TIMSS 2015 GRADE 5
National Report

Understanding mathematics achievement amongst Grade 5 learners in South Africa

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Dr Vijay Reddy
TIMSS National Research Coordinator
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List of acronyms

CAPS	Curriculum Assessment Policy Statement
CJCP	Centre for Justice and Crime Prevention
DBE	Department of Basic Education
DME	Data Management Expert
DoE	Department of Education
DPC	Data Processing Centre
ECD	Early Childhood Development
GDP	Gross domestic product
HSRC	Human Sciences Research Council
ICT	Information and Communications Technology
IEA	International Association for the Evaluation of Educational Achievement
IRT	Item Response Theory
LMIP	Labour Market Intelligence Partnership
LoLT	Language of learning and teaching
NDP	National Development Plan
NPC	National Planning Commission
NSC	National Senior Certificate
NSSF	National School Safety Framework
Q1-5	Quintile 1-5
RSA	Republic of South Africa
SE	Standard Error
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SES	Socioeconomic status
StatsSA	Statistics South Africa
TIMSS	Trends in International Mathematics and Science Study
TIMSS-N	TIMSS-Numeracy
UIS	UNESCO Institute for Statistics
WinW35	Windows Within-School Sampling Software

Executive summary

South African learners perform poorly by both local and international standards. Progress over the last twenty years has been steady, but slow, even in 2015, when compared to other countries. Across the country mathematics achievement is both highly unequal and socially graded. But what is the current state of the education system in the early grades?

Against a policy landscape which increasingly places Early Childhood Development (ECD) at the heart of educational reform and strategies to reduce the impact of poverty and redress inequalities inherited under apartheid, this report provides baseline information regarding mathematics achievement at the Grade 5 level and is a new indicator of the health of our educational system.

Our aim is to provide the first nationally representative, internationally comparative compendium of data on Grade 5 learners in South Africa. We take a broad look at a range of factors associated with achievement, including individual characteristics, family background and household resources, as well as a detailed look at schooling environments, and seek to unpack the nature of pervasive educational inequalities further, and earlier in the schooling system, than previous analysis has been able to. The findings highlight the importance of early achievement and the need to understand the multiple layers of influence on educational pathways, with the conclusions and recommendations highlighting an unequal, yet treatable system.

We use data from TIMSS, the Trends in International Mathematics and Science Study, which was conducted in South Africa for the first time at Grade 5 in 2015, and describe in detail the current picture of achievement for learners in the country, highlighting key individual, family, school and provincial differences. The analyses also include key developments concerning preschool attendance, early learning environments and academic skills, as well as the importance of educational expectations and academic beliefs, and the damaging effects of bullying. Finally, we use simple regression analysis to summarise the ways in which different factors operate together.

Key findings

According to the TIMSS benchmarks, three in five Grade 5 South African learners (61 per cent) do not exhibit the minimum competencies in basic mathematical knowledge required at the Grade 5 level. Girls outperform boys by an average of 16 points, and learners who are younger or older than those who are the "correct" age for their grade, on average, do less well academically.

Provinces can be clustered into three broad performance groups:

- Higher (Western Cape and Gauteng);
- Middle (Mpumalanga, Free State, Northern Cape and KwaZulu-Natal); and
- Lower (North West, Limpopo and the Eastern Cape).

Interestingly, while it has one of the highest averages, Gauteng also has the largest range of scores indicating considerable variation across learner performance in the province, possibly reflecting the linguistic diversity particular to this province.

When achievement is broken down by school type, the patterns further reveal the depth of the inequalities present in the system. Approximately 84 per cent of learners in independent schools, 67 per cent of those attending public fee-paying schools and just 25 per cent of those at public no-fee schools achieved the minimum level of competency.

Analysis of achievement and contextual data also point to a number of key relationships:

- *Inequality in the South African education system remains a huge problem and exists throughout the system.* When broken down by school type, the depth of inequalities in achievement is only amplified, exacerbating household level socioeconomic differences: learners in independent and public fee-paying schools not only have higher average mathematics achievement scores than those in public no-fee schools, but also have better and greater access to educational resources and safer school environments.

- The results *retell the predictable story* seen before in South Africa of advantage begetting advantage at one end of the distribution, and compounding disadvantage at the other. However, the more "good" contexts learners experience, the better.
- *What parents have is important but so too is what they do.* What parents *do* matters alongside what they have and many features of the early educational environment experienced by learners have been shown to improve performance, and understanding their importance is vital to improving performance across all learners and is a much under-studied aspect of educational pathways in South Africa.
- *The benefits of early participation are not universal.* Enrolment in education prior to Grade 1 has increased greatly in recent years and those attending preschools scored higher than those who did not attend. However, learners who then go on to no-fee schools appear not to gain the same advantage from attending early education settings as their counterparts in fee-paying and independent schools.
- Too many learners lack the *prerequisite knowledge* to perform sufficiently well in day-to-day learning tasks.
- *Individual access to workbooks is positively related to mathematics achievement.* Those with no, or shared, access do less well in TIMSS mathematics achievement than learners with their own workbook. This disadvantage is further compounded by them being more likely to be in schools where general resource shortages are greater.
- *Grade repetition is not working for the vast majority of learners.* By Grade 5, 39 per cent of learners are at least a few months "over-age" for their grade, with a quarter having repeated at least one grade (at least six months older than the oldest possible "correct" age for the grade). Older, and younger, learners perform significantly worse academically and are more likely to go on to repeat subsequent grades, and thus fall further behind.
- *School climate, bullying and school safety issues pose real threats to learner achievement.* Schools with fewer discipline problems, learners feeling safe in a school, and fewer teacher absences are associated with better achievement. Those who experience bullying not only perform less well academically, but are more likely to become bullies themselves. Learners' experience of bullying in Grade 5 is particularly worrying, with more than double the proportion at Grade 9 reporting frequent experiences of bullying, higher than in any other TIMSS participating country.
- *Language proficiency* in the language of the test is also related to achievement. Learners who regularly speak the language of the test at home are at a particular advantage, with those for whom English or Afrikaans is a second or third language performing at a lower level.
- *Achievement in mathematics is more than just a numbers game.* The development of mathematical skills is hierarchical, with foundational knowledge successively built on over time. These abilities are also associated with motivating forces such as how good a learner thinks they are at mathematics and whether they see themselves as capable of understanding and improving.

Policy implications and recommendations

Together the findings presented here form the basis of a number of policy implications and recommendations:

Early educational contexts

1. Just having "a place to go" in terms of a childcare environment is not enough. Early learning settings need to be cognitively rich and stimulating for all children, particularly those who are already more likely to come from disadvantaged and poorly resourced households, to help learners start school with the best possible chances. In seeking to standardise and improve Grade R provision for all learners, adequately trained ECD practitioners are essential for effective and equitable implementation. Service delivery in the form of improved resources, learning materials, funding, security for children while at the ECD facility, and toilet amenities are vital. In future, we must track the achievements of learners who attended Grade R classes in ordinary public schools and those who attended stand-alone ECD facilities.

Executive summary

Schools

2. Schools often exacerbate many of the inequalities that begin at home, compounding early disadvantage with a lack of resources and poor educational climates. The diverse educational achievements highlighted throughout our report suggest differentiated strategies for those at different points on the achievement scale and this is best exemplified through the categorisation of fee-paying and no-fee schools.

   For those at the lower end of the achievement spectrum, mostly no-fee schools, improved home and school resources and experiences can contribute to better achievement. For those performing at the higher achievement end, mostly fee-paying and independent schools, the focus should be on improving in-school and in-class experiences and challenging learners for excellence in performance.

   In fee-paying and independent schools improving the proficiency in the language of instruction for all learners and decreasing the frequency of bullying experienced by learners should improve achievement scores. Far more interventions are required for learners in no-fee schools, starting from shifting home engagements from play to mediated play which promotes learning and improving school awareness of learners' early skills and abilities, school resources and school climate.

Teaching practices

3. To assist in the smooth transition to formal schooling and ensure all learners have the best possible start, Grade 1 classes should spend the first two weeks of school implementing the School Readiness Baseline Assessment programmes to identify how learners perform and targeted investments should be made in Grades 1 and 2 to remediate those at risk of falling behind.

4. For grade repetition to be effective, learners falling behind and at risk of having to repeat need proper remediation and teaching strategies sufficiently adapted so as to accommodate any necessary remedial action required.

5. Teaching strategies for mathematics should also routinely include skills and practices that boost learner confidence, motivation and self-concept of their own ability.

Resources

6. The quickest and easiest change that should be acted on with immediate effect based on the results presented here is to ensure that all learners have individual access to a workbook. Having individual, not shared, access to a workbook is positively related to mathematics achievement. Increasing access from its current level of 87 per cent to 100 per cent as soon as possible, and understanding where this resource is lacking, may also help in terms of more equitable distribution of resources in the most deprived schools.

School climate

7. High levels of safety and discipline problems in schools are negatively associated with achievement, and often go in tandem with bullying behaviours. Issues around bullying and school safety and discipline need to be tackled and seriously dealt with. National policies, such as the National School Safety Framework (NSSF) designed to create safe and violence-free learning environments, and/or legislative changes can go some way to tackling the problems of bullying and safety, but schools have to take seriously and tackle the issues particular to their learners at a school-by-school level.

PART A

EARLY ACHIEVEMENT IN SOUTH AFRICA

Early achievement in South Africa

1. Introduction

South African learners perform poorly by both local and international standards (DBE, 2012; Moloi & Chetty, 2010; Reddy et al., 2015). Nationally, a high proportion of young people exit the school system prematurely and the considerable grade repetition within the system further exacerbates both low average levels of schooling and persistently high inequalities (Branson & Lam, 2010; Branson & Zuze, 2012). When compared to other countries, only a third of Grade 9 learners in South Africa meet the minimum competency level in international assessments of mathematics and science, with just one per cent reaching the advanced level (Zuze, Reddy, Visser, Winnaar & Govender, 2017), limiting educational success and future participation in the short term, as well as employment opportunities in the longer term. The importance of developing mathematical skills and acquiring the requisite knowledge cannot then be overemphasised as learners are equipped with problem-solving and analytical skills, ready to face a labour market that increasingly rewards technical capabilities and high-level thinking, both of which are equally important aspects of nurturing effective future citizens and thought leaders.

To date, South Africa has participated in five cycles of the Trends in International Mathematics and Science Study (TIMSS) at the Grade 8/9 level. First conducted in 1995, average performance has improved considerably over the past two decades – albeit from a low base – with particular gains at the lower end of the distribution (see Zuze et al., 2017, for a detailed insight into trends across TIMSS at Grade 9). But Grade 9 is a long way into the educational system and the disparities that exist there are the product of years of compounding inequalities across the system, often beginning before learners even start formal schooling. Without intervention, these inequalities continue to widen throughout school, into adulthood and even across generations. Exploring patterns in educational achievement earlier on is vital in order to better understand how and when inequalities manifest and how they might best be tackled by policy reform and targeted intervention.

In recognition of its importance for learning and development, the South African Government has made strides in policies surrounding ECD (Soudien et al., 2017). At a broad level, the National Development Plan (NDP) (NPC, 2012) places quality early childhood education at the centre of strategies to reduce the acute impacts of poverty. It further sets quality ECD as a top priority for the country to improve the quality of education and the long-term prospects of future generations and society as a whole. For example, the National Integrated Early Childhood Development Policy aims to transform ECD service delivery in South Africa, covering the period from conception until the year before children enter formal school (RSA, 2015). Crucial to this is the active participation of parents and caregivers, alongside early learning programmes in centres that complement the parents' role. The aim is to create nurturing environments which ensure healthy foetal growth, provide safety, food, love and early learning opportunities and support physical, psychological, emotional, social and cognitive development (RSA, 2015). Other policies prioritising Grade R, increasing enrolment of five- and six-year-olds in school, and the distribution of national workbooks to all learners, similarly seek to redress inequalities inherited under apartheid.

This report examines, for the first time, nationally representative, internationally comparative data on Grade 5 learners in South Africa. It takes a broad look at a range of factors associated with achievement, including individual characteristics, family background and household resources, as well as a detailed look at schooling environments, and seeks to unpack the nature of some of those inequalities further, and earlier in the schooling system, than previous analysis has been able to. The findings highlight the importance of early achievement and the need to understand pathways through education and the results point to an unequal, yet treatable system.

1.1 Getting the foundations right

Learning is more than simply a formal process that begins on the first day of school. Rather it is the result of the gradual accumulation of cognitive, linguistic, perceptual, motor and social processes. These processes provide the foundation for later successful achievement. Early abilities are gradually built on in hierarchical ways as existing skills are adapted and improved upon, allowing for new skills to be gradually mastered. The origins of literacy and numeracy skills begin long before children enter the classroom (Entwisle & Alexander, 1990; Pungello et al., 1996; Whitehurst & Lonigan, 1998). While early proficiency is a key stepping stone to subsequent mastery, learners

South African studies have shown that once learners enter the formal education system, the availability of key school resources is linked to a host of educational outcomes, with higher levels of resources associated with better academic performance, educational throughput and qualifications gained.

struggle with mathematics in later grades often because they have failed to master fundamental skills and basic concepts early on (see for example, DBE, 2016).

Learning and educational outcomes are further shaped by the contexts in which they occur, again beginning long before Grade 1 starts. For example, a large and growing body of international evidence highlights the importance of good quality preschools for children as a key developmental context for children's cognitive and socioemotional outcomes (Brinkman, Hasan, Jung, Kinnell, Nakajima & Pradhan, 2017; Ramey & Ramey, 2004).

As learning is not restricted to the classroom, research on the factors associated with achievement also focuses on the home as one of the most salient contexts for shaping individual outcomes. The home environment plays an essential role in the early development of children, influencing what they are exposed to, the language they hear, what they can expect and learn to believe, as well as how they approach others during the early years, to name but a few. This subsequently starts them off along differing pathways as they move into the school-age years. Parents and other regular caregivers form an integral part of the early childhood period. Within supportive and nurturing relationships with parents and caregivers, children are able to grow and thrive (Shonkoff & Phillips, 2000).

South African studies have shown that once learners enter the formal education system, the availability of key school resources is linked to a host of educational outcomes, with higher levels of resources associated with better academic performance, educational throughput and qualifications gained (Fiske & Ladd, 2004; Oosthuizen & Bhorat, 2006; Taylor & Yu, 2009; van der Berg, 2008). Socioeconomic variances at the school level also affect the educational outcomes of South African learners, as learners in the most affluent quintile of schools significantly outperform schools in the other four quintiles (Reddy, 2006; van der Berg, 2008; Reddy et al., 2011; Reddy et al., 2015).

TIMSS 2015 Grade 5 data enables a focus on the many different factors associated with mathematics achievement including individual and family characteristics, as well as school contexts and a comparison across educators.

1.2 Social inequalities

Research in this area demonstrates that variability across children's early cognitive skills emerges early, widens with age and is highly socially graded. For example, using data from the United Kingdom, Feinstein (2003) showed that many children from low socioeconomic status (SES) households who scored well on tests of early cognitive achievement (22 months) over time were surpassed on such tests by children from high SES backgrounds whom they earlier outscored. The reverse event was found to be extremely uncommon. These findings indicated that SES differences in cognitive achievement and school attainment may not be a simple matter of fixed relationships between innate ability and SES grouping, but are the result of complex interactions between innate ability, the wider family and social environment. This social gradient has been shown to exacerbate as learners progress through the education system, being more striking at later ages, and continues on into adulthood (Bynner, Joshi & Tsatsas, 2000; Feinstein, 2004; Feinstein & Bynner, 2004).

Exploring differences in educational achievement as learners move through the school system rather than at just one point in time helps our understanding of how inequalities persist and so how, when and where they can, then, best be levelled and eased by targeted intervention and policy focus. TIMSS-Numeracy 2015 thus provides a mechanism to assess the mathematical competencies of Grade 5 learners not possible before in South Africa in order to make informed decisions about how best to improve teaching and learning in mathematics.

1.3 Signposting the rest of the report

The remainder of this report is structured as follows: in section 2 of Part A, we describe the data used for the report, as well as outline the analytic strategy adopted; in section 3 we discuss the current context of education and skills in South Africa, presenting the first of the descriptive analyses in section 4 where we report the big picture of national achievement in mathematics internationally, by province and school type. In Part B, our descriptive analysis continues and gives an overview of learners and their home environment, moving on to a comparison of schooling environments in Part C. Part D summarises the detail provided in Parts B and C, and Part E focuses in particular on learners performing just below the low threshold of the test. Finally, in Part F of the report, we draw the results together with concluding comments, policy implications and key recommendations.

2. Methodology

2.1 Data

The data used in this report comes from the TIMSS. First established in 1995, the TIMSS assesses mathematics and science knowledge of fourth and eighth grade learners around the world. The study was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating countries to compare learners' educational performance across borders. The main aim of the TIMSS is to determine the nature and extent of learner achievement as well as understand the context in which it occurs. It is one of the most established studies of educational quality worldwide and provides comparative data from a diverse set of educational systems.

The TIMSS 2015 sample for South Africa was drawn from the 2013 Department of Basic Education (DBE) master list of all schools in South Africa, which comprised 17 824 schools (16 682 public and 1 142 independent schools), that offered Grade 5 classes. Statistics Canada drew the South African sample by using the province, school type (public and independent) and language of learning and teaching (LoLT) (Afrikaans, English and dual medium) as stratification variables. A total of 300 schools were sampled, of which 297 participated in the study. A total of 10 932 learners, 10 493 parents and 298 mathematics educators participated in the study (Reddy et al., 2016b). Appendix A1 describes the TIMSS research design and methodology in detail.

TIMSS is designed to align broadly with the mathematics curricula across participating countries and the results are therefore able to suggest the degree to which learners have learned mathematical concepts and skills likely to have been taught in school. In addition to individual assessment data on mathematics achievement, TIMSS also collects background information on the participating learners, their families, educators and schools to allow cross-national comparison of educational contexts that may be related to learner achievement. Achievement data are scaled to a centre point of 500, representing the average for a typical learner across all the countries surveyed, and a standard deviation of 100 points, where 40 points is roughly equivalent to one school grade's learning[1]. (Appendix A2 presents a curriculum analysis which reports details on learner performance in the TIMSS content domains and summarises the CAPS and TIMSS assessment frameworks). Throughout this report, average achievement scores are reported followed by the Standard Error (SE), in this way: (376, 3.4). The Standard Error represents the statistical accuracy of the estimate.

[1] *40 points is about the equivalent to a grade level of education and is an approximation, based largely on the difference between seventh and eighth grades in 1995 (communication with TIMSS & PIRLS Centre at Boston College).*

TIMSS-Numeracy

In 2015, 49 countries took part in TIMSS 2015 at the Grade 4/5 level. Of these, seven countries (Bahrain, Indonesia, Iran, Jordan, Kuwait, Morocco and South Africa) participated in TIMSS-Numeracy (TIMSS-N). TIMSS-N was introduced by the IEA in 2015 to assess the foundational mathematical knowledge, procedural understanding and problem-solving strategies of learners at the end of primary school. It asks learners to answer questions and work out problems similar to those posed in TIMSS, but uses easier numbers and more straightforward procedures. TIMSS-N is designed to assess mathematical knowledge in Grades 4, 5 or 6 for countries where most children are still developing foundational mathematical skills. Given its low performance in mathematics at Grade 9 and in other national and regional assessments (Annual National Assessment, SACMEQ), South Africa chose to participate in TIMSS-N at the Grade 5 level. The TIMSS-N results are reported on the same scale as the TIMSS Mathematics scale.

2.2 Performance benchmarks

TIMSS describes achievement at four international performance benchmarks along the achievement scale in order to better understand how achievement scores translate into what learners can actually do and to allow cross-country comparison:

- Low (400-475 points);
- Intermediate (475-550 points);
- High (550-625 points); and
- Advanced (above 625 points).

For example, at the "low" level, learners have only basic mathematical knowledge, while those scoring at the "high" level are able to apply their knowledge and understanding to solve problems (see Table 2.1 for further detail here). These competency indicators attempt to provide a meaningful description of what learners know and are able to do, and enable broad comparisons of mathematical ability across participating countries. Learners scoring less than 400 points are deemed below the level of the test.

Table 2.1: Description of TIMSS international benchmarks, 2015

Benchmark	Points range	Description for mathematics
Low	400 – 475	*Students have some basic mathematical knowledge* Students at this level can add and subtract whole numbers, have some understanding of multiplication by one-digit numbers, and can solve simple word problems. They have some knowledge of simple fractions, geometric shapes, and measurement. Students can read and complete simple bar graphs and tables
Intermediate	475 – 550	*Students can apply basic mathematical knowledge in simple situations* Students at this level demonstrate an understanding of whole number and some understanding of fractions and decimals. Students can relate two- and three-dimensional shapes and identify and draw shapes with simple properties. They can read and interpret bar graphs and tables
High	550 – 625	*Students can apply knowledge and understanding to solve problems* Students at this level can solve word problems involving operations with whole numbers, simple fractions, and two-place decimals. They demonstrate understanding of geometric properties of shapes and angles that are less than or greater than a right angle. Students can interpret and use data in tables and a variety of graphs to solve problems
Advanced	Above 625	*Students can apply understanding and knowledge in a variety of relatively complex situations and explain their reasoning* Students at this level can solve a variety of multi-step word problems involving whole numbers. They show an increasing understanding of fractions and decimals. They can apply knowledge of a range of two- and three-dimensional shapes in a variety of situations. They can interpret and represent data to solve multi-step problems

Source: TIMSS http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/performance-at-international-benchmarks/

2.3 The current study

This report presents the findings of TIMSS at the Grade 5 level which was conducted for the first time in South Africa in 2015. We present a detailed account of achievement in mathematics which situates South African performance against an international big picture as well as a provincial and school-level backdrop. The analysis includes important developments concerning preschool attendance, early learning environments and academic skills, as well as the importance of educational expectations and academic beliefs, and the damaging effects of bullying. We also summarise the ways in which different factors operate together, mediating and moderating relationships with average performance.

The study also serves as a baseline against which future results may be compared. Moreover, Grade 5 learners in 2015 who move uninterrupted through the next few grades will make up the Grade 9 cohort of TIMSS learners in 2019, meaning that we will be able to chart the progress of this nationally representative group of young people more closely than has been previously possible.

A separate report presents the findings from the Grade 9 study, also conducted in 2015, and discusses changes in South Africa's performance in mathematics and science over the last two decades (Zuze et al., 2017). We do not comment extensively on the Grade 9 findings, but draw some comparisons throughout the report where doing so reveals particularly interesting results. Rather, our aim is to provide the first comprehensive picture of achievement for Grade 5 learners across South Africa highlighting key individual, family, school and provincial differences.

