# Chapter 9
# Mathematics Achievement and the Inequality Gap: TIMSS 1995 to 2015

**Vijay Reddy, Andrea Juan, Kathryn Isdale, and Samuel Fongwa**

## 9.1 Introduction

Numerical, mathematical[1] and analytical skills are key for participation as citizens in a modern society and as workers in the new knowledge economy.

> [Mathematics] is a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. It helps to develop mental processes that enhance logical and critical thinking, accuracy and problem-solving that will contribute in decision-making (Department of Basic education 2011, p. 8).

Foundational reading and numerical skills are critical for any future learning and knowledge and skill acquisition in these domains cannot be leap-frogged.

Mathematics achievement is 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 an important indicator of the competencies available for the workplace. Learners with sound mathematical skills, can participate in

[1] We acknowledge the importance of reading and literacy skills. These are dealt with in the Chaps. 8 and 9.

V. Reddy (✉) · A. Juan
Education and Skills Development, Human Science Research Council, Durban, South Africa
e-mail: vreddy@hsrc.ac.za; ajuan@hsrc.ac.za

K. Isdale
QER Consulting, Cape Town, South Africa
e-mail: kate.isdale@gmail.com

S. Fongwa
Education and Skills Development, Human Science Research Council, Pretoria, South Africa
e-mail: sfongwa@hsrc.ac.za

 
N. Spaull, J. D. Jansen (eds.), *South African Schooling: The Enigma of Inequality*, Policy Implications of Research in Education 10,
https://doi.org/10.1007/978-3-030-18811-5_9

higher level cognitive reasoning and problem solving tasks and possess abilities that make them more easily trainable in a number of jobs, giving them higher labour market mobility and freedoms. Currently the jobs which are in highest demand and are best rewarded in South Africa, are those with mathematics and science foundations (Reddy et al. 2016a). South Africa has embarked on an inclusive economic development pathway dependent on science, technology and innovation for which mathematics and science competence are necessary for social and economic progress (National Planning Commission 2012).

However, results from national, regional and international achievement studies (Annual National Assessments, Southern African Consortium for Monitoring Educational Quality, Progress in International Reading Literacy Study, Trends in International Mathematics and Science Study) all point to poor performance in reading, mathematics and science for South African youth. This chapter aims to tease out some of the contextual factors linked to the current achievement trends observed from the studies. The chapter uses the lens of inequality to show how access to socioeconomic resources at the individual, home and school levels shapes the mathematics performance of learners. The first part of this chapter uses grade 9 data from the Trends in International Mathematics and Science Study (TIMSS)[2] to paint a textured picture of South African mathematics achievement patterns over the last 20 years. The second part of the chapter will examine the continuities and discontinuities in home and school conditions and their influence on achievement patterns using grade 5 TIMSS data.

## 9.2 Mathematics Achievement, Inequality and Quality

The journey towards improved educational outcomes (including achievement) is a long and arduous process for policy makers and researchers globally. This is further complicated in low income countries and households where achievement outcomes are both a determinant and consequence of the stage of development. Children from poor families are less likely to start, progress or complete schooling successfully due to contextual and personal challenges linked to their socioeconomic backgrounds. These challenges are exacerbated in the science related subjects where more individual and social resources are needed to support learners through the challenging curriculum and content. The reasons for these achievement patterns are complex and multi-dimensional, and go beyond simply household incomes.

We borrow the framework of inequality of opportunities (UNDP 2013) to enhance our understanding of achievement levels and gaps in unequal societies. Inequality of opportunity refers to actual opportunities that give people the freedom

[2]TIMSS is designed to assess the mathematics and science knowledge of learners. South Africa participated at Grade 5 and 9. See the TIMSS 2015 Grade 9 National Report (Zuze et al. 2017) and the TIMSS 2015 Grade 5 National Report (Isdale et al. 2017) for the TIMSS methodology.

to pursue a life of their own choosing. Lanzi (2007) expands that any evaluation of human training outcomes will be limited if it does not adequately account for the effects of social norms, inequalities and individual freedoms (or lack thereof), as well as power structures explicitly or implicitly responsible for the outcomes.

What then would constitute an equality of opportunity framework to explain achievement gaps? TIMSS uses the curriculum, broadly defined, as the organising concept in considering how educational opportunities are provided to learners (Mullis and Martin 2013). This framework is structured around four broad areas: home contexts, school contexts, classroom contexts and learner attitude towards learning. In this chapter we will focus on home and school contexts, as well as early learning environments and experiences.

### *9.2.1 Homes*

Home resources refer to the tangible assets within a home and provide an indicator of home socioeconomic status, as well as the intangible assets like parental education, exposure to early literacy and numeracy activities, parental involvement in homework and pre-school education. A meta-analysis of 58 studies, found that socioeconomic status (measured by parental education, parental income, and parental occupation) is a moderate to strong predictor of academic achievement, with low socioeconomic status predicting low achievement (Sirin 2005). Learners with more educated mothers tend to exhibit higher academic achievement scores (Reynolds and Walberg 1991; Carneiro et al. 2013).

Other researchers, however, argue that it is actually what goes on in the home that is associated with learners' achievement, in combination with socioeconomic status. Variables such as parental support, encouragement and expectations for their child's schooling play an important role in academic achievement. Arguably learners from better social classes seem to have better parental support and learning expectations from parents compared to those from families of a lower social status. The early learning environment, experiences and nurturing of children are correlated with the extent of their cognitive development and school readiness (Melhuish et al. 2008). For children from different social and economic circumstances, disparities in cognitive and non-cognitive, as well as literacy and numeracy skills are already evident when they enter school and these abilities are predictive of subsequent academic performance (Shonkoff et al. 2000). Cunha et al. (2006) explain that *skill begets skill*, and that skill formation is a life cycle process. The attainment of skills at one stage of the life cycle consequently raises their ability to attain skills later on. Early childhood education is therefore an integral part of basic education as the skills formed during this period are necessary for the attainment of future skills (Cunha et al. 2006).

