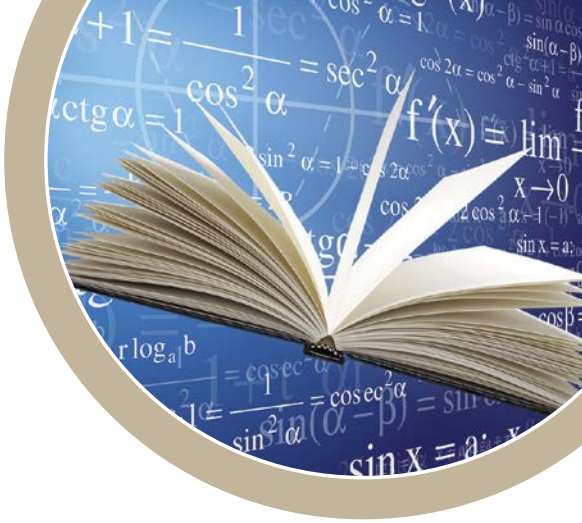

TIMSS 2019

Highlights of Gauteng Province Grade 9 Results in Mathematics and Science

Building Achievement and Bridging Achievement Gaps

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Tables and Figures

SECTION A: 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 (TIMSS) 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 around 30 schools). These small provincial samples lead to achievement estimates with high standard errors. Two provinces, Western Cape and Gauteng, sought a more precise provincial achievement estimate. As such, the TIMSS 2019 sample size in these two provinces was increased to 150 schools, and the Western Cape and Gauteng provinces in addition to being part of the national sample, participated as self-standing entities called "benchmarking participants." Participation as benchmarking entities in international assessments provides provinces with the opportunity to assess the comparative international standing of their learners' achievement and to view their curriculum and instruction in an international context.

This report presents the Highlights of TIMSS 2019 results for Gauteng. 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 in SA and Gauteng as a Benchmarking Participant

Gauteng is the smallest province in South Africa, accounting for only 1.5% of the land area, but the most densely populated. It comprises the largest share of the South African population with approximately 15.5 million people (26%) living in the province. Gauteng is a diverse province with different peoples, cultures and languages. All eleven official languages are spoken in the province: IsiZulu is the most spoken by individuals in households across Gauteng (23%), followed by Sesotho (13%), Sepedi (12%), English (11%) and Afrikaans (10%).[1] Gauteng is highly urbanised, containing the country's largest city, Johannesburg, its administrative capital, Pretoria, and other large areas such

[1] Statistics South Africa (2016). *Community Survey 2016. Provincial Profile Gauteng*. Statistics South Africa: Pretoria

as Midrand and Vanderbijlpark. In 2017, Gauteng had a Gross Domestic Product (GDP) per capita of R111 171 - the highest in South Africa - in comparison to the overall South African average of R81 875 per capita.[2] At 31%, the province has a higher unemployment rate than the national average standing at 30% in 2020[3], but the lowest provincial poverty rate of 33%.[4] Gauteng's Human Development Index[5] is the second highest in South Africa at 0.73, compared to the South African average of 0.70 in 2018.[6]

Although indicators of socio-economic status are higher than the national averages, the economy of Gauteng is dominated by the city of Johannesburg and other urban centres, and as one travels from the City, indicators, such as unemployment and poverty, increase. This provincial context provides insight in the context in which learners live and learn.

Statistics Canada selected the South African sample and Gauteng provincial sample of 150 schools from the 2018 Department of Basic Education's (DBE) List of schools that offered Grade 9 classes (648 Public and 348 Independent schools). Public schools accommodate 88% of the province's learners, and independent schools 12%. The sampling was based on school type (public, independent) as the explicit stratification variables and school poverty ranking as the implicit stratification variable. The realized Gauteng sample was 150 schools, 150 school principals, 151 mathematics and science teachers and 5 633 learners.

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

- What are the mathematics and science achievements and achievement gaps in TIMSS 2019?
- What are the mathematics and science trend achievements from 2011 to 2019?
- What influences mathematics and science achievement in the Gauteng province?

Structure of the Highlights of Grade 9 Gauteng Results Report

This TIMSS 2019 Gauteng 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 HSRC.

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

Section B reports the TIMSS 2019 mathematics and science achievements for Gauteng. We report on achievement patterns at three levels: (i) International, (ii) Gauteng alone, 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 international participants, but which could provide South Africa with aspirational targets) that showed an association with mathematics and science achievement. For the TIMSS 2019 Gauteng full report, we will conduct multivariate analyses to identify achievement predictors more robustly.

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

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

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

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

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

[5] The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living.

[6] Global data lab.(2018).*Sub-national HDI – Area database* Retrieved 26 August 2020 from https://globaldatalab.org/

SECTION B: ACHIEVEMENTS AND ACHIEVEMENT GAPS

1 INTERNATIONAL MATHEMATICS AND SCIENCE ACHIEVEMENT, 2019

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 benchmarking participants) participated in the eighth-grade assessments (Norway, South Africa, the 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 is set to a Centrepoint (point of reference which remains constant from assessment to assessment) of 500 and a standard deviation of 100.

Table 1, on the left, presents the average mathematics achievement (with standard errors) and Table 2, on the right, the average science achievement (again with standard errors) for countries who participated in the eight/ninth grade assessments. The countries are arranged from highest to lowest achievement score.

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.

Gauteng scored on average of 421 TIMSS points in mathematics. This score was not significantly different from Jordan and Egypt, 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.

The science average for Gauteng was 422, not significantly different from the benchmarking participant Abu Dhabi, but different from all other countries.

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)

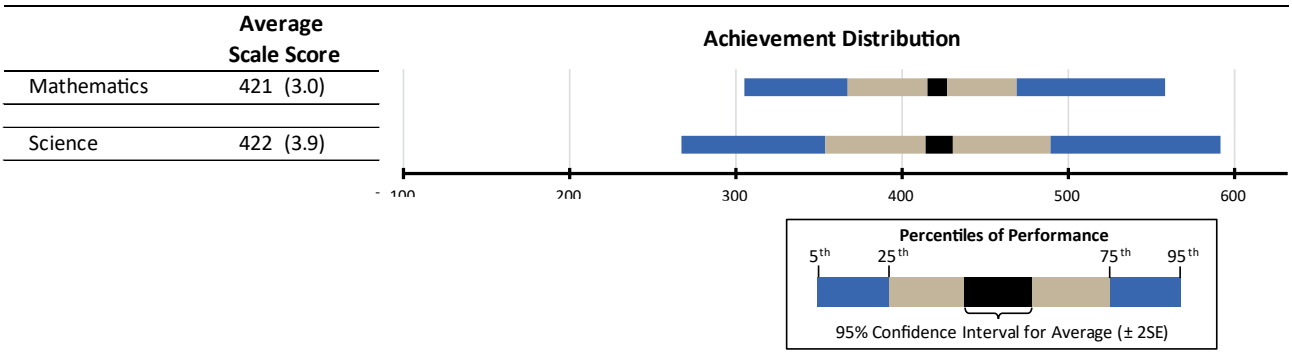
2 GAUTENG MATHEMATICS AND SCIENCE PERFORMANCE

The TIMSS 2019 mathematics assessment comprised 211 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 Gauteng 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 Gauteng province, together with the scale score distribution. The length of each of the bars on the graph is indicative of the variation in achievement: the shorter the distribution the less the variation in achievement and hence the more homogeneous performance, and vice versa.

