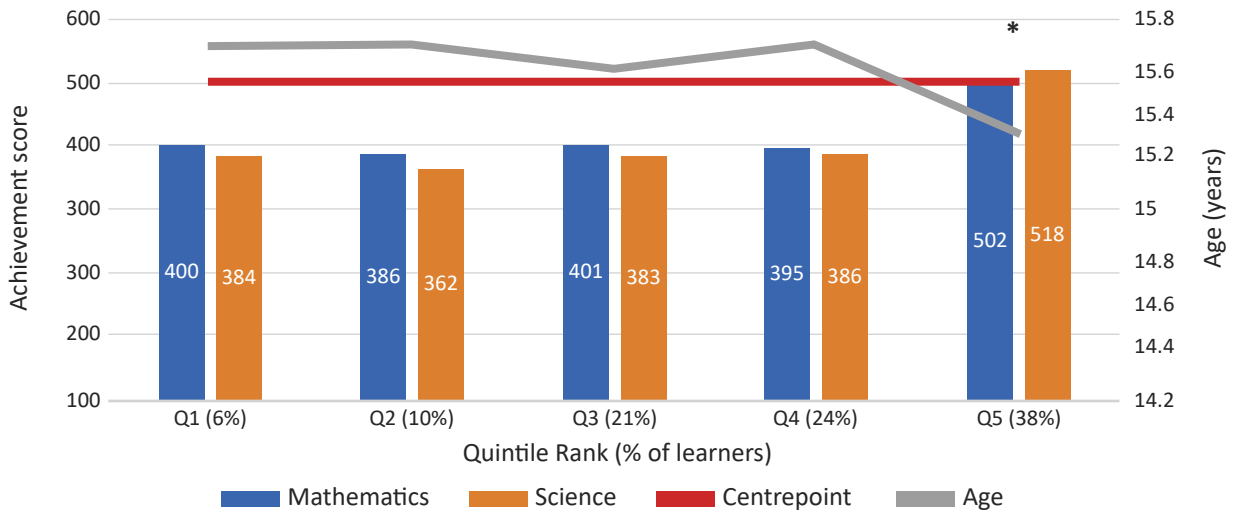
3. Mathematics and Science Achievement of Local Relevance

3.1 Mathematics and Science Achievement by School Poverty Index

Learners in Western Cape, like other provinces in South Africa, come from homes with varying household incomes and schools vary considerably with regard to infrastructure and resources. In order to support homes and schools, the Department of Basic Education (DBE) calculated a poverty index for each public school according to the poverty level of the community around the school, as well as, school infrastructural factors. Public schools are categorised into five (unequal) groups, called quintiles, with Quintile 1 being the most under-resourced schools and Quintile 5 the most resourced. Figure 4 sets out the average mathematics and science achievements, and age, for schools in each quin-tile category as determined by the DBE Master list of schools[4].

[4] Independent schools are not reported on here due to the small sample size in the Western Cape.

Figure 4: Average mathematics and science achievement, and average age, by school poverty ranking, 2019 (% learners)



*Denotes significant difference

In Western Cape public schools, the majority (60%) of learners were in Quintile 4 and 5 schools. There was no statistical difference between the average mathematics and science scores of the learners in the Quintile 1 to 4 schools. Learners in Quintile 5 schools achieved a mathematics score of 502 (9.8) and a science score of 518 (10.9). The difference between the average mathematics and science scores for learners in the Quintile 5 schools was statistically significant from learners in Quintile 1, 2, 3 and 4.

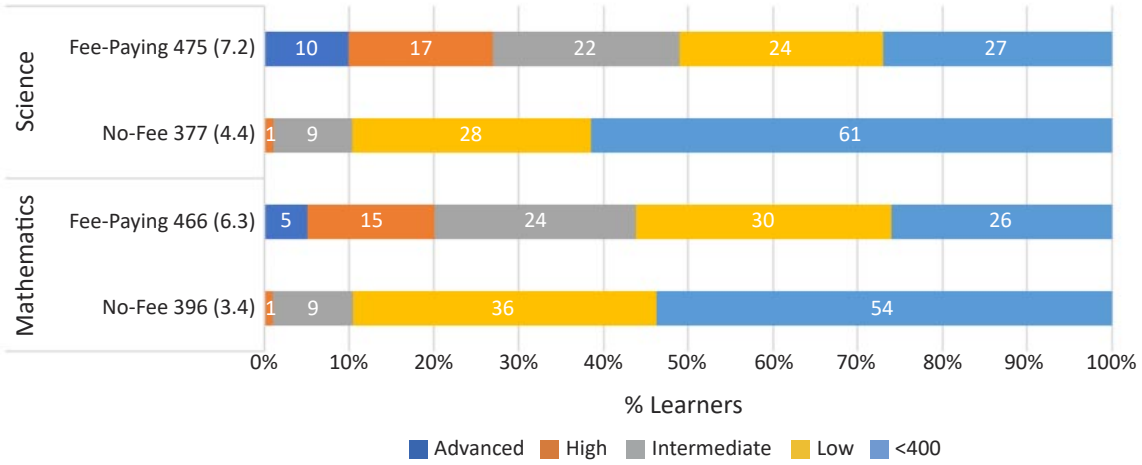
The average age of Grade 9 learners in Western Cape is 15.5 years. Learners in Quintile 1,2 and 4 schools are 15.7 years and in Quintile 3 schools are 15.6 years. Learners in Quintile 5 schools were slightly younger (15.3 years) and those in the other quintiles.

3.2 Mathematics and Science Achievement and Ability by School Fee Status

As part of the government's pro-poor strategy to support education, Quintiles 1, 2 and 3 schools in receive government subsidies so that learners are exempt from paying fees. Quintiles 4 and 5 school receive a lower subsidy and may charge school fees. Due to the changing composition of the learners in Quintile 4 and 5 schools, the WCED does offer additional financial support to some of these schools. Public schools are thus differentiated into no-fee schools and fee paying schools.

In Western Cape 40% of learners are in public schools attend no-fee schools. We report achievement by school fee status of learners: no-fee (Quintile 1 to 3) schools and fee-paying schools (Quintile 4 and 5 and independent school). From the DBE EMIS data we established that the learner population group profile is quintile 4 and 5 are 17% African, 68% Coloured and 14% White. Figure 5 presents the average mathematics and science achievement scores and ability levels for learners by these two categories of schools.

