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MATHEMATICS PERFORMANCE OF SOUTH AFRICAN PRIMARY SCHOOL LEARNERS

Lessons from TIMSS 2019

JOEL GONDWE

Joel holds a postdoctoral fellowship, funded by the NRF, at the Department of Economics, Stellenbosch University.

1 INTRODUCTION AND LITERATURE REVIEW

1.1 Inequality between schools: The context of South African learning

Education policies in South Africa during apartheid were inherently racially driven and consequently discriminatory in nature. Following the end of apartheid, attempts have been made at educational reforms to address the detrimental effects of this era. However, socio-economic integration has not proceeded smoothly (Taylor & Yu, 2009). Today, school enrolment patterns still have a strong socio-economic dimension. To some extent, socio-economic status (SES) has therefore replaced race as a major determining factor of the South African school culture and environment (Shepherd, 2011). For example, following democratisation, there has been a steady "flight" of affluent black learners from historically disadvantaged (mostly black) schools to previously white and Indian schools, with almost no migration in the opposite direction (Soudien, 2004). Eventually, the historically black schools were left serving the economically disadvantaged, poorer learners, while most children of more affluent parents benefitted from the better-resourced, higher-quality white and Indian schools.

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TODAY, INEQUALITY IN EDUCATIONAL OUTCOMES STEMS MAINLY FROM DIFFERENCES IN EDUCATIONAL QUALITY, RATHER THAN DIFFERENCES IN ATTAINMENT SINCE ATTAINMENT GAPS HAVE NARROWED CONSIDERABLY IN RECENT DECADES.

As a result, there is still considerable inequality between schools. However, patterns of educational inequality have changed. Today, inequality in educational outcomes stems mainly from differences in educational quality, rather than differences in attainment (the highest level of education achieved), since attainment gaps have narrowed considerably in recent decades (Lam, 1999; Van der Berg, 2008).

The high degree of inequality between schools is evidenced by South Africa's high intraclass correlation coefficient or rho, which expresses the variance in performance between schools as a proportion of overall variance. Previous findings report that South Africa had by far the highest rho values for reading at 0.70 and for mathematics at 0.64 (Van der Berg, 2008).[1] This indicates that inequalities in educational achievement are more a product of differences in income, with learners from higher income groups on average outperforming their poorer counterparts. This is further evidenced by Van der Berg (2007): Using the National Senior Certificate pass rate of 2003, he showed that, while 1 in 10 white learners (who typically attend higher-quality schools) achieved an A-aggregate in matric, only 1 in 1 000 black learners (who typically attend lower-quality schools) achieved similar results. Interestingly, however, about half of the black matriculants who achieved an A-aggregate had attended formerly white and Indian schools. This implies that access to better-quality schools increases all learners' chances of performing to the best of their abilities, irrespective of race.

Similar themes of enduring inequality from the apartheid regime on a provincial level are also common in South African literature. For example, even though there have been attempts to equalise school spending in post-apartheid South Africa, Crouch and Hoadley (2018) note that apartheid expenditure was biased towards Gauteng and the Western Cape. In the early 1990s, as a case in point, the education expenditure per learner in the Western Cape and Gauteng was two to three times higher than that of the Eastern Cape (Gondwe & Wills, 2022). Related to this, the institutional arrangements that governed these two provinces during apartheid were more established and better suited to support future functioning systems compared to the other provinces (Gondwe & Wills, 2022). It seems logical that these inherited advantages would likely lead to better academic performance in these two provinces

1 International studies report rho values that range from as low as 0.08 to a high of 0.399 (Van der Berg, 2008)

compared to the other provinces, since they had a head start, at least from an institutional perspective. Indeed, the Western Cape and Gauteng remain two of the best-performing provinces in South Africa (Reddy et al., 2020a; Gondwe & Wills, 2022).

This backdrop, rife with a history of inequality and division, serves as the broader context for this paper. By examining Grade 5 mathematics performance, this paper primarily investigates how learner performance for selected sub-samples relates to and is affected by, a select set of standard covariates. In other words, it aims to identify what factors account for differences in learner achievement within the sub-samples towards the end of primary school. For reasons referred to above, the sub-samples of choice were the following: The Western Cape, Gauteng, a single group representing the rest of the provinces, no-fee schools (quintiles 1 to 3), fee-paying schools (quintiles 4 and 5 and independent schools), and the full South African sample. This categorisation isolates performance among learners in similar environments so that the coefficients can better be interpreted as applying to that particular sub-sample.[2]

The remainder of this paper proceeds as follows: Section 2 provides a brief description of the data used, followed by the methodology. Next, Section 3 provides a descriptive analysis of how Grade 5 mathematics performance differs across provinces and groups of schools. Section 4 provides the regression results, and the conclusions are captured in Section 5.

2 DATA AND METHODOLOGY

2.1 Data

The analysis that follows makes use of a single but reliable source of data on South African education: the Trends in International Mathematics and Science Study (TIMSS) 2019 assessment. TIMSS is a cross-national study that tests the mathematics and science knowledge of Grade 4 and 8 learners. The assessments have been conducted every four years since 1995, with the most recent assessment carried out in 2019, just before Covid-19 started causing global disruption – including in education – in 2020. As a result, it was still possible for the assessment to include as many as 580 000 learners from 64 participating countries. Even though TIMSS is typically administered to Grade 4 learners, this has not been the case for South Africa, which decided instead to administer it at the Grade 5 level in 2019 (Reddy et al., 2020b). In addition – similar to the previous assessment in 2015 that was administered at the Grade 4 level – South Africa also opted to administer an easier version of the mathematics assessment.

In practice, TIMSS 2019 in South Africa was the result of the collaborative efforts of the Department of Basic Education (DBE) and the Human Sciences Research Council (HSRC). The Grade 5 assessments were conducted among 11 903 learners in 297 schools, while the contextual tools were administered to 294 mathematics educators, 11 720 parents, and 297 school principals.[3]

2 This procedure accounts for different data-generating processes that likely apply to these unique samples.
3 For a detailed report on the TIMSS methodology, including survey design, see Martin et al. (2020).

ALTOGETHER, THIS DATA CONTAIN SUFFICIENT DETAIL ON LEARNER MATHEMATICS ACHIEVEMENT, DEMOGRAPHICS, BACKGROUND INFORMATION ON LEARNERS AS REPORTED BY PRIMARY CAREGIVERS OR GUARDIANS, AND SCHOOL-LEVEL ADMINISTRATIVE DATA.

Altogether, this data contain sufficient detail on learner mathematics achievement, demographics, background information on learners as reported by primary caregivers or guardians, and school-level administrative data.