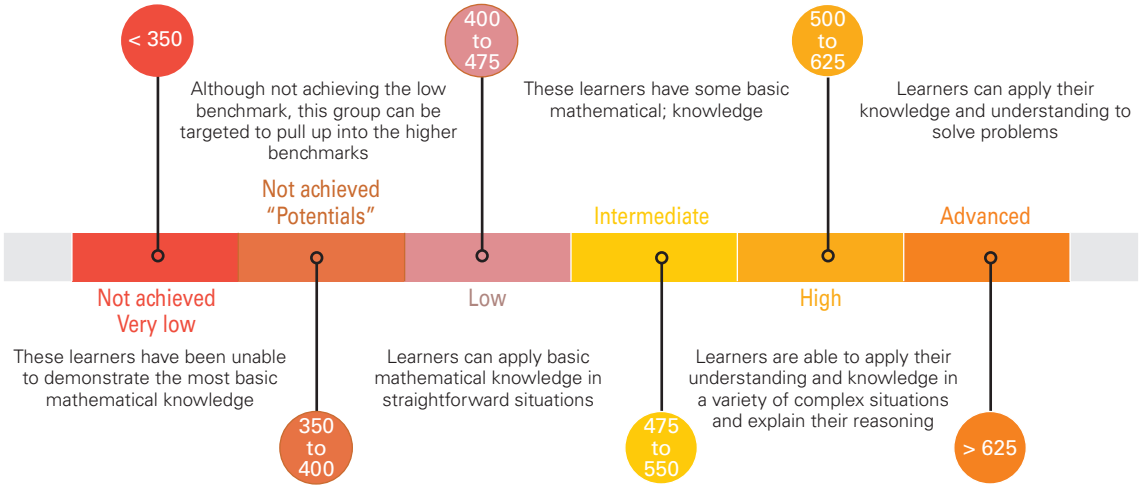
2.4 Analytical approach

The TIMSS data for South Africa has been used extensively to report on progress in mathematics and science at the Grade 9 level. In line with this research and the complementary report for the 2015 data at Grade 9, our analytic approach compares average scores and proportions of learners at different points in the achievement distribution across different groups of learners, family backgrounds and schooling environments using TIMSS performance benchmarks.

South Africa is one of the lower-performing countries in mathematics at Grade 5, however, with the national average of 376 points falling short of the lowest performance benchmark set by TIMSS (see Table 2.1 above). As such, many learners are bunched together in the "below minimum competency" bracket preventing a more nuanced understanding of who these learners are and the particular challenges they face. Moreover, in order for the TIMSS performance information to benefit policy and curriculum reform, it is important to understand the mathematics competencies associated with all the locations within the range of scores on the achievement scale.

Consequently, the analytical approach taken in this report, as in the comparable one for Grade 9 learners (Zuze et al., 2017), is to introduce a fifth benchmark: learners who score between 350 and 400 points. This allows us to take more into account the local learning context specific to South Africa and include detailed descriptions of the Grade 5 cohort against proficiency levels more closely aligned with the current national education landscape. These learners can be viewed as a "potential" success group in that they could, given the right interventions and/or appropriate triage, move above the 400-point achievement mark bringing up the long tail of low performance and so the overall average. This innovative new direction will deepen our interpretation of achievement and help us understand both where the biggest improvements are needed and what is required to support specific groups of learners, families and educators.

Figure 2.1: TIMSS benchmarks



Adapted from: Mullis et al., 2016

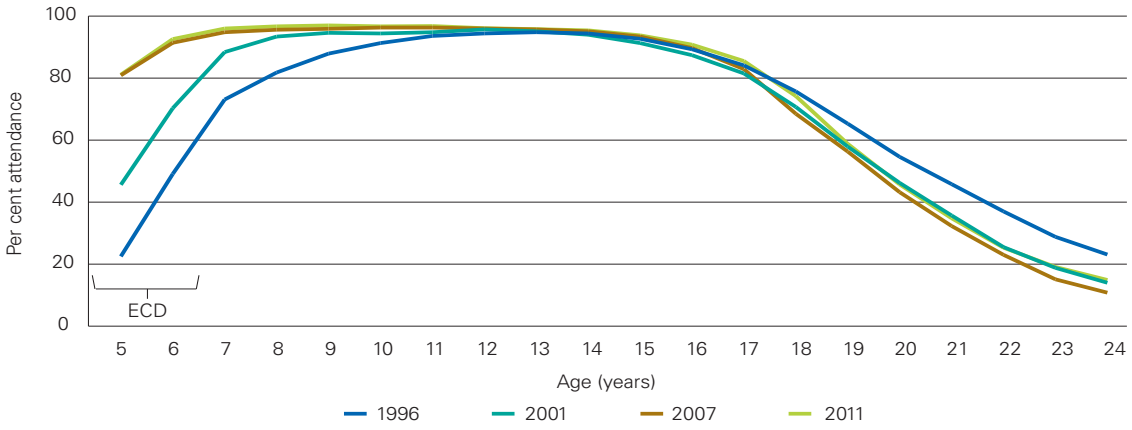
3. Education and skills in the South African context

3.1 Prioritisation of Grade R and early years enrolment

Prior to 1994, reception class (Grade R) was not accessible to all learners within South Africa with only 19 per cent of the five- to six-year-old population participating. In 2001, Grade R became a national priority in White Paper 5 on Early Childhood Education (DoE, 2001); phasing in Grade R as the first year of schooling started in 2001, making attendance universal but not compulsory. Norms and standards for Grade R funding were subsequently formalised in 2009, providing a legislative foundation for a Grade R roll-out. Most recently a formalised curriculum for Grade R has been included in the Curriculum Assessment Policy (DBE, 2012).

As a result, significant progress has been made in meeting the goal of ensuring access to education. Census data, for example, shows that the enrolment rates of five- and six-year- olds has increased dramatically between 1996 and 2011 (Figure 3.1). In 2015, 792 325 children[2,3] were enrolled in Grade R, and approximately 1.2 million children were enrolled in Grade 1 (DBE, 2015, 2016b). This success in improving access to primary education has been underpinned by improvements in funding (DoE, 2006), alongside pro-poor policies and programmes, such as scholar transport (DoT, 2015) and school nutrition (DoE, 2004).

Figure 3.1: Education institution attendance (5-24 years old)



Source: StatsSA, 2016

[2] This figure does not include stand-alone ECD sites.
[3] In 2016 there were 1 208 992 learners enrolled in Grade 1. This means that approximately 65 per cent of these learners were in Grade R, in ordinary schools, in 2015.

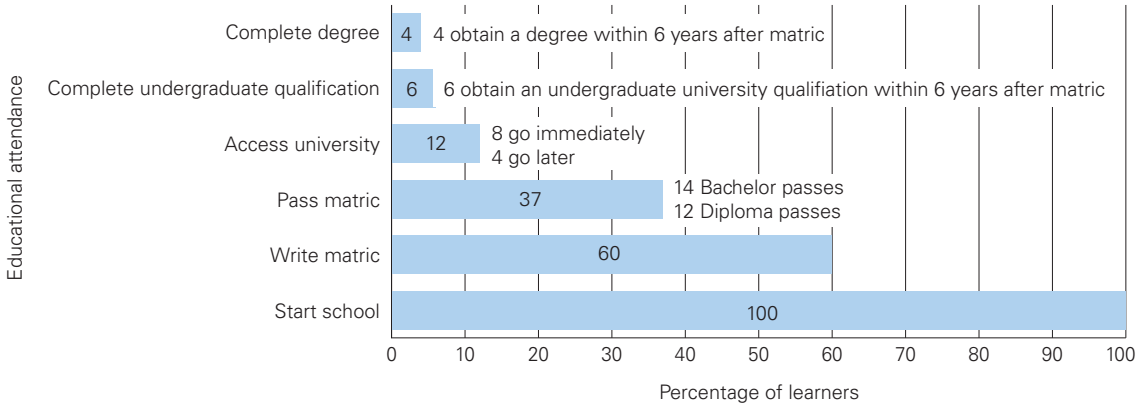
However, despite the massive increase in the number of learners enrolled in Grade R, the expected benefit for all learners has not occurred. The relationship between Grade R and subsequent learning outcomes has been explored by van der Berg et al. (2013), who showed that its association was small with almost no impact shown for those in the poorest three school quintiles. This may be due to poor quality in ECD and Grade R centres and practitioners who have limited understanding of their role in child development. The authors argue that offering Grade R seems only to extend inequality as it serves to benefit learners in more affluent schools already receiving a higher quality of education, and thus question assurances that learners enter Grade 1 prepared for formal education even if they attended Grade R.

3.2 Educational throughput

Overall enrolment rates at primary and secondary school in South Africa are high and comparable with industrialised countries (Reddy et al., 2016a); uptake at the primary level is almost universal and remains high into the teenage years (StatsSA, 2016). Yet the proportion of learners reaching Grade 12, successfully matriculating from high school and moving into post-secondary education is troublingly low (van Broekhuizen et al., 2017).

For example, using newly available data linking learners who pass their Grade 12 National Senior Certificate (NSC) and public university learners, van Broekhuizen et al. (2017) track individuals over a six-year period and examine the nature and extent of transitions from school into and through university. Their analyses show that very few of those starting primary school actually make it into the final year of secondary school and go on to write the NSC (or matriculation) school-leaving examination (see also van Wyk, 2015). Figure 3.2 shows that just 60 per cent of those who start primary school will go on to write their matric examination, with only around two-thirds of this group actually passing. Just 12 per cent of those starting primary school go on to access university within six years of matriculating[4] and only 4 per cent will complete a degree qualification.

Figure 3.2: Estimated percentage of learners who start school and achieve university degrees based on the experience of the 2008 NSC cohort



Source: Reproduced from van Broekhuizen et. al., (2017) calculations using integrated unit-record 2008 NSC and 2009 – 2014 HEMIS data.

These participation and progression rates are low, particularly by international standards (UIS, 2017). In part they reflect the legacy of apartheid education in South Africa and the gaps in achievement between historically privileged and disadvantaged groups. There are also considerable problems in terms of grade repetition, which are often as high as 20 per cent per grade (Lee et al., 2005), rising considerably after Grade 9 (Branson, Hofmeyr & Lam, 2014; Isdale et al., 2016). Indeed, Lam and colleagues argue that grade progression is poorly linked to actual ability and learning, particularly amongst African learners, highlighting persistent racial difference in the schooling system, and call for better, more accurate assessment of performance (Lam, Ardington & Leibbrandt, 2011).

[4] *For context, the number of students enrolled in public universities in 2015 was 985 212. (See Table 1 in DHET, 2017).*

Poor educational throughput also has undesirable developmental knock-on effects. First, the education system is contributing to rising numbers of unemployed young people with an incomplete secondary education. Second, the sector is generating insufficient numbers of matriculants who are adequately prepared for enrolment in higher education (StatsSA, 2015). Thus youth represent a particularly vulnerable group in South Africa, with one of the highest youth unemployment rates among G20 countries (OECD, 2016), and nearly one in three young people (aged 15-29) are not in education, employment or training.

Alongside these low participation rates, South Africa has a lower return to its educational expenditure than many other countries: as a percentage of gross domestic product (GDP), educational spend is equally comparable with other middle-income countries, yet educational outcome levels are far lower (Reddy et al., 2016a). If left unchallenged, low levels of throughput, increasingly staggered educational pathways and low returns to educational spend will lead to considerable skill shortages in South Africa's labour market (Isdale et al., 2016; Reddy et al., 2016a).

4. The big picture: understanding mathematics achievement

Our analysis of the Grade 5 cohort begins by presenting the national picture of Grade 5 mathematics achievement. The TIMSS-N assessment was administered for the first time in South Africa in 2015, providing a new opportunity to examine in detail our performance at an earlier age in the education pipeline and present the big picture of mathematics achievement across country, province and school type.

In order to illustrate South Africa's position in relation to other countries, the following section describes achievement scores by:

(i) average mathematics scale scores in 2015 for all participating countries (Table 4.1); and

(ii) the mathematics achievement profile of selected countries using the TIMSS performance benchmarks (Figure 3.2).

We also describe differences across South Africa's nine provinces and by school type.

4.1 South African mathematics performance in relation to that of other countries

Table 4.1 ranks the 49 participating countries according to the average scale scores from highest to lowest. The top five ranked countries are from East Asia – Singapore (618, 3.8), Hong Kong SAR (614, 2.9), Korea (608, 2.2), Chinese Taipei (596, 1.8) and Japan (593, 1.9). The bottom five countries are Jordan (389, 3.0), Saudi Arabia (384, 4.0), Morocco (378, 3.0), South Africa (376, 3.4), and Kuwait (354, 4.6). The score differences between South Africa, Morocco and Saudi Arabia are not statistically significant.

Thirty-one of the 49 countries performed above the centre point of 500. While there were small differences from one country to the next, there is a considerable range of achievement from the top-performing to the lowest-performing countries, 264 points, which is over two and a half standard deviations (a measure of the spread of data).

Early achievement in South Africa

Table 4.1: Average mathematics achievement across all participating countries

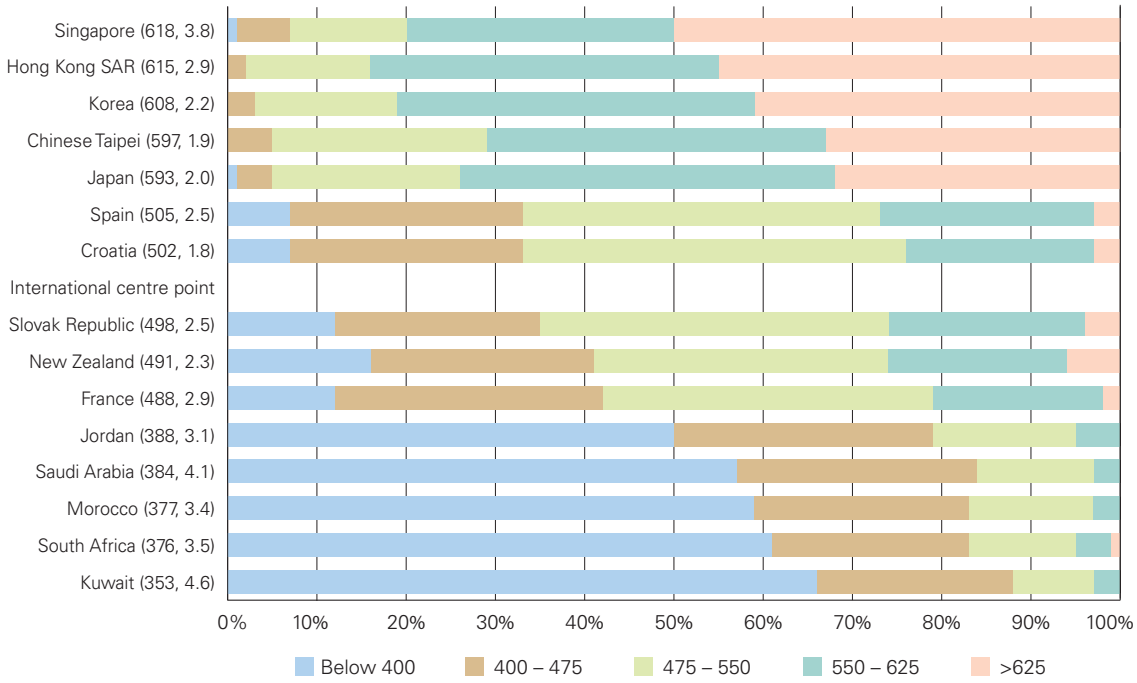
Country	Ave scale score	SE
Singapore	618	3.8
Hong Kong SAR	614	2.9
Korea	608	2.2
Chinese Taipei	596	1.8
Japan	593	1.9
Northern Ireland	570	2.9
Russian Federation	564	3.4
Norway (participated at Grade 5)	549	2.5
Ireland	548	2.2
England	546	2.9
Belgium (Flemish)	546	2.1
Kazakhstan	544	4.5
Portugal	541	2.2
United States	539	2.3
Denmark	539	2.7
Finland	535	2.0
Lithuania	535	2.5
Poland	535	2.1
Netherlands	530	1.7
Hungary	529	3.2
Czech Republic	528	2.2
Bulgaria	524	5.2
Cyprus	523	2.7
Germany	522	2.0
Slovenia	520	1.9
Sweden	519	2.8
Serbia	518	3.5
Australia	517	3.1
Canada	511	2.2
Italy	507	2.6
Spain	505	2.5
Croatia	502	1.7
TIMSS centre point	**500**	
Slovak Republic	498	2.5
New Zealand	491	2.3
France	488	2.9
Turkey	483	3.1
Georgia	463	3.6
Chile	459	2.4
United Arab Emirates	452	2.4
Bahrain	451	1.6
Qatar	439	3.4
Iran, Islamic Republic of	432	3.2
Oman	426	2.5
Indonesia	398	3.7
Jordan	389	3.0
Saudi Arabia	384	4.0
Morocco	378	3.0
South Africa (participated at Grade 5)	376	3.4
Kuwait	354	4.6

Source: Mullis et al., 2016

Figure 4.1 compares performance for a selection of countries that participated in TIMSS 2015: the five highest-performing countries, five around the TIMSS centre point of 500 points, and the five lowest-performing countries using the TIMSS performance benchmarks.

In the five highest-performing countries – Singapore, Hong Kong SAR, Korea, Chinese Taipei and Japan – almost all learners scored above the 400 points, the low benchmark set by TIMSS for learners demonstrating the minimum mathematics competencies (see Table 2.1 for further detail on TIMSS performance benchmarks). All five countries have an average performance in the "high" benchmark, 550-625 points, with more than three-quarters of these learners achieving scores above 550 points, and in Singapore half of all learners scoring at the "advanced" level, that is over 625 points.

Figure 4.1: TIMSS 2015 average scale score in mathematics by TIMSS benchmarks in a selection of countries



Source: Mullis et al., 2016.

For the five countries performing around the centre point – Croatia, Spain, Slovak Republic, New Zealand and France – between 7 and 16 per cent of learners performed below the low TIMSS benchmark, and between 2 and 6 per cent score at the advanced level.

The distribution profile of the five lowest-performing countries – Jordan, Saudi Arabia, Morocco, South Africa and Kuwait – shows that between 50 and 65 per cent of learners scored below 400 points. While South Africa is one of the lowest-performing countries, it is nevertheless promising to note that 1.3 per cent of learners scored in the advanced category. South Africa stands out in this regard as none of the other bottom countries have learners performing at this level.

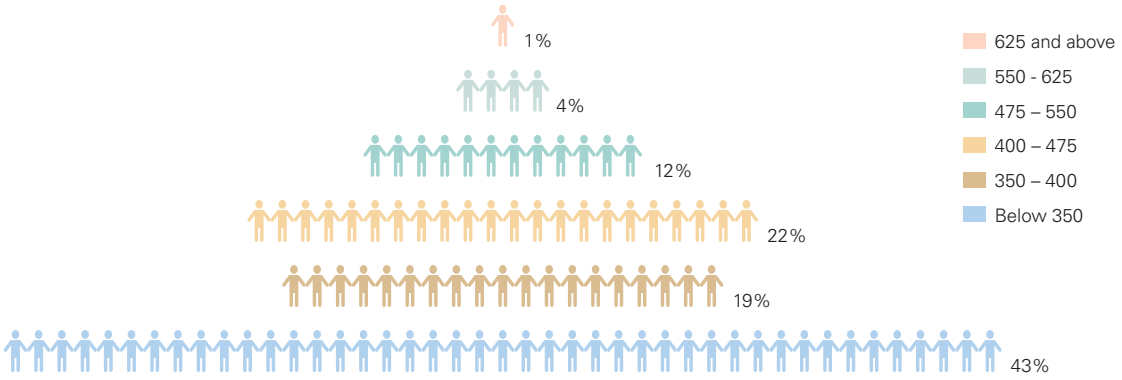
4.2 Mathematics achievement in South Africa

TIMSS mathematics items are designed to measure learner knowledge and proficiency, which can vary from one learner to another. The average scale score for South African Grade 5 learners was 376 points (SE=3.4). According to the TIMSS benchmark classification, just two-fifths of learners in South Africa (39 per cent) achieve at or above the TIMSS base threshold of 400 points. In other words, three-fifths of learners (61 per cent) do not exhibit the minimum competency levels required for basic mathematical knowledge in Grade 5 as defined by the international component of the study (Mullis et al., 2016; Martin, Foy & Hooper, 2016).

The distribution of home and school resources in South Africa is vastly unequal, and as noted above, grouping over 60 per cent of those scoring less than 400 into a single category prevents a more detailed understanding of how these low-scoring individuals differ and so what might be done in order to boost their mathematical skills, particularly for those scoring just below the 400 mark. Therefore, as noted above, to provide a more textured picture of South African performance, our analysis includes a fifth local category of learners scoring between 350 and 400 points (see Figure 4.2).

At the top of this locally situated distribution, 5 per cent of South African learners achieve scores of 550 points and above. Just over one in ten (12 per cent) achieve between 475 and 550 points, and 22 per cent score just above the TIMSS lowest benchmark threshold, between 400 and 475 points. Figure 4.3 also shows that 19 per cent of all learners can be considered "potentials", with 43 per cent not achieving even this local proficiency level.

Figure 4.2: Mathematics achievement in South Africa by TIMSS and local benchmarks



Authors' own calculations from TIMSS 2015 achievement dataset

Again, we note that within the 5 per cent of learners achieving above 550, 1.3 per cent attained the advanced level (above 625 points) of mathematical proficiency. Advanced level learners are able to apply their knowledge in a variety of complex situations and explain their reasoning (see Table 2.1). Individuals in this small "pocket of excellence" possess the potential to participate in postgraduate studies.