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

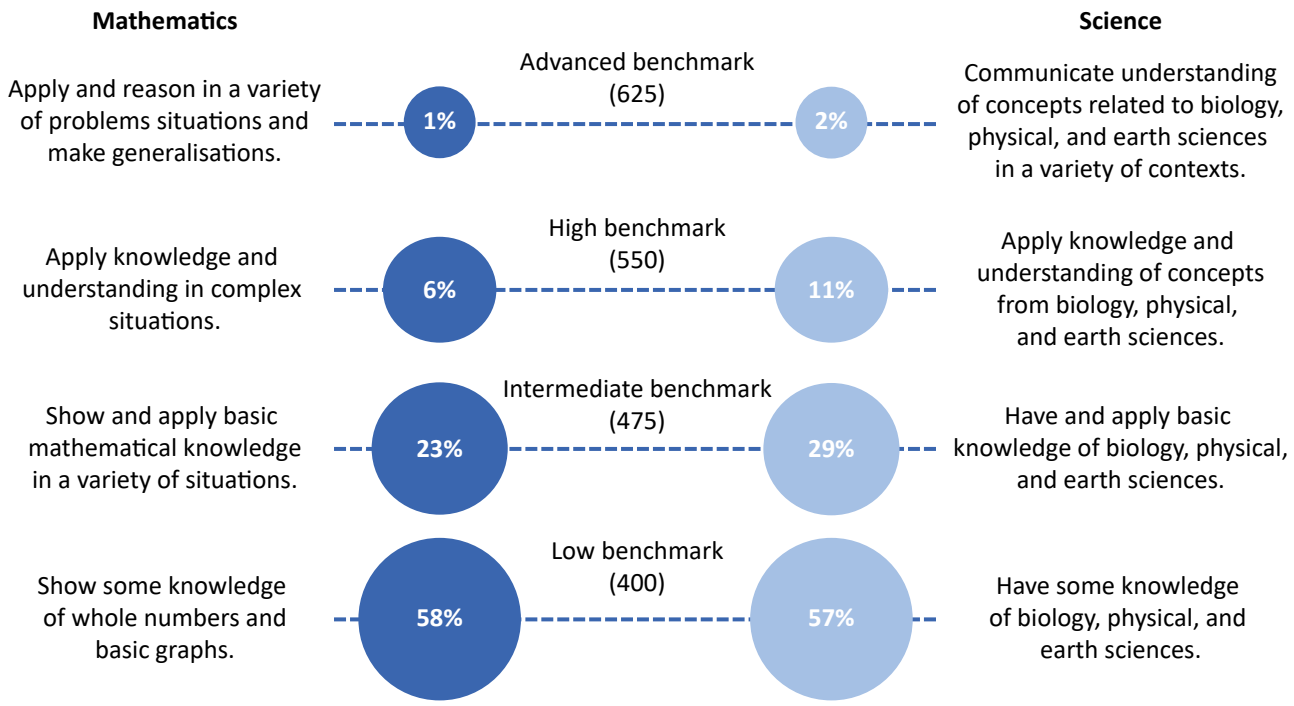


The Gauteng average scale score for **mathematics is 421 (SE 3.0)** and for **science is 422 (SE 3.9)**. This score is higher than the South African national average of 389 (2.3) for mathematics and 370 (3.1) for science. The length of the bars points to a wider achievement distribution for science than mathematics, a reflection of higher variation in science learner ability. The achievement distribution (difference between achievements at 95th and 5th percentile) for science, at 324 points, is wider than for mathematics, at 253 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 Gauteng mathematics and science ability profile is presented in Figure 2.

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

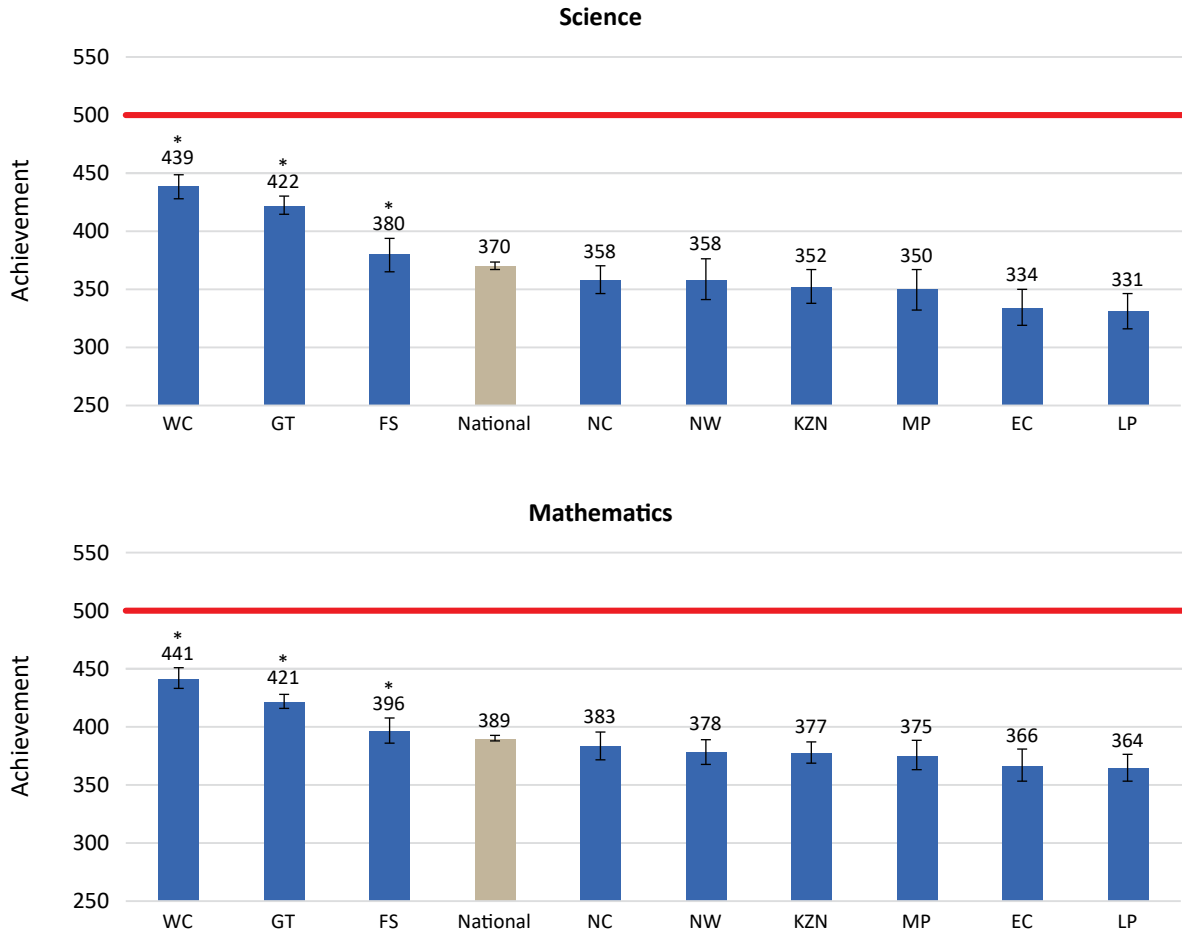


On the TIMSS scale, learners who achieve above 400 TIMSS points are described as having acquired basic mathematical or science knowledge for that grade. Close to three in five mathematics (58%) and science (57%) learners demonstrated they had acquired basic mathematical science knowledge. There are some talented learners in Gauteng: 2% of science learners (compared to the international average of 7%) and 1% 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 Gauteng TIMSS performance relative to other provinces