2.2 Methodology

The broad underlying model used follows the rationale put forward in the education production function literature, an approach widely applied by education economists. The production function investigates the factors that determine education outcomes (usually test scores) and provides insight into which factors play the most important role in education outcomes. Put differently, this approach regards the desired education outcome as the result of a production process that combines several inputs to produce that outcome, hence the name education production function. The model to be estimated takes the following form:

$$A_i = f(B_i)\ldots(1)$$

where A_i is learner i's achievement, and B_i is a vector of the learner's family background and other school inputs. Simply put, equation (1) regards the relevant learner's achievement as being the result of the selected inputs that are introduced into the model as a vector of control variables. While the list of explanatory variables could be more exhaustive, this paper limits itself to a few covariates considered to be standard explanatory variables in the education literature.[4] These include learner SES (along with its squared term), learner gender, location, school quintile[5], a dummy for whether or not a learner was overage, and whether the learner attended preschool.

Despite or perhaps because of its simplicity and consequent ease of coefficient interpretation, the model in equation (1) is plagued by mainly two problems: firstly, omitted variable bias (particularly "ability", which is difficult to measure and therefore commonly proxied by performance in standardised tests), and secondly, input measurement. An example of the second point is that the school, peer, and family inputs that influence learner achievement happen over time and are dynamic in nature. In other words, it is possible

4 For examples of papers that use more comprehensive lists of regressors refer to Van der Berg (2008), Shepherd (2011), and Spaull (2013).

5 For TIMSS 2019, the DBE's classification of schools into quintiles was available and was used in preference to school quintiles derived from asset ownership of learners' households.

for a learner to attend several schools, be taught by an array of teachers – with different levels of education, experience, and pedagogical training – and be subject to an ever-changing family SES. Any measure of such dynamic inputs is therefore likely to introduce some degree of measurement error into the model, since any measures of current inputs are far less accurate indicators of past inputs (Shepherd, 2011). An additional problem with estimating education production functions is multicollinearity, which occurs when two explanatory variables are closely related (Bowles & Levin, 1968).

Taken together, these challenges make it difficult to determine accurate estimates. One should therefore not lean too heavily on the results or simply ignore these issues, as that may lead to misleading conclusions. Because of this, the magnitudes of the coefficients do not necessarily present their true impact on educational achievement, even though they do suggest some correlation between learner test scores and the covariates, which could be causal.

3 DESCRIPTIVE ANALYSIS

3.1 How Grade 5 mathematics performance across regions measure up to the TIMSS international benchmarks

This section primarily presents and discusses findings from the descriptive analysis of learner mathematics achievement in the four broader regions of the Western Cape, Gauteng, the seven other provinces (grouped together as a single larger region), and the full South African sample. To provide comparable learner scores, TIMSS uses Item Response Theory (IRT) scaling methods to create a set of plausible achievement estimates for each learner (Reddy et al., 2020a; Reddy et al., 2020b). These can be used to calculate unbiased estimates of group characteristics, such as means and variances (Wu, 2005).

Each learner is assigned five plausible values that, when taken together, resemble individual test scores and have approximatelythe same distribution as the latent variable (Mislevy, 1991; Mislevy et al., 1992). This score is then transformed to have a mean of 500 and a standard deviation of 100. Finally, to facilitate the interpretation of these achievement scales, TIMSS describes four points on the transformed IRT scale called international benchmarks.

The four points are advanced (a score of 625 or more), high (between 550 and 624), intermediate (between 475 and 549), and low (between 400 and 474). These benchmarks translate to actual learner mathematics ability. For example, a learner who reaches the low international benchmark of 400 has demonstrated only basic mathematical knowledge. A learner who reaches the advanced benchmark, on the other hand, not only possesses a better understanding of the subject matter but can also apply their knowledge and understanding in different, relatively complex situations and explain their reasoning (Mullis et al., 2020).

Following this, Figure 1 shows the percentage of each sample population that reached these respective four benchmarks. The figure also includes the international median for all participating countries in TIMSS 2019 to place these regional performances against benchmarks in a broader international context. Figure 2 presents similar information in a slightly different way. It highlights the actual percentage of learners who achieved a particular score between the different benchmark points (i.e. 0–399, 400–474, 475–549, and 550 and above).