Figure 5: Mathematics and science achievement at international benchmarks by fee-status, 2019



As expected, the differences in the material school and home conditions for learners attending fee-paying and no-fee schools leads to unequal achievements. The average mathematics and science scores for learners in fee paying and no fee schools were significantly different. The mathematics and science scores for learners in no-fee schools is 396 points and 377 points respectively. Learners in fee-paying schools score higher mathematics and science scores at 466 and 474 respectively. This means that the mathematics achievement gap was 70 points and the science achievement gap was 96 points.

When the achievement scale scores were translated to ability levels in no-fee schools 46% of mathematics learners and 39% of science learners showed they had acquired basic mathematical and science knowledge. It is noteworthy that 1% of mathematics and science learners achieved scores above 550 points (High Benchmark).

In fee paying schools, three quarters of mathematics (74%) and science (73%) learners demonstrated they had acquired basic mathematical and science knowledge. One in ten science learners and one in twenty mathematics learners achieved scores above the advanced benchmark level.

3.3 Gender and Achievement

Internationally, evidence on the relationship between gender and achievement was mixed across countries and also within countries. In Western Cape, Grade 9 boys outperformed girls by an average 11 points for both mathematics and science (Figure 6). These differences are not statistically significant for either subject. Similarly, for learners in fee paying schools, boys outperform girls, but the difference is not statistically significant. However, in no-fee schools, on average boys and girls scored almost the same in science (378 for girls and 376 for boys) and mathematics (396 for girls and 396 for boys).

Figure 6: Mathematics and science achievement by gender, 2019

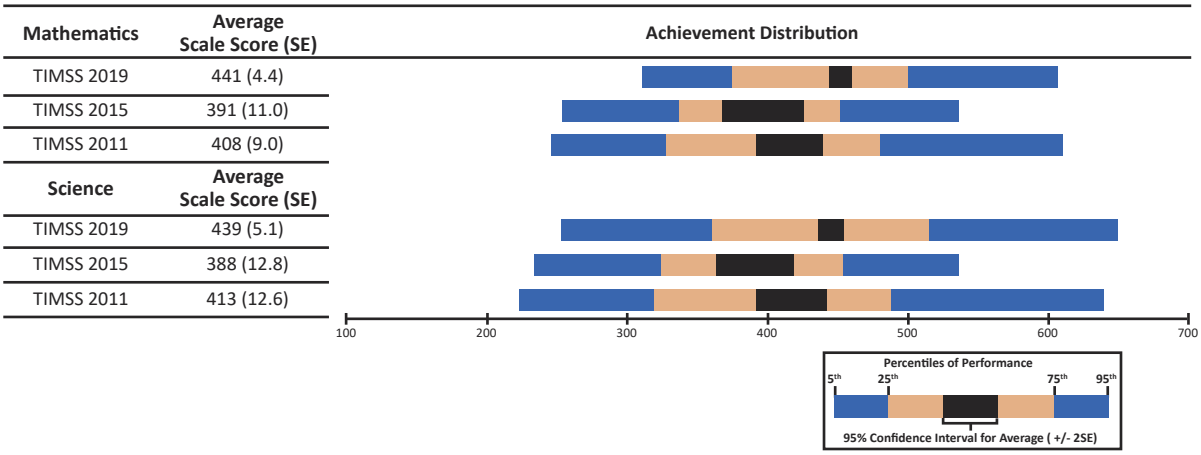
The achievement differences between girls and boys are not statistically significant.

We did, however, observe interesting gender achievement differences by mathematics and science content and cognitive domains. On average, boys had significantly higher achievements in the mathematical content domains of Number and Geometry and the science domains of Physics and Earth Sciences. With regards to cognitive domains, boys achieved significantly higher scores for items requiring applying and reasoning skills in mathematics, and items requiring reasoning skills in science.

4. Change in Mathematics and Science Achievement: 2011 to 2019

Western Cape participated with smaller samples as part of the South African TIMSS sample in the previous rounds of the study. The provincial achievement estimates were less precise with larger confidence intervals. In Figure 7 we compare the shape and size of Western Cape achievements from 2011 to 2019, with the caveat that 2011 and 2015 estimates are less precise.

Figure 7: Average mathematics and science achievement and scale score distributions, 2011 to 2019



The TIMSS 2015 Highlights of South African Results Report (Reddy et al, 2016) reported that between 2003 and 2015 Western Cape mathematics and science achievements had declined by 23 points and 33 points, respectively. Figure 7 suggests that in 2015, the Western Cape sample was not representative of the province and the mathematics and science achievements may have been under-estimated. Therefore, the comparison between 2011 and 2019 is more meaningful.

Between 2011 and 2019, the mathematics achievement increased from 408 to 441 points, an increase of 33 points. In the same time period the science achievement increased from 413 to 439 points, an increase of 26 points. The difference is statistically significant for mathematics at the 95% confidence level and for science at the 90% confidence level.

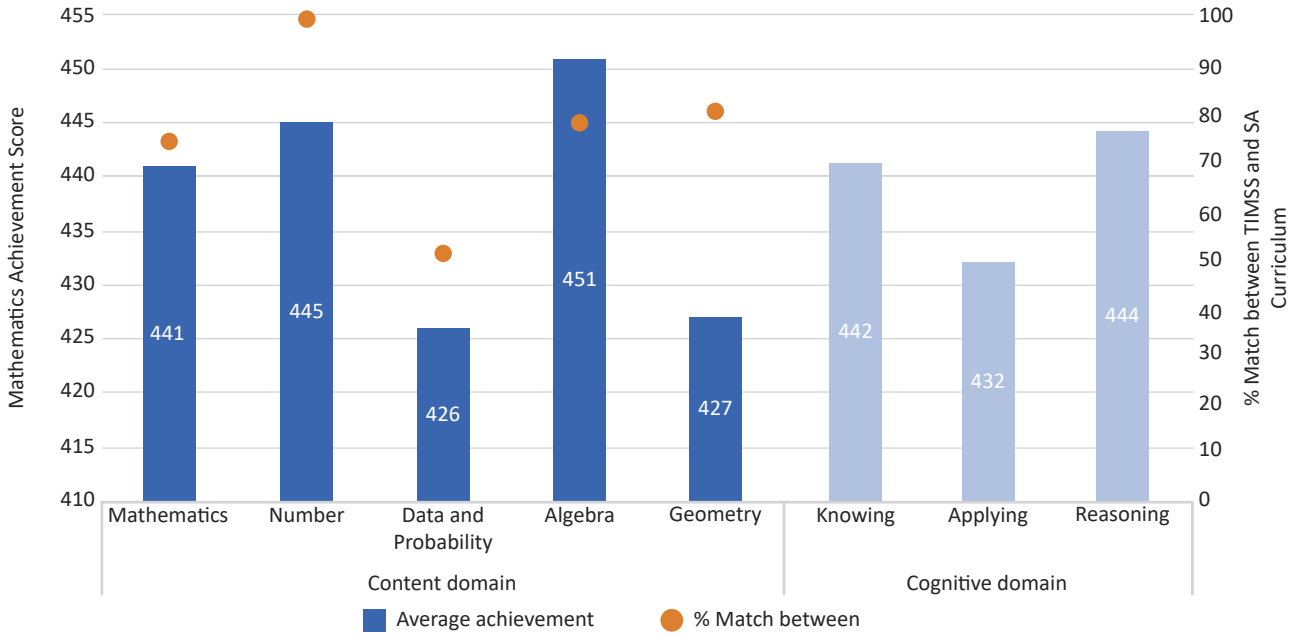
Observing the achievement range between the 5th and 95th percentile (length of the bars in Figure 7) for 2011 to 2019, we see that positive gains were achieved at the lower end of the achievement distribution, which means that those with the lowest achievements are improving.