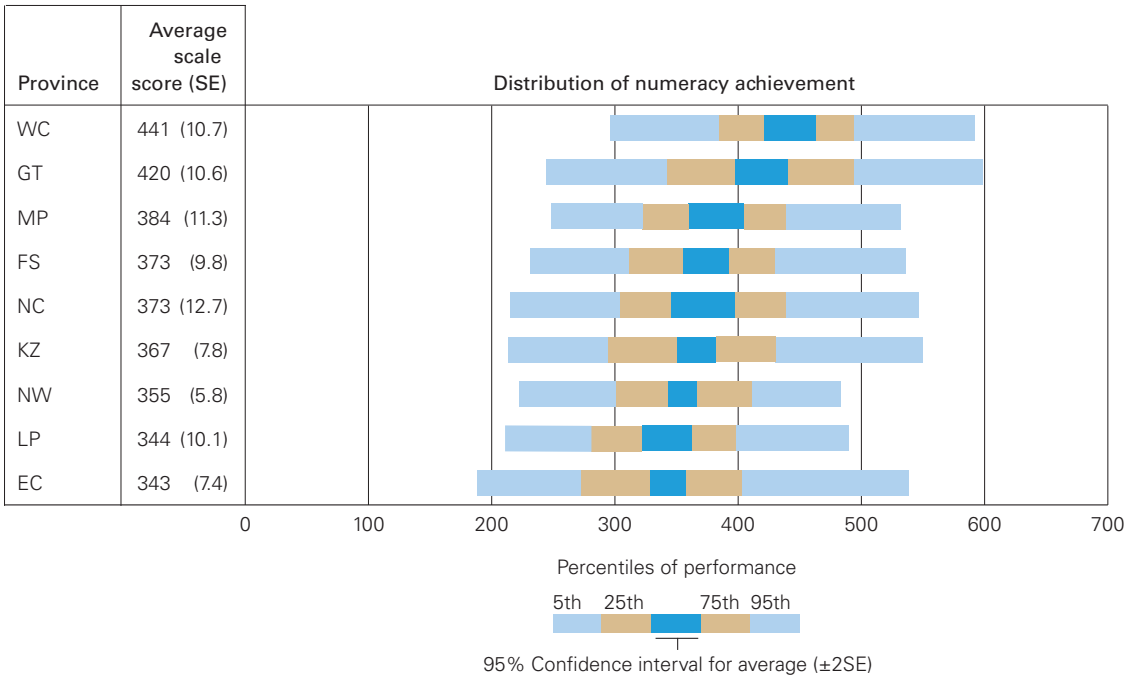
4.3 Provincial mathematics achievement at Grade 5

In South Africa the national DBE shares responsibility for basic schooling with provincial departments, but it is the responsibility of each provincial department to finance and manage schools directly. Given the responsibilities of the provincial departments and the varied levels of resources, it is also useful to report on differences across the nine provinces. Figure 4.3 describes the provincial mathematics achievement and distribution and Figure 4.4 sets out the provincial performance by TIMSS benchmarks, including the local South African categories below the 400-point mark. The provinces are ranked by average achievement score.

The top-performing provinces were the Western Cape (441, 10.7) and Gauteng (420, 10.6), both performing, on average, above the TIMSS low-level benchmark but well below the TIMSS centre point of 500, followed by Mpumalanga (384, 11.3), which falls below the lowest level competency mark. The three lowest-performing provinces were the North West (355, 5.8), Limpopo (344, 10.1) and the Eastern Cape (343, 7.4). These top and bottom three provincial rankings are the same for mathematical achievement in TIMSS at Grade 9 (see Zuze et al., 2017; Reddy et al., 2016c), though in a slightly different order, with Gauteng just outperforming the Western Cape at the top end, and Limpopo doing better than the North West at the bottom.

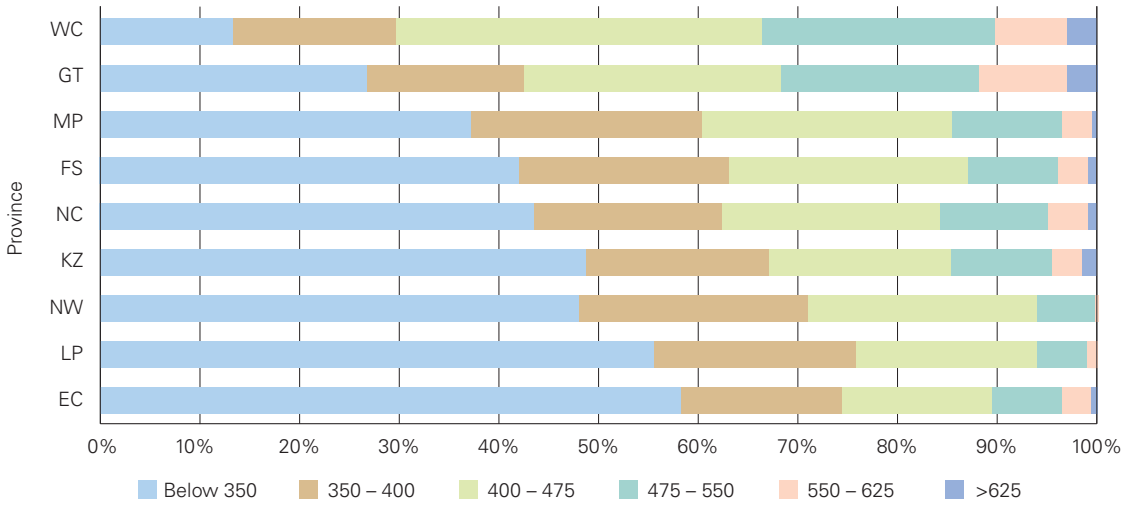
At Grade 5, the highest-performing province, the Western Cape, achieved an average score 65 points above the national average of 376, while the Eastern Cape scored 33 points below this national average. This difference between the top- and the bottom-performing provinces, 98 points, is just under a standard deviation. TIMSS points can also be interpreted in terms of grades, with 40 points being roughly equal to one grade level. Thus a one standard deviation difference of 100 points is equivalent to two and half grades and further amplifies the wide variation amongst South African learners' performance.

Figure 4.3: Provincial mathematical achievement and distribution



Authors' own calculations from TIMSS 2015 achievement dataset. SE in brackets.

Figure 4.4: Provincial achievement by proficiency benchmarks



Authors' own calculations from TIMSS 2015 achievement dataset.

Interestingly, while it has the second highest average achievement, Gauteng also has the greatest spread of scores (348 points), with the Eastern Cape not far behind with a range of 340 points. This is a reflection of the particularly high variation in learner ability in these two provinces. For example, in Gauteng more than a quarter of learners (27.5 per cent) score below 350, but it also has the highest proportion of learners, 11.3 per cent, scoring above 550 points, with 3 per cent of those achieving the TIMSS advanced level of above 625 points. By contrast, in the Eastern Cape almost three-fifths of learners (59.9 per cent) score below 350 and only 4.1 per cent achieve over 550, with just 0.6 per cent (seven learners) performing at this highest benchmark.

The North West (246, 5.8) and Limpopo (267, 10.1) showed the narrowest range of scores. As these provinces exhibited the lowest averages, their smaller ranges suggest that the majority of learners are performing equally poorly: 56 per cent of learners from Limpopo and 60 per cent from the Eastern Cape score below 350 points, the lower of our two local benchmarks. As the highest-performing province, the Western Cape appears to have the most even spread across the different benchmark levels: a third of learners (32 per cent) score less than 400, with 12 per cent scoring below 350 – a third (36 per cent) between 400 and 475, with 23 per cent between 475 and 550, and the remaining one in ten achieving over 550 points.

The detail in Figures 4.3 and 4.4 highlights vast provincial inequalities in Grade 5 mathematics achievement across South Africa. For example, 31 per cent of the Western Cape and 43 per cent in Gauteng scored below 400 points in comparison with the national average of 61 per cent, while 75 per cent of those in Limpopo performed below the level of the test. In the remaining six provinces, between 60 per cent and 74 per cent of learners scored below the 400-point threshold. These provinces have a huge amount of work to do to raise the level of inputs so that their outcomes are improved.

Across the nine provinces, between 16 and 23 per cent of learners can be considered "potentials", that is, scoring just below the threshold of the TIMSS low benchmark (between 350 and 400 points). By contrast, learners who achieved the advanced benchmark (above 625 points) are predominantly from Gauteng (3 per cent), the Western Cape (3 per cent) and KwaZulu-Natal (1.5 per cent). Understanding this diversity in performance is key if we are to raise the level of mathematical skills across all learners.

4.4 Differences in average mathematics achievement, by school type

Nationally, the South African schooling system comprises public schools (96 per cent of learners) and independent schools (4 per cent of learners) (DBE, 2016c). The schools in the country vary considerably with regard to infrastructure and resources. To determine how achievement scores varied with resource availability at schools, a poverty index for each school has been calculated by the DBE, based on indicators of poverty, employment and education in the area surrounding the school. Schools are divided into five groups called the quintile rank of the school, with independent schools considered separately[5].

The most economically disadvantaged are grouped into quintile 1 (Q1) and the most affluent schools assigned a quintile 5 (Q5) ranking. All schools in quintiles 1 to 3 are no-fee schools, while those in quintiles 4 and 5 are fee-paying schools. Independent schools are not government owned and the quintile ranking does not apply, but the majority charge school fees. The quintile categories are a good indicator of the general poverty levels of schools, but there are exceptions, with the amount of fees charged and indirect costs to parents through additional educational contributions affecting overall school resources (see Branson, Kekana & Lam, 2013, for further discussion here). Of the learners who participated in the TIMSS-N 2015 assessment, 70 per cent attended no-fee schools, 27 per cent fee-paying schools and 4 per cent independent schools (see Appendix A3 for a summary of results by school type).

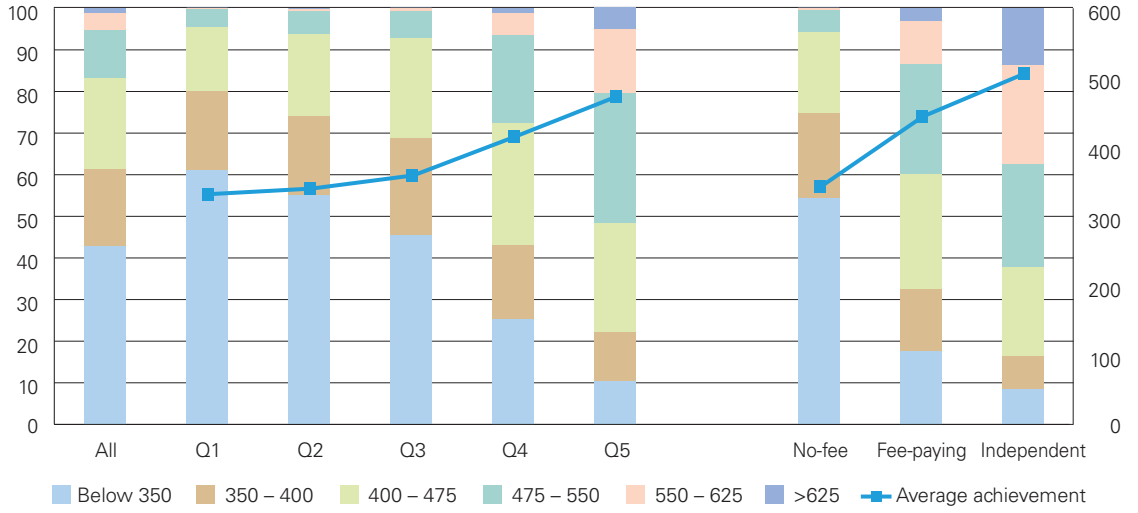
[5] *Under the National Norms and Standards for School Funding every public school in South Africa is ranked into one of five quintiles.*

Figure 4.5 reports achievement at TIMSS plus local South African benchmarks comparing public and independent schools, reporting the additional detail of school quintile, as well as the overall average performance in each school type. Predictably, learners in more affluent, better-resourced schools score, on average, higher than those in no-fee schools where access to resources for teaching and learning is more limited. For example, the blue line, which shows the average achievement score across each of the school quintiles and broad school types, reports a stark 100-point difference – or a full standard deviation – between no-fee (343, 3.4) and fee-paying (444, 7.7) public schools. There is a further jump of 62 points to the independent school average (506, 11.9), which is just above the TIMSS centre point. Thus learners in independent schools are outperforming learners in no-fee schools by, on average, over one and half standard deviations or the equivalent of around four school grades.

In terms of our performance benchmarks, the school-level inequalities are also highly apparent: in no-fee schools just 25 per cent of learners are scoring above 400, while in fee-paying schools this figure is 67 per cent and in independent schools 84 per cent. The contrasting proportion of learners scoring below 350 is 55 per cent in no-fee schools, 18 per cent in fee-paying schools and just 8 per cent in independent schools, respectively. It is also evident from Figure 4.5 that there are so-called "potentials" – those scoring 350 to 400 points – across all school types: one in five learners in no-fee schools, 15 per cent in fee-paying schools and 8 per cent of those in independent schools.

The performance at TIMSS benchmarks at the individual school quintile levels show similarly predictable gradients: in Q1 schools one in five (20 per cent) score above 400 points, with a further 19 per cent considered "potentials"; while for learners in Q2 schools, 26 per cent score above the low TIMSS benchmark and 19 per cent are "potentials"; and in Q3 schools 31 per cent of learners achieve a score over 400 points, with a further 24 per cent scoring between 350 and 400 points.

Figure 4.5: Average mathematics achievement and proficiency benchmarks by school quintile and type



Authors' own calculations from TIMSS 2015 achievement dataset

Surprisingly, achievement in Q4 schools is the most evenly distributed, indicating a wide range of ability levels within this school type. For example, 57 per cent of learners score over 400 points, with 6 per cent achieving over 550 points. Learners in Q5 schools perform better than those in Q4 schools (by 1.5 grade levels), with 21 per cent achieving over 550 points and just 10 per cent below 350 points.

While the differences between school types are clear in Figure 4.5, what is less obvious is the possible ceiling in South African learners' performance. In independent schools, for example, 37 per cent of learners achieve above 550 points – 14 per cent at the "advanced" TIMSS level of 625 points and above. A further 25 per cent score between 475 and 550 points, but nearly a half of these learners (46 per cent) are performing below the centre point of the TIMSS assessment, 16 per cent of whom are below the minimum competency level of the test. Young people attending independent schools have been repeatedly shown as coming from the most affluent, educated, well-resourced homes (Reddy et al., 2012) and should, some may argue, be performing substantially better than they are. And in comparison with other countries, the proportion of learners scoring at high and advanced levels in TIMSS is relatively low. Thus the bigger picture story here may not just be the long tail of low achievement, particularly apparent in the no-fee, most disadvantaged schools, but also the extent of low performance for those in the most advantaged ones. Improving the academic performance and educational outcome of South African learners requires a whole distribution shift, not just a pulling up at the very bottom.

We return a more detailed comparison of Grade 5 schooling environments in Part C of the report, and across the remainder of the report distinguish primarily between no-fee, fee-paying and independent schools only.

Section summary

South Africa is one of the lowest-performing countries in mathematics in comparison to other participating countries and the national average falls short of the lowest international performance benchmark. Three in five South African learners (61 per cent) do not reach the minimum competencies in basic mathematical knowledge required at the Grade 5 level.

Provincially, performance can be clustered into three groups: higher (Western Cape and Gauteng), middle (Mpumalanga, Free State, Northern Cape and KwaZulu-Natal) and lower (North West, Limpopo and the Eastern Cape). While it has one of the highest averages, Gauteng also has the largest range of scores, indicating considerable variation across learner performance in the province. When achievement is broken down by school type, the patterns further reveal the depth of the inequalities present in the system. Approximately 84 per cent of learners in independent schools, 67 per cent of those attending fee-paying schools and just 25 per cent of those at no-fee schools achieved the minimum level of competency. These proportions are comparable with those at Grade 9, where 81 per cent of learners in independent schools, 60 per cent of learners in fee-paying schools and 19 per cent of learners in no-fee schools performed at or above the 400-point benchmark in mathematics. On a more positive note, just over 1 per cent of learners nationally achieved the TIMSS advanced level of more than 625 points, including a handful of those in no-fee schools. This is significant as no learners in the other lowest-performing countries managed to achieve at this level.

We now turn our attention to Part B of the report, which examines in detail different learner characteristics and home environment factors that are associated with mathematics achievement.

PART B

LEARNERS AND THE HOME ENVIRONMENT

Learners and the home environment

5. A profile of Grade 5 learners in 2015

The first section of Part B focuses on some of the individual-level differences between learners as they relate to South African performance in TIMSS-N in 2015, specifically gender and age, and the LoLT. Individual differences are often less immediately obviously policy amenable but nevertheless have important relationships with achievement: a focus on underachievement amongst girls, for example, has led to a shift wherein, in many countries, girls now outperform boys in terms of mathematics performance and increased their lead in literacy (Parker, van Zanden & Parker, 2017); and children born at the end of the academic year tend to have lower educational attainment than those born at the start of the year (Crawford, Dearden & Greaves, 2013); and learners who are more proficient in the language of assessment have a clear advantage over their peers (Pretorius et al., 2016).

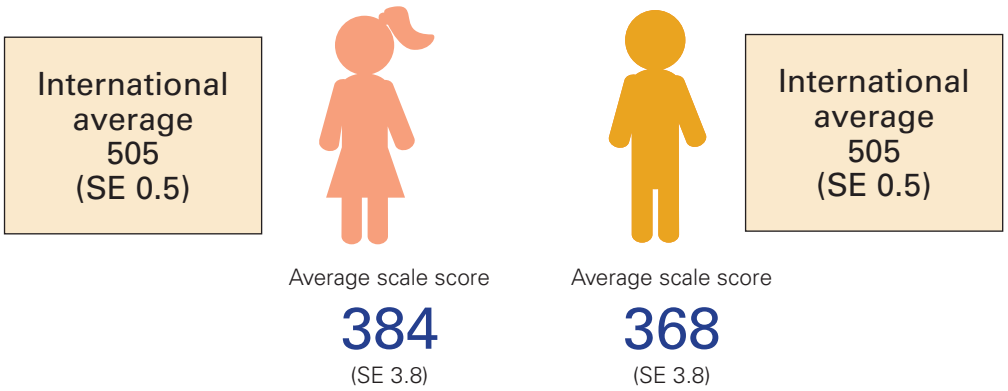
5.1 Gender, age and achievement

Gender

International evidence on the relationship between gender and academic performance is somewhat mixed, not only across countries but also within countries at different points in time. This has been attributed to cultural variations in opportunity structures for females (Else-Quest et al., 2010). In South Africa, research shows that male learners are more likely than females to both repeat grades and so be older than the average grade-age (Isdale et al., 2016; Zuze & Reddy, 2014), as well as to drop out of school altogether (Bhorat et al., 2015; Branson, Hofmeyr & Lam, 2014).

At Grade 5, girls outperform boys by an average 16 points. Figure 5.1 shows the average mathematics score by gender with girls (384, 3.8) performing significantly better than boys (368, 4.4), but both well below the international average for both boys and girls of 505 (0.5) points.

Figure 5.1: Average mathematics achievement for boys and girls



Source: Mullis et al., 2016.

The South African Grade 5 TIMSS-N sample showed a relatively even distribution of boys (48 per cent) and girls (52 per cent), which is comparable to the population of Grade 5s in 2014: 49 per cent girls and 51 per cent boys (DBE, 2016d). Of the 49 countries which participated in TIMSS at the Grade 4 or 5 level, 21 showed a difference in score favouring girls. Of these, in eight countries, including South Africa, the difference was statistically significant. The difference in South Africa was smaller than just three countries: Saudi Arabia (43 points), Oman (22 points), Jordan (20 points).

This result contrasts with the one at Grade 9 which finds no significant gender differences in mathematics or science performance (Zuze et al., 2017). While the achievement difference at Grade 5 is small, just 16 points, it is nevertheless significant; but it is interesting to note that this apparent advantage is lost over the next four years. This may reflect the impact of decreasing self-confidence in mathematics during the adolescent years. Jacobs, for example, finds that self-perceptions of competence and subjective task value decline as children grow older (Jacobs et al., 2002), with girls' levels significantly lower than those of boys in mathematics, at Grade 6. It may also represent an upward shift in the performance of girls over time more generally. Data from five age cohorts from the Longitudinal Study of Australian Youth born between 1981 and 1993 (N = 66, 522), for example, show that girls have closed the gap in mathematics and increased their lead in literacy over recent years (Parker, van Zanden & Parker, 2017). If this is similarly the case for South Africa, we may expect girls to maintain, and possibly even extend, this advantage in the 2019 TIMSS assessments.

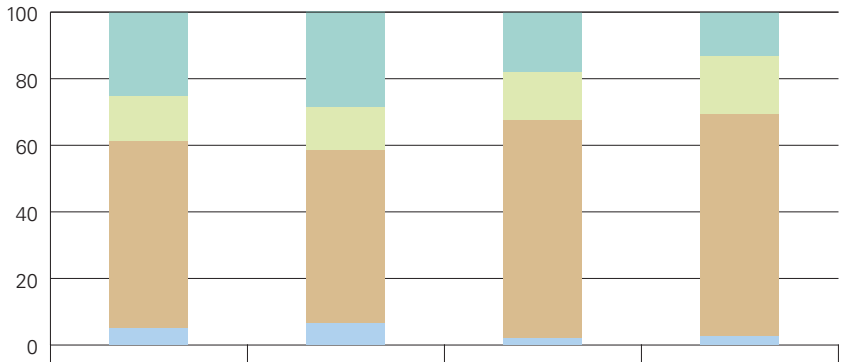
Age

For this analysis, the age at the time of the test administration (October 2014) was used. As the requirement for starting Grade 1 is for the learner to be turning six years old by June, we have chosen wide age bands to reflect "correct age" for learners in Grade 5. Learners in Grade 5 who start school at the correct age and progress through without repetition or interruption should be between 10.5 and 11.5 years old. The average in the TIMSS-N 2015 cohort is 11.5 years, with girls slightly younger than boys, at 11.3 years and 11.7 years respectively, indicating possible grade repetition across learners at this stage, but, in line with extant research, more so for boys.

Figure 5.2 gives the age distribution of Grade 5 learners by school type and again shows evidence of possible grade repetition, more so for learners in no-fee schools. For example, just over half of learners (52 per cent) in no-fee schools are between 10.3 and 11.6 years old, the approximate age for Grade 5 learners having moved smoothly, without interruption, through school. By contrast, this figure is around two-thirds of all learners in fee-paying and independent schools. Similarly, there are more over-aged learners in no-fee schools: over a quarter of learners (29 per cent) are over the age of 12 years in no-fee schools, compared to 18 per cent in fee-paying schools, and just 13 per cent in independent schools.

Interestingly, Figure 5.2 shows that there are more younger learners, those under the age of 10.3 years, in Grade 5 from no-fee schools (6.5 per cent) than from fee-paying (1.9 per cent) or independent schools (2.7 per cent). This could reflect that in no-fee schools there may be a lack of Grade R provision, meaning that learners in some areas may actually start in the grade system earlier than their counterparts in fee-paying or independent schools.