Socio-economic conditions differ from province to province. The provincial macro-indicators of economic affluence expressed through the GDP and poverty rate, coupled with the number of learners in each provincial education department and the percentage of learners in no-fee schools, provides us with the picture of opportunity gradient amongst provinces. These macro-level statistics are presented in the table below the provincial achievement graphs in Figure 3. There is a clear relationship between the macro socio-economic 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	NC	NW	KZN	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 the nearest neighbour

The top three performing provinces are the same for both mathematics and science: for mathematics, Western Cape ranks the highest with an achievement score 441 (4.4), followed by Gauteng with 421 (3.0) and Free State with 396 (5.5). Similarly, for science, the average achievement in Western Cape is 439 (5.1), followed by 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).

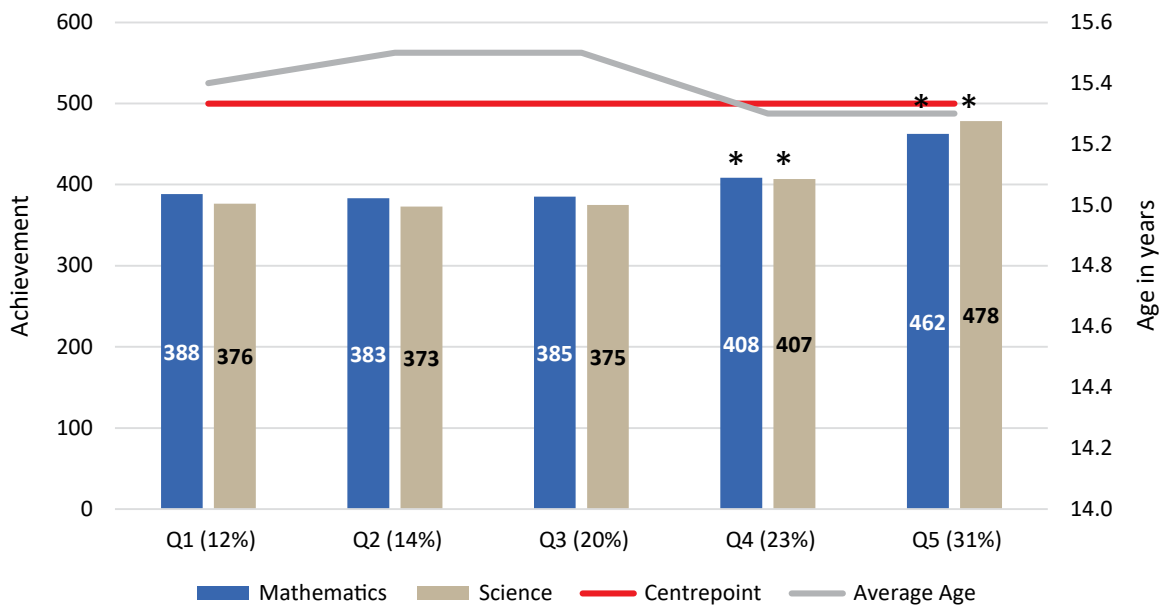
3 MATHEMATICS AND SCIENCE ACHIEVEMENT OF LOCAL RELEVANCE, 2019

Gauteng is a diverse province with high levels of income poverty and inequality. A single national achievement score does not tell the Gauteng story. Rather it needs a textured achievement story reported through the categories of (i) School poverty index, (ii) School Fee-Status (Fee-Paying and No-Fee), and (iii) gender.

3.1 Mathematics and science achievement by poverty index rank of schools, 2019

Learners from Gauteng, 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 DBE calculated a poverty index for each public school reflecting 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 quintile category as determined by the DBE Master list of schools.[7]

Figure 4: Mathematics and science performance by poverty rank of schools, 2019



* Denotes significant difference

In Gauteng public schools, just over half the learners (54%) were in Quintile 4 and 5 schools. There was no significant difference between the average mathematics and science scores of the learners in Quintile 1 to 3 schools. The learner average mathematics and science achievement scores in Quintile 4 schools are significantly higher than the averages in Quintile 3 and significantly lower than averages in Quintile 5 schools. While the average achievement scores for learners in the more resourced Quintile 5 schools is higher than other schools, they have not yet reached the TIMSS Centrepoint of 500.

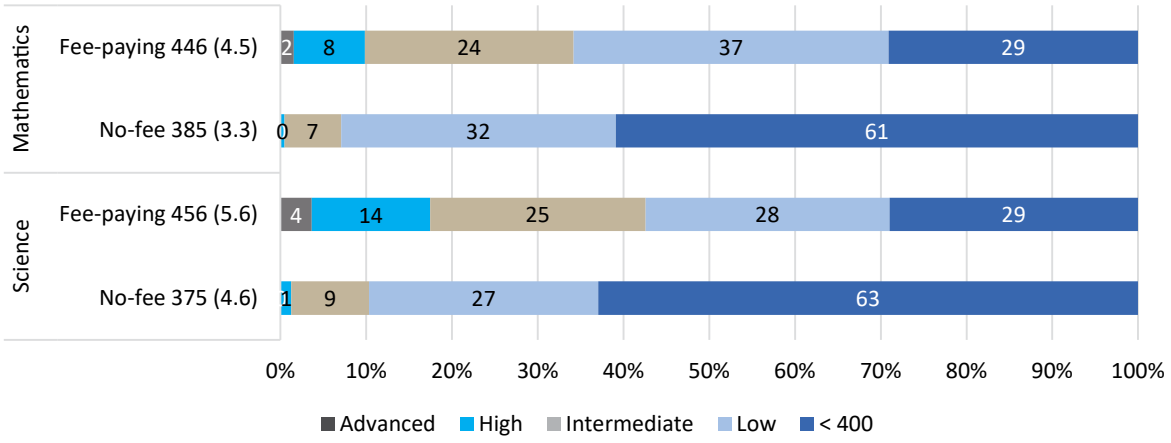
The average age for learners in Quintile 1, 2 and 3 schools are 15.4; 15.5 and 15.5 years respectively and in Quintile 4 and 5 learners are at younger average of 15.3 and 15.3 years. The higher average ages suggest higher levels of learners' grade repetition.

[7] Independent schools are not reported on separately here due to the small sample size in the Gauteng provincial sample.