5. Mathematics and Science Achievement by Content and Cognitive Domains

The mathematics and science assessment is organized around two dimensions: a content domain specifying the subject matter to be assessed and a cognitive domain specifying the thinking processes that learners use as they engage with content. Each item in the mathematics and science assessment is associated with a content and cognitive domain thus providing insights on performances from the content and cognitive perspective (Mullis and Martin, 2017).

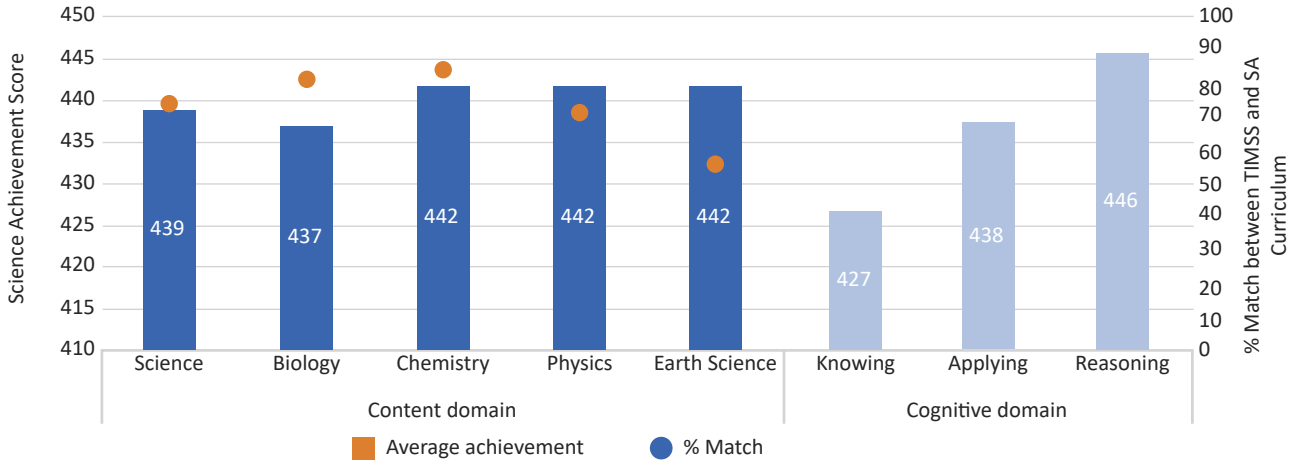
We explored the relationship between achievement outcomes and the content taught to learners. Educators were asked to indicate whether the topic was taught before this grade, mostly taught in this grade or not yet introduced. Figure 8 show the TIMSS mathematics content domains coverage as reported by educators and learner average achievement and Figure 9 the TIMSS science content domains coverage as reported by educators and learner average achievement

Figure 8: Mathematics achievement by content and cognitive domains, achievement and content coverage, 2019



Learners achieved higher scores in number and algebra content areas with lower scores for and geometry and data and probability. The differences between the overall mathematics average score and average scores for Algebra, Data and probability and Geometry were statistically significant. Only half the data and probability topics had been covered in class before learners took the TIMSS assessment.

Figure 9: Science achievement by content and cognitive domain, achievement and content coverage



Learners achieved similar scores in each of the content areas of Biology, Chemistry, Physics and Earth Sciences. This despite educator reports that Earth Science content was not part of the general science curriculum but in the Social Sciences curriculum. Further, only half (56%) the Earth Sciences topics had been covered in class before learners took the TIMSS assessment.

SECTION C: EXPLAINING MATHEMATICS AND SCIENCE ACHIEVEMENT

Achievement is influenced by home, school and classroom environments and the interactions therein. Understanding the relationships between these key characteristics and learner achievement provides important signals about how science and mathematics skills develop and possible strategies to improve overall mathematical and scientific performance. These contexts will be discussed in this section.

6. Home Assets and Educational Resources

In an equal and fair world, educational outcomes would be dependent on ability and effort. In a context of inequality, personal conditions such as where one lives influence achievement outcomes. The extant literature shows a strong positive relationship between achievement and socioeconomic status(SES), including parental education.

Education studies (globally and in South Africa) have confirmed that the link between academic achievement and indicators of SES is strong and consistent in South Africa. To this end the TIMSS study collects information that allows us to better understand these relationships. This section will focus on the home socioeconomic status as described by the assets in the home. The assets include basic assets, educational resources and digital resources. The language spoken at home is considered one of these resources.

Figure 10 reports the availability of the resources at the provincial level, and the extent of disparities in home resources for learners in fee-paying and no-fee schools. At a basic resource level, the majority of learners had access to running water and flush toilets, but there are still one in five learners in no-fee schools that do not have access to water flush toilets and running water in their homes.

Having more books at home is positively related to higher achievement. Thirty-five percent of learners in fee paying schools reported having more than 25 books in their homes, compared to 11 of learners in no-fee schools – a difference that is statistically significant. The highest educational level of parents in the household is a predictor of learner performance. A significantly higher proportion of learners in feepaying (41%) than in no-fee schools (25%) had a parent or caregiver with a qualification above Grade 12.

Digital learning is becoming increasingly important globally. Approximately two-thirds (64%) of learners in Western Cape have the digital hardware and half (54%) have an internet connection at home. These conditions are more favourable for learners in fee-paying schools who report close to double the availability of these resources.