Figure 5.2: Age distribution by school type



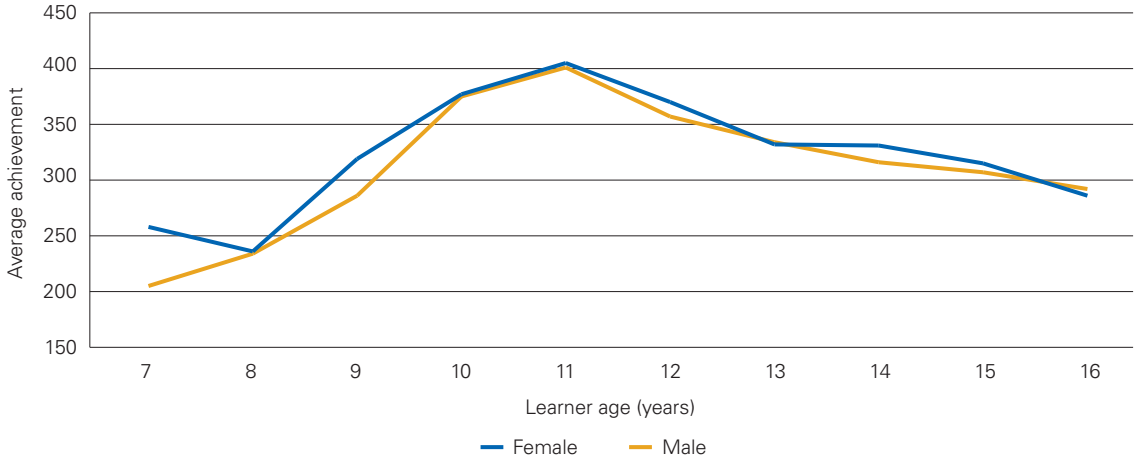
	All	No-fee	Fee-paying	Independent
Over 12 years old	25.20	28.58	18.04	13.27
11.7 – 12 years	13.48	12.86	14.58	17.47
10.3 – 11.6 years	56.20	52.08	65.49	66.49
Under 10.3 years	5.14	6.49	1.89	2.73

Authors' own calculations from TIMSS 2015 learner background dataset 8

Being held back in the grade system matters because once repetition begins it is more likely to continue, with staggered and interrupted progression through the system becoming more marked in the later grades; the corollary of this being that, without adequate remediation, performance continues to decline with age (see Isdale et al., 2016 and in press, for more detail here).

Figure 5.3 shows the relationship between achievement in TIMSS numeracy and age, by gender, and clearly shows that performance is at its peak for learners in the "correct" grade, and is lower both before and after. Note also that the gender advantage favouring girls operates across all ages.

Figure 5.3: TIMSS average numeracy score by age and gender



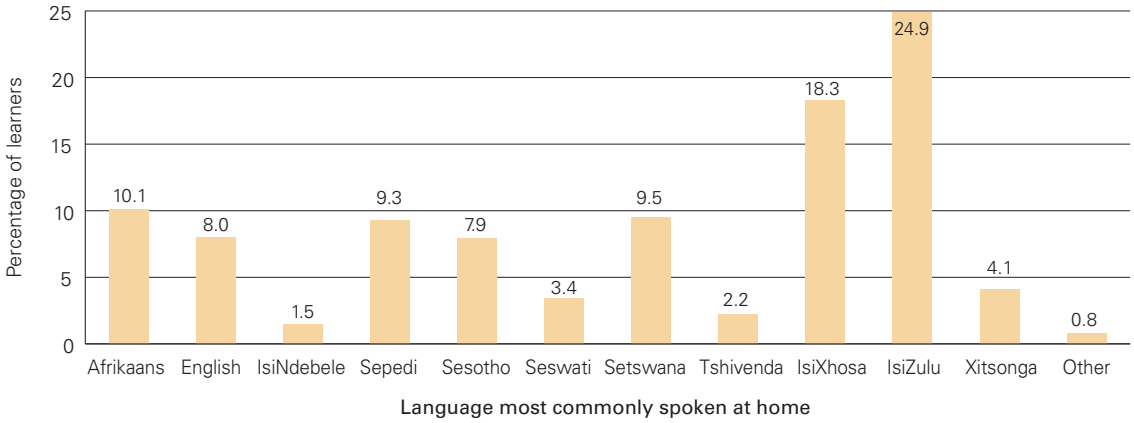
Authors' own calculations from TIMSS 2015 achievement and learner background datasets

5.2 Language of learning and teaching (LoLT)

An additional factor is the equivalence between the home language of the learner and the instructional language of the school. Poor performance in both literacy and numeracy 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, van der Berg, Wills, Gustafsson & Kotze, 2016). Since the TIMSS assessments are given in Grade 5, the overwhelming majority of learners complete the tests in English (91 per cent, with the remaining 9 per cent being administered in Afrikaans), giving those who are more proficient in English (or Afrikaans) a distinct advantage. Across the TIMSS 2015 cohort, just under a third of learners (31 per cent) always or almost always spoke the LoLT in the home, giving them, on average, a 93 point advantage over those who never do.

Figure 5.4 shows the language most commonly spoken at home as reported by the learner. Those whose most commonly spoken language at home is English or Afrikaans perform best in the TIMSS assessment (490, 12.5) and 419 (10.3) points respectively). Figure 5.4, however, shows that just 10 per cent primarily speak Afrikaans at home, with just 8 per cent speaking English most frequently. The most common languages spoken by the Grade 5 TIMSS cohort are IsiXhosa (18 per cent) and IsiZulu (25 per cent).

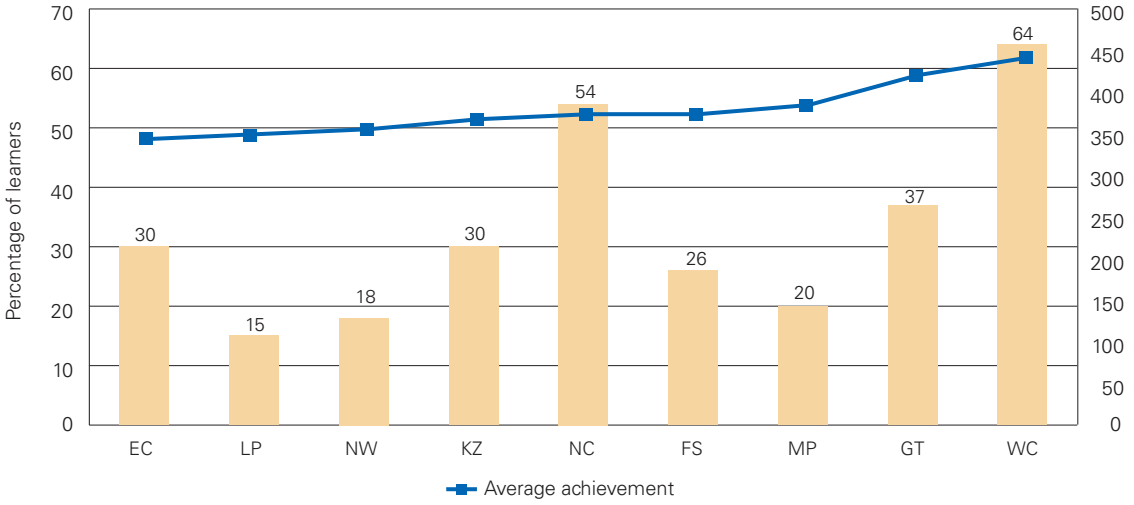
Figure 5.4: Learner-reported most commonly spoken language at home



Authors' own calculations from learner background datasets

Given that South Africa has eleven national languages, coupled with provincial differences in the frequency with which they are used, there are clear differences across the country in terms of the languages spoken at home. Figure 5.5 shows that learners in the Western Cape (64 per cent) and Northern Cape (54 per cent) are most likely to always or almost always speak the language of the test's administration, and those in Limpopo (15 per cent) and the North West (18 per cent) least likely to.

Figure 5.5: Provincial differences in learner reports of how frequently they speak the language of the test at home and related average TIMSS performance



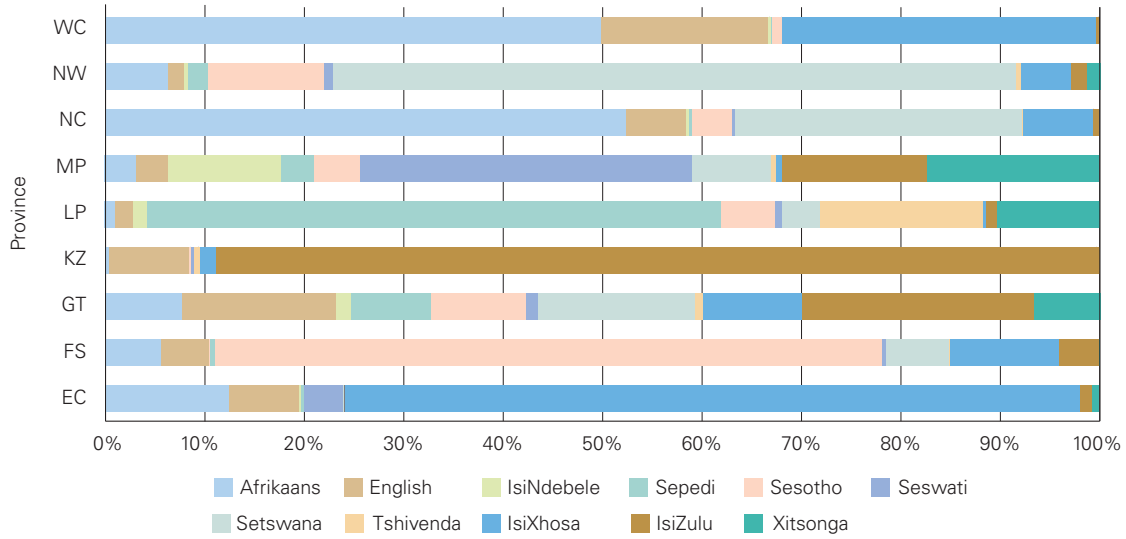
Authors' own calculations from TIMSS 2015 achievement and learner background datasets

Interestingly, only just over a third of Gauteng's learners (37 per cent) frequently speak the language of the test at home, but they report the second highest achievement average across the nine provinces. This may, however, go some way to explaining the fact that Gauteng has one of the largest variations in achievement data (see Figure 3.5 above) since it also has the greatest linguistic diversity: all other provinces have at least a third of learners speaking one of the 11 national languages, and most have at least half speaking just one language (Figure 5.6). The largest proportion of Gauteng learners speaking any one language, on the other hand, is just under a quarter (23 per cent) who speak IsiZulu, with 16 per cent speaking English and 15 per cent Setswana.

PART B

Learners and the home environment

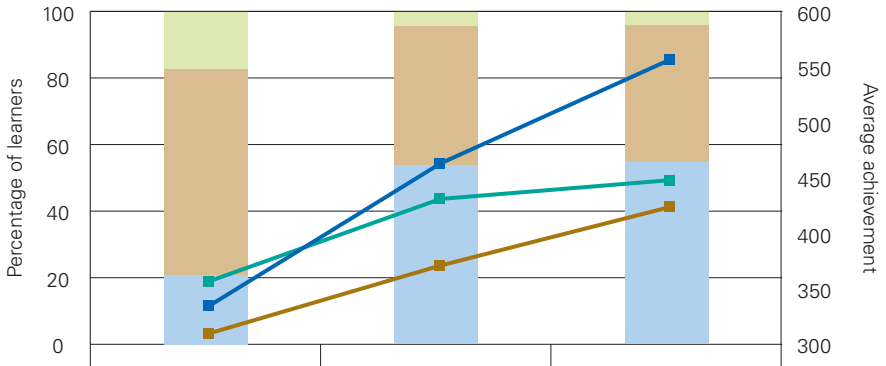
Figure 5.6: Provincial differences in learner reports of language spoken the most frequently at home



Authors' own calculations from learner background datasets

Figure 5.7 reports the frequency of learners speaking the language of the test by school type, as well as the corresponding average achievement. Those in no-fee schools are far less likely to always speak the language of the test, with over 60 per cent reporting they only do so "sometimes" and more than one in six learners reporting never (18 per cent) speaking the test language at home. This places a clear barrier on the ability of no-fee school learners to do well in the test and has been argued by some authors as one of the key issues with the TIMSS assessment tools as predominantly black learners are required to frequently take the test in a language that is not their home language (Taylor, van der Berg, Reddy & Janse van Rensburg, 2015). Interestingly, learners in fee-paying schools and those in independent schools are equally likely to speak the language of the test at home, while only one in five (20 per cent) of those in no-fee schools do so.

Figure 5.7: Average achievement by frequency of speaking test language and school type



	No-fee	Fee-paying	Independent
Never	17.6	4.6	4.0
Sometimes	61.8	41.8	41.4
Always	20.6	53.7	54.6
Always	335	463	557
Sometimes	357	431	448
Never	310	371	424

Authors' own calculations from TIMSS 2015 achievement and learner background datasets

The achievement between those who always or never speak the language of the test at home is different in the three school types. In no-fee schools the difference between these groups is just under a grade, in fee-paying schools it is just over two grades and for independent schools three grades.

6. How learners live and learn

This section of the report focuses on the relationship between various aspects of the home environment and achievement in TIMSS-N. Education and learning are shaped by many different contexts and the interactions between them; key amongst them are family background characteristics, the physical resources available in the home and indicators of SES. For example, learners from lower SES backgrounds do less well academically and are more likely to attend the most impoverished schools with a higher proportion of other low SES learners. A better understanding of how different household resources relate to learner outcomes is integral to improving learner performance across the board.

6.1 Home resources

South Africa is a very diverse country and home and school resources are vastly unequal across learners. Table 6.1, for example, reports that, on average, just 31 per cent of learners have their own computer at home and a slightly higher proportion, 36 per cent, have an internet connection. Just over half, 56 per cent, have access to water-flush toilets and less than two-thirds, 64 per cent, have running water. When considered by school type, those attending fee-paying and independent schools have greater access to a host of different household resources: more than half (51 per cent) of learners in fee-paying schools and two-thirds (67 per cent) in independent schools have an internet connection at home, compared to just over one in four (28 per cent) of those in no-fee schools. Similarly, well over half (56 per cent) of learners in independent schools have their own computer at home, whereas only 27 per cent of those in no-fee schools do.

There is also evidence of socioeconomic variation within the different school types: in independent schools, one in six (17 per cent) learners is without access to running water, 11 per cent do not have water-flush toilets, and only 28 per cent receive a government grant. Contrast this with the no-fee schools, where 59 per cent do not have access to water-flush toilets, 41 per cent are without running tap water and 86 per cent are in households which receive a government grant.

Table 6.1: Reported percentages of learners' household assets, by overall SA average and school type

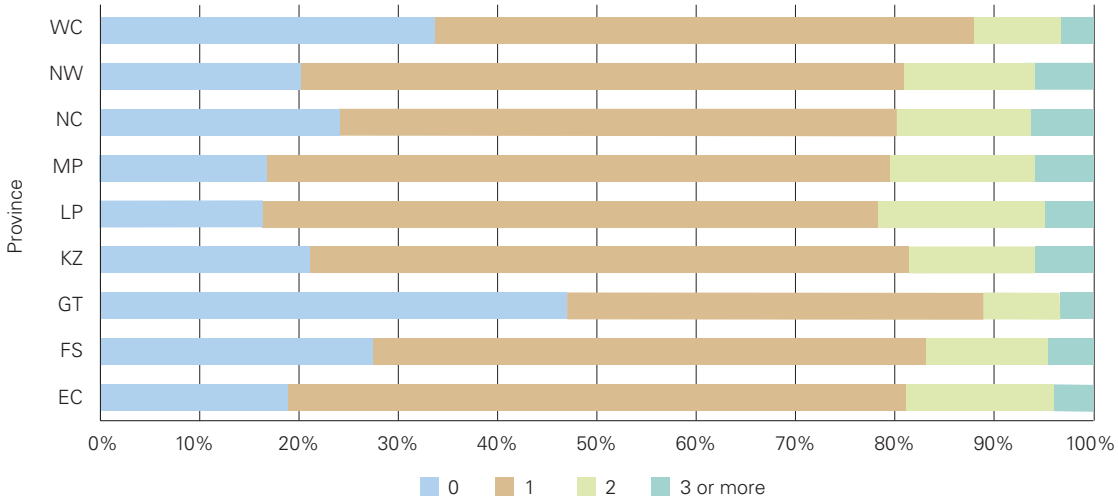
Resource at home	SA average	School type		
		No-fee	Fee-paying	Independent
Computer (own)	31%	27%	39%	56%
Computer (shared)	45%	41%	52%	59%
Internet connection	36%	28%	51%	67%
Water-flush toilets	56%	41%	87%	89%
Fridge	86%	82%	95%	97%
Dictionary	67%	60%	82%	87%
Electricity	83%	78%	93%	94%
Running tap water	64%	59%	76%	83%
Government grant	74%	86%	50%	28%

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

Parents[6] were also asked whether they or anyone in the household was in receipt of any one of eight[7] different social grants. On average, 74 per cent of households were in receipt of at least one grant. Of those receiving a social grant, the vast majority (89 per cent) receive a Child Support Grant, while 22 per cent are in receipt of a Grant for Older Persons. Figure 6.1 shows the total number of social grants received per household by province, and provides an indication of differences in area-level poverty.

The highest performing provinces, Western Cape and Gauteng, have the lowest level of social grant receipts: 34 per cent and 47 per cent of households respectively do not receive any government grant assistance. In Mpumalanga (17 per cent), Limpopo (17 per cent) and the Eastern Cape (19 per cent), only around one in five households is not in receipt of some kind of government financial assistance.

Figure 6.1: Number of social grants received by province



Authors' own calculations from TIMSS 2015 early learning and learner background datasets

6.2 Indicators of socioeconomic status (SES)

The level of maternal education provides a further indicator of household demographics and has been consistently shown to be a key predictor of child achievement (Carneiro, Meghir & Parey, 2012). Table 6.2 reports that, on average, just under half (46 per cent) of learners in South Africa come from households where mothers have a post-Grade 12 education. This breaks down to 37 per cent of learners in no-fee schools, 62 per cent in fee-paying schools, and 84 per cent of those in independent schools. Provincially, again we see considerable differences: learners from Gauteng (60 per cent) and KwaZulu-Natal (54 per cent) come from the most educated homes, while a third of those from the Eastern Cape have mothers with some form of post-Grade 12 education. The difference in performance in households where mothers have a post-Grade 12 qualification and those with less than a Grade 12 education is 105 points, over a standard deviation and equivalent to more than two grades.

The number of books present in the home is another well-recognised indicator of household resources and the cognitive environment in the home (Juan & Visser, 2017): the difference in average performance between those with access to fewer than 25 books and those with more than 25 books at home is 45 points, or the same as one school grade. And again, this inequality is apparent across both schools and provinces: just one in five learners (20 per cent) comes from a household with more than 25 books. Again, those in independent schools are more

[6] *The Early Learning Survey was completed by the child's parent, guardian, or any of their primary caregivers.*
[7] *Child Support Grant; Grant for Older Persons; Disability Grant; War Veteran's Grant; Care Dependency Grant; Foster Child Grant; Grant-in-aid; Social Relief of Distress.*

advantaged, with half (50 per cent) of all learners having more than 25 books at home, while only one in six (16 per cent) of those in no-fee schools has such access. As with maternal education, learners from Gauteng report having more books at home, with over a quarter (27 per cent) having access to this number of books at home, compared to just 15 per cent of those living in the North West.

Table 6.2: Indicators of home environment by province and school type

		% with maternal above Grade 12	% with more than 25 books at home	% with parent whose highest occupation is professional
Province	WC	38%	19%	17%
	GT	60%	27%	26%
	MP	48%	22%	16%
	FS	35%	20%	17%
	NC	39%	19%	17%
	KZ	54%	20%	20%
	NW	38%	15%	11%
	LP	42%	17%	14%
	EC	33%	18%	18%
Overall	SA average	46%	20%	18%
School type	No-fee	37%	16%	11%
	Fee-paying	62%	26%	31%
	Independent	84%	50%	55%

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

Another indicator of household SES and the availability of resources is parental employment. The final column of Table 6.2 shows that fewer than one in five South African learners (18 per cent) live in households where the highest level of occupation of at least one parent is professional or managerial[8]. Again, provincially Gauteng records the highest level of occupational status, with over a quarter of learners from homes with professionally employed parents, and predictably those in independent schools are from more socioeconomically advantaged households: 55 per cent, compared to 31 per cent in fee-paying schools and just 11 per cent in no-fee schools.

In attempting to summarise the physical and socioeconomic resources present in the home, a scale combining these indicators[9] has been constructed by TIMSS administrators for each participating country, called the Home Resources for Learning Index[10]. In South Africa, one-third of learners (34 per cent) come from households considered to have few resources in comparison with an overall international average of 9 per cent and a corresponding difference in performance of 79 points, the equivalent of two school grades. Just two per cent of South African learners reported coming from households with many resources, in contrast with an international average of 17 per cent. Interestingly, however, learners in South Africa from the most highly resourced homes score, on average, 30 points more than their international counterparts.

In comparison with the other bottom-performing countries in the TIMSS 2015 assessment at Grade 4/5, South Africa only fares better than Kuwait. For example, while it has roughly half the proportion of households with few resources than that of Morocco, its average performance is 25 points lower.

[8] *Managers include jobs such as chief executive officers, senior officials, legislators and managers across all sectors. Professional occupations include physical, mathematical and engineering sciences, health professionals, educators, and other professionals working in business, administration, ICT, legal and government sectors.*

[9] *The Home Educational Resources scale is made up of the total number of books in the home as reported by the child; the number of study supports in the home (including internet connection at home, and own room); the number of children's books as reported by the parent; the highest level of education of either parent; and the highest level of occupation of either parent.*

[10] *For further detail see: http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/home-environment-support/home-resources-for-learning/*

Learners and the home environment

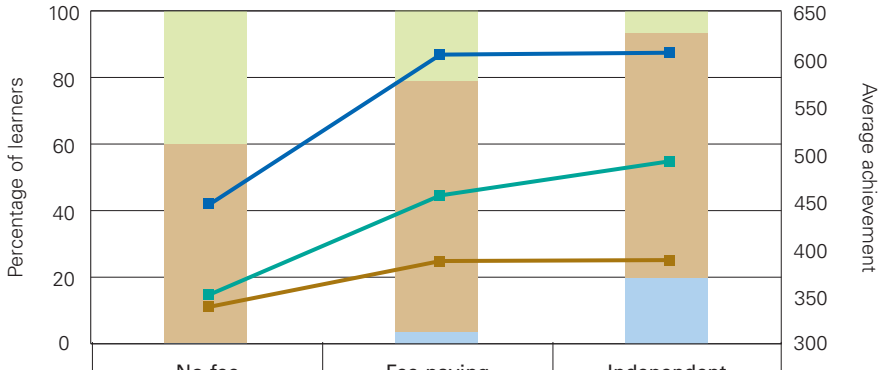
Table 6.3: Proportion of learners and average mathematics achievement scores by Home Resources for Learning Index

	Few resources		Some resources		Many resources	
	% learners	Average achievement	% learners	Average achievement	% learners	Average achievement
South Africa	34 (1.2)	348 (3.2)	65 (1.2)	391 (4.1)	2 (0.4)	599 (10.0)
International	9 (0.1)	427 (1.5)	74 (0.2)	501 (0.4)	17 (0.2)	569 (0.9)
Other bottom-performing countries:						
Jordan	16 (1.1)	340 (7.2)	82 (1.1)	405 (2.9)	2 (0.3)	–[11]
Saudi Arabia	14 (1.0)	371 (8.0)	84 (1.0)	391 (3.8)	1 (0.3)	–
Morocco	62 (1.4)	373 (4.8)	38 (1.4)	400 (4.4)	1 (0.1)	–
Kuwait	3 (0.3)	317 (9.1)	94 (0.5)	359 (4.8)	3 (0.5)	425 (16.3)

Source: Mullis et al., 2016. SE in brackets.