3.2 Mathematics and science achievement and ability by school fee status, 2019

As part of the government's pro-poor strategy to support education, Quintile 1, 2 and 3 schools receive subsidies that make it possible to exempt learners from paying school fees. Thus, public schools are differentiated into fee-paying and no-fee schools. We report on achievement by two school types: no-fee (Quintiles 1, 2 and 3 public schools) and fee-paying (Quintiles 4 and 5 public schools, and independent schools). Of the Gauteng learners who participated in TIMSS 2019, 41% attended no-fee schools and 59% attended fee-paying schools. The learner population group demographic in Quintile 4 and 5 schools are 70% African, 7% Coloured, 3% Indian and 19% White (EMIS data). 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 and ability and 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 from each other. The mathematics and science scores for learners in no-fee schools is 385 (3.3) points and 375 (4.6) points, respectively. Learners in fee-paying schools achieve higher mathematics and science scores: 446 (4.5) and 456 (5.6) points, respectively. This means that the mathematics achievement gap is 61 points between school fee-paying status, and the science achievement gap is 81 points.

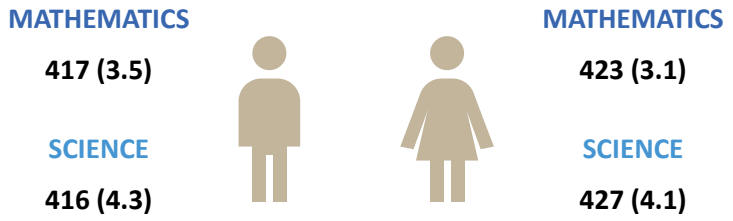
When the achievement scale scores were translated to ability levels, in no-fee schools four in ten mathematics (39%) and science (37%) learners showed they had acquired basic mathematical and science knowledge. It is noteworthy that close to 0.5% of mathematics and 1% of science learners in no-fee schools achieved scores above the High Benchmark of 550 points.

In fee-paying schools, 71% of mathematics and science learners demonstrated that they had acquired basic mathematical and science knowledge. It is noteworthy that 10% of mathematics learners and 17% of science learners at fee-paying schools achieved scores higher than the High Benchmark of 550 (meaning that they can apply knowledge and understanding in complex situations).

3.3 Mathematics achievement by gender, 2019

Internationally, evidence on the relationship between gender and achievement was mixed both across and within countries. In Gauteng, girls outperformed boys by 6 points for mathematics and 11 points for science, and the difference in performance is statistically significant for both mathematics and science. This pattern of girls outperforming boys is observed for mathematics and science in both fee-paying and no-fee schools, and is statistically significant for science, but not for mathematics. Figure 6 shows the TIMSS 2019 mathematics and science performance of boys and girls.

Figure 6: Mathematics and science achievement by gender, 2019



Girls had higher mathematics and science achievements than boys, and the difference is statistically significant for both subjects.

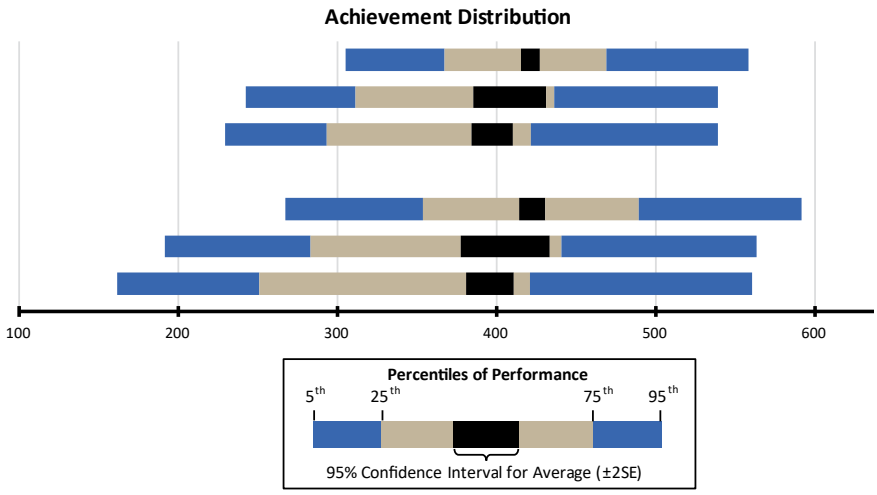
We also observed interesting gender achievement differences by mathematics and science content and cognitive domains. Girls had significantly higher achievements in the mathematical content domains of Algebra, and the science domains of Biology and Chemistry. With regard to the cognitive domains, girls achieved significantly higher scores for items requiring knowing skills in mathematics and science, and items requiring application skills in science.

4 TREND IN GAUTENG'S MATHEMATICS AND SCIENCE ACHIEVEMENT, 2011 TO 2019

The Gauteng province participated with a smaller number of schools as part of the overall South African TIMSS sample in the previous rounds of the study. However, the provincial achievement estimates were less precise with larger standard errors and confidence intervals. In Figure 7, we compare the shape and size of Gauteng 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

Mathematics	Average Scale Score (SE)
TIMSS 2019	421 (3.0)
TIMSS 2015	408 (11.4)
TIMSS 2011	397 (6.3)
Science	**Average Scale Score (SE)**
TIMSS 2019	422 (3.9)
TIMSS 2015	405 (13.8)
TIMSS 2011	396 (7.6)



Between TIMSS 2011 and 2015, the Gauteng mathematics and science scores improved by 11 and 9 points respectively, a difference which was not statistically significant. Between 2015 and 2019, the mathematics and science scores improved by a further 13 and 17 points, respectively. Between 2011 and 2019, the mathematics achievement increased from 397 to 421 points, an increase of 24 points. In the same period, the science achievement increased from 396 to 422 points, an increase of 26 points. These increases from 2011 to 2019 are statistically significant for both mathematics and science at the 99% level.

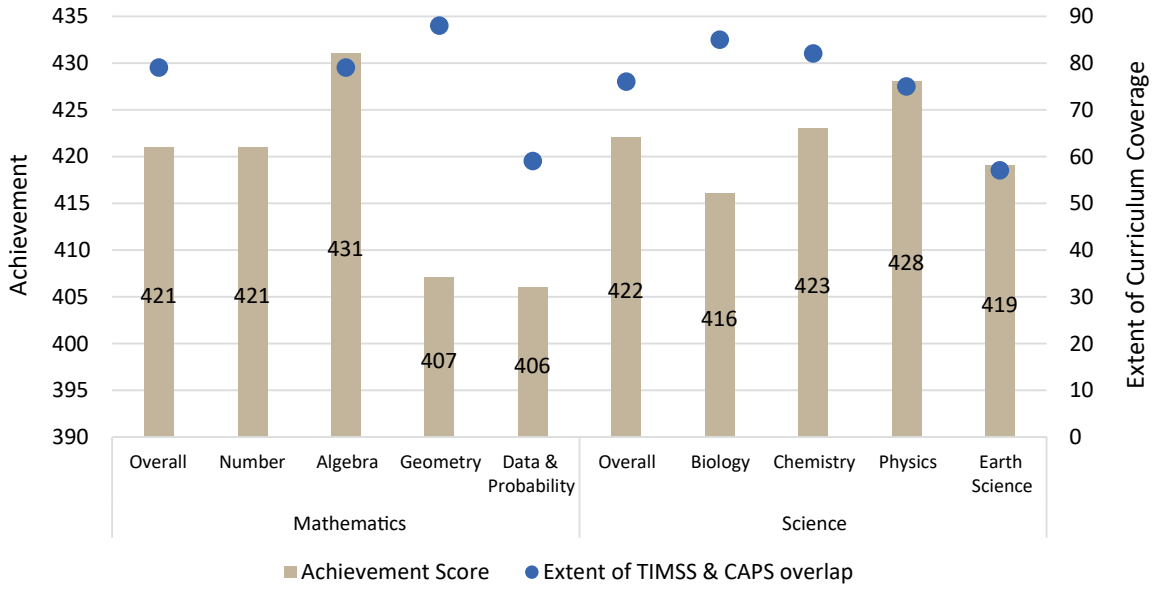
Examining the achievement range between the 5th and 95th percentile (the length of the bars in Figure 7) for 2011 to 2019 cycles, we see that the best achievement gains are at the lower end of the achievement distribution, meaning that learners with the lowest levels of achievement improved the most.