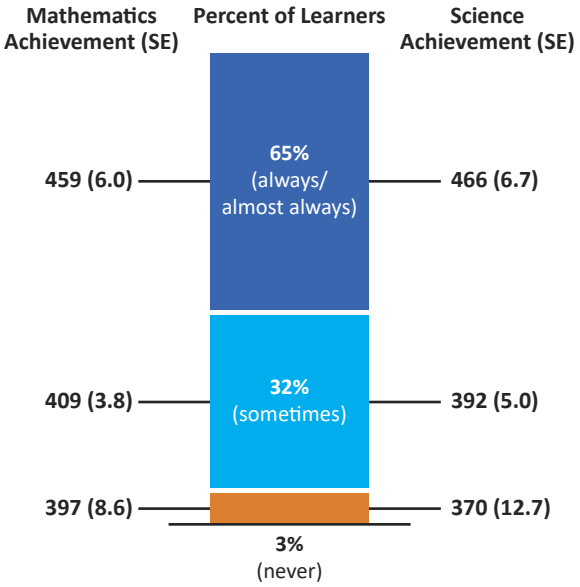
Figure 10: Percent of learners with access to resources

	Basic			Educational			Digital	
	Water flush toilets*	Running water*	Hot running water*	Own room*	Over than 25 books at home*	One parent with a post grade 12 qualifica-tion+*	Computer or tablet*	Internet connection
National	93	88	56	65	26	35	64	54
No-Fee	84	80	27	58	11	25	41	34
Fee-Paying	97	92	72	69	35	41	77	66

+20% of learners did not know

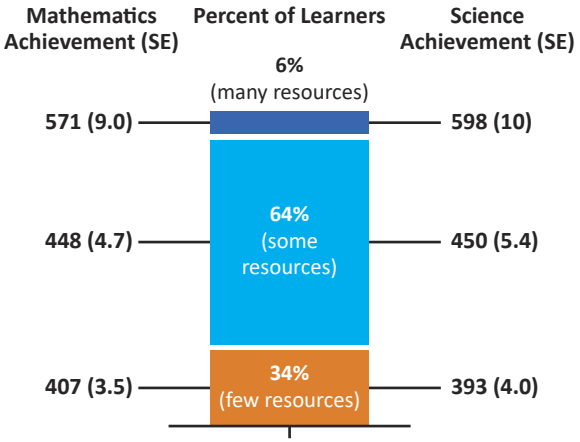
*Denotes a significant difference between learners in fee paying and no-fee schools

Percentage of learners who speak the language of the test at home and Achievement, 2019



If a learner's language of learning and teaching (LOLT) corresponds to the language frequently spoken by the learner, a positive association with achievement is noted, especially in language-intensive subjects like science. The figure on the left reports the frequency with which the learners speak the LOLT at home and the corresponding average achievement. Almost two-thirds of the learners spoke the language of the test at home "always or almost always". The pattern, when disaggregating by school fee status, is stark. Only 37% of learners in no-fee schools speak the LOLT at home, in comparison to 80% of learners in fee paying schools. The achievement difference is also stark, with learners who speak the LOLT at home more often scoring higher than those who spoke it less frequently or not at all. The difference in the average scores of learners who "always/almost always" spoke the LOLT at home, and those who sometimes spoke the LOLT at home is 50 points for mathematics, and a higher 74 points for science.

Percentage of learners with Home Educational Resources and Achievement, 2019

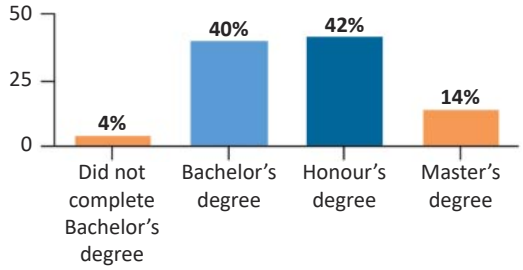


TIMSS constructed a *Home Educational Resources* scale based on learners' reports, summarising the availability of books and other study supports (own room and internet connectivity) in their homes, as well as the highest level of their parents' education. In Western Cape, one-third of learners (34%) come from households categorised as possessing few resources. Just 6% of Western Cape learners reported coming from households with many educational resources, in contrast with an international average of 14%. In keeping with the international patterns, learners with higher levels of home educational resources tended to score higher in mathematics and science than their counterparts with less resources.

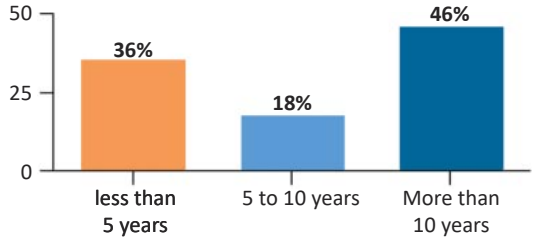
7. Enabling School Environments

The findings above show that learners from public schools, particularly no-fee schools, come from homes that have fewer physical resources, and have less-educated parents. The multiple disadvantages faced by learners from poor homes make the role of schools in attempting to level the playing field more important. The following section reports on the profile of the principal and the spatial location of the school.

Percent of learners in schools by Principal qualifications

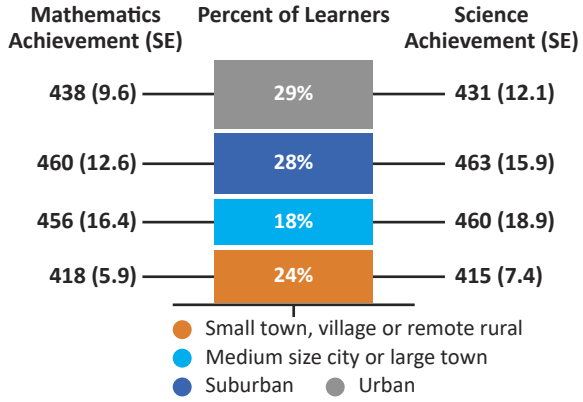


Percent of learners attending schools in relation to Principals' experience in years



The role of principals has moved beyond daily management and administrative tasks to focus more on improving teaching and learning in schools. The experience and qualifications that principals have, matter. Almost all leaners (96%) were in schools where the principal had a Bachelor's degree or higher. On average, learners attended schools where the principal had nine years of experience as a principal. One third of learners (36%) attended schools where principals had less than five-years of experience, 18% of learners where principals had between 5 and 10 years of experience, and 46% of learners had principals with 10 or more years of experience.