### 9.2.2 Schools

Children enter schools with different levels of readiness for learning. The role of the school is to start the learning process from where the child is, and to bridge the gap between the less prepared and better prepared learners through various forms of pedagogical support. However, in South Africa due to the historical imbalances in the provision of educational resources from the previous government, two types of schools have emerged: affluent, functional schools and poor, dysfunctional schools (Van der Berg 2008). These historical inequalities are again compounded by current managerial inefficiencies which continue to affect the historically disadvantaged schools. Only about one third of schools could be considered as functional (Van der Berg 2008).

Many teachers seem to underestimate the role that the school and classroom environments play in learner success. As with the home environment, the school environment cannot simply be characterised just by the availability of resources. Aspects such as classroom morale, teacher support, availability of classroom materials and a goal directed school and classroom enhance the learners' cognitive and overall development. Murugan and Rajoo (2013) posits that the quality of classroom learning and the instructional environment is a significant determinant for learners' mathematics achievement. The time that learners spend engaging in the learning experience, including engaging with the teacher, and the time spent on personal learning through doing homework and group work, affects their final achievement scores.

South African studies have established that the availability of key school resources influences educational outcomes, with higher levels of resources being linked to better educational outcomes (Fiske and Ladd 2004; Oosthuizen and Bhorat 2006; Van der Berg 2008). Socioeconomic inequalities at the school level play a role in the educational outcomes of South African learners, as learners in the richest quintile of schools outperform schools in the other four quintiles substantially (Van der Berg 2008). Zuze et al. (2017) showed that although schools with more resources and better facilities were at an advantage, the climate of learning played a unique and significant role that went beyond resources.

A noteworthy factor in performance among learners, is the disjuncture between the language of classroom teaching and learning, and the language of home communication. For the majority of learners in Grades 4 to 12 the language of teaching is different from the language spoken in the home (Howie et al. 2017; Reddy et al. 2015). Poor performance in both literacy and numeracy assessments across the foundation phase Grades 1 to 3 has been cited as one of the major factors linked to poor learning outcomes later in school (Bergbauer 2016; Van Staden 2016), with many children completing these early grades unable to read properly in their home language and with very little understanding of English, the main language of instruction used from Grade 4 (Spaull et al. 2016; Howie et al. 2017).

Given these inequalities of opportunity, Stewart's (2002) notion of horizontal inequality helps shape the analyses. She defines horizontal inequalities as those among a group which have emerged based largely on historical biases, often as a result of colonialism and which tend to persist over many generations because of manifold connections between dimensions of deprivation and privilege. She argues that horizontal inequality is not only unjust, but may lead to reduced resource allocation as well as lessening societal attainment of quality health and education, especially for the deprived group.

The next section provides a broad overview of South Africa's mathematics achievement. We show that while South Africa has made significant progress in mathematics performance, it continues to show low achievement levels when compared to countries at similar levels of development. Furthermore, using fee-paying and no-fee schools as two schooling groups experiencing horizontal inequality due to historical biases, we show how personal level inequalities and schooling level inequalities result in achievement gaps within the system.

## 9.3 South African Mathematics Achievement from 1995 to 2015: Improving but Overall Low Achievement

The TIMSS offers a dual opportunity to benchmark South African mathematics achievement against other participating countries, and to monitor that achievement over time. The TIMSS was first administered in South Africa in 1995, and subsequently in 1999 to Grade 8 learners. In 2003, TIMSS was administered to Grade 8 and 9 learners, and in 2011 and 2015 just to Grade 9 learners. This unique trend dataset offers an opportunity for the country to measure and analyse mathematics achievement patterns over 20 years.

In TIMSS 2015, South Africa, with a mathematics achievement score of 372[3] (SE,[4] 4.5), was one of the lower performers (again) of the 39 participating countries. The five highest ranked countries were from East Asia: Singapore (mathematics achievement score of 621), Republic of Korea (606), Chinese Taipei (599), Hong Kong SAR (594) and Japan (587). The five lowest ranked countries were from Africa and the Middle East: Botswana (391), Jordan (386), Morocco (384), South Africa (372) and Saudi Arabia (368).[5]

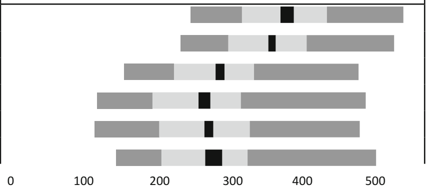
While South Africa's low ranked position of the participating countries is the focus of much of the public discourse, the more informative story is how South Africa's average mathematics achievement score changed from 1995 to 2015.

[3]The TIMSS CenterPoint is 500 and the standard deviation is 100.

[4]Standard Error (SE) is a measure of the statistical accuracy of an estimate.

[5]Of the five lowest achieving countries, the only country with a statistically different score to that of South Africa was Botswana

| Mathematics | Average Scale score | Score distribution: At 5th & 95th percentile | Achievement distribution |
|---|---|---|---|
| Grade 9 2015 | 372 (4.5) | 242-529=287 | |
| Grade 9 2011 | 352 (2.5) | 229-516=287 | |
| Grade 9 2003 | 285 (4.2) | 152-472=320 | |
| Grade 8 2003 | 264 (5.5) | 117-484=367 | |
| Grade 8 1999 | 275 (6.8) | 113-485=372 | |
| Grade 8 1995 | 276 (6.7) | 142-496=354 | |



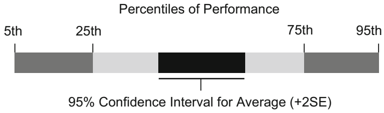




**Fig. 9.1** Trends in mathematics achievement in TIMSS 1995, 1999, 2003, 2011 and 2015. (Sources: Reddy et al. 2016b; Zuze et al. 2017)

Figure 9.1 plots the South African mathematics achievement for TIMSS 1995, 1999, 2003, 2011 and 2015.[6]

The first piece of good news is that the South African average mathematics achievement increased from 1995 to 2015. The changes can be described in three phases: from 1995 to 2003 the average mathematics achievement was not statistically different, possibly because of the collateral damage due to the political and structural changes that took place with the change to a democratic country in 1994. In contrast, from 2003 to 2011 the average mathematics achievement improved by 67 points (Reddy et al. 2012), an improvement of an average of 7.4 TIMSS points per year. From 2011 to 2015 mathematics achievement improved by a further 20 points (Reddy et al. 2016b), an improvement of an average of 5 TIMSS points per year.