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 to determine the extent of overlap between the TIMSS and Curriculum and Assessment Policy Statements (CAPS) curriculum. Figure 8 shows the TIMSS mathematics and science content domains coverage as reported by educators and learner average achievement.

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



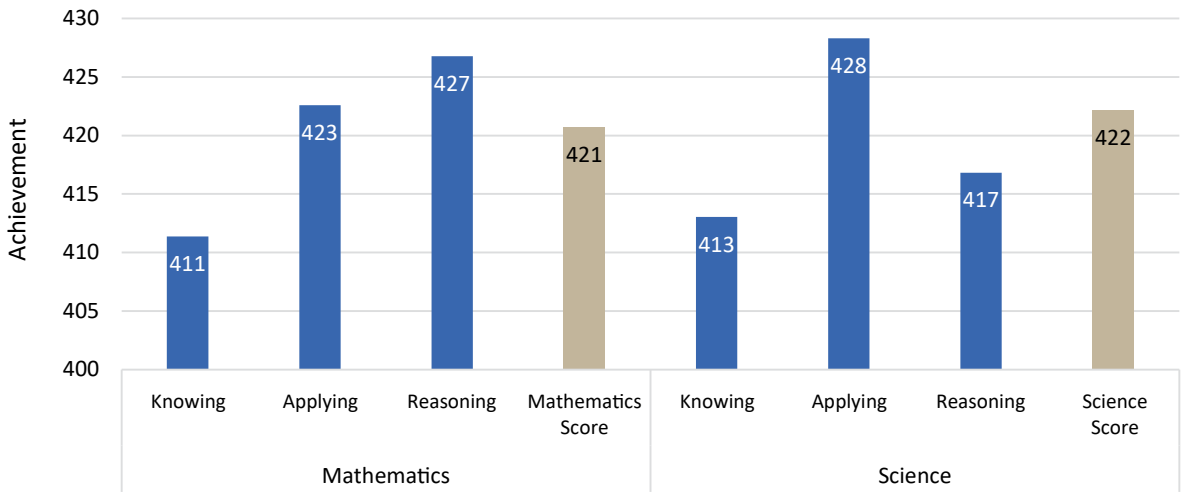
At the ninth grade level, on average, 79% of the overall mathematics topics were taught at the time of the TIMSS test. Coverage of number topics (98%) was high, with the coverage for algebra, geometry, and data and probability topics at 79%, 88% and 59%, respectively. While there is not a direct relationship between curriculum coverage and achievement, performance in the number content area was close to the overall mean, significantly higher for algebra (by 10 points), and significantly lower for geometry (by 14 points) and data and probability (by 15 points).

On average, the overall science curriculum coverage was 76%, with the highest coverage for biology topics at 85%, followed by chemistry with 82% coverage. The coverage for physics and earth science topics was 75% and 57%, respectively. The achievement scores for the chemistry and earth science domains was similar to the overall average score. The achievement for biology was significantly lower than the overall mean score and the physics score was significantly higher than the overall mean.

In relation to how learners achieved by the cognitive domains of knowledge, applying and reasoning, there were surprises in the results. In mathematics, Gauteng learners performed significantly lower than the overall mean on knowledge items (by 10 points) and significantly higher on reasoning items (by 6 points). In science, again learners performed significantly lower than the overall mean on science knowledge items (by 9 points) and reasoning items (by 5 points), and significantly higher on applying items (by 6 points). Figure 9 presents the patterns for mathematics and science.

There were also significant gender differences by content and cognitive domains. Girls achieved significantly higher scores in the mathematical content domains of Algebra, and the science domains of Biology and Chemistry. Girls also scored significantly higher than boys in answering knowing items in mathematics and science and applying items in science.

Figure 9: Learner performance by mathematics and science cognitive domains, 2019



SECTION C: EXPLAINING MATHEMATICS AND SCIENCE ACHIEVEMENT

Home, school and classroom environments, and the interactions therein, influence achievement scores. 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 three contexts (Home, School and Classroom) 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, however, personal conditions, such as where one lives, influence achievement outcomes. The extant literature shows a strong positive relationship between achievement and socio-economic 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, including in South Africa. TIMSS collects information to better understand these relationships. This section will focus on the home socio-economic status as described by the assets in the home. The assets include basic assets, educational materials and digital resources. The language spoken at home is also one of these resources.

Figure 10 reports the percentage of learners who have, what are categorized, as basic, educational or digital assets at home. These assets are a proxy measure of a home environment that supports learning and having these assets is positively associated with higher mathematics and science achievement. We report on their availability, firstly at the province level, and then for learners in fee-paying and no-fee schools.

Figure 10: Percent of learners with access to resources at home

Resource	Gauteng	Fee-paying	No-fee
Running tap water*	89	93	84
Flush toilet*	91	97	82
Hot running water*	58	73	38
One parents with a post grade 12 education*	48	52	41
Over 25 books in the home*	24	29	16
Own room*	71	74	66
Always/Almost always speaking the language of the test at home*	39	51	21
Internet connection*	52	63	36
Computer or Tablet*	65	75	51

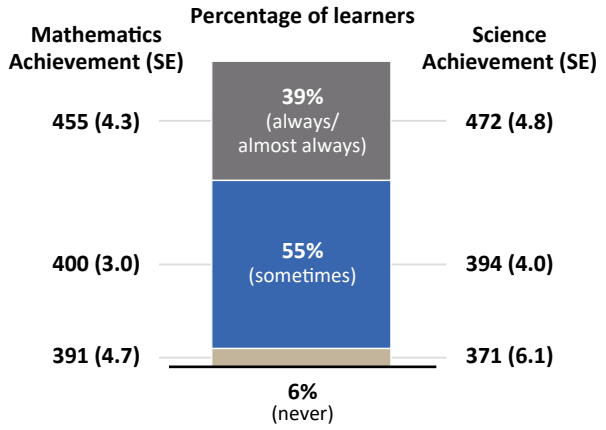
* Difference in availability of assets in fee-paying and no-fee schools is statistically significant

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.

The highest educational level of parents in the household is a predictor of learner performance. A significantly higher proportion of learners in fee-paying (52%), than in no-fee schools (41%), had a parent or caregiver with a qualification above Grade 12. Having more books at home was positively associated with higher achievement. A quarter of Grade 9 learners reported having over 25 books in the home, with higher numbers (29%) in fee-paying schools compared to no-fee schools (16%).