Percentage of learners by where they live, and mathematics and science achievement

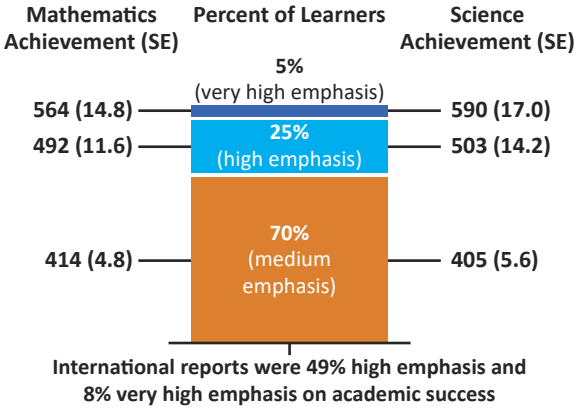


Principals were asked to describe the area surrounding their schools to get a sense of whether the school was situated in an urban, suburban, large city, small town or village or remote rural area. The geographic location of a school is generally related to the socioeconomic status of learners. Western Cape, as described earlier, is a spatially diverse province. Learners and schools in rural remote areas will generally be poorer, while schools in urban and suburban areas will have access to better resources. Generally, learners at- tending schools in urban areas and suburbs attained significantly higher achievements than those attending schools in small towns, villages or remote rural areas.

7.1 School Climate Promoting Academic Achievement

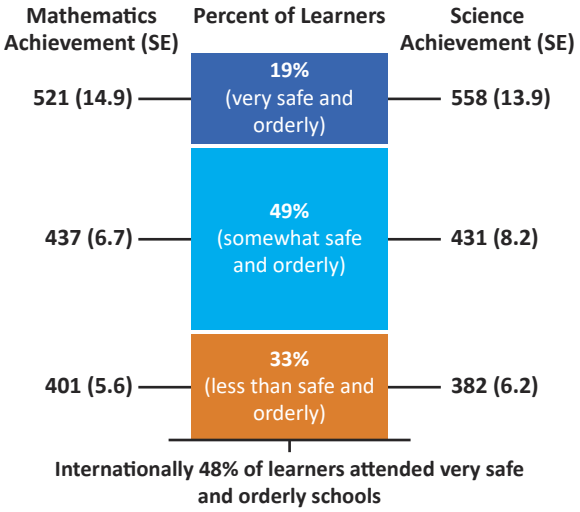
A school with a positive climate is one where a strong emphasis is placed on academic success, learners feel safe, and all disciplinary rules are adhered to.

Principal reports on emphasis on academic success by achievement



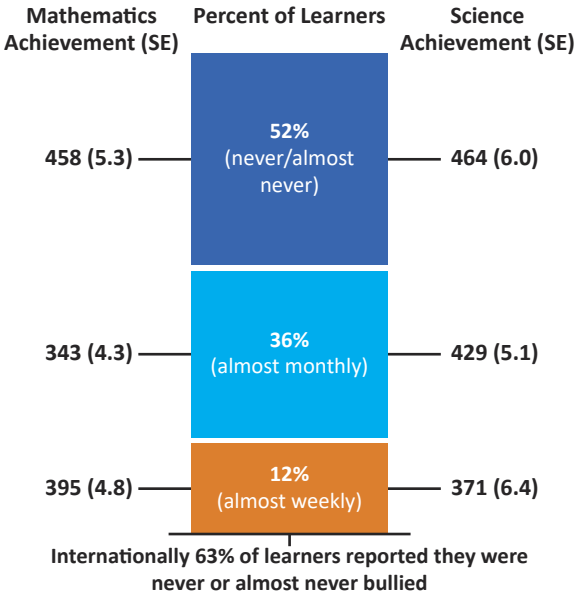
Principals responded to a set of 11 items constituting a *School Emphasis on Academic Success* scale. Three in ten Western Province learners attended schools with a higher emphasis on academic achievement, and seven in ten learners were in schools with "medium" emphasis. This compares to six in ten internationally. Higher proportions of learners in fee paying schools (40%) attended schools which placed a greater emphasis on academic success than no-fee schools (12%). Learners in schools that emphasised academic success achieved significantly higher mathematics and science scores.

Educator reports on safety and order by achievement



Mathematics and science educators rated their schools on eight statements, which was used to create a *Safe and Orderly Schools* scale. One in five (19%) Western Cape learners (as compared to 48% internationally) responded that their school was 'safe and orderly'. We examined the differences between no-fee and fee-paying schools and found that, more learners (42%) attended no-fee schools described as less than safe and orderly than in fee paying schools (26%). Learners in schools that have a higher safety and orderly rating achieve significantly higher mathematics and science scores (mathematics score is 521 points in very safe and orderly schools, in comparison with 401 points in less than safe and orderly schools).

Frequency of being bullied and achievement



Learners responded to fourteen statements on how often they experienced bullying (physical, verbal or through digital devices) from their school peers to create a *Student Bullying* scale. On average, half of Western Cape learners (52%), in contrast to 63% internationally, reported they were "never or almost never" bullied. For the learners (48%) who experienced some form of bullying, verbal bullying constituted the highest form of bullying, followed by physical and low incidences of cyber bullying. When the data was disaggregated by school fee paying status, 45% of learners in no-fee schools and 56% of learners in fee paying schools hardly experienced bullying. With each reported increase in the frequency of bullying, learners had progressively lower average achievement. Learners who were hardly bullied achieved a mathematics score of 458 points, in comparison with 395 points for those bullied almost weekly.

8. Classroom Contexts and Learning

The classroom is where most teaching and learning takes place and thus it is important to investigate how factors within a classroom are associated with mathematics and science achievement. We report on educators, instructional practices, and mathematics and science resources.

8.1 Educator Profile and Professional Development

Educators with the requisite subject knowledge and experience contribute to higher mathematics and science achievements. The mathematics and science educators' responses to the TIMSS questionnaires are not provincially representative of educators but are indicative of their views. The findings are reported at the level of learners affected.

of learners were taught by mathematics and science educators with, at least, a Bachelors degree

76%
of learners were taught by educators with a mathematics specialisation

88%
of learners were taught by educators with a science specialisation

of learners were taught by mathematics or science educators with, more than 10 years of teaching experience

The educators are well qualified, with 82% of mathematics learners and 90% of science learners taught by educators who had completed at least a Bachelor's degree. Educators with a mathematics specialisation taught three-quarters (76%) of learners, and educators with a science specialisation taught 88% of learners.

Over half the mathematics learners (57%) and two thirds (65%) of science learners were taught by educators with 10 or more years of teaching experience.

Mathematics and science educators with similar experience taught learners in fee paying and no-fee schools. Similarly, the qualifications of the mathematics educators were similar for learners in these two school types, but there was a difference for science. A significantly higher number of learners in fee-paying schools, as opposed to no-fee schools, were taught by a science educator with a Bachelor's degree or higher.