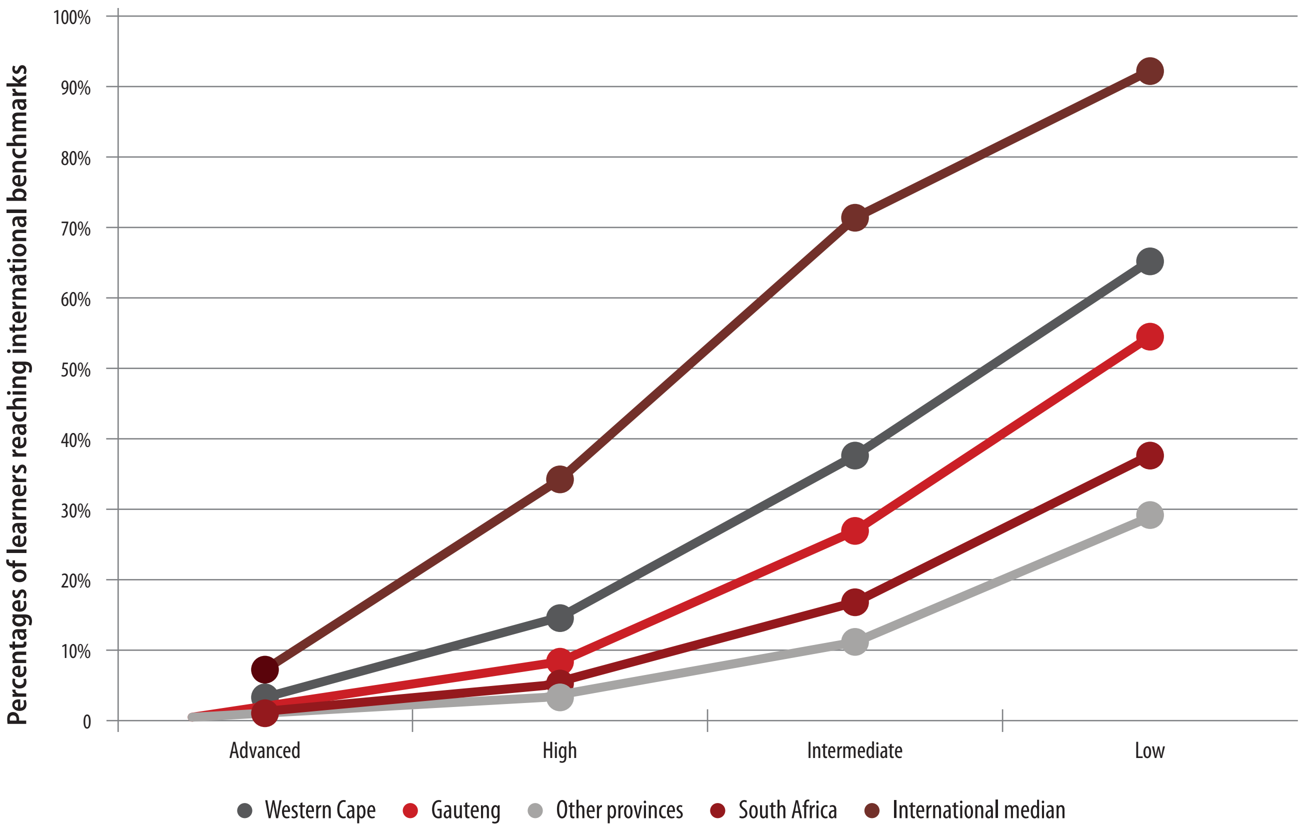
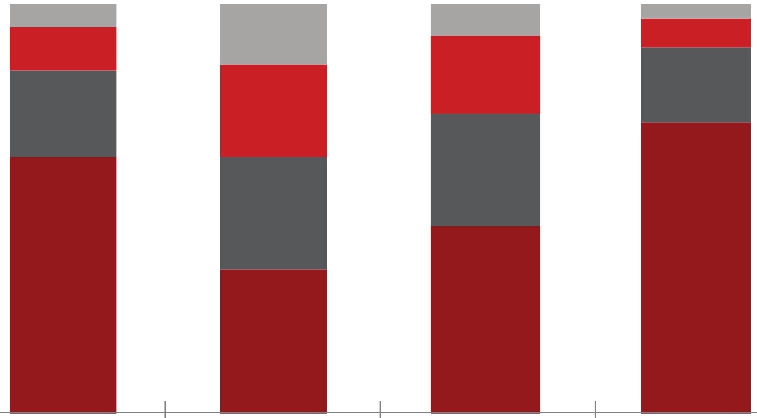


FIGURE 1: Percentages of Grade 5 learners reaching the respective international benchmarks of mathematics achievement by region and nationally in TIMSS 2019

Source: Author's own calculations



	South Africa	Western Cape	Gauteng	Other provinces
High and advanced (>550)	5%	15%	8%	3%
Intermediate (475–549)	11%	23%	19%	7%
Low (400–474)	21%	27%	28%	18%
Below low (<399)	63%	35%	46%	71%

FIGURE 2: Percentage of Grade 5 learners in each international benchmark category for mathematics achievement by region and nationally in TIMSS 2019

Source: Author's own calculations

Overall, the percentage of Grade 5 learners in the Western Cape and Gauteng who reached at least the low benchmark or higher (65% and 54% respectively) is higher than the percentage of learners reaching this benchmark in the seven other provinces (28%). While this is certainly impressive for the two historically high-performing provinces (Wills et al., 2016; Gondwe & Wills, 2022), it is still considerably lower than the international median, which had up to 92% of (mostly) Grade 4 learners reaching this same benchmark. This means that, for many countries participating in the TIMSS 2019 Grade 4/5 assessment cycle, more than 90% of their learners reached what is considered to be a minimum level of proficiency, with six countries where all learners reached this benchmark.[6]

In the case of South Africa as a whole, only 37% of the learner sample reached the low benchmark or higher. This is despite the fact that these learners completed a less difficult version of the TIMSS mathematics test and were assessed at a higher grade (Grade 5) than other participating countries (Grade 4). When one considers that the mathematics curriculum builds on knowledge of certain mathematical concepts as learners move from one grade to the next, having so many learners not reach the minimum level of mathematics proficiency at such an early stage is a real concern. These low benchmark percentages would be a precursor to low mathematics performance in higher grades, where mathematical concepts become increasingly more complex.

Similar to Grade 9 mathematics performance in TIMSS 2019, just 1% of South African Grade 5 learners reached the advanced benchmark (Gondwe & Wills, 2022; Reddy et al., 2020b). The same low figures were evident in all provinces except the Western Cape, with a slightly higher proportion of 3%. As can be seen from both Figures 1 and 2, a notably higher share of Grade 5 learners reaches the high benchmark in the Western Cape (15%), compared to both Gauteng (8%) and the seven remaining provinces (3%).

6 These six countries – five of which are East Asian – are Hong Kong, Chinese Taipei/Taiwan, Singapore, Korea, Japan, and the Russian Federation (Mullis et al., 2020).

3.2 Demographic comparisons of Grade 5 mathematics learner achievement in South Africa

Having established what share of learners reaches the four respective benchmarks on the IRT assessment scale, the remainder of this section compares actual Grade 5 learner achievement for the four sample regions. Figure 3 begins by showing the average mathematics performance of Grade 5 learners in the four samples.

As one would expect from the regions that had the highest share of their learners reaching the minimum accepted level of proficiency (low international benchmark), Grade 5 learners from the Western Cape and Gauteng on average performed significantly better than those in the remaining seven provinces. Interestingly, unlike the Grade 9 mathematics outcomes where Western Cape learners performed significantly better than learners from Gauteng (Gondwe & Wills, 2022), this was not the case in Grade 5. Instead, learner performance in these two regions was not statistically different.