The achievement distribution between the 5th and 95th percentile provides a measure of the achievement gap. In 1995, this difference was just over 3.5 standard deviations. In 2015, the achievement gaps narrowed slightly, by 0.6 of a standard deviation, to 287 points.

TIMSS further categorises learners who achieve above 400 points,[7] as having met the minimum competencies for that grade (Mullis et al. 2016). In 2003, 11% of Grade 9 learners achieved a mathematics score higher than 400 points, in 2011 this more than doubled to 25% and in 2015 increased further with one third of the learners achieving above this minimum competency benchmark. While

[6]The percentile graph plots the trend in mathematics achievement distribution between the bottom and upper ends at the 5th and 95th percentile at the Grade 8 level (1995, 1999, 2003) and at the Grade 9 level (2003, 2011,2015).

[7]Learners have some knowledge of whole numbers and basic graphs.

this improvement is laudable, the other side of the coin is that in 2015 two-thirds of Grade 9 learners were unable to achieve these minimum mathematical competencies. Likewise, the change in the overall average mathematics achievement from *very low* (1995 to 2003) to *low* (2011, 2015) is to be applauded, but the concern is that progress and gains in learning seem to be slowing down. If the progress continues at the current rate, in the TIMSS 2027 cycle, South Africa could be closer to the National Development Plan mathematics achievement target of 430 TIMSS points (National Planning Commission 2012). In addition, half the learners should achieve above the minimum competency level. TIMSS 2019 will provide a third data point to better extrapolate the achievement trajectory.

The second piece of good news is that although South Africa is one of the lower performing TIMSS countries, from 2003 to 2015, it showed the largest positive improvement of all participating countries in mathematics. South Africa started from a very low base and thus had greater potential to improve (Reddy et al. 2016b), but it is nevertheless encouraging to note that the highest achievement gains were at the lower end of the distribution spectrum, that is, the most disadvantaged groups. TIMSS scores at the 5th percentile, improved by almost one standard deviation[8] from 152 points in 2003 to 242 points in 2015. At the 95th percentile, mathematics scores increased by 0.6 of a standard deviation from 472 points in 2003 to 529 points in 2015. The achievement improvement at the 5th percentile is possibly due to the many social protection policies and interventions for the most disadvantaged households and schools (social grants, school feeding programme, no-fee policy for schools, free health care). These social protection policies, even though not implemented optimally, have made a difference in decreasing the levels of poverty, and would have had a knock on effect of improving living and learning conditions and learning outcomes (Woolard et al. 2011).

South Africa is characterised by high levels of unemployment, income poverty and inequality, so a single average achievement score does not tell the full story. For a more textured achievement story we would need to disaggregate the achievement score for different socioeconomic status groups. To provide economic relief to the low income households, government has removed the barrier of school fees for two thirds of school going learners, thus public schools are categorised as either fee-paying or no-fee schools. We use these school types, fee-paying and no-fee schools, as a proxy for school SES.[9] Figure 9.2 sets out the mathematics achievement (average scores and competence levels) for learners in no-fee and fee-paying schools.

The average mathematics achievement for learners in no-fee schools was 341 (SE 3.3) and 430 (SE 8.9) for learners in fee-paying schools, reflecting the achievement gap between learners from higher and lower SES households. The achievement gap between these two school SES types is approximately one standard

[8]The standard deviation (SD) measures the dispersion of a dataset relative to its mean.

[9]The TIMSS 2015 Grade 9 sample comprised of 65% learners who attended public no-fee schools and 35% who pay fees (31% in public fee-paying and 4% in independent schools).

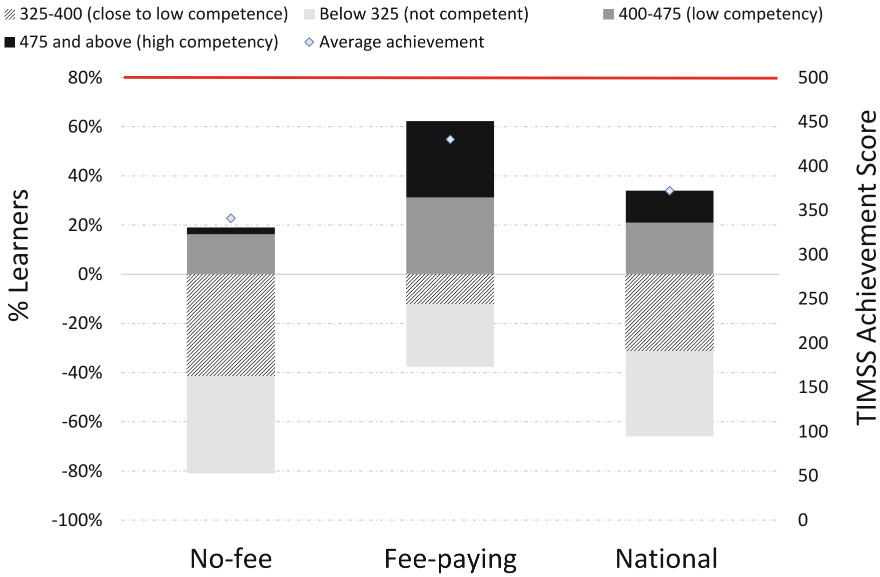



**Fig. 9.2** Average TIMSS 2015 mathematics score and competence level by no-fee and fee-paying (public and independent) schools

deviation, meaning that performance levels are almost four grade levels apart.[10] This further demonstrates the extent of inequalities between school types. While low achievement levels in no-fee schools are well documented, the TIMSS results also showed that the average mathematics achievement score of learners in fee-paying schools fell well below the centerpoint and placed this group at a similar performance level as Chile, Thailand and Iran.