Mathematics and science educators responded to questions regarding their participation in professional development activities during the last two years, as well as their future professional development needs.

Figure 11: Professional Development Participation and Needs

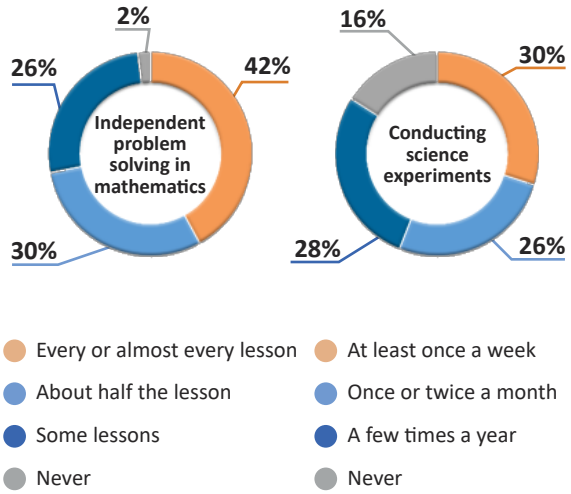
	Mathematics		Science	
Professional activities	**Educators Participation in Prefessional Development**	**Educators Indicating a Need in Professional Development**	**Educators Participation in Prefessional Development**	**Educators Indicating a Need in Professional Development**
Content	85	53	74	47
Curriculum	79	46	72	46
Assessment	62	50	62	62
Pedagogy/Instruction	58	62	57	59
Integrating Technology into Instruction	58	80	52	72
Improving Learners' Critical Thinking or Problem-Solving Skills	47	80	42	78
Addressing Individual Learner Needs	40	75	38	73

Compared to other participating countries, Western Cape educators attended a higher number of professional development activities. There is a sizable gap between the mathematics and science educators' top professional development needs and their recent professional development activities. The top recent professional development activities for mathematics and science relate to content (mathematics 85% and science 74%), curriculum (mathematics 79% and science 72%) and assessment (62% for both mathematics and science). The lowest levels were reported for professional development activities focusing on integrating technology into instruction, improving learners' critical thinking, and addressing individual learners' needs. The participation patterns between educators in fee-paying and no-fee schools is similar for mathematics, while for science there were higher reports of professional development activities for educators in no-fee schools. It is pleasing to note that the majority of educators (93%) attended professional development activities outside the precious teaching and learning times.

The most cited professional needs (over 70%) for both mathematics and science are integrating technology into instruction, improving learners' critical thinking or problem-solving skills, and addressing individual learners' needs. Educators recognise technology is becoming increasingly important for instruction.

8.2 Classroom Pedagogical Practices

Percent of learners engaged in Pedagogical Practices

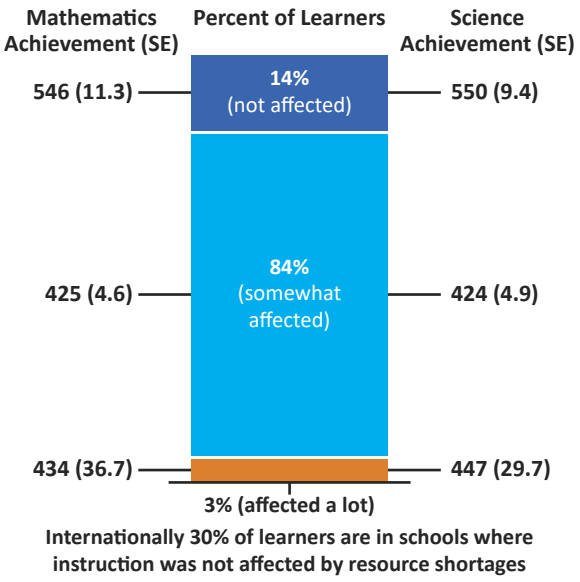


Classroom instruction and engagements are at the core of the learning process. The day-to-day classroom activities are more likely to have a direct impact on mathematics and science learning. Learners being involved in independent problem solving in mathematics and conducting science experiments will more likely influence their mathematics and science achievement. The majority of learners reported participating in both activities, but the frequency varied. Almost half (42%) of mathematics learners engaged in independent problem solving in almost every lesson, and one in three conducted science experiments at least once a week.

8.3 Mathematics and Science Resources and Materials

Access to instructional resources and materials in a school is important for maintaining a conducive learning environment and the provision of quality instruction in classrooms. The resources that are in a classroom influence instruction, learning and subsequently achievement.

Principal reports of mathematics and science instruction being affected by resource shortages

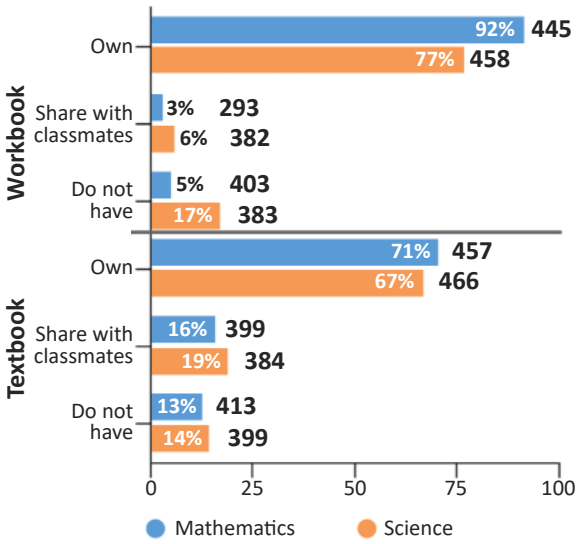


Internationally 30% of learners are in schools where instruction was not affected by resource shortages

The *Instruction Affected by Mathematics Resource Shortages* scale summarises principals' reports of two kinds of resource shortages that affect instruction: general school resources, and resources specific to mathematics and science instruction. Overall, principal reports of resource shortages affecting instruction for mathematics was the same as for science. On this international scale, only 2% of mathematics learners and 3% of science learners in no-fee schools were not affected by resource shortages. In the case of fee-paying schools, a slightly higher proportion, 16% of mathematics learners and 20% of science learners, were not affected by resource shortages. The majority of learners were affected by resource shortages. As would be expected, learners not affected by resource shortages scored significantly higher than those affected by resource shortages.