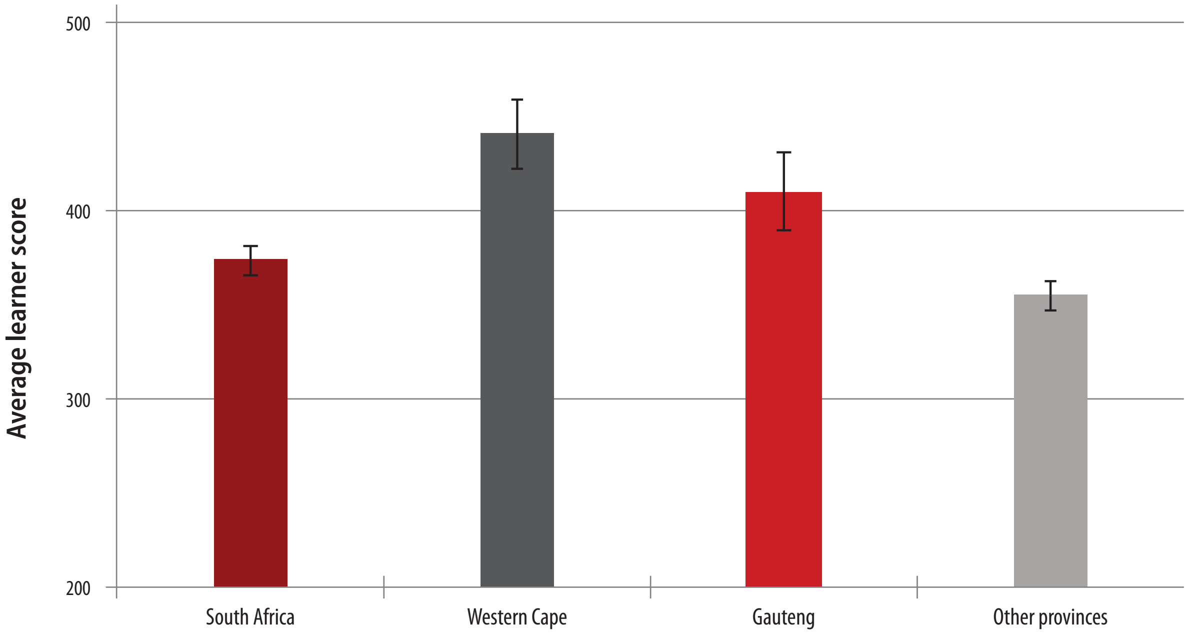


FIGURE 3: Mean Grade 5 learner performance in mathematics by region and nationally in TIMSS 2019

Source: Author's own calculations

Figure 4 moves beyond the overall regional and national performance differences and instead presents decompositions of performance by gender. Interestingly, the significant girl advantage for the national sample observed here and found in Reddy et al. (2020b) does not apply in the Western Cape and Gauteng. At first glance, it may appear as if the girl advantage persists in these two provinces; however, the observed difference is actually not statistically different due to larger standard errors. Furthermore, it should be noted that the girl advantage was also observed in the TIMSS 2019 Grade 9 mathematics assessments. However, unlike for Grade 5, the advantage was not statistically significant at the national level, even though the standard errors were typically smaller owing to larger sample sizes (Reddy et al., 2020a). Meanwhile, international evidence from TIMSS 2019 on the relationship between mathematics achievement and gender is still mixed, with only 12 of the 64 participating countries exhibiting this same girl-boy gap for mathematics performance.

While it is beyond the scope of this paper to investigate the causes (if any) of this girl advantage, the release of the Thrive by Five Index in April this year may offer a possible explanation. This index is the result of South Africa's first nationally representative survey of preschool children that provides a barometer of development outcomes for children between the ages of 4 and 5. It was formed by collecting data on three developmental domains associated with desirable longer-term outcomes: Early Learning, Physical Growth, and Social-Emotional Functioning. As an example, within the Early Learning developmental domain, children are typically grouped into three categories (Giese et al., 2022):

1. On Track – children who meet the learning standard and can complete all their age-specific tasks.
2. Falling Behind – children who are falling behind the standard and would need assistance to catch up with other children of their age.
3. Falling Far Behind – children who have fallen far behind the standard and would need intense and substantial intervention if they are to ever catch up with their peers.

The index shows that in most domains, girls did better than boys, with 9% more girls than boys being categorised as "On Track" for their overall learning. Based on this, it would seem plausible that the advantage girls have over boys starts as early as preschool and persists throughout the earlier years of primary school and even into the later years, up to Grade 9. However, by that time, the girl advantage is not that significant.

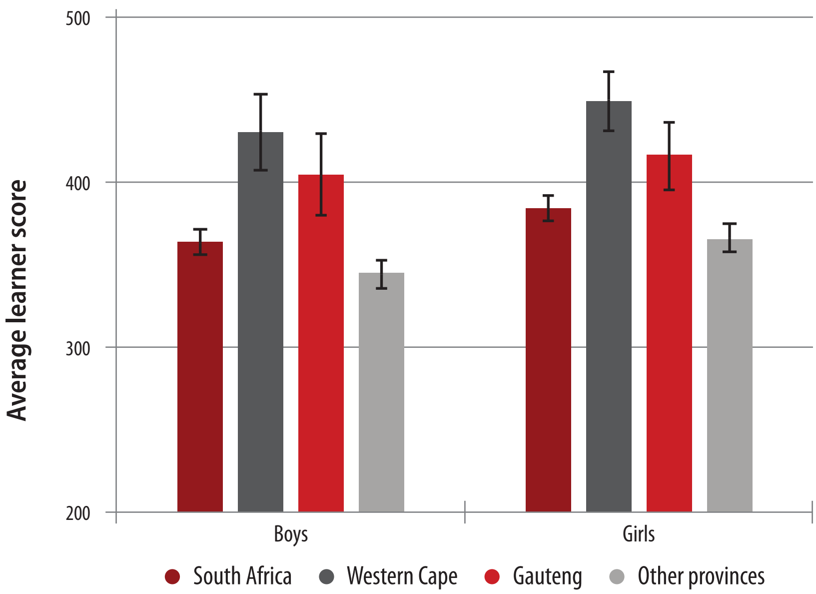


FIGURE 4: Mean Grade 5 learner performance in mathematics by gender and region in TIMSS 2019

Source: Author's own calculations

THE INDEX SHOWS THAT IN MOST DOMAINS, GIRLS DID BETTER THAN BOYS, WITH 9% MORE GIRLS THAN BOYS BEING CATEGORISED AS "ON TRACK" FOR THEIR OVERALL LEARNING.

Owing to the high level of income inequality in South Africa mentioned earlier, it makes sense for this analysis to show learner performance according to some measure of wealth. Fortunately, the TIMSS Grade 5 learner sample is ranked into five poverty index groupings commonly referred to as quintiles. These quintiles were calculated and provided by the DBE as a proxy for economic well-being. Schools were classified into the quintiles based on the poverty level of their immediate communities. For South Africa, the first three quintiles include poor, no-fee schools, whereas quintiles 4 and 5 are usually richer, fee-paying schools, with learners more likely to come from generally affluent areas (Reddy et al., 2020b). In other words, the lower the quintile, the more likely it is that the learner comes from a poorer household. In addition, Figures 5 and 6 also include the average Grade 5 mathematics scores for learners in private independent schools, which make up 8% of all schools in South Africa (Reddy et al., 2020b).[7] While Figure 5 shows how the average learner in each quintile performed relative to the other samples, Figure 6 compares how successive quintiles within one sample performed relative to each other.