When the mathematics achievement scores are analysed for each of the school types, the patterns reveal the extent of the inequalities: only one in five (19%) learners in no-fee schools and three in five (62%) learners in fee-paying schools had accumulated knowledge and skills above the minimum competency level. This means that 81% of learners in no-fee schools and 38% of learners in fee-paying schools did not have the minimum knowledge and skills needed for that grade. We introduced an additional benchmark, at 325 points, to establish how close learners were to the minimum benchmark. It is promising to note that in no-fee schools, half the group below the score of 400 points were categorised at close to the minimum competence level and two thirds of learners in fee-paying schools were in this category. This group of *almost competent*, could, with the appropriate school-based interventions be supported to achieve mathematics scores over 400 points.

[10]The difference between Grade 8 and 9 scores in TIMSS 2003 was 21 points (see Reddy 2006). We estimate with the learning gains over time, the score difference between Grade 8 and 9 is around 25 TIMSS points.

Within the general national profile of low and unequal performance, 13% of learners scored above 475 points. These learners would have a higher probability of passing the Grade 12 examinations and gaining access to post-secondary education. It is encouraging to note that 3.2% of South African mathematics learners achieved mathematics scores at the *high level* of achievement (above 550 points), an achievement higher than other low performing countries.

In trying to understand the depth of inequalities responsible for the achievement gaps between fee-paying and no-fee schools, further analysis was conducted. Based on these analyses, three key factors emerged as important in understanding achievement gaps within the South African context. These relate to home conditions, the early education environment and school learning conditions.

## 9.4 Home to School: Continuities or Discontinuities?

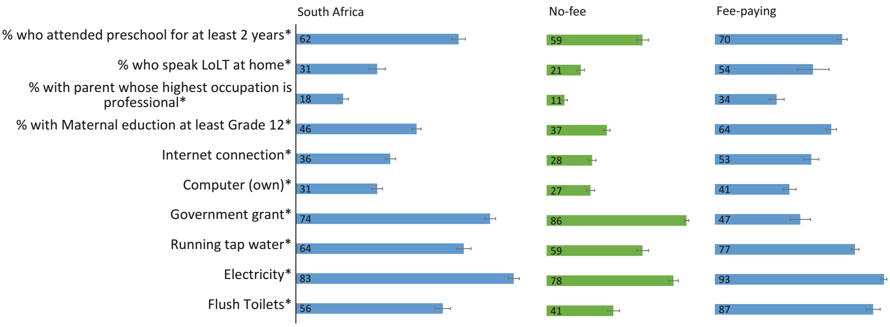
The South African educational challenge, as in other middle income countries, is to raise the achievement levels of children in schools, decrease the inequalities between the affluent and the poor, and increase the rate of change of progress in achievement outcomes. There are many factors that shape individual learning. In this section we will demonstrate the influence of the continuities and discontinuities in home and school conditions on achievement patterns.

We use the TIMSS 2015 Grade 5 data, which included information about both home and school contexts and activities, to describe the conditions in which learners attending fee-paying and no-fee schools live and learn. Although interrelated, we structure our argument through the description of home resources, early learning environments and school resources and climate separately. Though important for a holistic understanding of learning experiences and outcomes, this analysis does not engage with teacher and classroom effects for which adequate data was not available.

### *9.4.1 Inequalities Begin in the Home*

Learning starts at home and schools should build on the educational capital accumulated there. The learning process is shaped by home contexts and the interactions within them; key are the basic physical resources, family background characteristics, and the learning resources. For South Africa we found that three-quarters of learners' households received at least one government social grant to contribute to the household income. As would be expected, a higher proportion of households of learners attending no-fee schools are recipients of social grants.

Household resources were vastly unequal across learners attending fee-paying and no-fee schools as shown in Fig. 9.3 below: overall 83% of Grade 5 learners had access to electricity; but access to basic amenities is concerning as only 64%




**differences significant at the 95% level*

*Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning and learner questionnaire data*

**Fig. 9.3** Reported percentages of learners' household assets, by overall frequency and frequency by school type (with 95% confidence intervals). *differences significant at the 95% level. (Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning and learner questionnaire data)

had access to running tap water and 56% to flush toilets in their homes. There is a statistically significant difference for these resources in the homes of learners in fee-paying and no-fee schools: in fee-paying schools 87% of learners had access to flush toilets compared to 41% in no-fee schools. Furthermore, while 77% of learners in fee-paying schools had running tap water, only 59% in no-fee schools had this amenity. Another resource which is becoming increasingly important for learning is digital technologies. The overall access to digital technologies and the internet in South Africa is low at approximately one-third of households. It is also unequal; learners in fee-paying schools have double the access compared to those attending no-fee schools.

Maternal education and parental occupation are two indicators of human and social capital, and signal what parents are able to afford for their children. These factors have consistently been shown as key predictors of achievement. On average, 37% of learners from no-fee schools and 64% of fee-paying learners came from households where mothers had a post-grade 12 education. This home educational difference led to one in 10 learners in no-fee schools and one in three learners in fee-paying schools having at least one parent in a job categorised as a professional occupation. These differences between fee and no-fee schools were statistically significant and contributes to learners' subsequent mathematics achievement.