While household resources are linked to individual achievement, clearly it is not a simple mechanism and operates differently in different contexts. Figure 6.2 develops this line of thinking by showing the Home Resources for Learning Index by school type, with the results indicating an interaction between household and school-level resources. For example, across school type, those with few resources fare poorly, with those in independent schools performing at the same level as those in fee-paying schools; for those with some resources, school type clearly makes a substantial difference, adding over 100 points, i.e. a full standard deviation and 2.5 school grades, to learner achievement between no-fee and fee-paying schools, and a further 36 points, equivalent to approximately another school grade, for those in independent schools. The real boost comes for the few who have many resources and who even in no-fee schools see their performance rise to above the low level TIMSS benchmark. We note, however, that as shown in Table 6.3 above, this is a very small proportion of learners.

Figure 6.2: Percentage of learners with few, some and many resources by school type (bar graph) and achievement (line graph)



	No-fee	Fee-paying	Independent
Few	39.9	21.2	6.8
Some	60.0	75.5	73.5
Many	0.1	3.4	19.7
Many	447	604	606
Some	352	456	492
Few	339	387	388

Authors' own calculations from TIMSS 2015 achievement and learner background datasets

[11] *A dash (-) indicates insufficient data to report achievement.*

7. The early educational environment

The physical resources present in the home are important predictors of individual achievement, but so too are the features of the early educational environment experienced by learners. And while the resources in the home and the nature of the home environment itself are correlated, each has its own relationship with academic outcomes. In other words, what parents have is important, but so too is what they do with the resource.

A large and growing body of international evidence demonstrates the ways in which learning is more than a formal process that begins on entering the Grade 1 classroom, but rather is a cumulative endeavour beginning with the understanding of many basic cognitive, linguistic, perceptual and motor processes, which provide the building blocks for subsequent learning. Increasingly, research in this area demonstrates that variability across different aspects of children's early literacy and numeracy skills emerges during the preschool years (see Shonkoff & Phillips, 2000, for a summary). As such, examination of what happened in learners' homes before they started school is an important piece in understanding the puzzle of individual performance at Grade 5.

7.1 Early educational activities

In the Early Learning Survey, parents were asked, "Before your child began primary school, how often did you or someone else in your home do the following with him or her?" In total, parents responded to 17[12] different types of early educational activities. Table 7.1 shows the proportion of learners whose parents reported "often"[13] engaging with them in seven activities at home, all of which are positively associated with higher scores in Grade 5 mathematics. For example, the difference in performance in households where parents often read books to their child, rather than never, is 60 points on average (Table 7.2). Where parents frequently play games involving alphabets, the difference is 44 points. Across the early educational activities considered, approximately one-third of learners experienced frequent engagement, rising to roughly four in ten of those in fee-paying schools and half of those in independent schools.

Table 7.1: Proportion of learners whose parent reported "often" engaging in selected early educational activities by province and school type

		Read books	Write numbers	Watch educational TV	Sing songs	Play with alphabets	Play with number toys	Play word games
Province	WC	44%	59%	60%	60%	35%	37%	35%
	GT	40%	57%	53%	55%	38%	34%	31%
	MP	36%	57%	55%	51%	28%	31%	28%
	FS	32%	53%	48%	48%	30%	31%	24%
	NC	36%	53%	54%	51%	30%	30%	25%
	KZ	30%	51%	43%	43%	28%	28%	25%
	NW	33%	57%	53%	47%	31%	33%	29%
	LP	31%	52%	46%	41%	26%	28%	25%
	EC	33%	48%	45%	44%	29%	28%	24%
Overall	SA average	35%	53%	49%	48%	30%	31%	27%
School type	No-fee	32%	52%	47%	44%	26%	27%	26%
	Fee-paying	40%	56%	56%	56%	40%	38%	30%
	Independent	53%	54%	51%	57%	48%	46%	32%

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

[12] *The activities are: read books, write numbers, watch educational TV, sing songs, play with alphabets, play with number toys, play word games, tell stories, talk about things you had done, talk about what you had read, write letters or words, read aloud signs and labels, counting rhymes or songs, count things, play shape games, play with building blocks and play board or card games.*

[13] *Responses were scaled often, sometimes, never or almost never.*

Learners and the home environment

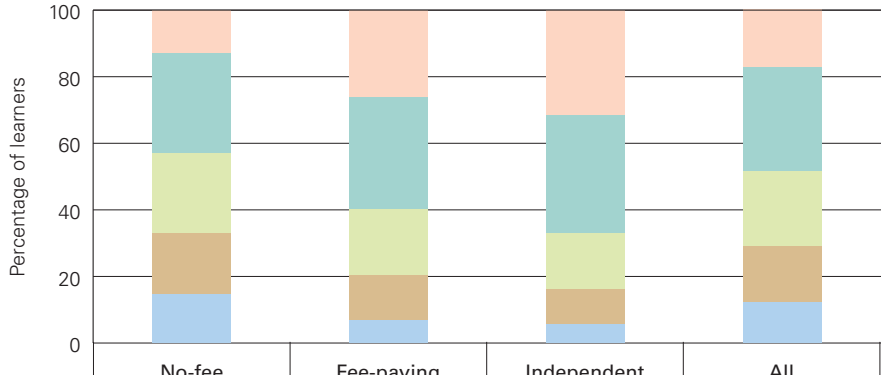
Table 7.2: Average achievement of learners by frequency of engaging in early learning activities

Activity	Frequency		
	Often	Sometimes	Never
Read books	401 (5.7)	371 (3.0)	341 (5.5)
Write numbers	386 (3.9)	377 (3.9)	360 (6.5)
Watch educational TV	389 (4.0)	378 (4.1)	350 (6.1)
Sing songs	392 (4.7)	370 (3.6)	362 (5.3)
Play with alphabets	403 (5.3)	375 (3.9)	359 (3.6)
Play with number toys	402 (5.5)	379 (3.6)	359 (4.2)

Authors' own calculations from TIMSS 2015 early learning and learner background datasets. SE in brackets.

Figure 7.1 reports the proportion of parents engaging frequently in these activities by school type and shows clear differences in the level of cognitive stimulation learners experience at home. Over a quarter of learners in fee-paying schools (26.1 per cent) and nearly a third in independent schools (31.8 per cent) live in households where parents report engaging in more than 10 of the above activities frequently, compared to just 13.1 per cent of those in no-fee schools. Learners in no-fee schools are also more likely to live in households where parents do not regularly engage in any educational activities (14.6 per cent), double the number of those in fee-paying (6.7 per cent) and independent (5.7 per cent) schools.

Figure 7.1: Percentages of parents engaging frequently in early educational activities by school type

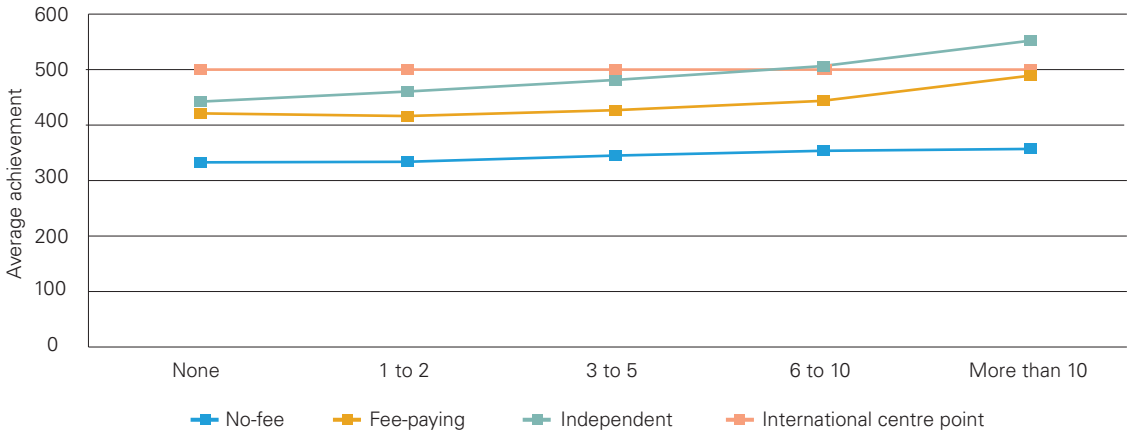


	No-fee	Fee-paying	Independent	All
More than 10	13.1	26.1	31.8	17.2
6 to 10	30.1	33.9	35.5	31.3
3 to 5	23.9	19.6	16.6	22.5
1 to 2	18.4	13.7	10.5	16.9
None	14.6	6.7	5.7	12.2

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

Figure 7.2 shows the positive relationship between engagement in early educational activities and subsequent TIMSS achievement: while smaller for learners in no-fee schools, the relationship is nevertheless positive with those in the most cognitively stimulating households achieving an average of 24 more points than those where no educational activities are frequently present. For learners in independent schools, regular engagement in more than six educational activities pushes average performance above the TIMSS centre point of 500.

Figure 7.2: Relationship between engagement in early educational activities and TIMSS achievement by school



Authors' own calculations from TIMSS 2015 achievement and learner background datasets

These 17 activities have also been condensed into a single index of early literacy and numeracy activities in the home[14]. Table 7.3 attempts to capture the interactions between different learner "contexts" by reporting the relationships between this feature of the home environment, the resources in the home (measured in terms of highest household education, see section 6.2 for more detail here) and learner performance in TIMSS. It reports the positive association between both household education and the early educational environment on the one hand, and individual achievement on the other. As each contextual indicator increases, so too does learner performance. Learners in households where there is frequent use of literacy and numeracy activities before school started and where parents have a post-secondary education (22 per cent of learners) score, on average, 170 points higher than those from households where early educational activities are a rarity and parental education is below Grade 12 (496 vs. 326). This is no small difference, with 170 scale score points being equivalent to over four grades.

Table 7.3: Relationship between literacy and numeracy activities before school, household education and mathematics achievement

		Overall	Household educational level		
			Below Grade 12	Completed Grade 12	Post-secondary
Frequency of activities	%	Average achievement	343 (3.0)	380 (4.2)	451 (6.3)
Never/almost never	7	339 (5.8)	326 (7.0)	351 (9.2)	428 (18.5)
Sometimes	66	367 (3.3)	340 (3.3)	374 (4.5)	429 (6.0)
Often	27	415 (6.2)	366 (5.4)	410 (6.0)	496 (8.6)

Authors' own calculations from TIMSS 2015 achievement and early learning datasets. SE in brackets.

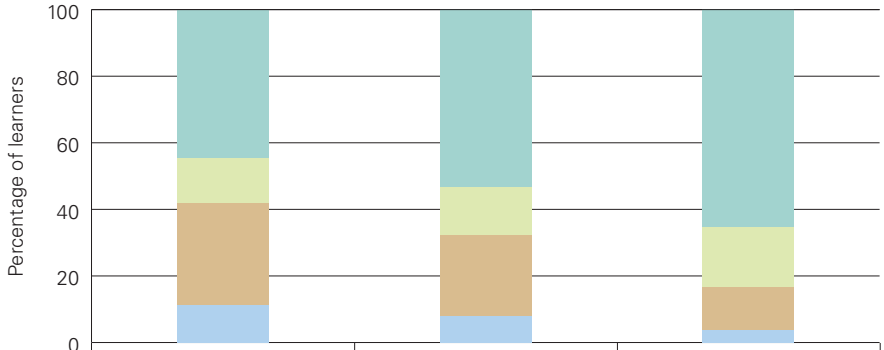
[14] *For further detail here see: http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/home-environment-support/early-activities-before-beginning-primary-school/*

PART B

7.2 Preschool attendance

Preschool attendance in South Africa has increased considerably over recent years with almost nine out of every ten learners (89 per cent) having some form of schooling prior to Grade 1[15] (Figure 7.3).

Figure 7.3: Preschool attendance by school type



	No-fee	Fee-paying	Independent
3 years or more	44.7	53.5	65.5
2 years	13.6	14.2	17.8
1 year or less	30.4	24.2	13.0
Did not attend	11.3	8.1	3.7

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

Moreover, as shown in Table 7.4, both in South Africa and internationally there is a positive relationship between years of attending preschool and mathematics achievement in Grade 5.

Table 7.4: Average achievement by preschool attendance, for South Africa and international average

Preschool attendance	South Africa		International average	
	%	Average achievement	%	Average achievement
Average		376 (3.4)		
Did not attend	10	353 (4.6)	12	466 (1.2)
1 year or less	28	362 (3.6)	16	488 (1.0)
2 years	14	384 (5.6)	18	499 (0.8)
3 years or more	48	390 (4.6)	54	512 (0.2)

Authors' own calculations from TIMSS 2015 early learning and learner background datasets and Mullis et al., 2016. SE in brackets.

But with nine out of ten learners receiving some level of schooling prior to Grade 1, is this preschool advantage realised across all learners? Figure 7.4 shows that when examined by school type, a similar pattern of incremental advantage emerges. However, building on the story shown in Table 7.1 demonstrating how different features of how individuals live and learn operate together, learners in no-fee schools do not appear to experience the same "achievement boost" from attending preschools that those in fee-paying and independent schools do.

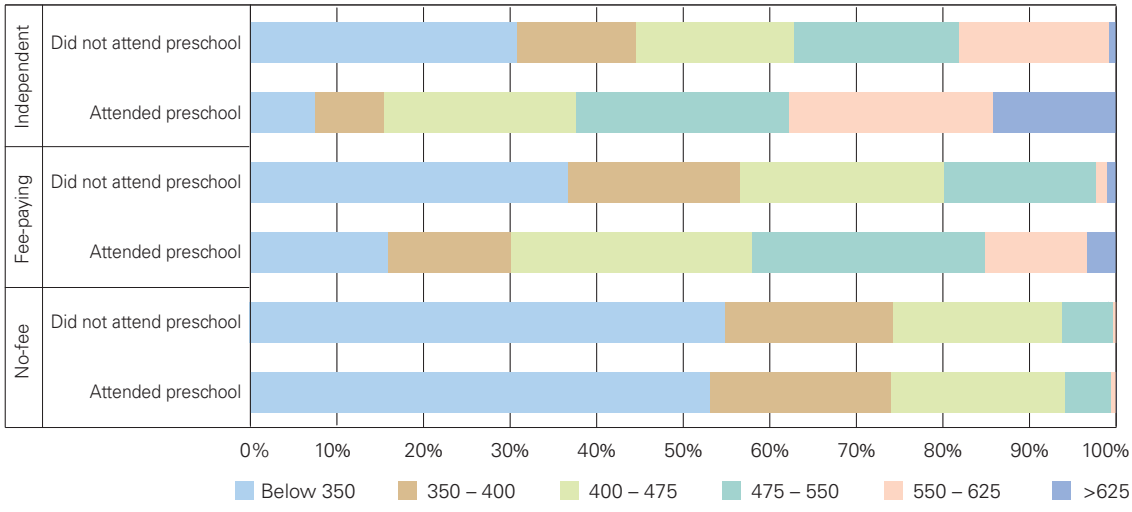
[15] *Ideally learners who were in Grade 5 in 2014 should have been in preschool or Grade R in 2009. In 2009 there were 620 223 learners in Grade R (not including those in stand-alone ECD sites). In 2010 there were 1 116 899 learners in Grade 1. Thus approximately 56 per cent of Grade 1 learners attended Grade R in ordinary public schools in 2009.*

The lack of benefit seen for those in no-fee schools may be an indication of the quality of preschool education available to those who go on to Q1 – Q3 schools, which is not as high as for those who subsequently attend fee-paying and independent schools.

For example, in both fee-paying and independent schools the proportion of learners scoring below 350 points is at least double when the learner did not attend preschool: 7 per cent vs. 28 per cent in independent schools, and 16 per cent vs. 38 per cent in fee-paying schools, in comparison with 54 per cent and 55 per cent in no-fee schools. This apparent advantage of attending preschool is seen across the achievement distribution and not just at the bottom, with 38 per cent of those in independent schools and 15 per cent in fee-paying schools having some form of preschool education scoring at or above 550 points, in contrast to just 24 per cent and 2 per cent respectively among those who did not attend preschool.

The lack of benefit seen for those in no-fee schools may be an indication of the quality of preschool education available to those who go on to Q1-Q3 schools, which is not as high as for those who subsequently attend fee-paying and independent schools. While the recent increase in children able to access preschool education is laudable, it is more than just attendance that matters. Rather, as with our observations about the positive role that a cognitively stimulating environment in the home can have on individual achievement, preschool environments need to be high quality, well-resourced contexts, particularly for those from the most disadvantaged households. It may also be the case that the educational benefits accrued in preschool are lost when these learners move into the formal schooling system and thus Figure 7.4 reflects the difficulties of poorly resourced, predominantly low SES schools being able to sustain any early gains made.

Figure 7.4: Average achievement by proficiency benchmarks by preschool attendance by school type



Authors' own calculations from TIMSS 2015 early learning and learner background datasets

8. Early academic skills

Further highlighting the role of good quality preschool education, learners who start school with sound early literacy and numeracy skills perform better in mathematics at Grade 5. Parents were asked to report on how well their child could do a range of literacy (such as recognising words, reading a story, and writing letters and words) and numeracy (including recognising and writing numbers, performing simple addition and subtraction) tasks when they began Grade 1. Across a range of measures, learners who had a solid foundation in literacy and numeracy skills prior to starting Grade 1 outperformed those with only minimal competencies by an average of 84 points, roughly equivalent to two whole grades.

8.1 Early literacy skills

Approximately half (49 per cent) of all learners were able to recognise most of the letters of the alphabet very well on beginning Grade 1, with just over a third (35 per cent) able to read some words very well and more than four in ten (43 per cent) able to write letters very well. These percentages are comparable to the TIMSS international average (Table 8.1).

Table 8.1: Proportion of learners with strong literacy skills prior to Grade 1

	Recognise most of the letters of the alphabet very well	Able to read some words very well	Write letters very well
South Africa	49%	35%	43%
TIMSS average	51%	33%	41%

Authors' own calculations from TIMSS 2015 early learning dataset; TIMSS early learning almanac, 2016

In South Africa, those in independent schools again fared better than those in the public sector, but the differences in reported early literacy skills across provinces were less pronounced, with Gauteng reporting the highest proportion of learners with strong literacy skills (see Table 8.2).

Table 8.2: Proportion of learners with strong literacy skills prior to Grade 1 by province and school type

		Recognise most letters of alphabet very well	Read some words very well	Write letters very well
Province	WC	47%	34%	42%
	GT	57%	40%	51%
	MP	50%	34%	42%
	FS	50%	39%	44%
	NC	43%	30%	40%
	KZ	50%	37%	42%
	NW	46%	37%	44%
	LP	44%	31%	41%
	EC	45%	32%	41%
Overall	SA average	49%	35%	43%
School type	No-fee	46%	35%	43%
	Fee-paying	54%	35%	44%
	Independent	62%	41%	51%

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

8.2 Early numeracy skills

In terms of early numeracy skills, only a quarter of learners were reported by parents as being able to count (26 per cent) or write numbers (24 per cent) on their own up to 100 or higher when they started Grade 1, with just one in five (21 per cent) able to recognise written numbers up to 100. As with early literacy skills, more learners in independent schools begin Grade 1 with strong numeracy skills: two-fifths (41 per cent) of those in independent schools, for example, were reported as being able to count up to 100 or higher in contrast to 35 per cent in fee-paying schools and 22 per cent in no-fee schools. Again, there is some provincial variation in learners' early academic skills – particularly with respect to counting on their own – with Gauteng reporting a nine percentage point higher proportion of learners able to count up to 100 than the national average.

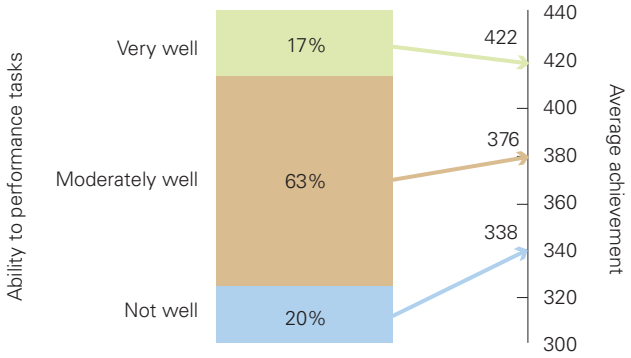
Table 8.3: Proportion of learners with strong numeracy skills prior to Grade 1 by province and school type

		Count on own up to 100 or higher	Recognise written numbers up to 100 or higher	Write numbers up to 100 or higher
Province	WC	32%	23%	25%
	GT	35%	28%	29%
	MP	20%	18%	21%
	FS	25%	24%	23%
	NC	23%	19%	22%
	KZ	27%	20%	24%
	NW	21%	20%	23%
	LP	21%	19%	22%
	EC	25%	19%	24%
Overall	SA average	26%	21%	24%
School type	No-fee	22%	19%	23%
	Fee-paying	35%	27%	27%
	Independent	41%	30%	29%

Authors' own calculations from TIMSS 2015 early learning and learner background datasets

When combined into an overall scale[16], we see a strong positive association between reported learner early academic skills and performance in Grade 5 mathematics.

Figure 8.1: Parent reports of how well the learner could perform literacy and numeracy tasks by average achievement



Authors' own calculations from TIMSS 2015 achievement, early learning and learner background datasets

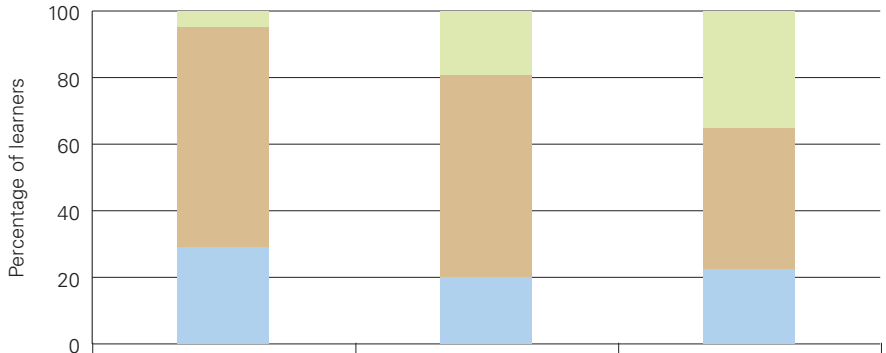
[16] *For further detail, see http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/home-environment-support/could-do-literacy-and-numeracy-tasks-when-began-primary-school/*

PART B

8.3 Principals' assessment of early academic skills

Principals were similarly asked what proportion of learners could do the same set of literacy and numeracy tasks on beginning Grade 1. On average, just over a quarter of learners (27 per cent) attend schools where principals reported that less than 25 per cent of their learners came to school with good, basic literacy and numeracy skills; nearly two-thirds (64 per cent) have between 25 per cent and 75 per cent of their learners equipped with these skills at Grade 1; and just 9 per cent of learners attend schools where principals preside over schools where more than three-quarters of learners begin school with strong basic skills. Figure 8.2 shows principal reports of learner skill level by school type and, as with the parental reports, shows that those in fee-paying and independent schools are more likely to start Grade 1 with stronger academic skills.