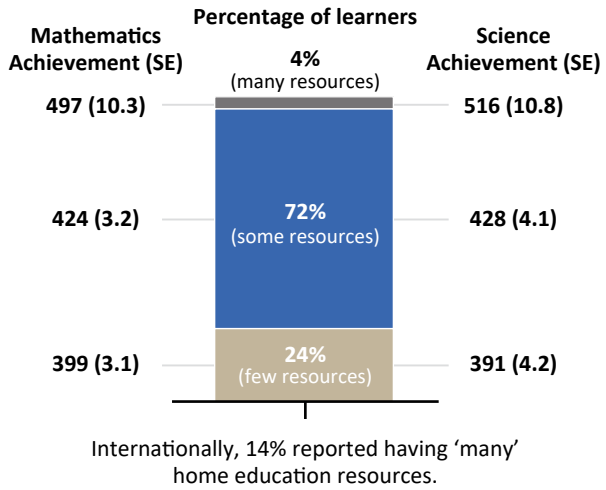
In a world where digital learning is becoming more important, nearly two-thirds (65%) of Gauteng learners have the necessary digital hardware and half (52%) have an internet connection at home. These conditions are more favourable for learners in fee-paying schools. In fee-paying schools, three-quarters of learners (75%) reported having a computer at home, and two-thirds (63%) had an internet connection. In contrast, in no-fee schools, half the learners (51%) had a computer at home and just over one-third (36%) had an internet connection.

Figure 11: Achievement by language of learning and teaching, 2019



If a learner's language of learning and teaching (LOLT) corresponds to the language frequently spoken by the learner, there is a positive association with achievement, especially in language-intensive subjects like science. Gauteng is the most linguistically diverse province in South Africa, with learners speaking 13 different home languages (see Section A for further detail on language diversity). The figure on the left reports the frequency with which the learners speak the LOLT at home and the corresponding average achievement. Just over a third (39%) of the learners spoke the language of the test at home "always or almost always". The pattern, when disaggregating by school fee-status, is different. Only 21% of learners in no-fee schools speak the LOLT at home, in comparison to half (51%) of those 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 speak it less frequently or not at all. The difference in the average scores of learners who frequently spoke the LOLT at home, and those who sometimes spoke the LOLT at home is 55 points for mathematics, and a higher 78 points for science.

Figure 12: Percent of learners with Home Educational Resources and Achievement, 2019



The *Home Educational Resources* scale, based on learners' reports about three types of home resources: parents' highest level of education, number of books in the home, and the availability of study supports (internet connection and own room) is presented.

In Gauteng, only 4% of learners (1% of learners in no-fee schools, compared with 6% in fee-paying schools) reported having 'many' educational resources at home. A quarter (24%) of learners reported having 'few' resources. There is a significant positive association between the availability of more home educational resources and mathematics and science achievements. This patterns also holds true for learners in fee-paying schools, but not for those attending no-fee schools.

7 SCHOOLS AS ENABLING LEARNING ENVIRONMENTS

The findings above show that learners in South African 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.

Figure 13: Percent of learners in schools by Principal qualifications, 2019

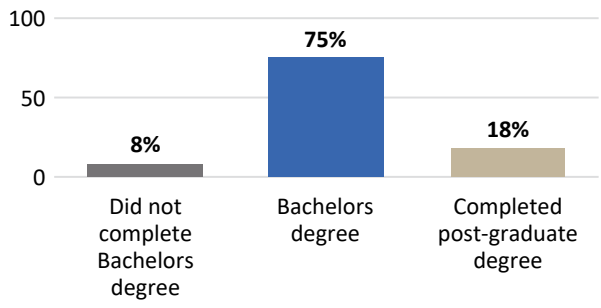


Figure 14: Percent of learners attending schools in relation to principals' experience in years, 2019

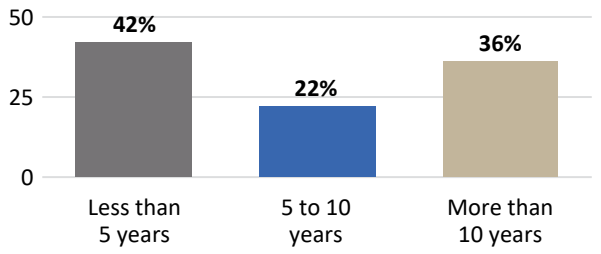
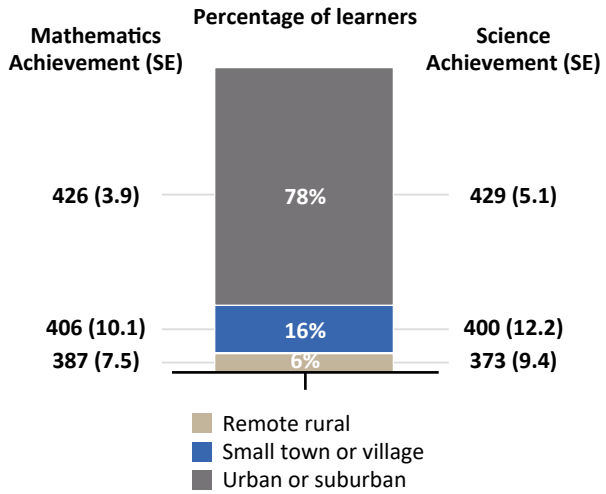


Figure 15: Percentage of learners by where they live, and mathematics and science achievement, 2019



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.

The majority of learners (93%) were in schools where the principal had a Bachelor's degree or higher. The principal's qualification level in fee-paying and no-fee schools is similar.

On average, learners attended schools where the principal had eight-years of experience as a principal.

Four in ten learners (42%) attended schools where principals had less than five-years of experience, 22% of learners where principals had between 5 and 10 years of experience, and one third (36%) of learners had principals with 10 or more years of experience.

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.

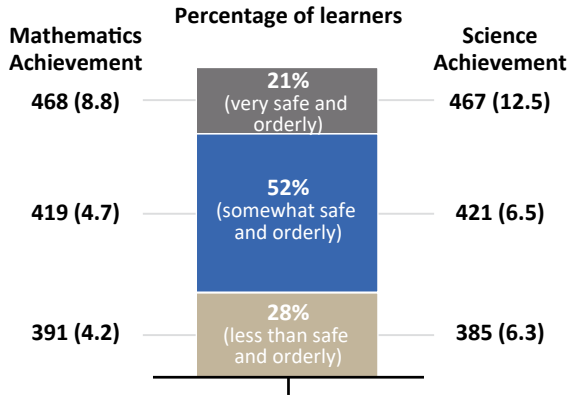
The geographic location of a school is generally related to the socio-economic status of learners. Gauteng, as described earlier, is the smallest province but the most densely populated. Learners and schools in rural remote areas will generally be poorer, while schools in urban and suburban areas will have access to better resources.

Learners attending schools in urban and suburban areas attained significantly higher achievement scores in mathematics and science than those attending schools in remote rural areas.