The equivalence between the home language and the language of instruction in schools was another factor considered. Ninety one percent of the TIMSS Grade 5 assessments were completed in English and 9% in Afrikaans, giving those who were more proficient in English (or Afrikaans) a distinct advantage. Only a third of learners (31%) taking the TIMSS 2015 assessments always spoke the language of learning and teaching (LOLT) in the home. These patterns are statistically different in the two school types, with 54% of learners in fee-paying schools and 21% from no-fee schools speaking the same language at home and at school.

The effects of these variables on mathematics achievement were estimated in a conditional correlational model, when all variables were considered jointly in a single regression. The analysis confirmed that higher levels of household education and occupations, speaking the language of the test at home, having an internet connection, and having more books in a home all positively influenced mathematics achievement (Isdale et al. 2017).

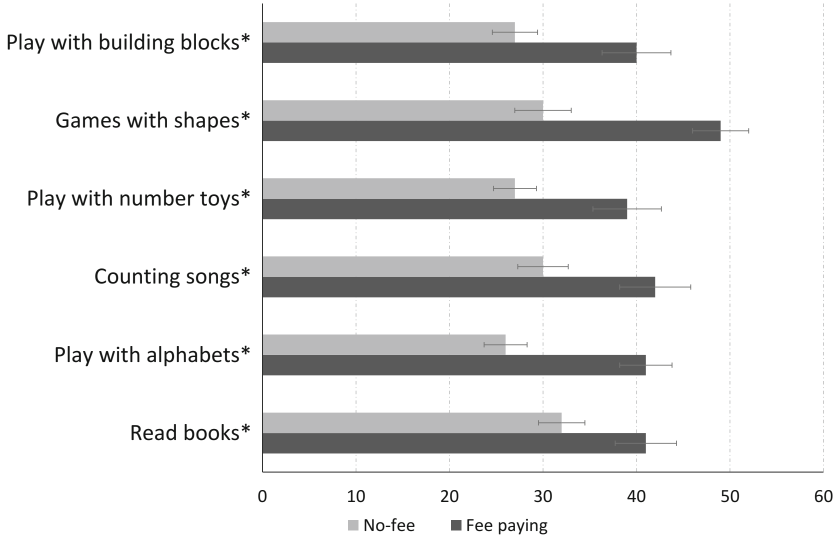
### *9.4.2 Varied Early Educational Environments*

A growing body of global evidence demonstrates that learning is more than a formal process that begins on entering a Grade 1 classroom, but is a cumulative endeavour beginning at home with the understanding of basic cognitive, linguistic, perceptual and motor processes which provide the building blocks for subsequent learning (Isdale et al. 2017). Parents of the Grade 5 learners who participated in TIMSS 2015 reported on the early educational activities[11] of their children. Close to one third of parents reported regularly engaging in some type of educational activities with their children: 35% read books, 30% played with alphabets, 34% sang counting songs, 31% played with number toys, 36% played with shapes and 31% played with building blocks. Figure 9.4 shows that, as expected, parents participated in these activities more in the homes of learners attending fee-paying than no-fee schools.

It is a social policy success that attendance to pre-Grade 1 facilities has increased considerably over recent years (Statistics South Africa 2017). Almost nine out of ten of the 2015 TIMSS learners reported pre-school attendance prior to Grade 1. The length of pre-Grade 1 attendance varied, with 62% of learners having attended two or more years of pre-school (59% for no-fee schools and 70% for fee-paying schools, a statistically significant difference). The mathematics achievement for learners who attended a pre-school for two years or more is statistically higher than those who did not attend (389 vs 353 TIMSS points).

Parents' assessment of their children's levels of literacy school readiness revealed that half of all learners were able to recognise most letters of the alphabet, 35% were able to read some words and 43% could write letters. For numeracy, one in four learners were able to count numbers up to 100 and one in five were able to recognise and write numbers up to 100 (Fig. 9.5). Parents of learners in both school types reported similar levels of skill in readiness for reading words, writing letters and writing numbers. The statistically significant difference between learners in the two school types, with learners in fee-paying schools scoring higher, are in recognising

[11] Notwithstanding that this is self-reported data from six years ago and the reported extent of the activities cannot be triangulated, these educational activity patterns still provides useful insights into home educational activities.



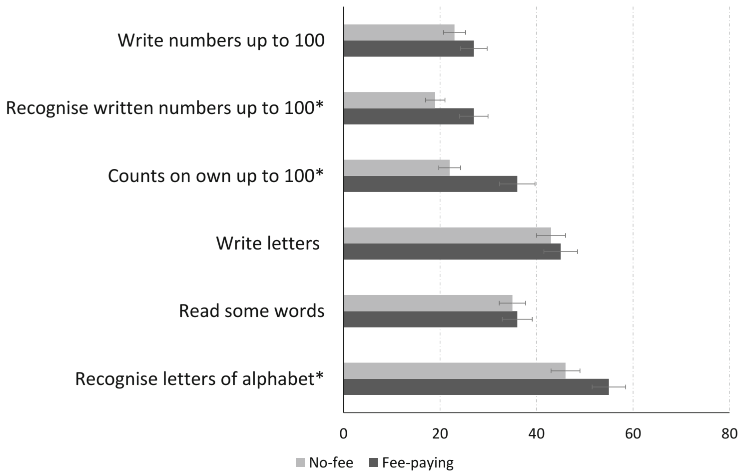

**differences significant at the 95% level*

*Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire*

**Fig. 9.4** Percentage of parents who reported 'often' engaging in early educational activities, by school type (with 95% confidence intervals). *differences significant at the 95% level. (Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire)

letters of the alphabet (by 9 percentage points), counting on their own up to 100 (by 14 percentage points) and recognising written numbers up to 100 (by 8 percentage points).