Figure 8.2: Principal reports of learner early academic skills by school type



	No-fee	Fee-paying	Independent
Less than 25%	28.9	20.0	22.4
25 – 75%	66.2	60.6	42.3
More than 75%	4.9	19.4	35.4

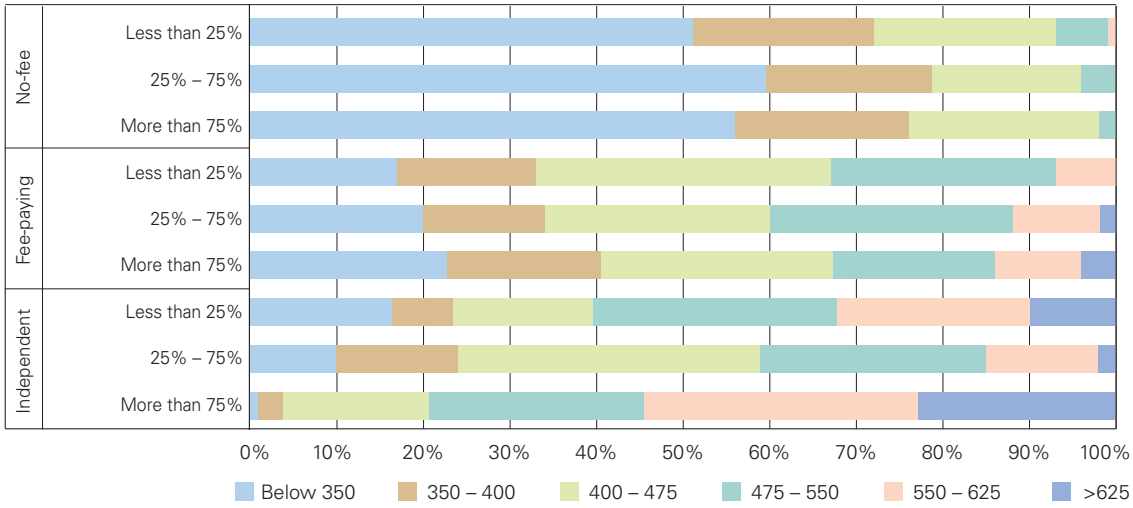
Authors' own calculations from TIMSS 2015 school and learner background datasets

We note with interest, however, that 5 per cent of learners attend no-fee schools where principals report that over three-quarters of learners start Grade 1 with good literacy and numeracy skills, and conversely that more than one in five learners (22 per cent) attend independent schools where less than 25 per cent of learners start Grade 1 without such basic skills. There are pockets of excellence throughout the system and these need to be further studied to understand the particular nuances of their learner populations. Moreover, parent and principal reports are correlated, indicating a reasonable degree of congruence between the two.

Is there a relationship between average levels of school entry capabilities of learners in a school and performance in Grade 5 TIMSS? For example, can being in a school where the average skill level of learners was higher raise individual performance? Figure 8.3 attempts to capture some of this detail by plotting TIMSS plus our local benchmarks at different levels of school average learner academic skills on starting Grade 1, across the three different types of school in order to see how different contexts might work together to support or hinder educational performance.

At the top end of the distribution, learners in the most able cohorts in independent schools are performing exceptionally well: 55 per cent score at or above 550 points, with a further 15 per cent scoring over 500 points, the TIMSS centre point, and just 4 per cent of learners scoring below the 400-point low TIMSS performance benchmark. At the bottom end of the distribution, however, being in a no-fee school even where a high proportion of children enter school with strong academic skills does not seem to be positively associated with TIMSS performance in the same way. Rather, the distribution of mathematics scores between schools with more than 75 per cent of learners with good literacy and numeracy skills in Grade 1 is very similar to those with less than 25 per cent of learners ready to learn. These results appear to suggest a better correlation of principal assessment of learner early academic skills in independent and fee-paying schools than in no-fee schools.

Figure 8.3: TIMSS-N benchmarks by principal reports of learners' early academic skills and school type



Authors' own calculations from TIMSS 2015 school and learner background datasets

PART B

9. Educational expectations and beliefs

Educational expectations about how far parents and learners themselves think they will go in education, and beliefs about individual competencies, play an important role in shaping academic outcomes and learner trajectories: parents with higher educational expectations have children who, on average, both achieve better during their school careers and go on to attain higher level qualifications (Davis-Kean, 2005). Similarly, the positive association between confidence in one's own academic ability and achievement is well documented across childhood and adolescence (Huang, 2011; Möller, Pohlmann, Köller & Marsh, 2009; Susperreguy, Davis-Kean, Duckworth & Chen, 2017).

9.1 Educational expectations

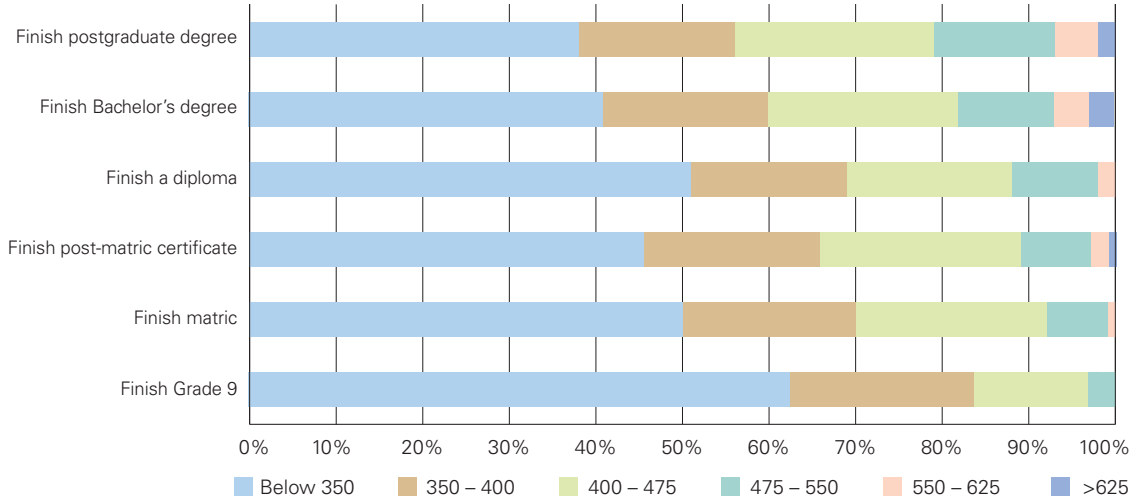
In the TIMSS survey, parents were asked "How far in his/her education do you expect your child to go", with responses ranging from "Finish Grade 9" to "Finish postgraduate degree".[17] Learners whose parents expect their child to leave education after finishing lower secondary school (just 2 per cent) score, on average, 27 points lower than those whose parents want them to leave after completing Grade 12 (11 per cent). Note, however, that in this study, as in the Grade 9 one, the majority of parents have exceptionally high expectations, with over half (54 per cent) of those asked wanting their child to finish a postgraduate degree.

Figure 9.1 reports the proportion of learners achieving on TIMSS plus locally set benchmarks, by parents' highest educational expectations and shows a clear gradient between anticipation of a higher qualification and Grade 5 achievement. For example, two-thirds (62 per cent) of learners whose parents expect their child to only finish Grade 9 score below 350 points with 3 per cent scoring above 475 points. Where parents expect some non-tertiary post-school education, just over four in ten (45 per cent) score below 350 points, with 3 per cent scoring above 550 points. For those learners of parents with the highest educational expectations, 38 per cent score below 350 points, with a further 18 per cent scoring between 350 and 400 points, but 21 per cent achieving over 475 points.

[17] *Unlike the TIMSS Grade 9 survey, this question was only asked of parents and not of the learner themselves.*

Learners and the home environment

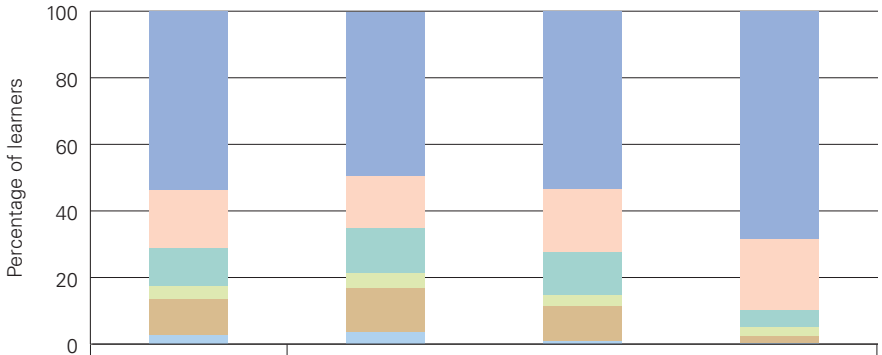
Figure 9.1: Proficiency benchmarks by parents' highest educational expectations



Authors' own calculations from TIMSS 2015 achievement, early learning and learner background datasets

Parents' own level of education is also positively associated with their expectations regarding how far their child will go: better-educated parents expect higher levels of education from their children (Figure 9.2). But reflecting the broader expansion of education across the country and the nature of the labour market, there is also evidence of a general upwards shift in how much education individuals should receive, with the vast majority of parents wanting their offspring to achieve higher qualifications than they themselves have.

Figure 9.2: Parents' educational expectations for learners, by overall group average and by highest household education



	Overall average	Highest household education		
		Below Grade 12	Completed Grade 12	Post-secondary
Finish postgraduate degree	53.9	49.5	53.6	68.6
Finish Bachelor's or equivalent	17.3	15.6	18.8	21.2
Finish short-cycle tertiary	11.5	13.7	12.9	5.4
Finish post-secondary, non-tertiary	3.9	4.4	3.2	2.5
Finish upper secondary	10.9	13.2	10.7	2.2
Finish lower secondary	2.5	3.6	0.8	0.2

Authors' own calculations from TIMSS 2015 early learning dataset

How confident learners feel in their own mathematical ability, in particular, has been shown to be an important factor in explaining academic achievement.

9.2 Academic beliefs

Learners themselves were asked about three aspects of their own feelings toward mathematics: enjoyment of mathematics; confidence in their ability to learn mathematics; and levels of educator engagement. Across all three measures there is a positive relationship with achievement (see Table 9.1). While the majority of learners report enjoying mathematics and finding their educator engaging, far fewer reported being confident in their ability to learn mathematics: around one in six (16 per cent) learners said they were very confident in their ability to learn mathematics, with a third stating they had low levels of confidence in the subject.

Table 9.1: Learner feelings about mathematics and related mathematics achievement

	Low		Medium		High	
	%	Average	%	Average	%	Average
Learner enjoyment of mathematics	8	350 (3.6)	46	345 (1.4)	46	416 (1.2)
Learner confident in learning mathematics	33	341 (1.5)	51	376 (1.3)	16	460 (2.3)
Learner finds educator engaging	6	314 (3.3)	25	345 (1.8)	68	396 (1.1)

Authors' own calculations from TIMSS 2015 achievement and learner background datasets

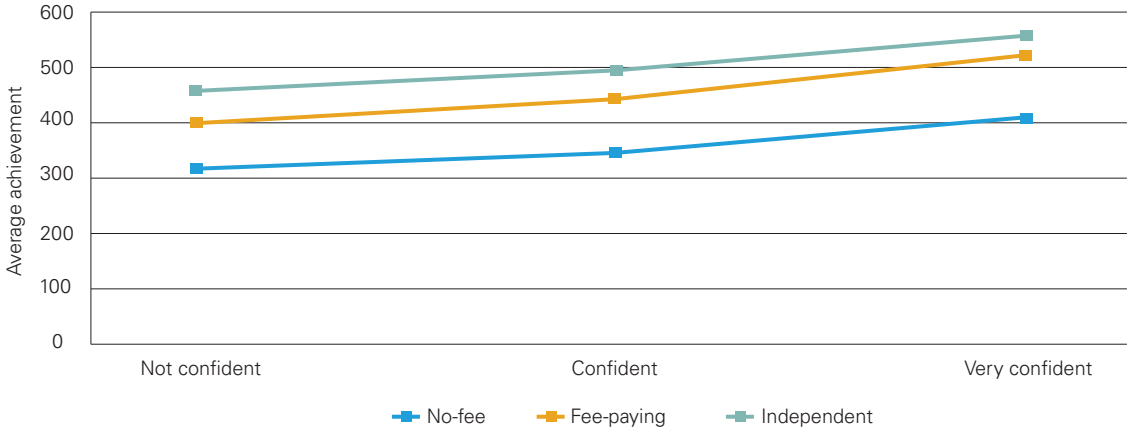
How confident learners feel in their own mathematical ability in particular has been shown to be an important factor in explaining academic achievement (Juan et al., 2015). The developmental path here is such that doing well in mathematics improves positive feelings about – and one's capability to do well in – mathematics; this, in turn, raises interest in doing well and so too the likelihood of becoming proficient in those skills over time, thereby improving future performance (Susperreguy, 2017; Watts et al., 2015).

The scale measures how confident learners feel about their ability in mathematics in terms of their level of agreement with nine statements, such as "I learn things quickly in mathematics", "Mathematics makes me nervous", "Mathematics is harder for me than for many of my classmates", "I am good at working out difficult mathematics problems".[18] South Africa has one of the lowest proportions of learners (16 per cent) reporting feeling very confident in mathematics, half the international average of 32 per cent. Particularly noteworthy, however, is that South Africa ranks alongside all five top-ranked countries: Singapore (19 per cent), Hong Kong SAR (19 per cent), Korea (13 per cent), Chinese Taipei (15 per cent), and Japan (15 per cent).

Learner confidence in their ability to learn mathematics is highest among those in independent schools. One-third (33 per cent) of those in independent schools rate themselves as being very confident in mathematics in contrast to just 21 per cent and 13 per cent in fee-paying and no-fee schools, respectively. It is important to note, however, that learners in no-fee schools with very high levels of confidence in their mathematical abilities score, on average, higher than those with low levels of confidence in fee-paying schools; and similarly, learners in fee-paying schools with very high confidence in their mathematical skills have higher scores than those in independent schools who only have moderate levels of self-confidence (see Figure 9.3).

[18] *For more detail on the scoring of the Confidence in Mathematics scale, see: http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/student-engagement-and-attitudes/students-confident-in-mathematics/*

Figure 9.3: Average learner mathematics achievement by confidence in their mathematical ability and school type



Authors' own calculations from TIMSS 2015 achievement and learner background datasets

Section summary

South Africa is a country marred by inequities: household resources are vastly unequal across learners and very low compared to international standards. Our results retell a predictable story seen before in South Africa, of advantage begetting advantage at one end of the distribution, and compounding disadvantage at the other: SES indicators, such as parents' level of education and the number of books in the home, are positively related to learner achievement; and those with more resources have higher achievement scores. Conversely, learners from households with the lowest level of resources do less well academically, are more likely to attend more impoverished no-fee schools and less likely to have the language of instruction as their home language.

But there is also evidence highlighting that what parents do matters alongside what they have: cognitively rich environments where caregivers engage frequently in early educational activities are associated with higher performance in Grade 5, and while resources in the home are positively associated with early educational activities, the more positive inputs a learner experiences, the higher their performance, regardless of social standing. In the same vein, we see that good quality preschool settings can offer another important contextual boost for learners and attendance is positively associated with achievement in mathematics for learners in fee-paying and independent schools. However, this benefit is not realised for those who go on to attend no-fee schools raising questions about the quality of preschool education in different settings. This raises the stakes for the role that the school system needs to play in order for education to be an equaliser across all learners, and requires a shift in the focus from access to education to ensuring quality engagements and interactions in classrooms.

Features of the home environment, such as educational expectations held by parents and learners' own academic beliefs, are associated with individual performance in TIMSS mathematics: the more parents expect of their children in terms of their eventual educational qualifications, the better they achieve in Grade 5 numeracy; the more learners themselves enjoy, are confident and engaged in mathematics, the better they do. As noted, however, how learners live is also closely linked with the schools young people attend. Moreover, these different factors do not exist in isolation and often work to compound both relative disadvantage as well as advantage; the learning environment itself is no exception. We now turn our attention to a more detailed examination of where learners go to learn.

PART C

A COMPARISON OF SCHOOLING ENVIRONMENTS

A comparison of schooling environments

10. Where learners go to learn

The preceding sections of this report demonstrated how some of the individual and family level factors related to performance in TIMSS and showed that learners from households with fewer physical resources, lower SES and less cognitively stimulating environments are, on average, underperforming in relation to their more advantaged counterparts by up to four school grades. The compounding disadvantage faced by learners from the poorest homes raises the stakes for schools to equalise opportunities and attempt to level the playing field of educational success.

10.1 School resources

Table 10.1 reports results on selected school characteristics[19]. Over three-quarters of learners (77 per cent) attend schools where a free lunch is provided and just over half (52 per cent) where a place is offered to do work before or after school. Only four in ten learners (42 per cent) attend schools with a library, more so in fee-paying (80 per cent) and independent (81 per cent) schools. As regards the provinces, learner access to a school library in Gauteng is on a par with access in independent schools (82 per cent), with learners in Limpopo having the lowest reported library resources (17 per cent).

Table 10.1: Selected school characteristics by province and school type

Selected school characteristics:		% learners in schools which provide free lunch	% learners in schools which have a place to do schoolwork before or after school	% learners in schools which have a library
Province	WC	88%	38%	50%
	GT	73%	73%	82%
	MP	77%	59%	50%
	FS	77%	41%	38%
	NC	58%	65%	28%
	KZ	75%	45%	34%
	NW	80%	45%	29%
	LP	90%	54%	17%
	EC	69%	47%	34%
Overall	SA average	77%	52%	42%
School type	No-fee	89%	52%	25%
	Fee-paying	56%	48%	80%
	Independent	20%	82%	81%

Authors' own calculations from TIMSS 2015 school background dataset

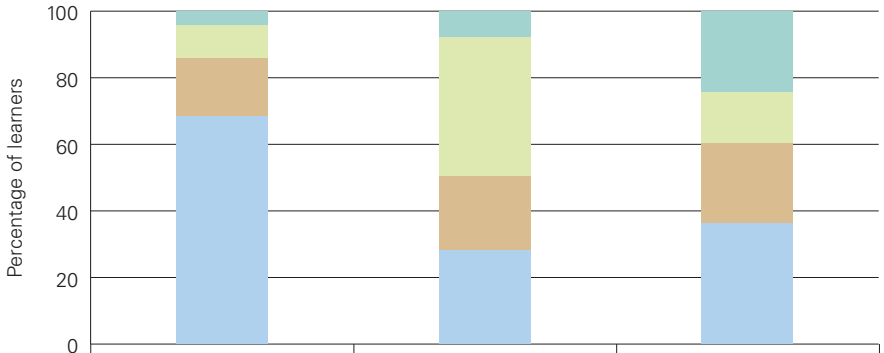
Computer resources

Part of the DBE's Action Plan to 2019 is to increase learners' access to computers (DBE, 2016c), but as is shown in Figure 10.1, this remains heavily skewed towards the most well-resourced schools. Just 4 per cent of learners in no-fee schools have access to more than 50 computers, whilst in fee-paying schools this figure is 8 per cent and is nearly a quarter, 24 per cent, in independent schools. At the other end of the scale, over two-thirds of learners in no-fee schools (68 per cent) are without access to any computers, compared with just 28 per cent of those in fee-paying and 36 per cent in independent schools[20].

[19] *Principals' responses to the School Questionnaire are reported by the number of learners who are in the school of the principals and thus is considered representative of learners.*

[20] *For clarity, this finding should be compared against actual enrolment figures since some no-fee schools may be very small and independent schools very large; however, information on the number of computers per learner was not available. We also note that our analyses are unable to take into account the actual use of computer resources as opposed to simply the availability of IT resources.*

Figure 10.1: Access to school computer facilities by school type

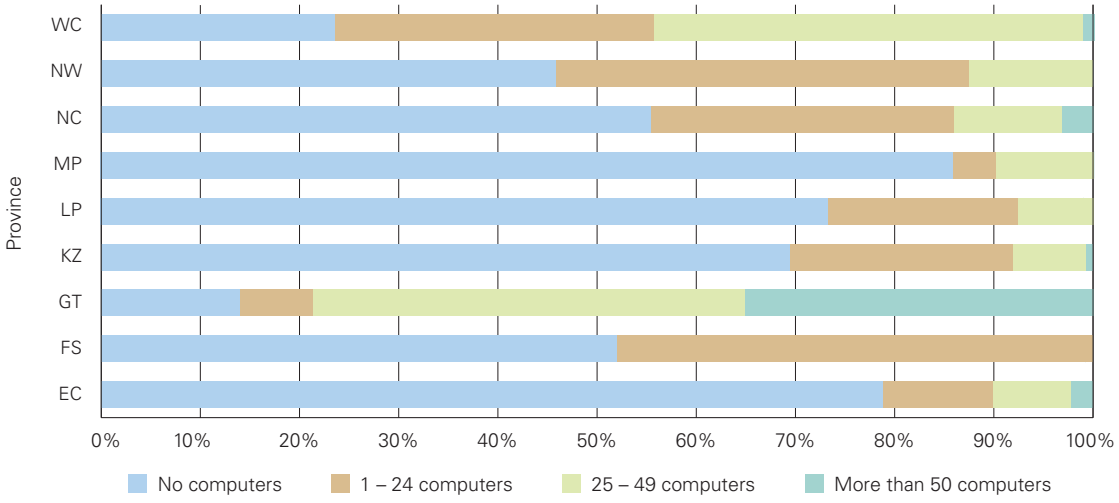


	No-fee	Fee-paying	Independent
More than 50 computers	4.4	8.0	24.2
25 – 49 computers	9.7	41.6	15.5
1 – 24 computers	17.5	22.5	24.2
No computers	68.4	28.0	36.1

Authors' own calculations from TIMSS 2015 school background dataset

Provincially there are also clear differences in the availability of computing resources. Gauteng has the highest proportion of schools (35 per cent) with more than 50 computers and conversely the lowest with no computer access at all (14 per cent). Mpumalanga (86 per cent) and the Eastern Cape (78 per cent) have a very high proportion of schools with no computers, and virtually none with over 50.