8.4 Access to Textbooks and Workbooks

Percent of learners with access to workbooks and textbooks, and related achievement



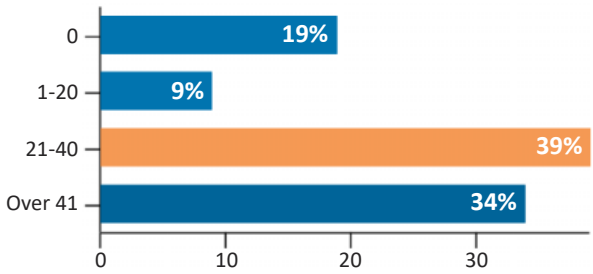
There is general agreement that workbooks and textbooks are an important resource to support teaching and learning, especially when used effectively. The provision of textbooks in South African public schools has been the focus of attention through a national workbooks programme. The infographic on the left reports the percentage of learners who had access to a workbook and textbook, and the corresponding average achievement scores.

The majority of learners either own or share a mathematics workbook (95%) or textbook (87%). For science, 83% have their own or share a workbook, and 86% own or share a textbook. Learners who have their own textbook or workbook achieve significantly higher mathematics and science scores than those who share or do not have workbooks and textbooks. Mathematics learners who have their own workbooks score 445 points, in comparison with 393 points for those who share a workbook. This pattern is the same for textbooks and for science. These findings suggest the importance of learners having their own textbooks and workbooks.

9. Technology in Education and Instruction

Prior to the COVID-19 crisis, educational systems around the world invested in resources to ensure that schools and classrooms included digital technology to enhance learning. The school closures that resulted from the pandemic have highlighted the importance of digital learning and the inequalities in access to digital resources.

Percent of Grade 9 learners attending schools with access to computers



According to principals, two in ten (19%) Grade 9 learners attended schools where there were no computers for learners to use in their classes, one in ten (9%) where there were between 1 and 20 computers, and three quarters of Grade 9 learners (73%) were in schools with over 20 computers (this number went up to 390 computers). The pattern of computer availability at the Grade 9 level is similar for fee-paying and no-fee schools.

Grade 9 learners in Western Cape seem to have comparatively good access to computers. Of the educators who reported having computers, we can report that two thirds of mathematics learners and three quarters of science learners used computers for instruction. The frequency of usage varied.

SECTION D: KEY FINDINGS AND IMPLICATIONS

This Highlights report has provided a current and trend perspective of Grade 9 mathematics and science achievement of the Western Cape province in an international assessment. In this final section we draw together the main findings from this analysis.

Findings from mathematics and science achievement data

1. **Achievement and ability in TIMSS 2019:** Western Cape achieved an average of 441 (4.4) scale points in mathematics and 439 (5.1) scale points for science. Western Cape achievements are higher than the South African average by 52 points for mathematics and 69 points for science. The TIMSS achievement scores can be translated to describe mathematical and science abilities. Two-thirds (64%) of mathematics learners and 60 % of science learners demonstrated that they had acquired basic mathematical and science knowledge. It is also noteworthy that 3% of mathematics learners and 6% of science learners (compared to an international average of 7%) reached the "advanced" ability levels meaning that they could use application and reasoning skills in a variety of mathematics and science problems.

2. **Achievement trends:** Within the limitations of the smaller sample size (and high standard errors) in TIMSS 2011 and 2015 we comment on the achievement trends in Western Cape. From 2011 to 2019 the Western Cape achievement scores improved in mathematics from 408 to 441, an increase of 33 TIMSS points and in science from 413 to 439, an increase of 26 TIMSS points. It is noteworthy that the best achievement improvements were among the lowest performing learners.

3. **Achievement in the international context:** Western Cape mathematics and science achievement ranks in the lower third of TIMSS participating countries. Its achievement is similar to Chile, Qatar and Iran. Western Cape province should use the TIMSS 2019 achievement scores, and its rank order in relation to other countries, to set the achievement targets in the medium term (10 years) and to track educational progress.

4. **Achievement gaps:** The performance of learners in Western Cape is unequal and socially graded. On the one hand, achievement gaps continue to be linked to socioeconomic backgrounds, spatial location and attending a fee-paying or no-fee schools. This confirms the well-known narrative that advantage begets advantage and home resource disadvantages continues to impede learning outcomes. On the other hand, the large achievement increases are from the lowest performing learners, contributing to a decrease the achievement gap. The achievement gap (difference in achievement scores between the learners in fee-paying and no-fee schools) is 70 points for mathematics and a higher 96 points for science.

5. **Achievement scores for learners in Quintile 4 schools:** Surprisingly, the average achievement scores for learners in Quintile 4 schools, designated as fee-paying in the Master List of Schools, was similar to that of Quintile 1,2 and 3 schools. This suggests a revisit of the categorisation of schools in Quintile 4 is needed.

6. **Gender and achievement:** The mathematics and science achievement scores were higher for boys than for girls, but this difference is not statistically significant. However, there are significant gender differences when examining the content areas and cognitive demands. Boys significantly outscore girls in content domains of Number and Geometry in mathematics and Physics and Earth Sciences in sciences. Boys also achieve significantly higher scores in items requiring the cognitive skills of applying and reasoning in mathematics and reasoning in science.

7. **Mathematics and science human capabilities for the future:** The changing South African economy has a higher demand for high-skilled tertiary education graduates, especially in Science, Engineering and Technology (SET) subjects. The proportion of Grade 9 learners demonstrating higher abilities in mathematics and science signals the SET pipeline to the exit level matriculation examination and tertiary studies. It is noteworthy that one third of mathematics (32%) and science (35%) Grade 9 learners reached the intermediate ability benchmark (i.e. learners have subject knowledge and can apply it). In order to meet the needs of our society and economy policy should focus on two objectives: striving for equity by decreasing the achievement gap and striving for increase proportions of higher performing learners by improving the achievement standard for all learners.

Findings from curriculum data (see the Curriculum Analysis Highlights Report)

8. Science achievement is slightly lower than mathematics and the wider science distribution graph points to greater variation in overall science abilities. The lower minimum science scores suggest that there are additional challenges (e.g. language of instruction, resources and educator knowledge) which have an impact on the teaching and learning of science. In addition to the focus on mathematical improvement programmes, provincial authorities must also focus on the science subjects.

9. TIMSS is a challenging assessment. Two thirds of the TIMSS assessment items require learners to use higher cognitive skills (application and reasoning) to correctly answer the questions. The South African assessment framework has a greater focus on the skills of knowing and solving routine problems and there is limited emphasis on the skills of applying and reasoning. School based and national assessments must include more assessment at higher cognitive levels to signal the higher expectations from learners.

10. Achievement performance was much higher on items where learners had to select a correct answer (multiple choice questions) rather than on items where they had to construct a written response. Learners have limited writing skills and could not coherently write a descriptions or an explanation. We recommend that the present Reading Strategy be extended to a Reading and Writing Strategy.