There was an association between the reported early literacy and numeracy skills and Grade 5 mathematics achievement scores: learners who were rated as having high levels of readiness in literacy and numeracy skills achieved an average mathematics score of 422; while those rated *moderately* achieved an average score of 376, and those rated as *not well* only scored an average of 338 points. This is corroborated by the conditional correlation model that found that levels of literacy and numeracy skills at school entry positively influence later mathematics achievement, even when taking into account a host of other variables known to influence academic performance (Isdale et al. 2017). This continuity in cognitive performance from home to school is one of the most replicated findings in developmental studies and further highlights the importance of the early educational environment.



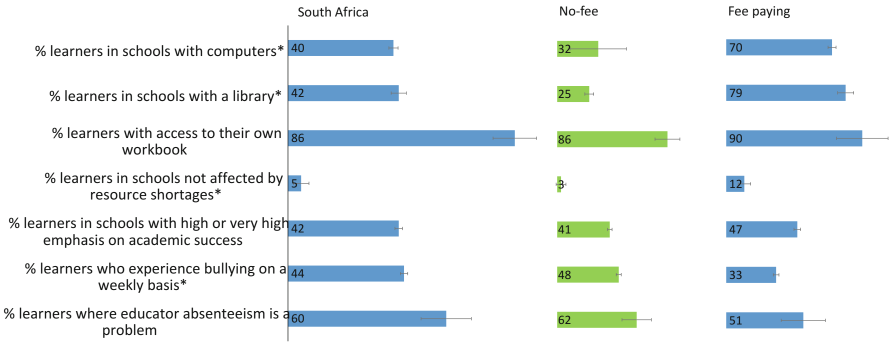

**differences significant at the 95% level*
*Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data*

**Fig. 9.5** Proportion of learners with strong literacy and numeracy skills prior to Grade 1 by school type (with 95% confidence interval). *differences significant at the 95% level. (Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data)

### *9.4.3 Inequalities Continue into Schools*

With these unequal educational starting points for children entering Grade 1, the expectation is that the schools with high quality resources and environments supportive of learning, will offset the home disadvantage. Inequalities, however, seem not to be limited to the home environment, but continue to the school environment and compound the inequality levels between learners in fee-paying and no-fee schools. Government policy highlights the importance of social transformation (that imbalances of the past are redressed and equal educational opportunities are provided for all) and inclusivity as a central tenet for the organisation, planning and teaching at each school (Department of Basic education 2011). However, these policies are silent on the resources needed for implementation. In this section we will examine whether schools contribute to the social transformation and inclusivity goals for all learners by examining the school resources and learning climate in fee-paying and no-fee schools (Fig. 9.6).

School resources are important to establish for a conducive learning environment. One of the key interventions of the South African government to improve learning outcomes was to develop and supply workbooks to all learners. This intervention is a policy success, with 90% of all learners reporting having access to workbooks, and there is positive association between having a workbook and a higher mathematics achievement score (Isdale et al. 2017). However, increased access to other resources




**differences significant at the 95% level*

*Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data*

**Fig. 9.6** School resources and climate characteristics by school type (with 95% confidence intervals). *differences significant at the 95% level. (Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data)

has not been achieved. Only 40% of Grade 5 learners attended schools where they had access to computers or a library, and this access was statistically significantly higher for fee-paying than no-fee schools. Principals' assessed the levels of resource shortages in their schools and only 5% of learners (against the international average of 27%) were rated as being in an environment not affected by resource shortages.

One-third of South African learners came from households considered to have few resources in comparison with an overall international average of 9 percent.[12] While household resources are linked to individual achievement, this relationship is also context dependent. Table 9.1 shows the TIMSS *Home Resources for Learning Index* by school type, with the results illustrating the interaction between household and school-level resources. As would be expected, across school types, those with few resources fare poorly, and achievement scores in both fee-paying and no-fee schools increased for learners with more resources. Learners with similar levels of home resources perform at different levels, with those in fee-paying schools performing at a much higher level than those in no-fee schools. Notable is that in fee-paying schools, the level of resources is strongly related to mathematics achievement (387 for few resources vs 460 for some resources). This is less so in no-fee schools (339 for few resources vs 352 for some resources), suggesting that even though the achievement score differences are statistically significant, there are factors other than resources that influence achievement.

In addition to resources, school climate has been identified as an important indicator influencing teaching and learning in schools. There are multiple dimen-

[12] A Home Resources for Learning Index was constructed from the number of books in the home, number of home study supports and the highest level of education for either parent.

**Table 9.1** Proportion of learners and average mathematics achievement scores by Home Resources for Learning Index

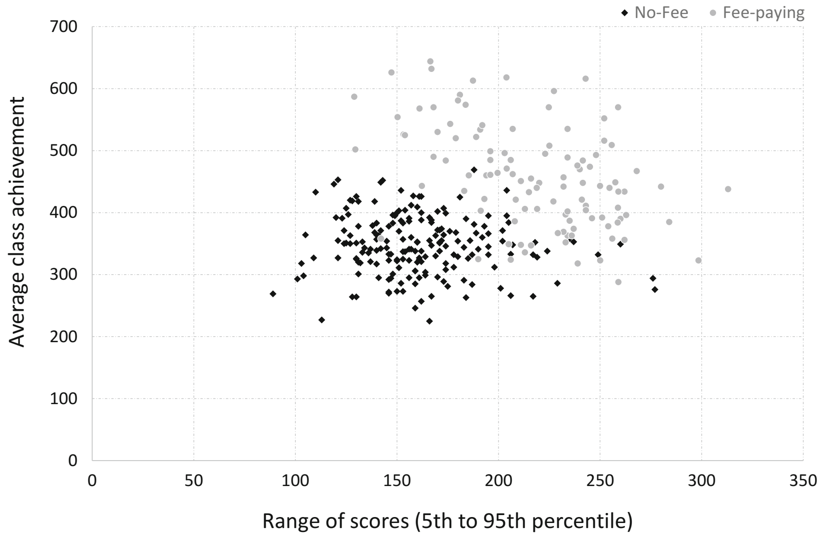
| | Few resources | | Some resources | | Many resources | |
|---|---|---|---|---|---|---|
| | % learners | Ave. score | % learners | Ave. score | % learners | Ave. score |
| South Africa | 34 (1.2) | 348 (3.2) | 65 (1.2) | 391 (4.1) | 2 (0.4) | 599 (10.0) |
| Fee-paying | 19 (1.8) | 387 (7.1) | 75 (1.8) | 460 (6.2) | 5 (1.1) | 605 (9.2) |
| No-fee | 40 (1.5) | 339 (3.7) | 60 (1.5) | 352 (3.8) | 0.1 (0.0) | Too few to estimate |
| International | 9 (0.1) | 427 (1.5) | 74 (0.2) | 501 (0.4) | 17 (0.2) | 569 (0.9) |