8 SCHOOL CLIMATE PROMOTING ACADEMIC ACHIEVEMENT

A school with a positive climate is one where strong emphasis is placed on academic success, learners feel safe, and all disciplinary rules are adhered to. Learners with higher achievement typically attend schools with a positive school climate that emphasises academic success, and are safe and orderly spaces for both learners and educators.

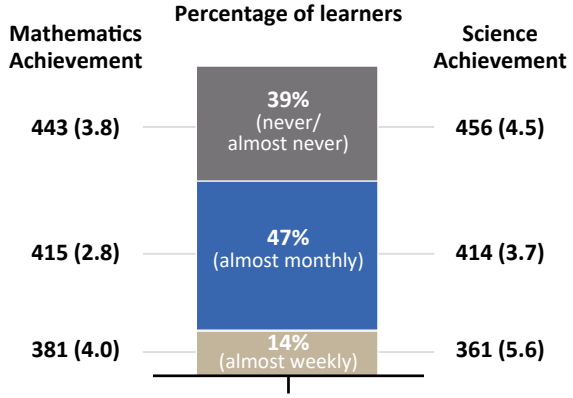
Figure 16: Educator reports on safety and order by achievement



Internationally, 48% of learners attended schools rated as safe and orderly.

Mathematics and science educators rated their schools on eight statements, which was used to create a *Safe and Orderly Schools* scale. In Gauteng 21% of learners, 29% in fee-paying and 6% in no-fee schools, attended schools rated as 'very safe and orderly'. There is a positive significant association between learners' mathematics and science achievement, and attending a safe and orderly school. Learners in schools that have a higher safety and orderly rating achieve significantly higher mathematics and science scores (mathematics score is 468 (8.8) in "very safe and orderly" schools, in comparison with 391 (4.2) in "less than safe and orderly" schools).

Figure 17: Frequency of being bullied and achievement



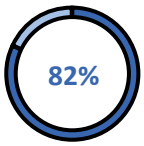
Internationally, 71% of learners reported they were hardly bullied.

Learners responded to 14 statements about how often they experienced bullying behaviours (physical, verbal or digital) from their school peers, to create a *Student Bullying* scale. On average 39% of Gauteng learners, 46% in fee-paying and 30% in no-fee schools, reported that they were hardly (never/almost never) bullied. For the learners who experienced some form of bullying (61%), physical bullying constituted the most common form of bullying, followed by verbal and low incidences of cyber bullying. With each reported increase in the frequency of bullying, learners had progressively lower average achievement. Learners who were hardly ever bullied achieved a mathematics score of 443 (3.8), in comparison with 381 (4.0) for those bullied almost weekly.

9 CLASSROOM CONTEXTS AND LEARNING

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

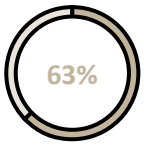
Educators with the requisite subject knowledge and experience contribute to higher mathematics and science achievements amongst learners. The mathematics and science educators' responses to the TIMSS questionnaires are not provincially representative of all educators, but are indicative of their views. 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

95% of learners were taught by educators with a mathematics specialisation

89% of learners were taught by educators with a science specialisation



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

The educators in Gauteng are well qualified, with 77% of mathematics learners and 87% of science learners taught by educators who had completed at least a Bachelor's degree. Educators with a mathematics specialisation taught 95% of learners, and educators with a science specialisation taught 89% of learners.

The average years of teaching experience is 14 years for both mathematics and science educators. Educators with 10 or more years of teaching experience taught two thirds of science learners and 60% of mathematics learners. There is no association between years of experience and achievement.

Mathematics and science educators with similar years of experience taught learners in fee-paying and no-fee schools. The qualification levels of the mathematics educators were similar for learners in these two school types, but for science, according to educator reports, all learners in no-fee schools were taught by an educator with science specialisation.

9.1 Professional development of educators

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 18: Professional development participation and needs

	Mathematics		Science	
	Educators Participation in Professional Development	Educators Indicating a Need in Professional Development	Educators Participation in Professional Development	Educators Indicating a Need in Professional Development
Content	90	60	78	59
Curriculum	79	63	73	58
Assessment	77	68	65	67
Pedagogy	64	72	50	64
Improving Learners' Critical Thinking and Problem Solving Skills	61	88	50	80
Integrating Technology into Mathematics Instruction	60	83	51	79
Addressing Individual Learner Needs	52	82	44	74

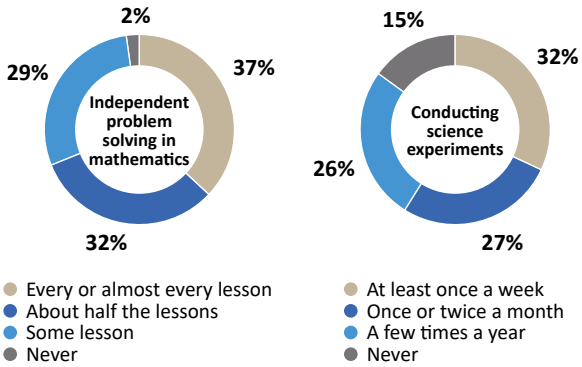
Compared to other participating countries, Gauteng educators attended a higher number of professional development activities. There is a sizable gap between the mathematics and science educators' top professional development needs and their recent professional development activities. The top recent professional development activities for mathematics and science relate to content (mathematics 90% and science 78%), curriculum (mathematics 79% and science 73%) and assessment (77% for both mathematics and 65% for 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. There were fewer professional development activities focusing on integrating technology into instruction, improving learners' critical thinking, and addressing individual learners' needs.

Interestingly, the most cited professional development needs (over 70%) were the topics with fewest development opportunities: 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, but there is a clear mismatch between the professional activities offered and those required by educators.

The participation patterns between educators in fee-paying and no-fee schools are 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 teaching and learning times.

Figure 19: Percent of learners engaged in pedagogical practices

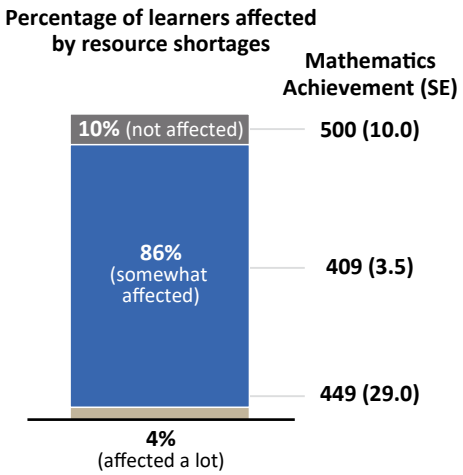


Classroom instruction and engagements are at the core of the learning process; day-to-day classroom activities are more likely to have a direct impact on mathematics and science learning. Learners being involved in independent problem solving in mathematics and conducting science experiments will more likely influence their mathematics and science achievement. The majority of learners reported participating in both activities, but the frequency varied. Around a third of mathematics learners (37%) engaged in independent problem solving in almost every lesson, and a third of science learners (32%) conducted science experiments at least once a week.

9.2 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 teaching, learning and subsequently achievement.