Figure 10.2: Access to school computer facilities by province



Authors' own calculations from TIMSS 2015 school background dataset

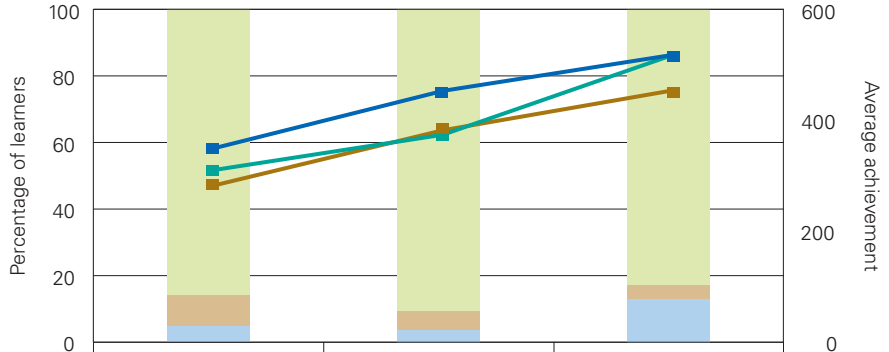
PART C

10.2 Access to workbooks

The DBE adopted the workbook initiative to address foundational causes of underachievement. Distributing national workbooks is a move towards providing quality education for all learners and ensuring that the curriculum is covered. In particular, the workbooks aim to improve literacy and numeracy rates by assisting with the correct pacing of the curriculum in order to promote effective teaching and learning. In addition, the workbooks are aimed at augmenting the provincial supply of textbooks. In 2014, the DBE printed and delivered 24 780 640 workbooks for Grades 1 to 9 to 23 673 schools. The DBE has set a target of every learner from Grades 1 to 9 being supplied with a workbook by 2019 (DBE, 2016c).

Overall access to workbooks for Grade 5 learners is excellent, with almost 95 per cent of learners in total having either their own (87.5 per cent) or a shared (8 per cent) workbook in class. Learners in schools without access to workbooks scored significantly lower than those with access, possibly reflecting a lower level of resources in the school more generally. In terms of school differences, Figure 10.3 shows that approximately 14 per cent of those in no-fee schools, 9 per cent of those in fee-paying schools and 17 per cent in independent schools do not have sole access to a workbook. However, given that just 4 per cent of the Grade 5 cohort attend independent schools, this deceptively large proportion actually equates to only around 60 learners in the sample versus over 900 in no-fee schools.

Figure 10.3: Proportion of learners with access to a workbook and related numeracy score by school type

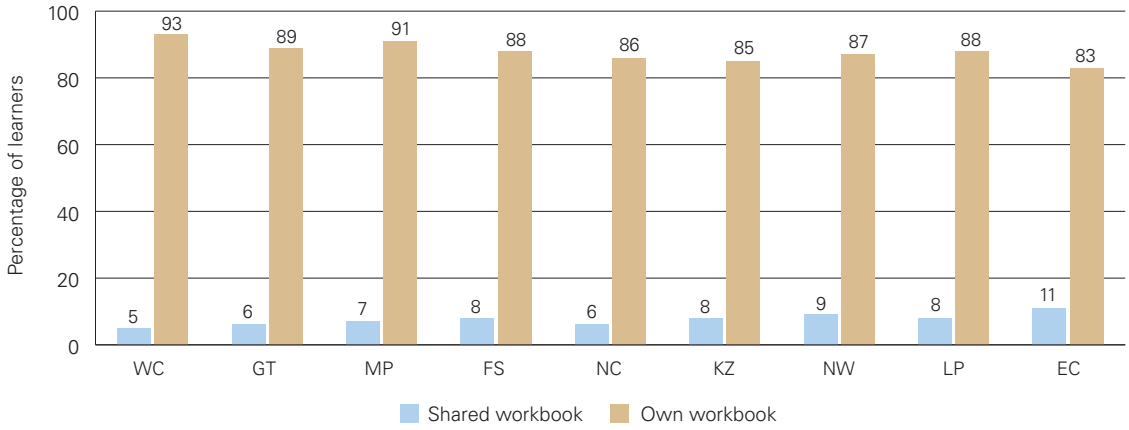


	No-fee	Fee-paying	Independent
Own workbook	85.9	90.7	83.0
Share a workbook	9.4	5.6	4.1
No	4.8	3.7	13.0
Own workbook	349	453	518
Share a workbook	310	374	518
No	282	382	454

Authors' own calculations from TIMSS 2015 achievement and learner background datasets

Figure 10.4 reports provincial access to workbooks and shows that learners in the Western Cape and Mpumalanga have the widest access to workbooks, with KwaZulu-Natal and the Northern Cape having the highest proportion of learners without access to workbooks at all (7 per cent and 8 per cent respectively). Learners in the Eastern Cape and the North West are slightly more likely to have shared workbook access, with those in the Western Cape having greatest access individually: 93 per cent of learners have their own workbook.

Figure 10.4: Proportion of learners with access to a workbook by province



Authors' own calculations from TIMSS 2015 achievement and learner background datasets.

10.3 Assessment of resource shortages

In addition to specific school characteristics reported above, principals responded to a set of thirteen questions concerning school and classroom resources on the Mathematics Resource Shortages scale[21]. These resources included general school resources as well as resources specifically for mathematics instruction.

The distribution of school resources in South Africa is markedly different from the international average (Table 10.2). In other participating countries, over a quarter of learners attended schools in which principals reported being unaffected by resource shortages, whilst in South Africa this was only the case in five per cent of schools.

Table 10.2: Principals' assessment of resource shortages and achievement, for South Africa and international average

	Not affected		Somewhat affected		Very much affected	
	% Learners	Average achievement (SE)	% Learners	Average achievement (SE)	% Learners	Average achievement (SE)
South Africa	5 (1.4)	498 (30.3)	88 (2.6)	371 (3.6)	7 (2.2)	341 (13.6)
International average	27 (0.5)	519 (1.5)	69 (0.5)	502 (0.5)	4 (0.2)	466 (3.1)

Authors' own calculations from TIMSS 2015 achievement and school background datasets

Taken together, we see that learners without access to workbooks are also in schools most affected by resource shortages. Thus, continuing to focus on improving resources, specifically in those schools most affected by shortages, should remain a top priority of ongoing policy initiatives.

Table 10.3: General school-level resource shortages and learner access to own workbook

School affected by resource shortages:	Learner has own workbook		
	No	Yes	Total
Not affected	9.6	90.4	100
Affected	12.6	87.4	100
Very much affected	16.0	84.0	100
Total	**12.6**	**87.4**	**100**

Authors' own calculations from TIMSS 2015 learner and school background datasets

[21] *For further detail on the items used in this scale, see Appendix A5. For further detail on how this scale is constructed, see http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/school-composition-and-resources/instruction-affected-by-mathematics-resource-shortages/*

11. School climate

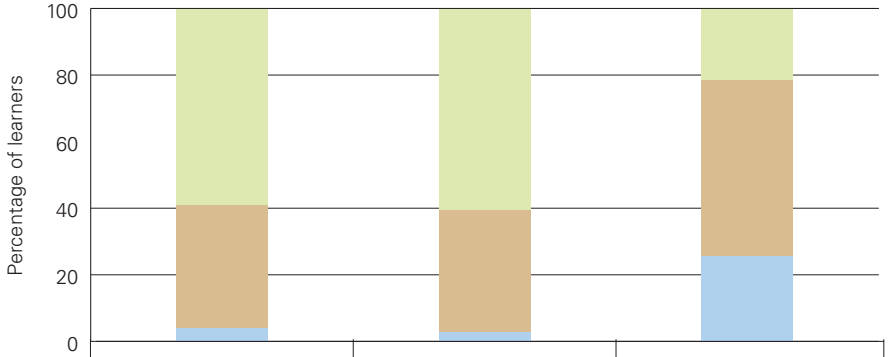
The climate of a school consists of many dimensions of the educational environment rated by principals, educators, parents and the learners themselves, and covering aspects of the learning environment, such as the emphasis placed on academic success, parents' perceptions of school performance, the extent to which learners enjoy and are proud to attend their school and feel they are treated fairly by their educators. School climate also includes aspects of safety, overall discipline and levels of bullying. In the same way that learners who are not confident in their own mathematical ability do less well in assessments of numeracy, schools with a poor academic climate or safety and discipline problems are not conducive to either teaching or learning. This is reflected in the NSSF, a collaborative effort by the Centre for Justice and Crime Prevention (CJCP) and the DBE to provide an all-inclusive strategy to address the violence occurring within schools (DBE et al., 2015). The overall aim of the NSSF is to create a safe, violence- and threat-free, supportive learning environment for learners, educators, principals, school governing bodies and administration.

11.1 Emphasis placed on academic success

To gain an understanding of school climate, principals were asked a series of 13 questions about how they would characterise their school, covering issues such as understanding and implementation of the curriculum, parental involvement and commitment to learning objectives, academic goals, and educators' approaches to teaching and learning (see Appendix A5).

Nationally, 5 per cent of learners are in schools where the emphasis on academic success is very high, a proportion which rises to 26 per cent in independent schools (see Figure 11.1 below). Just over a third, 36 per cent, place a high emphasis on academic success and 59 per cent only a moderate emphasis. In terms of international comparisons, 7 per cent of learners are in schools with a very high emphasis on academic success, while 54 per cent place a high emphasis and the remaining 39 per cent a medium emphasis. There are also interesting provincial differences, with Mpumalanga (17 per cent) and the Free State (18 per cent), ranked third and fourth in terms of overall TIMSS achievement, reporting the highest levels of emphasis here. There is also a strong positive association between learners' achievement in TIMSS and the school's emphasis on academic success: learners who attended schools where a very high degree of emphasis is placed on academic success scored an average of 29 points more than those at schools that placed only a moderate emphasis.

Figure 11.1: Emphasis placed on academic success by school type



	No-fee	Fee-paying	Independent
Medium emphasis	59.0	60.5	21.5
High emphasis	37.1	36.8	53.0
Very high emphasis	3.9	2.7	25.5

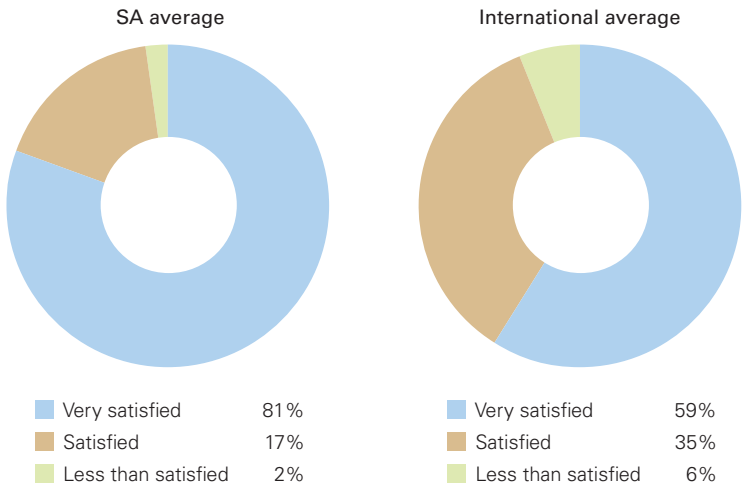
Authors' own calculations from TIMSS 2015 school background dataset

School climate also includes aspects of safety, overall discipline and levels of bullying. The overall aim of the NSSF is to create a safe, violence- and threat-free, supportive learning environment for learners, educators, principals, school governing bodies and administration.

11.2 Parents' perceptions of school performance

Parents responded to a series of nine questions regarding how they felt about their child's school, covering topics such as whether the school does a good job of including parents, provides a safe environment, cares about individual progress, does a good job helping them in mathematics, and separately in reading and science (see Appendix A5)[22]. Figure 11.2 shows that more than four out of five (81 per cent) parents reported being very satisfied with the performance of the school, higher than the international average of 59 per cent. Just 2 per cent of South African parents reported being less than satisfied with their child's school, less than the international average of 6 per cent.

Figure 11.2: Parents' perceptions of school performance, by SA and international average



Authors' own calculations from TIMSS 2015 early learning dataset; Mullis et al., 2016

In both South Africa and internationally, there is a positive relationship between parents' perception of school performance and learner performance. In South Africa, those in schools where parents are very satisfied score, on average, 22 points more than those in schools where parents are satisfied, and 47 points more than where parents are less than satisfied.

[22] *http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/school-climate/parents-perceptions-of-school-performance/*

11.3 School belonging

In terms of their own sense of the climate of the school, learners were asked seven questions about whether they liked school and learnt a lot, felt safe and proud to be there, as well as whether educators were fair to them. The items are summed together to create an overall index[23].

The majority of learners have a strong sense of belonging in their school and again there is a positive association between enjoying and being comfortable in the learning environment and Grade 5 mathematics achievement. Interestingly, there is little difference between South African learners and the international average in terms of learner sense of belonging at Grade 5 (see Table 11.1).

Table 11.1: Sense of learner belonging and related numeracy achievement by South African and international averages

Sense of school belonging:	Little sense		Some sense		High sense	
	% Learners	Average achievement	% Learners	Average achievement	% Learners	Average achievement
South Africa	5	330 (3.8)	27	356 (1.9)	68	391 (1.1)
International average	4	482 (1.2)	30	499 (0.6)	66	510 (0.4)

Source: Mullis et al., 2016. SE in brackets.

11.4 Discipline, safety and bullying

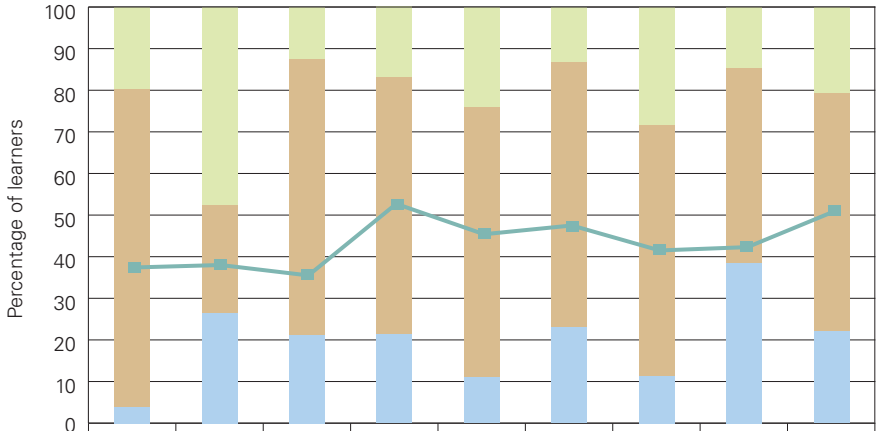
A particular area for policy concern in South Africa is the levels of discipline and safety within South African schools due to increasingly frequent episodes of violence reported in both mainstream and social media (Ncontsa & Shumba, 2013). Moreover, while concerns about school safety are increasing internationally, violence in schools is considered to be a more serious problem in South Africa than elsewhere (Reddy et al., 2015).

Principals were also asked about levels of discipline, safety and bullying in their schools, ranking ten areas on a scale from "not a problem" to a "serious problem". These areas covered aspects of the school experience including arriving late and absenteeism, to vandalism and theft, and intimidation and physical fights among learners as well as towards staff (see Appendix A5).

Just over one in five learners (22 per cent) attend schools reported to have severe discipline problems, with Gauteng having almost double the national average (43 per cent), Mpumalanga having the lowest levels of severe problems (13 per cent) and Limpopo the highest proportion of hardly any problems at all (39 per cent). That Gauteng should report such a high level of disciplinary problems is particularly interesting when set against the backdrop of being the second highest performer (but widest score distribution) in terms of numeracy achievement, the greatest proportion of high SES families and the most well-resourced schools across South Africa. Interestingly, learner reports of bullying are actually amongst the lowest in Gauteng, with 38 per cent of learners stating they experience bullying on a weekly basis, and highest in the Eastern Cape (51 per cent) which reports mid-level moderate to severe safety and discipline problems. These results highlight that while these aspects of school climate are often related, they are nevertheless separate dimensions which require complementary resolutions rather than assuming that solving one will automatically stop the other.

[23] *http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/school-climate/students-sense-of-school-belonging/*

Figure 11.3: School safety and discipline problems and learner experiences of bullying by province

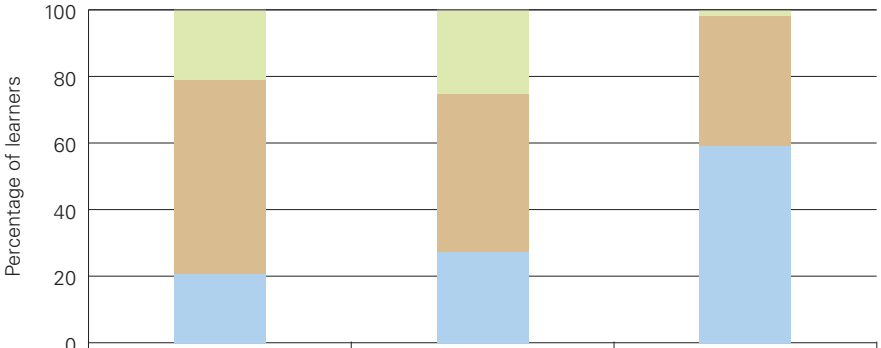


	WC	GT	MP	FS	NC	KZ	NW	LP	EC
Moderate to severe problems	19.9	47.6	12.6	16.9	24.0	13.2	28.4	14.8	20.8
Minor problems	76.2	25.9	66.2	61.9	65.0	63.9	60.3	46.7	57.1
Hardly any problems	3.9	26.5	21.2	21.3	11.0	22.9	11.3	38.5	22.1
Learners who experience bullying on a weekly basis	37.4	38.0	35.5	52.7	45.4	47.5	41.5	42.3	51.0

Authors' own calculations from TIMSS 2015 school and learner background dataset

As with Grade 9 learners, public schools, both no-fee (21 per cent) and fee-paying (25 per cent), report far higher levels of moderate to severe problems in terms of safety and discipline than do independent schools, where just 2 per cent report having serious issues.

Figure 11.4: School safety and discipline problems by school type



	No-fee	Fee-paying	Independent
Moderate to severe problems	21.3	25.4	2.1
Minor problems	58.1	47.4	38.9
Hardly any problems	20.7	27.3	59.1

Authors' own calculations from TIMSS 2015 school background dataset

A stable environment in which both learners and educators feel safe and where poor discipline does not occur is strongly associated with performance: learners in schools with severe disciplinary problems score an average of 41 points lower than those in schools where there were hardly any problems. As noted above, 40 points is roughly equivalent to one school grade, indicating again that schools often compound learner risk, rather than helping to alleviate it.

PART C

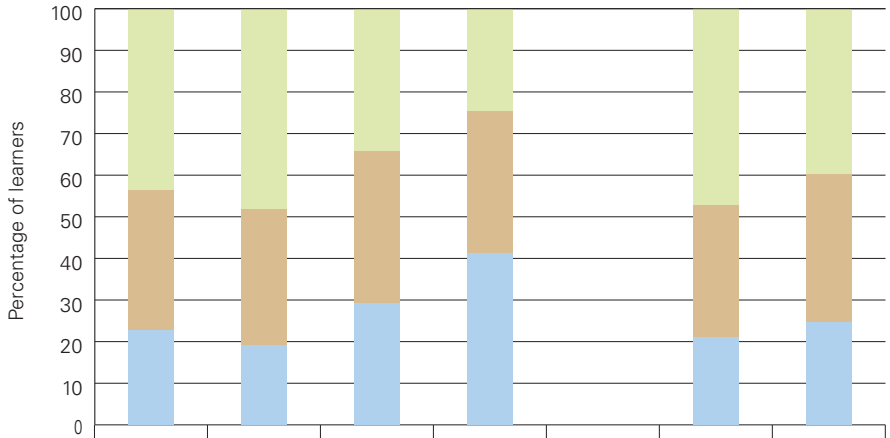
A comparison of schooling environments

The experience of bullying similarly disrupts the learning environment and hinders performance. At the Grade 9 level, for example, more than one in six learners, 17 per cent, report being exposed to some form of bullying on an almost weekly basis, compared to an international average of just 8 per cent (Mullis et al., 2016). Moreover, learners who are almost never bullied score 68 points – or a grade and a half – higher than those who experience bullying almost weekly. The Grade 5 picture is even more disturbing.

Figure 11.5 reports that across South African schools, a staggering 44 per cent[24] of learners report experiencing bullying on a weekly basis[25]. This is the highest of any participating country at the Grade 4/5 level, and more than two and a half times the international average of 16 per cent. Learners who almost never experience bullying score, on average, 72 points higher than those who are bullied frequently. Bullying is more common in public schools, particularly no-fee schools, with almost half (48 per cent) of learners there reporting being bullied on a weekly basis compared to just a quarter in independent schools.

In line with other literature, boys are more likely to be bullied than girls, with almost half of all male learners (47 per cent) reporting being bullied on a weekly basis, compared with 40 per cent of girls.

Figure 11.5: Experience of bullying by school type and gender



	All	No-fee	Fee-paying	Independent		Male	Female
About weekly	43.6	48.3	34.3	24.7		47.2	39.8
About monthly	33.6	32.5	36.4	34.0		31.8	35.6
Almost never	22.7	19.2	29.3	41.3		21.0	24.6

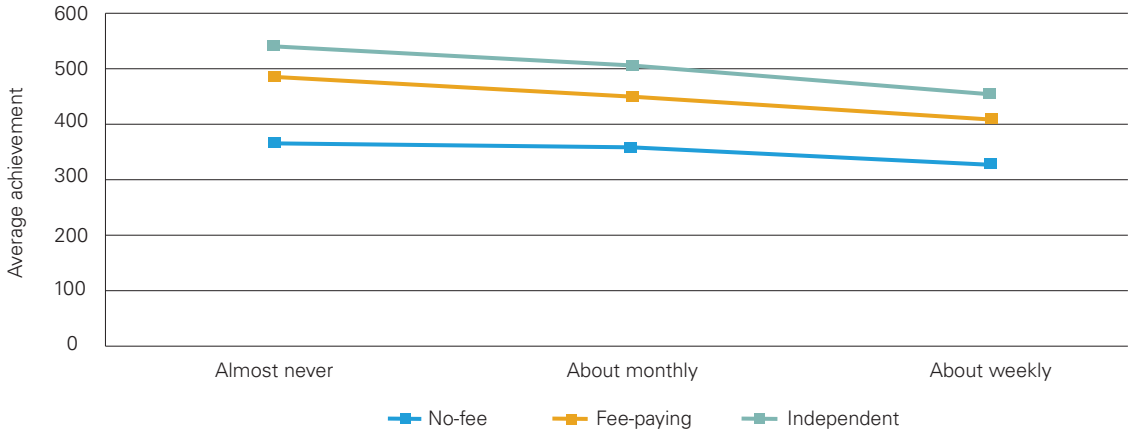
Authors' own calculations from TIMSS 2015 learner background dataset

Interestingly, while those in no-fee schools are more likely to experience severe bullying, the relationship between frequency of bullying and achievement appears stronger for learners in fee-paying and independent schools: the difference in points between those who experience bullying at least once a week and those who never or rarely experience bullying is 77 and 86 points respectively, roughly two full grades, versus 38 points for those in no-fee schools (Figure 11.6). It is also the case that learners in fee-paying schools who are almost never bullied score roughly 30 points more than those in independent schools who experience weekly bullying.