South African figures based on authors' own calculations from TIMSS 2015 Grade 5 learner questionnaire and achievement datasets. International figures from Mullis et al. (2016)

sions of school climate, many of which contribute to enhanced learning. A critical aspect of school climate relates to school safety and discipline, and incidences of bullying. A high proportion (44%) of Grade 5 South African learners reported experiencing at least one form of bullying on a weekly basis: one in two learners in no-fee schools and one in three learners in fee-paying schools (the difference is statistically significant). Forty-two percent of learners were in schools which placed a high emphasis on academic success and surprisingly this pattern is similar for both school types. Another factor contributing to school climate is the extent of teacher absenteeism. 60% of learners are in schools where teacher absence is a problem, and these patterns are also similar in fee-paying and no-fee schools.

In addition to low and unequal resources and poor learning climates in schools, there is a high variation of learner achievement in any one classroom (Fig. 9.7). The mathematics achievement distribution between the 5th and 95th percentile in fee-paying schools was 289 TIMSS points and in no-fee schools it was 223 TIMSS points, signalling higher levels of learner variation in fee-paying than no-fee schools. TIMSS tests intact classes of learners. In Fig. 9.7 we plotted the average class mathematics achievement against the mathematics distribution in the class (at the 5th and 95th percentile). In no-fee schools, the class average mathematics achievement scores are lower than for fee-paying schools, and the achievement distribution for the majority of no-fee classrooms are between 100 to 200 TIMSS points. In the case of fee-paying schools, the achievement distribution within the classroom are between 150 and 260 TIMSS points. These high achievement distributions place a serious burden on classroom teachers in terms of responding to the diverse needs of *all* learners.

Many of these factors are related to mathematics achievement. The conditional joint regression correlational model, estimates that achievement scores were slightly correlated with the presence of computers and libraries in a school and that achievement scores are negatively related to higher incidences of teacher absenteeism, poor school discipline and higher incidences of bullying (Isdale et al. 2017).




*Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data*

**Fig. 9.7** Grade 5 intra-class achievement distribution. (Source: Authors' own calculations based on TIMSS 2015 Grade 5 early learning questionnaire data. Note: TIMSS tests intact classes)

## 9.5 Breaking Out of Low and Unequal Achievement

One cannot separate the discussion of educational inequalities (achievement gaps) from that of educational outcomes (achievement levels). In summary, South African mathematics achievement, though improving, is still low and unequal. Between 1995 and 2015, South African mathematics achievement improved by 0.9 of a standard deviation. The highest improvement was at the lower levels of the achievement spectrum, that is, for the most disadvantaged groups, probably as a result of social protection policies instituted by the state. The achievement distribution has decreased slightly (0.6SD) from 1995, but is still one of the wider distributions (2.9SD) of all TIMSS participating countries. The achievement gap for those attending fee-paying and no-fee schools is close to one standard deviation and only 19% of learners in no-fee schools and 62% in fee-paying schools, demonstrate mathematical competencies above the minimum threshold value. In addition, there are wide achievement distribution patterns within classrooms, and more so for classrooms in fee-paying schools.

There is a general continuity in conditions from home to school. On most of the indicators important for supporting educational outcomes: home and school physical and educational resources, the early educational activities that parents are involved in with the children, and the characteristics of school life, our findings show that they are not available to the majority of the population. Further, there are differences for learners attending fee-paying and no-fee schools, reflecting the inequality of opportunities. The learners in fee-paying schools are advantaged by both home and school conditions, leading to higher achievement scores. School climate characteristics, however, are similar in both school types. The story in general is that advantage begets advantage, and while a few of the disadvantaged learners have evaded their predicted pathway, for the majority of these learners the school environment reproduces the conditions at home leading to low achievement outcomes.

Improving educational outcomes is a complex and multi-dimensional exercise, especially in an educational system starting from a low achievement base with high achievements gaps. The state must continue with social protection policies and resources for the homes that poorer children live in and the schools they attend, in order to improve the material conditions. Further, the quality of the learning experience for all learners must be addressed, through improved teaching and learning practices and learning climates in schools and classrooms.

The long term strategy to improve the achievement outcomes is to target the early years of learning. *Skill begets skill* and therefore solid knowledge and skills foundations are essential to move towards further learning. Social policies must prioritise investments in the earlier years of formal learning. This means two years of pre-Grade 1 schooling must be compulsory. It is not enough for children only to attend these institutions, the institutions in turn must be staffed by competent and caring teachers who provide high quality learning experiences and support to learners. In addition parents must be supported in terms of how to engage with their children to stimulate cognitive development. The first 1000 days of a child's life are focused on interventions for a healthy being, the next 1000 days of schooling (Grade RR, R, 1,2,3) must create a solid learning foundation.

While there are policies in place to address inequalities in schools and classrooms, they have not been accompanied by resources (financial and human) and support mechanisms to effectively implement the policies. Disrupting inequalities will require political will, additional resources and support and the commitment from all members of society. The process to increase achievement levels is not linear or smooth. It will involve the interplay of home and school material conditions, accompanied by high quality classroom teaching and learning interactions. This process will take time and we must set realistic expectations for the changes.