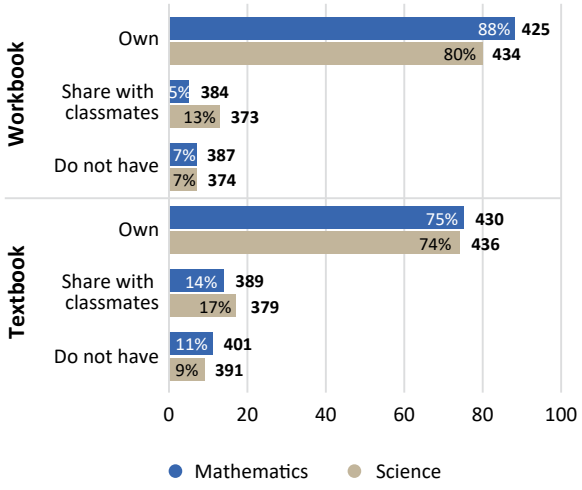
Figure 20: Mathematics resource shortages affecting instruction



The *Instruction Affected by 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. Examples of resources on this international scale are specialized teachers, computer software, library materials, audio-visual resources, and calculators.

Overall, principal reports of resource shortages affecting instruction for mathematics was the same as for science. On this scale, one in ten Gauteng learners were 'not affected' by resource shortages. The pattern is different between the two school types, with just 1% of mathematics learners in no-fee schools reporting that they were not affected by resource shortages, compared to 17% in fee-paying schools. As would be expected, learners "not affected" by resource shortages scored significantly higher mathematics scores, 500 (10.0), than those "affected a lot" by resource shortages, 449 (29.0).

Figure 21: Percent of learners having mathematics and science textbooks and workbooks



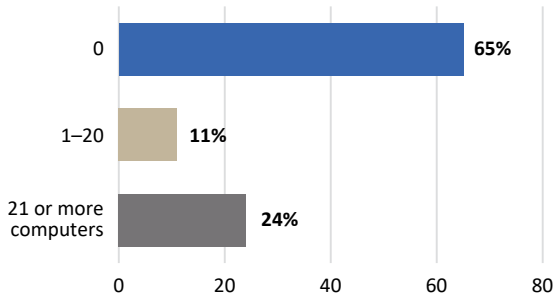
There is general agreement that textbooks are an important resource to support teaching and learning, especially when used effectively. The provision of textbooks in South African public schools has been the focus of attention through a national workbooks programme. The graphic on the left reports the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

The majority of learners either have their own or share a mathematics workbook (93%) or textbook (89%). For science, 93% have their own or share a workbook, and 91% 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 425 (3.1) points, in comparison with 384 (6.2) 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.

9.3 Technology in Education and Instruction

Prior to the COVID-19 crisis, educational systems around the world were investing 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.

Figure 22: Percent of Grade 9 learners attending schools with access to computers



According to principals, two-thirds (65%) of Grade 9 learners in Gauteng attended schools where there were no computers for them to use in their classes. One in ten (11%) learners attended schools with between 1 and 20 computers, and a quarter of Grade 9 learners (24%) were in schools with over 20 computers. The Gauteng Department of Education's (GDE's) computer implementation plan started their rollout first in Grade 12, followed by Grade 11 and then 10[8]. The next phase of the computer rollout programme will be to Grade 9 classes.

The pattern of computer availability at the Grade 9 level is not vastly different for fee-paying and no-fee schools. Three quarters (73%) of Grade 9 learners in no-fee schools and almost 60% of learners in fee-paying schools did not have access to computers in school.

[8] Gauteng Department of Education (2015). Success and challenges of the Gauteng ICT Rollout, 2014-2019. PowerPoint presentation prepared for the ICT Advisory Committee. GDE, Johannesburg.

SECTION D: KEY FINDINGS

This Highlights report has provided a current and trend perspective of Grade 9 mathematics and science achievement in Gauteng 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:** The Gauteng province achieved an average of 421 (3.0) scale points in mathematics and 422 (3.9) scale points for science. Gauteng's achievements are higher than the South African average by 32 points for mathematics and 52 points for science. The TIMSS achievement scores can be translated to describe mathematical and science abilities. Close to three in five (58%) mathematics learners and 57% of science learners demonstrated that they had acquired basic mathematical and science knowledge. It is also noteworthy, that 6% of mathematics learners and 11% of science learners are competitive at higher mathematical and science ability levels (i.e. scoring over 550 points and able to apply knowledge in complex situations).

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 Gauteng. From 2011 to 2019, Gauteng achievement scores significantly increased in mathematics from 397 points to 421 points, an increase of 24 TIMSS points, and in science from 396 points to 422 points, an increase of 26 TIMSS points. It is particularly noteworthy that the best achievement improvements were among the lowest performing learners.

3. **Achievement in the international context:** The Gauteng mathematics and science achievement ranks in the lower quarter of TIMSS participating countries. Its achievement is similar to Jordan, Egypt and AbuDhabi. The Gauteng 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 Gauteng is unequal and socially graded. On the one hand, achievement gaps continue to be linked to socio-economic 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 highest achievement increases are from the lowest performing learners, contributing to the decrease the achievement gap. The achievement gap (difference in achievement scores between learners in fee-paying and no-fee schools) is 61 points for mathematics and a higher 81 points for science.

5. **Gender and achievement:** The mathematics and science achievement scores were significantly higher for girls. There were also significant gender differences when examining the content areas and cognitive demands: Girls significantly outscore boys in content domains of Algebra in mathematics and Biology and Chemistry in science. Girls also achieve significantly higher scores in items requiring the cognitive skill of knowing in mathematics and science and applying skills in science.

6. **Mathematics and science human capabilities for the future:** The changing South African economy has a 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 23% of mathematics and 29% of science 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 increased proportions of higher performing learners by improving the achievement standard for all learners.

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

7. Science achievement is slightly lower than mathematics and the achievement distribution for each subject area is different, with a wider variance of scores in science. The achievement distribution (difference between achievements at 95th and 5th percentile) for science at 324 points is wider than for mathematics at 253 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, pointing to higher inequalities for science than for mathematics. 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.

8. 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.

9. Achievement performance was higher on items where learners had to select a correct answer (multiple choice questions) than on items where they had to construct a written response. Learners have limited writing skills and could not coherently write 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 are influenced by home, school and classroom environments and the interactions therein. Parents and communities look to schools and classrooms to discontinue home disadvantages.

10. Home conditions continue to be unequal with close to 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.

11. 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's 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 qualifications and content knowledge into higher learner achievement levels. Education and training are high-cost opportunities and the impact of these investments should be further investigated.

12. Compared to other TIMSS participating countries, Gauteng 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.

13. School and subject specific resources matter for educational success. Compared to the international measure of resources, many schools indicated there were significant shortages. The resource lever that Gauteng could respond to immediately 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, like computers, must be rolled out to Grade 9 classes, in both fee-paying and no-fee schools

The value of participating as a benchmarking entity:

14. In the 2019 round of TIMSS, the Western Cape and Gauteng provinces expanded their sample size to 150 schools. This led to a more precise estimate 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, Gauteng 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).

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. and Martin, M.O.(Ed) (2017) TIMSS 2019 Assessment Frameworks TIMSS and PIRLS International Study Centre. Chestnut Hill, MA: Boston College

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.

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