In all four samples, average learner performance within the first three quintiles is not only lower than that of learners in quintiles 4 and 5 but also similar (not statistically different). Within the Western Cape, there appears to be no difference in learner performance among the wealthier two quintiles. In contrast, for both Gauteng and the seven remaining provinces, top quintile learners perform significantly better than quintile 4 learners. Looking at the wealthiest learners (quintile 5) only, performance is similar across regions. This again indicates that school quality goes a long way in giving every learner equal opportunity to optimise their ability. This is not the case among the poorer learners – especially the poorest two quintiles – where, on average, learners from Gauteng and the Western Cape outperform their counterparts from the remaining seven provinces. To emphasise this advantage, note that a quintile 1 learner from the Western Cape on average performs better than a quintile 1 through quintile 3 learner from the remaining seven provinces. This difference is statistically significant.

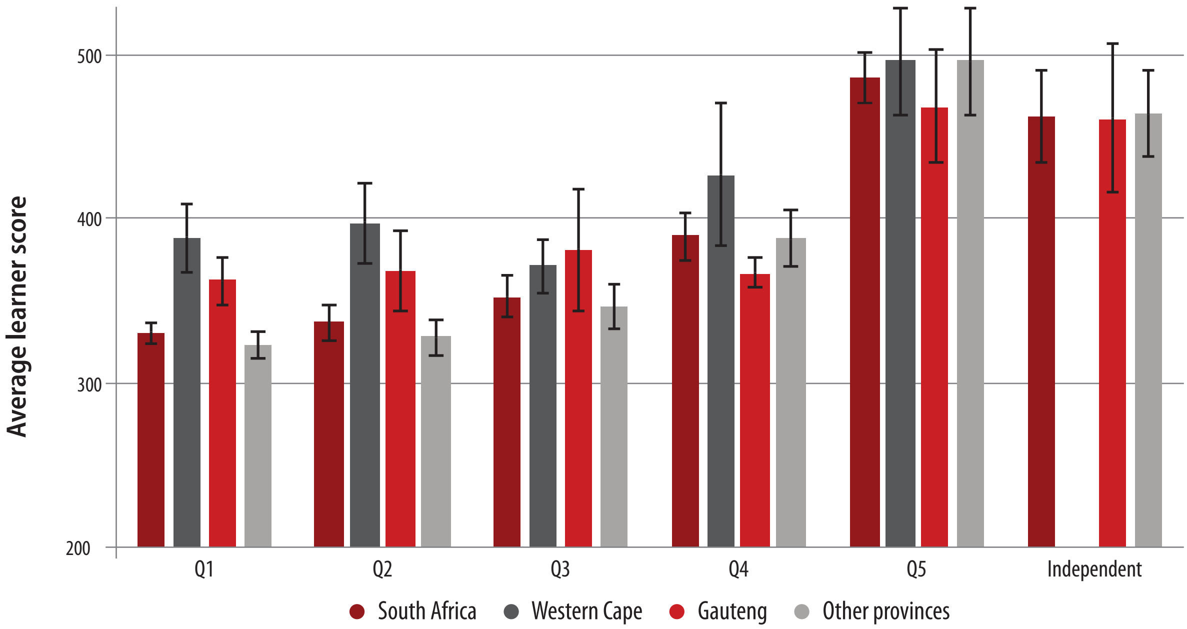


FIGURE 5: Mean Grade 5 learner performance in mathematics by quintile and region in TIMSS 2019

Source: Author's own calculations

7 The independent schools were deliberately over-sampled to provide reasonable estimates (Reddy et al., 2020b).

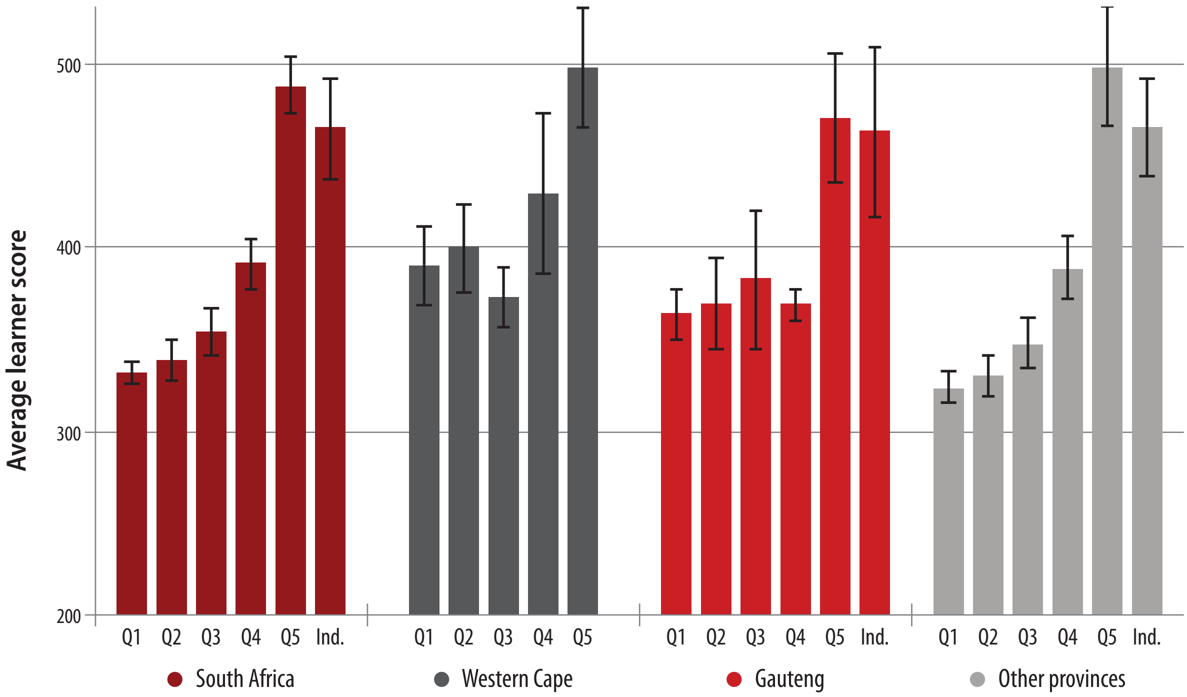


FIGURE 6: Mean Grade 5 learner performance in mathematics by quintile within regions in TIMSS 2019

Source: Author's own calculations

To draw attention to the differences in performance between learners from the poorer, no-fee schools (quintiles 1 to 3) and the richer, fee-paying schools (quintiles 4 and 5) as well as independent schools, Figures 7 and 8 show the percentage of learners who reach the respective international benchmarks for each of these groups of schools and the average performance of learners in each group. The results are glaringly unequal. While 67% of learners in the rich schools reaches at least the low benchmark, only 24% of learners in poorer schools reaches the same benchmark. Put differently, if there were 10 learners in each group, only 2 learners from poorer schools would reach the low benchmark compared to 7 from the richer schools. This means that there are fewer learners in poorer schools who are on track with their learning by the time they reach Grade 5, judged by performance against the low international benchmark. Worse still, up to 94% of learners within the poorer part of the education system do not reach the intermediate benchmark.