## References

Bergbauer, A. (2016). *The role of non-conventional inputs in South African education: An analysis of prePIRLS 2011*. Stellenbosch: University of Stellenbosch.

Carneiro, P., Meghir, C., & Parey, M. (2013). Maternal education, home environments, and the development of children and adolescents. *Journal of the European Economic Association, 11*(suppl_1), 123–160. https://doi.org/10.1111/j.1542-4774.2012.01096.x

Cunha, F., Heckman, J. J., Lochner, L., & Masterov, D. V. (2006). Chapter 12 interpreting the evidence on life cycle skill formation. In E. Hanushek & F. Welch (Eds.), *Handbook of the economics of education* (Vol. 1, pp. 697–812). Elsevier. https://doi.org/10.1016/S1574-0692(06)01012-9

Department of Basic education. (2011). *Curriculum and assessment policy statements: Mathematics grades* (pp. 7–9). Pretoria: Government Printers.

Fiske, E. B., & Ladd, H. F. (2004). *Elusive equity: Education reform in post-apartheid South Africa*. Washington, DC: Brookings Institution Press.

Howie, S., Van Staden, S., Tshele, M., Dowse, C., & Zimmerman, L. (2017). Progress in international reading literacy study 2016. South African Children's Reading Literacy Achievement. Summary Report. Centre for Evaluation and Assessment, Pretoria.

Isdale, K., Reddy, V., Juan, A., & Arends, F. (2017). TIMSS 2015 grade 5 national report: Understanding mathematics achievement amongst Grade 5 learners in South Africa. https://doi.org/20.500.11910/11847

Lanzi, D. (2007). Capabilities, human capital and education. *The Journal of Socio-Economics, 36*(3), 424–435. https://doi.org/10.1016/j.socec.2006.12.005

Melhuish, E. C., Phan, M. B., Sylva, K., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2008). Effects of the home learning environment and preschool center experience upon literacy and numeracy development in early primary school. *Journal of Social Issues, 64*(1), 95–114.

Mullis, I. V. S., & Martin, M. O. (Eds.). (2013). *TIMSS 2015 assessment frameworks*. TIMSS & PIRLS International Study Center, Boston College.

Mullis, I. V., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 international results in mathematics*. Boston: Boston College.

Murugan, A., & Rajoo, L. (2013). Students' perceptions of mathematics classroom environment and mathematics achievement: A study in Sipitang, Sabah, Malaysia. In *International Conference on Social Science Research*, Malaysia.

National Planning Commission. (2012). *National development plan 2030: Our future–make it work*. Pretoria: The Presidency.

Oosthuizen, M., & Bhorat, H. (2006). Educational outcomes in South Africa: A production function approach. In *Canada: Secretariat for Institutional Support for Economic Research in Africa Working Paper No. 2006/05*.

Reddy, V. (2006). *Mathematics and science achievement at South African schools in TIMSS 2003*. HSRC Press.

Reddy, V., Prinsloo, C., Arends, F., Visser M (2012) *Highlights from TIMSS 2011: The South African perspective*. Pretoria: HRSC Press https://doi.org/20.500.11910/2877

Reddy, V., Zuze, T. L., Visser, M., Winnaar, L., Juan, A., Prinsloo, C. H., Arends, F., & Rogers, S. (2015). *Beyond benchmarks: What twenty years of TIMSS data tell us about South African education*. HSRC Press. https://doi.org/20.500.11910/2004

Reddy, V., Bhorat, H., Powell, M., Visser, M. M., & Arends, F. (2016a). Skills supply and demand in South Africa. https://doi.org/20.500.11910/10186

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A. L., Prinsloo, C., & Isdale, K. (2016b). TIMSS 2015: Highlights of mathematics and science achievement of grade 9 South African learners. https://doi.org/20.500.11910/10673

Reynolds, A. J., & Walberg, H. J. (1991). A structural model of science achievement. *Journal of Educational Psychology, 83*(1), 97.

Shonkoff, J. P., Phillips, D. A., & National Research Council. (2000). The developing brain. In D. A. Phillips & J. P. Shonkoff (Eds.), *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academies Press.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research, socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75*(3), 417–453. https://doi.org/10.3102/00346543075003417

Spaull, N., Vvan der Berg, S., Wills, G., Gustafsson, M., & Kotzé, J. (2016). *Laying firm foundations: Getting reading right*. SSRN Scholarly Paper ID 2973191. Rochester: Social Science Research Network.

Statistics South Africa. (2017). *Education series volume III: Educational enrolment and achievement, 2016*. Pretoria: Statistics South Africa.

Stewart, F. (2002). Horizontal inequalities as a source of conflict. In F. O. Hampson & D. Malone (Eds.), *From reaction to conflict prevention: Opportunities for the UN system* (pp. 105–136). Boulder: Lynne Rienner Publishers.

UNDP. (2013). *Humanity divided: Confronting inequality in developing countries*. New York: UNDP.

Van der Berg, S. (2008). How effective are poor schools? Poverty and educational outcomes in South Africa. *Studies in Educational Evaluation, 34*(3), 145–154. https://doi.org/10.1016/j.stueduc.2008.07.005

Van Staden, S. (2016). *Language and grade 4 reading literacy achievement in prePIRLS 2011*. Stellenbosch: University of Stellenbosch, ReSEP Working Paper Series 03/2016.

Woolard, I., Harttgen, K., & Klasen, S. (2011). The history and impact of social security in South Africa: Experiences and lessons. *Canadian Journal of Development Studies/Revue canadienne d'études du développement 32*(4), 357–380. https://doi.org/10.1080/02255189.2011.647654

Zuze, L., Reddy, V., Winnaar, L., & Govender, A. (2017). *TIMSS 2015 grade 9 national report*. HSRC Press: Cape Town.