Findings from contextual data

Mathematics and science achievement is influenced by home, school and classroom environments and the interactions therein. Parents and communities look to schools and classrooms to discontinue home disadvantages

11. Home conditions continue to be unequal with one in five learners in no-fee schools not having access to basic resources such as a water flush toilet or running water. Learners from homes lacking these basic amenities have the lowest educational outcomes.

12. The findings regarding principals and educators are not representative of the population, but provide indicative patterns. The educational qualifications of principals, and mathematics and science educators are high. Over 80% of learners were in schools where the principal, mathematics and science teacher had, at least, a Bachelor qualification. The majority of educators indicated a specialisation in mathematics or science. Further the mathematics and science educators attended a high number of professional development courses. While the high education and training levels are applauded, the focus must now shift to translating these educational qualification and content knowledge into higher learner achievement levels.

13. Compared to other TIMSS participating countries, Western Cape responses regarding school climate show there is cause for concern. High numbers of educators and learners feel unsafe in school and there are high incidences of bullying. The school climate is reflective of the climate of the community in which the school is based. A healthy school climate requires the leadership and support of the school management and the surrounding community. Learners in schools with a healthier school climate (emphasis on academic success, fewer disciplinary problems and incidences of bullying, safe and orderly schools) have higher achievements.

14. School and subject specific resources matter for educational success. Compared against the international measure of resources, many schools indicated there were resource shortages. The resource levers that Western Cape could respond to is to improve the accessibility of science workbooks and textbooks and mathematics textbooks so that every learner has their own copy. Access to digital resources is reasonable where 80% of learners, in both fee-paying and no-fee schools, are in schools where Grade 9 learners have access to computers.

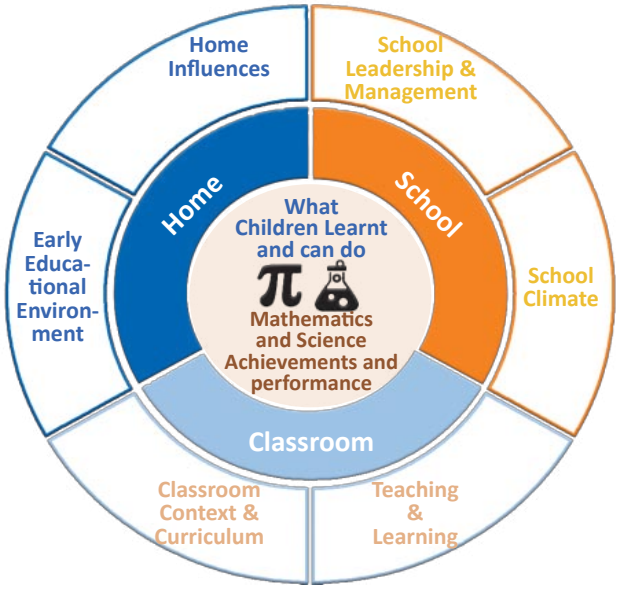
The value of participating as a benchmarking entity:

15. The Western Cape and Gauteng provinces expanded their sample size to 150 schools. This led to more precise estimates of achievement scores and affords an opportunity for a more textured analysis of the teaching and learning in the province. Further, it provides the province with the opportunity to assess the comparative international standing of their learners' achievement. We recommend that for a better understanding of educational achievement and effectiveness, Western continues with a programme of international achievement studies, like the Trends in International Mathematics and Science Study and the Progress in International Reading Literacy Study (PIRLS).

Notes

TIMSS Conceptual Framework

TIMSS uses the curriculum as the organising principle of how educational opportunities are provided to learners. The curriculum model has three aspects: (i) the intended curriculum, (ii) the implemented curriculum and (iii) the attained curriculum. The intended curriculum refers to the mathematics and science knowledge that society intends learners to learn; the implemented curriculum refers to how the educational system is organised (curriculum coverage) and the attained curriculum refers to what learners have learnt (learner achievement scores).



Numerical, mathematical, scientific and analytical skills are key for participation as citizens and workers in the new knowledge and technology based society and economy. School mathematics and science achievement levels provide a signal of the ability of learners to participate in society as engaged citizens, to continue studying mathematics, science and other technical subjects, as well as the competencies available for the workplace.

Since 1994, the South African government has emphasised the centrality of education, especially reading, numeracy, mathematics and science, for development. School mathematics achievement is one of the key indicators to measure the health of our educational system. The TIMSS achievement measures are a valuable resource to monitor South African educational outcomes. Linked to the high level of inequality in the country, our analysis focuses on *Building Achievement* and *Bridging Achievement Gaps*.

Related Publications

Mullis, I.V.S., Martin, M.O., Foy, P., Kelly,D. & Fishbein,B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. TIMSS and PIRLS International Study Centre. Chestnut Hill, MA: Boston College

Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). TIMSS 2019 Assessment Frameworks. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/timss2019/frameworks/

Reddy, V., Prinsloo, C., Arends, F., Visser, M., Winnaar, L., Feza, N., Rogers, S., Janse van Rensburg, D., Juan, A., Mthethwa, M., & Maja, M. (2012). *Highlights from TIMSS 2011: the South African Perspective*. HSRC: Pretoria, South Africa.

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A and Prinsloo, C.H., and Isdale, K. (2016). *TIMSS 2015: Highlights of Mathematics and Science Achievement of Grade 9 South African Learners.* Human Sciences Research Council.

Reddy, V., Isdale, K., Juan, A., Visser, M., Winnaar, L., & Arends, F. (2016). *TIMSS 2015: Highlights of Mathematics and Science Achievement of Grade 5 South African Learners.* HSRC: Pretoria, South Africa.

Acknowledgements

- We appreciate the Western Cape Department of Education and the Department of Basic Education in the trust they placed in the HSRC to conduct this important study and the spirit of collaboration to implement this study.
- TIMSS is a very big study with a life span of four years. It was supported by a number of people through the different phases of the study. Thanks to provincial co-ordinators who facilitated access to schools; school principals, educators and learners who participated in the study; short term staff who assisted in administrative, scoring and data capturing tasks.
- The HSRC research and administrative teams for their contributions and staying the course of this demanding study for four years.

To cite this document:

Reddy, V., Juan, A., Winnaar, L., Arends, F., Harvey, J., Hannan, S and Zulu, N. 2020. *TIMSS 2019: Highlights of Western Cape Province Grade 9 Results in Mathematics and Science: Building Achievement and Bridging Achievement Gaps.* HSRC: Pretoria.