INTERESTINGLY, RELATIVELY POOR PERFORMANCE AMONG POORER LEARNERS MADE A MORE SIGNIFICANT CONTRIBUTION TO THE DIFFERENCE IN PERFORMANCE THAN OUTSTANDING PERFORMANCE OF THE RICH, WHOSE MEAN PERFORMANCE ALMOST MET THE INTERMEDIATE INTERNATIONAL BENCHMARK.

Concerning achievement, rich schools outperform poor schools by 105 points (447 compared to 342). On average, learners from the richer schools far outperform everyone else. Interestingly, relatively poor performance among poorer learners made a more significant contribution to the difference in performance than outstanding performance of the rich, whose mean performance almost met the intermediate international benchmark. Indeed, while the mean score of the rich learners places them in the upward tier of the low benchmark, that of the poor learners places them below even the low benchmark.

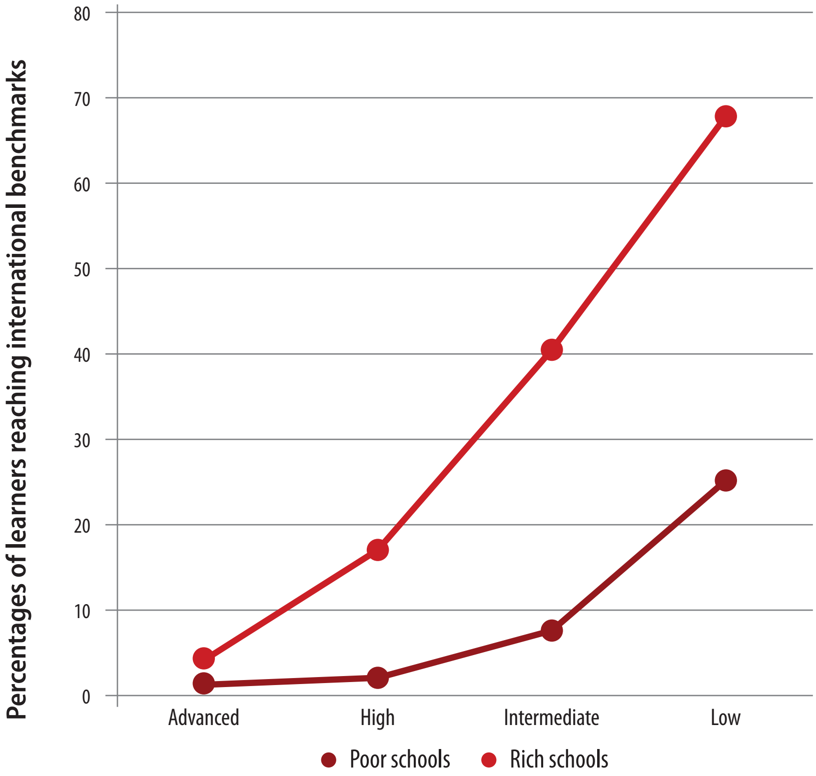


FIGURE 7: Percentages of Grade 5 learners reaching the respective international benchmarks of mathematics achievement by rich and poor schools in TIMSS 2019

Source: Author's own calculations

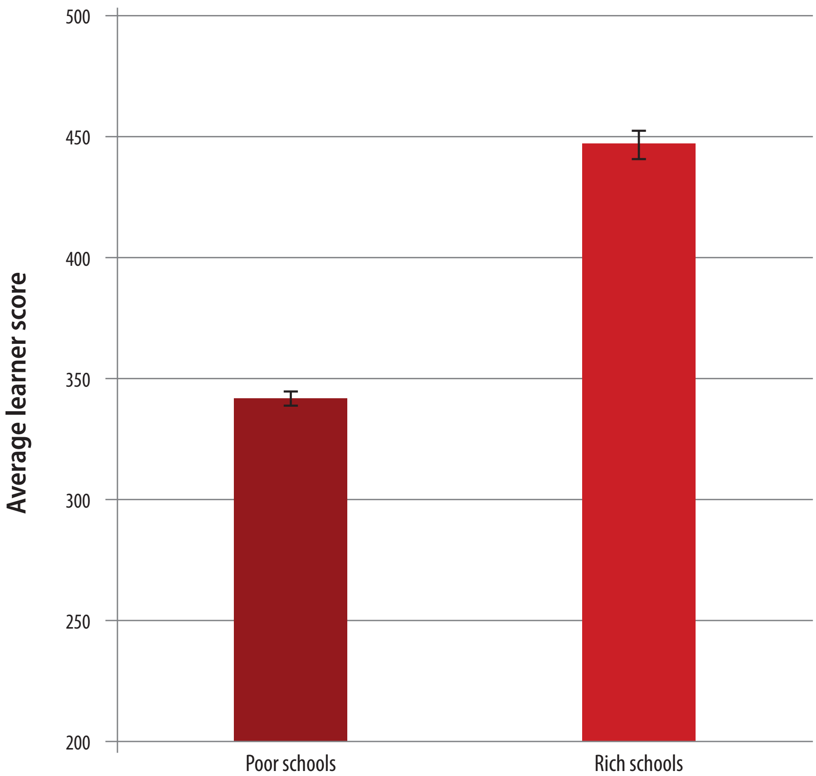


FIGURE 8: Mean Grade 5 learner performance in mathematics by rich and poor schools in TIMSS 2019

Source: Author's own calculations

4 EMPIRICAL RESULTS

4.1 Multivariate regression analysis

This section explores the results from estimating the production function shown in equation (1). The regression analysis not only accounts for the complex survey design of the TIMSS data; it also uses appropriate techniques developed for use with plausible values, since TIMSS does not assign single scores to each individual learner, as is typically the case with other international assessments. Furthermore, all models include coefficient results for the full set of selected covariates.

As a starting point, Table 1 shows estimates for all four samples in the following order: column 1 shows the Western Cape, column 2 Gauteng, column 3 the sample of the seven remaining provinces, and column 4 the full South African sample. This helps isolate the effect of the same set of explanatory variates on the different samples, which this paper theorises to be different due to the uniqueness of each sample. For example, it is reasonable to assume that the effect of attending preschool on learner performance in the Western Cape – where learners on average outperformed their Grade 5 counterparts – is more significant compared to others.

As done in the descriptive section, this same train of thought is carried over to Section 4.2. In this section, the focus is solely on the coefficients of the same explanatory variables; however, schools are split into rich schools and poor schools. Whereas the focus was more on regional and national performance divergences before, it changes to poor, usually less-resourced schools versus richer, generally better-endowed schools. Again, schools from quintiles 1 through 3 are grouped together to form the "poor schools" category, while quintiles 4 and 5 and independent schools together make up the "rich schools" category. In both discussions, all coefficient estimates are interpreted as the impact of a marginal change in the explanatory variable on expected learner performance after controlling for the other included variables.

IT IS REASONABLE TO ASSUME THAT THE EFFECT OF ATTENDING PRESCHOOL ON LEARNER PERFORMANCE IN THE WESTERN CAPE – WHERE LEARNERS ON AVERAGE OUTPERFORMED THEIR GRADE 5 COUNTERPARTS – IS MORE SIGNIFICANT COMPARED TO OTHERS.

4.2 National and regional performance in mathematics

In all models, SES appears to have a positive and significant impact on learner performance. Considering the plethora of international research that has been reporting similar findings from as early as 1966, with the renowned Coleman Report (Coleman et al., 1966), this comes as no surprise. In the South African context, this finding is consistent with the country's high levels of income inequality as well as the persistent reports of differences in performance between rich and poor learners (Van der Berg, 2008; Taylor & Yu, 2009). From a magnitude standpoint, one immediately notices that for the relatively poorer "Others" sample, the impact of learner SES – though also positive – is less than half the impact in richer regions like the Western Cape. This suggests that for learners from poorer areas, the positive impact of coming from a well-resourced family is much smaller than in other regions like Gauteng. This is similar to an observation by Van der Berg (2008) that found that SES only started playing a role at a higher income threshold, whereas at low levels, individuals and schools did not appear to gain much in terms of their performance.

> LEARNERS WHO WENT TO SCHOOLS IN URBAN AREAS PERFORMED SIGNIFICANTLY BETTER THAN THOSE IN RURAL-BASED SCHOOLS, EXCEPT IN THE WESTERN CAPE, WHERE PERFORMANCE BY SCHOOL LOCATION DID NOT APPEAR TO BE STATISTICALLY DIFFERENT.

Looking at overage learners (12 years and older), it is apparent that older learners in all regions do worse than learners who are on track with their learning according to their age. Interestingly, learners in the Western Cape who are older and likely repeating a grade perform worse in Grade 5 mathematics than overage learners in Gauteng and the seven other provinces, controlling for other factors. Furthermore, learners who went to schools in urban areas performed significantly better than those in rural-based schools, except in the Western Cape, where performance by school location did not appear to be statistically different. In Gauteng, learners who attended urban schools gained about twice the advantage of learners who attended urban schools in the other seven provinces. Girls on average perform better than boys, however, as noticed in the descriptive analysis, this pro-girl advantage, though evident in all regions, is only significant in the "Others" and full South African sample. Lastly, as already seen in the descriptive section, quintile 5 and independent schools perform much better than the rest. This advantage is most evident in the "Others" sample.

TABLE 1: Multivariate OLS (Ordinary Least Squares) regression results

	WESTERN CAPE	GAUTENG	OTHERS	SOUTH AFRICA
SES	17.28***	14.68***	7.529***	10.40***
	(2.905)	(1.998)	(1.496)	(1.104)
SES-squared	–0.0642	0.975	0.175	0.581
	(1.370)	(0.828)	(0.683)	(0.515)
Female	9.381	8.578	12.94***	12.69***
	(6.132)	(6.295)	(3.185)	(2.473)
Urban	–1.801	41.20**	20.88*	21.82**
	(16.26)	(14.48)	(8.855)	(6.799)
Overage	–52.66***	–35.66***	–38.78***	–39.86***
	(5.753)	(6.743)	(3.456)	(2.625)
Preschool	11.80	5.776	4.734	5.637*
	(6.050)	(6.705)	(3.036)	(2.610)
Quintile 2	0.191	0.503	5.544	5.855
	(21.84)	(9.316)	(7.599)	(6.521)
Quintile 3	–31.22*	20.55	12.55	11.15
	(14.26)	(14.15)	(7.472)	(6.057)
Quintile 4	10.98	–7.256	41.25***	30.71***
	(20.12)	(9.976)	(10.27)	(7.382)
Quintile 5	63.59**	76.12***	125.3***	107.9***
	(19.51)	(16.95)	(17.57)	(9.631)
Independent	–	71.41**	110.8***	95.33***
	–	(22.20)	(10.77)	(11.86)
N	1 126	1 503	8 707	11 336
R-squared	0.412	0.363	0.313	0.375

Notes: The estimation uses five plausible values. Standard errors are indicated in parentheses. Significance is at the *10%, **5% and ***1% level of significance.

Source: Author's own calculations

4.3 Performance by school economic status: poor versus rich

To clearly showcase the differences in the bimodal system of South African primary education (Shepherd, 2011; Spaull, 2013), this section reports the results of running the same regression specification as in equation (1), but for the poor and rich school sub-samples separately, as shown in Table 2. Keep in mind that the descriptive analysis showed that only 24% of learners from poor schools reaches the low benchmark on the TIMSS Grade 5 assessment scale, compared to 67% for the richer schools. With this in mind, the coefficient estimates for these two schooling systems will be considered.

Looking at the R-squared term, it is immediately apparent that, overall, the covariates in this simple regression do a far better job of explaining learner performance in the richer schools (with an R-squared term of 35%) than in the poorer schools (with R-squared at 13%). This likely speaks to the fact that the well-resourced schools are better at converting their inputs into improved learner performance and that poorly functioning school systems and processes may significantly detract from performance in many poor schools.

Moving on to the explanatory variables themselves, it is evident that higher SES in the poorer part of the education system does not lead to as high an increase in learner performance as it does in richer schools. In the rich school sub-system, learner performance improves by up to 18 points when SES increases by one standard deviation, compared to only 5 points in the poor school sub-system. This may be related to poorer schools being of lower quality and therefore less responsive to an improvement in learners' SES.

> IT IS EVIDENT THAT HIGHER SES IN THE POORER PART OF THE EDUCATION SYSTEM DOES NOT LEAD TO AS HIGH AN INCREASE IN LEARNER PERFORMANCE AS IT DOES IN RICHER SCHOOLS.

On the one hand, the idea that higher SES does not guarantee a significant improvement in performance could be seen as a good thing. It means that the education system is doing a good job of providing learners with a fair opportunity to achieve high scores irrespective of their home background. On the other hand, however, it is not ideal for such an equality to occur at such a low level of performance. In fact, it could be particularly disheartening for parents and caregivers to realise that, unless they cross a particular SES threshold (in this case, crossing over to a quintile 4 or 5 school), their efforts to improve their children's academic performance may be inconsequential (see also Van der Berg, 2008).

Unlike the richer schools, schools located in urban areas in the no-fee sub-system tend to perform significantly better than those located in rural areas. Among the richer schools, the urban advantage was insignificant. Again, this is likely pointing to the issue of school quality, where urban-based schools in quintiles 1 to 3 may be more efficient than their rural counterparts. As expected, older learners perform worse than on-track learners in both groups. Interestingly, the pro-girl achievement gap is more pronounced in poorer schools, whereas it is insignificant in richer schools. The reason for the girls' outperformance in poorer schools is not clear.

Lastly, the estimated effects of attending preschool, though positive in both sets of schools, are only significant among the richer schools. That is, for learners in the poorer part of the schooling system, it makes no difference in their Grade 5 performance whether or not they attended preschool. In stark contrast, in rich schools, even as late as in Grade 5, the effects of attending preschool are equally significant to the impact of coming from a higher SES background (15 and 18 points respectively). Taken together with the fact that more learners from this part of the schooling system reach at least the low international benchmark for mathematics, this may imply that learners who attend preschool are simply better suited to thrive in primary school, since they enter that part of the school system at an advantage. This is a likely scenario, because as research elsewhere has shown, inequality in the South African education system begins to manifest as early as preschool (Giese et al., 2022). Poor children are more likely to live in households without access to early learning programmes (ELPs). In fact, a three-year-old child in the richest quintile is twice as likely to attend an ELP as a child in the poorest quintile (Hall et al., 2019). In addition, even when children in the poorest quintiles have access to ELPs, these programmes are likely to be of inferior quality to ELPs for children from wealthier backgrounds (Giese et al., 2022). This is important since children who attend high-quality ELPs are more likely to outperform their peers, finish secondary school, and earn higher wages (García et al., 2016). This makes it clear that attending preschool would not have the same effect on these two groups of learners' performance in primary school. More generally, it is clear that the relationships between school performance and the covariates highlighted in this paper are significantly different for these two groups of schools.

GENERALLY, IT IS CLEAR THAT THE RELATIONSHIPS BETWEEN SCHOOL PERFORMANCE AND THE COVARIATES HIGHLIGHTED IN THIS PAPER ARE SIGNIFICANTLY DIFFERENT FOR THESE TWO GROUPS OF SCHOOLS.

TABLE 2: Multivariate OLS regression results for poor versus rich schools

	POOR SCHOOLS (Q1–Q3)	RICH SCHOOLS (Q4, Q5, AND INDEPENDENT)
SES	5.480***	18.07***
	(1.247)	(2.151)
SES-squared	–0.933	0.662
	(0.529)	(0.941)
Female	14.65***	6.881
	(2.598)	(5.019)
Urban	31.39***	4.249
	(8.282)	(9.187)
Overage	–39.09***	–42.15***
	(2.889)	(4.867)
Preschool	1.765	15.25***
	(3.234)	(4.449)
Quintile 2	6.260	–
	(6.525)	–
Quintile 3	11.05	–
	(6.094)	–
Quintile 5	–	73.93***
	–	(7.805)
Independent	–	61.14***
	–	(12.55)
N	8 129	3 207
R-squared	0.126	0.350

Notes: The estimation uses five plausible values. Standard errors are indicated in parentheses. Significance is at the *10%, **5% and ***1% level of significance. For column 1, quintile 1 is the reference category, and for column 2, quintile 4 is the reference category.

Source: Author's own calculations

5 CONCLUSION

This paper sought to identify the factors that account for differences in Grade 5 learner performance in mathematics among several samples of interest: both regionally (the Western Cape, Gauteng, the seven remaining provinces, and South Africa as a whole) and on an SES basis (poor versus rich schools). This was done using an education production function, where TIMSS 2019 Grade 5 mathematics test scores were regressed on a selection of learner factors. The data have made it possible to show that these samples are indeed characterised by unique data-generating processes, as can be seen from the different coefficient estimate sizes and significance for each of the sub-samples.

From both the descriptive and regression analysis, it is clear that the current state of South Africa's education system cannot be separated from the high levels of inequality in the country, despite many brave attempts to do so. Although there have been pockets of progress, the haunting legacy of apartheid still looms. Furthermore, the manifestation of the apartheid legacy is now also strongly linked to socio-economic inequality.

Following from this, it is glaringly apparent that outside of rich schools and individuals, the effect of all but one of the included inputs is neutralised. This is particularly concerning given that similar findings were reported by Van der Berg (2008) using data from 2000, more than two decades ago. This suggests that, even though many years have passed since the end of apartheid, poorer schools still find it challenging to overcome inherited socio-economic disadvantages. However, it is encouraging that among the poor schools, learners who attend schools located in urban areas perform significantly better than their rural peers, likely because these schools are more effective.

Provincially, the Western Cape and Gauteng continue to be the best-performing provinces in mathematics at both Grade 5 and Grade 9 levels (Reddy et al., 2020a; Reddy et al., 2020b). Overage learners (who are likely repeating grades) in the Western Cape, however, perform the worst, perhaps indicating that the Western Cape's progression policy is less strict. Higher SES has a more significant impact on performance in the Western Cape and Gauteng compared to the other seven provinces. Furthermore, even though girls perform better than boys in all provinces, girls' performance is similar to that of boys in the Western Cape and Gauteng.

Overall, South Africa has a long way to go to catch up to the international education community. While the findings in this paper show how learners from richer backgrounds outperform everyone else, even they – and indeed South Africa as a whole – desperately lag behind numerous other countries as it pertains to the TIMSS Grade 5 performance. In fact, of the 64 participating countries, South Africa only outperformed Pakistan and the Philippines, making it one of the poorest-performing countries (Mullis et al., 2020). Likewise, even the mean learner performance of the best-performing South African samples (the Western Cape, Gauteng, and rich, fee-paying schools) do not reach the TIMSS centerpoint score of 500.

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