[24] *39% of Grade 5 learners reported being made fun of or being called names.*

[25] *Students were scored according to their responses to how often they experienced eight bullying behaviours on the Student Bullying scale. For further detail on how this scale is constructed, see http://timss2015.org/timss-2015/mathematics/school-safety/student-bullying/*

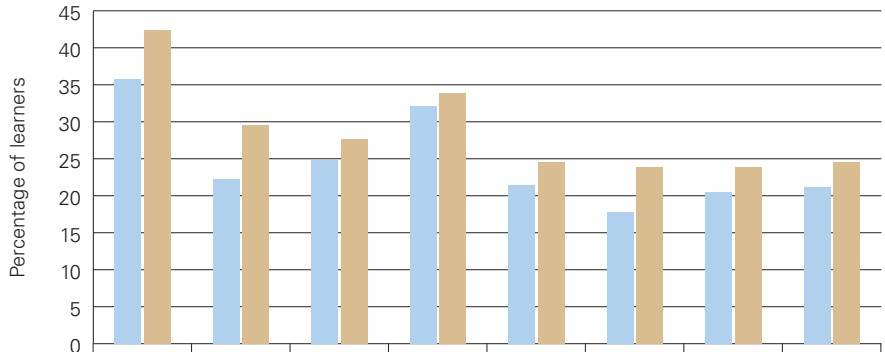
Figure 11.6: Average achievement by experience of bullying and school type



Authors' own calculations from TIMSS 2015 achievement and learner background datasets

Figure 11.7 shows that across all forms of bullying asked about, boys were more likely than girls to experience frequent bullying, with being made fun of and theft the most common types of bullying experienced by both groups (see also Juan et al., under review).

Figure 11.7: Proportion of learners experiencing different forms of bullying at least once a week by gender



	Made fun of me/ called me names	Left me out of their games	Spread lies about me	Stole something from me	Hit or hurt me	Made me do things I didn't want to do	Shared embar-rassing infor-mation	Threat-ened me
Girls	35.7	22.2	24.8	32.1	21.4	17.8	20.5	21.2
Boys	42.4	29.5	27.6	33.8	24.5	23.8	23.9	24.6

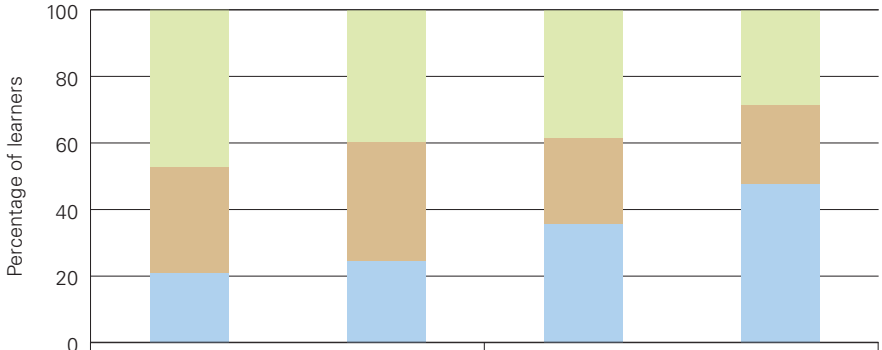
Authors' own calculations from TIMSS 2015 learner background dataset

As an interesting counter to the experience of bullying, TIMSS also asks learners themselves how often they carry out the same eight forms of bullying against classmates, which can be measured on the same frequency scale.

As in Figures 11.5 and 11.7 above, boys are more likely to be the perpetrators of bullying: almost four in ten boys (39 per cent) bully others on a weekly basis in comparison with just three in ten girls. Nearly half of all girls (48 per cent) never perpetrate bullying behaviour.

PART C

Figure 11.8: Proportion of learners experiencing and perpetrating different levels of bullying by gender

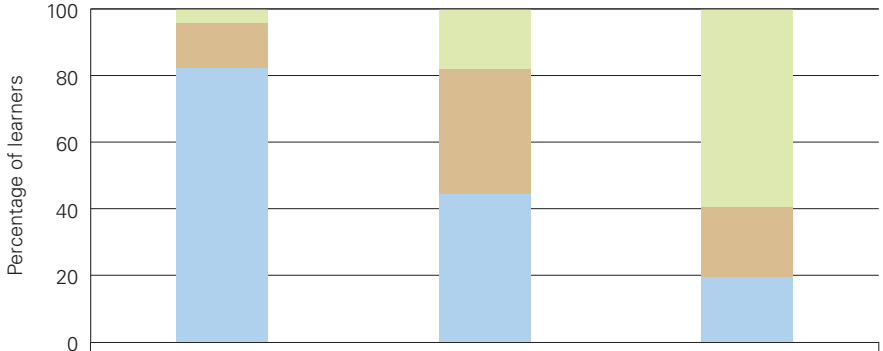


	Experiences bullying		Perpetrates bullying	
	Male	Female	Male	Female
About weekly	47.2	39.8	38.7	28.8
About monthly	31.8	35.6	25.7	23.6
Almost never	21.0	24.6	35.6	47.6

Authors' own calculations from TIMSS 2015 learner background dataset

As in Juan et al. (under review) reporting at the Grade 9 level, bullying and victim behaviours at Grade 5 are highly correlated, that is, the more bullying a learner experiences, the more they themselves bully: just 4 per cent of those who never experience bullying themselves report frequently bullying others, compared to 59 per cent of those who experience frequent bullying; and 82 per cent of learners who report almost never experiencing bullying do not bully others.

Figure 11.9: Proportion of learners perpetrating bullying by experience of bullying



	Experience of bullying		
	Almost never	About monthly	About weekly
About weekly	4.5	18.0	59.4
About monthly	13.4	37.8	21.3
Almost never	82.2	44.2	19.3

Authors' own calculations from TIMSS 2015 learner background dataset

12. A profile of Grade 5 educators

Educators[26] are an integral feature of the school context and provide a further lens through which to view potential factors related to learner achievement. At the primary school level, the majority of learners were taught by female educators (66 per cent) between the ages of 40 and 49 (50 per cent).

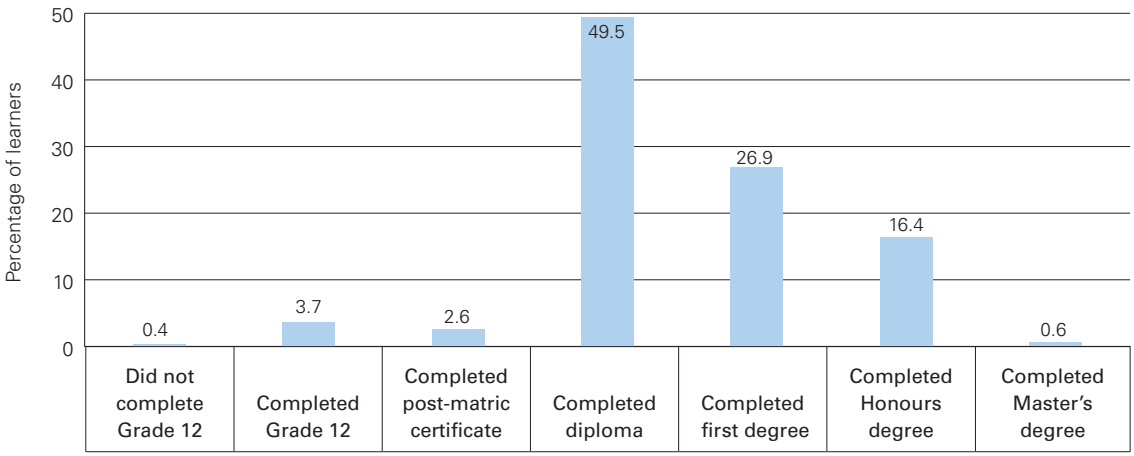
Table 12.1: Age and gender of educators

Age	Female	Male	Total
Under 25	2.5	1.0	2.0
25 – 29	10.3	5.9	8.9
30 – 39	10.7	13.5	11.6
40 – 49	48.6	51.8	49.6
50 – 59	25.9	22.6	24.8
60 or more	2.1	5.2	3.1
Total	**100**	**100**	**100**

Authors' own calculations from TIMSS 2015 educator dataset

In terms of qualifications, less than half of learners (44 per cent) were taught by educators who had completed at least a Bachelor's degree, with 1 per cent having completed a Master's programme. Sixty-six per cent of learners were taught by educators with 10 or more years of teaching experience, with 39 per cent of educators having served over 20 years in the profession.

Figure 12.1: Educator highest level of education

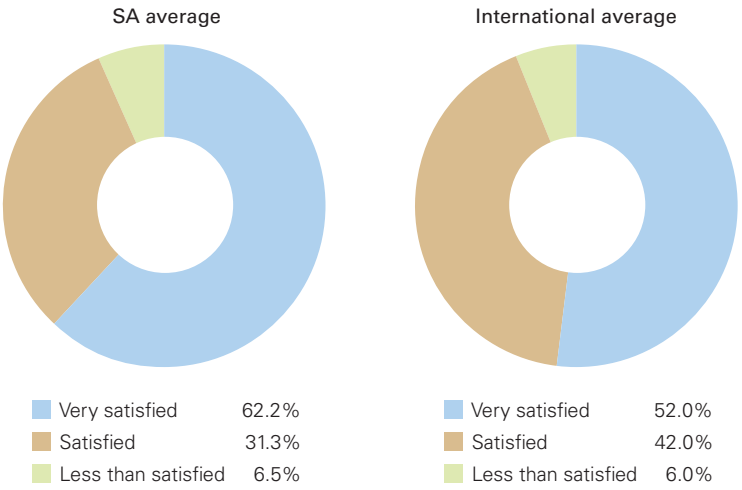


Authors' own calculations from TIMSS 2015 educator dataset

South Africa was ranked 12th highest amongst participating countries in terms of educators' levels of job satisfaction: 62 per cent of learners were taught by educators who were very satisfied with their profession, compared to 52 per cent internationally.

[26] *Note, however, that educators' responses to the TIMSS questionnaires are not nationally representative but indicative of those sampled in the study.*

Figure 12.2: Educator satisfaction, for South Africa and international average



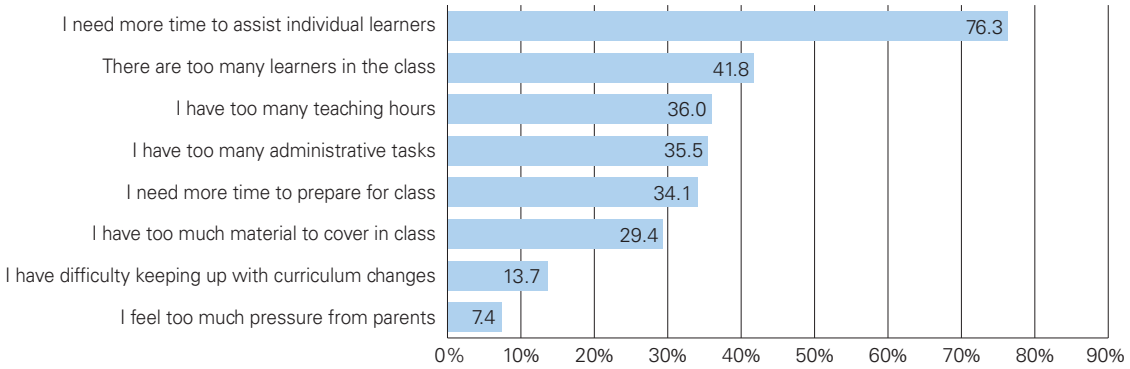
Authors' own calculations from TIMSS 2015 educator dataset; Mullis et al., 2016

12.1 Challenges facing educators

Educators were asked about the extent to which they faced certain challenges in their day-to-day teaching, rating each on a four-point scale from "Agree a lot" to "Disagree a lot". Figure 12.3 reports the extent to which educators state that they face particular challenges "a lot".

The most common challenge faced by educators relates to the time needed to assist individual learners: three-quarters (76.3 per cent) of those questioned reported that this was a particular challenge affecting their teaching. Very few educators reported feeling too much pressure from parents (7.4 per cent) or difficulty keeping up with changes in the curriculum (13.7 per cent).

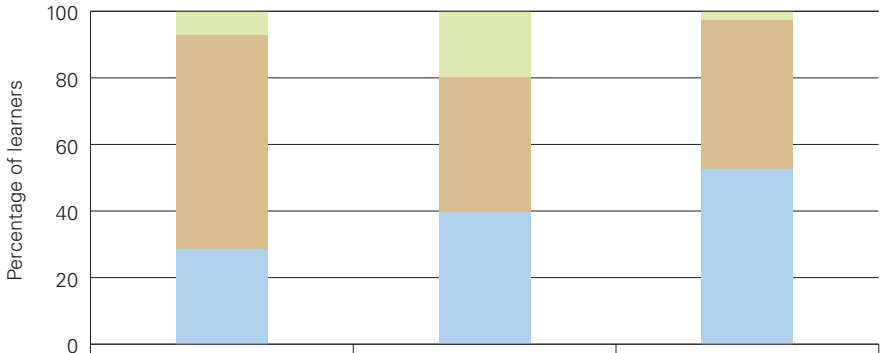
Figure 12.3: Percentage of educators reporting facing each challenge "a lot"



Authors' own calculations from TIMSS 2015 educator dataset

Summarised into an overall score[27], Figure 12.4 reports the level of challenges educators report facing, by school type. Learners in no-fee schools have educators who report the lowest level of "few challenges" and the highest proportion of those reporting "some challenges". Interestingly, however, learners in fee-paying schools have educators who report the greatest proportion of "many challenges": one in five learners in fee-paying schools (20 per cent) is taught by educators who report facing many challenges affecting their function as an educator, in contrast to 7 per cent in no-fee schools and 3 per cent in independent schools.

Figure 12.4: Challenges facing educators by school type



	No-fee	Fee-paying	Independent
Many challenges	7.1	19.8	2.7
Some challenges	64.2	40.7	44.8
Few challenges	28.6	39.5	52.6

Authors' own calculations from TIMSS 2015 educator dataset

12.2 Limitations for teaching

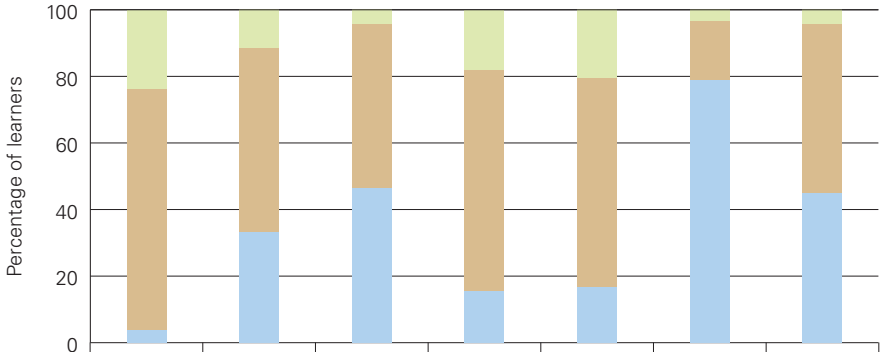
Educators were also asked about the limits to how they teach their class, for example, with regard to learners lacking the necessary skills, suffering from lack of basic nutrition, uninterested learners and the presence of learners with physical, mental or emotional disabilities.

Of those asked, nearly all claimed that learners lacked prerequisite knowledge or skills: just 4 per cent of learners had educators who reported that this was not a limitation to learning in the classroom, with nearly a quarter (24 per cent) stating it was a considerable problem. Disruptive and uninterested learners are also reported as limiting factors for educators, with 84 per cent of learners being taught in classrooms where this affects the teaching "some" or "a lot" of the time.

Nearly 80 per cent of learners are in classrooms unaffected by teaching limited by learners with physical disabilities; over half (55 per cent), however, have educators whose teaching is affected by learners with mental, emotional or psychological disabilities.

[27] *For more detail on how the scale is constructed, see: http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/mathematics/school-climate/challenges-facing-educators/*

Figure 12.5: Limits to educator instruction

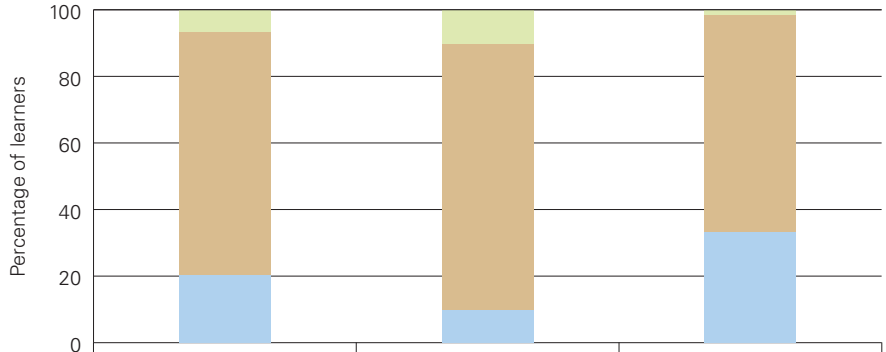


	Learners lacking prerequisite knowledge or skills	Learners suffering from lack of basic nutrition	Learners suffering from not enough sleep	Disruptive learners	Un-interested learners	Learners with physical disabilities	Learners with mental, emotional or psycho-logical disabilities
A lot	23.9	11.6	4.3	18.3	20.7	3.4	4.5
Some	72.4	55.3	49.4	66.1	62.8	17.7	50.8
Not at all	3.7	33.2	46.3	15.6	16.6	78.9	44.8

Authors' own calculations from TIMSS 2015 educator dataset

The school-level differences are not quite as marked for the limitations to teaching as the challenges educators face. Again, however, learners in fee-paying schools have a lower proportion of educators reporting they are not limited in their teaching than learners in no-fee schools. Only 2 per cent of learners in independent schools have educators who report being very limited in how they teach their class, compared to 7 per cent in no-fee schools and one in ten in fee-paying schools.

Figure 12.6: Limits to educator instruction by school type



	No-fee	Fee-paying	Independent
Very limited	6.9	10.2	1.7
Somewhat limited	72.8	79.9	65.0
Not limited	20.3	9.9	33.3

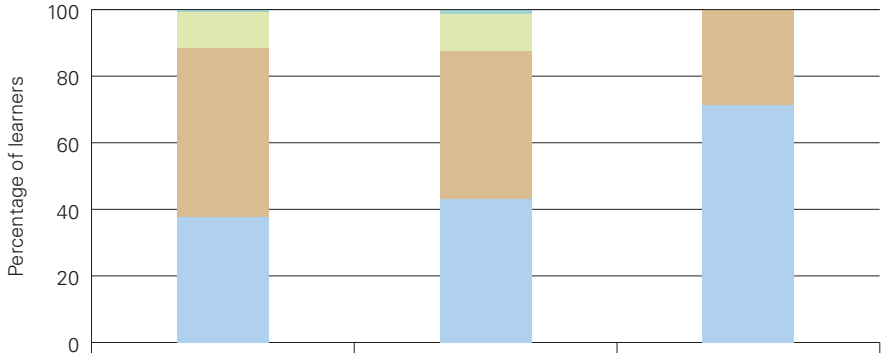
Author's own calculations from TIMSS 2015 educator dataset

12.3 Educator absenteeism

Principals were asked about the extent to which educator absenteeism was a problem among educators at their schools. Figure 12.7 reports the percentage of learners in each school type by the level of problematic educator absence.

In both no-fee and fee-paying schools, around 12 per cent of learners are in schools where educator absenteeism is reported to be a moderate or serious problem. For learners in independent schools, educator absenteeism is not a serious problem, with nearly three in ten (29 per cent) in schools where absenteeism is a minor problem, and the rest where it is not a problem at all.

Figure 12.7: Educator absenteeism by school type



	No-fee	Fee-paying	Independent
Serious problem	0.8	1.4	0.0
Moderate problem	10.9	11.2	0.0
Minor problem	50.6	44.3	28.6
Not a problem	37.7	43.1	71.4

Author's own calculations from TIMSS 2015 school background dataset

PART C

Section summary

After the family, schools are one of the most salient social contexts for children over the age of five years; and the results shown here present further challenges for the South African educational system. Library and computing facilities are most restricted in no-fee schools, where, on average, just one in four pupils has access to a library at school and over two-thirds attend schools with no computers at all. There is a clear positive relationship between access to workbooks and average test scores across all school types, as well as in terms of overall resourcing; but those without access to workbooks are again further disadvantaged through attending schools that are generally more poorly resourced.

Principals place less academic emphasis on schools than many of our international counterparts and report serious problems with discipline and safety. Additionally, learner experience of bullying in Grade 5 is more than double that at Grade 9 and is higher than in any other participating country. Interestingly, however, learners' own sense of school belonging is comparable with the international average and an overwhelming majority of parents report being very satisfied with the overall performance of their children's schools. This raises the concern of whether poor school climate has become normalised in some schools.

Most learners are taught by educators who report being qualified, with fair levels of teaching experience. Educators interviewed in TIMSS reported very high levels of job satisfaction, but noted that the main challenge to their teaching was needing more time to assist individual learners. Additionally, almost all educators reported that learners lacking prerequisite knowledge and/or skills was a considerable impediment to their teaching, with those in independent schools least affected by challenges and limitations to their day-to-day activities. Reflecting results reported in Part B, this further highlights the importance of learners building up their knowledge and skills from Grade R.

While there is a high level of absenteeism amongst educators, this is far less of a problem in independent than in public school settings.

PART D

SUMMARISING INFLUENCES ON GRADE 5 MATHEMATICS ACHIEVEMENT

Summarising influences on Grade 5 mathematics achievement

13. Summarising relationships

This first report examining the mathematics achievement of Grade 5 learners in South Africa considers a broad range of factors related to performance, from individual skills and characteristics, household demographics and assets, early childhood parenting practices, school-level differences including resources and climate, and provincial variation. How best, then, to summarise these relationships and condense the results presented into a useful and coherent story?

Correlations offer one of the simplest ways to express the relationship between variables. Performing a regression of an individual measure of interest on our measure of achievement provides a summary coefficient which describes the "effect"[28] of that variable on TIMSS numeracy performance. This approach shows the average unconditional association such that a one-unit increase in the value of the independent variable is associated with an increase (+) or decrease (-) in achievement. Table 13.1 shows a series of separate regressions expressing the relationship between each predictor variable (gender; age; frequency language of the test is spoken at home) and average mathematics achievement, not the associations when all three of these variables are included in a single regression. So, for example, in Table 13.1 below, girls score an average of 15.4 more points than boys, not controlling for any other factors[29]. Where the independent variable is categorical, as is the case here for both age blocks and the frequency the test language is spoken at home, each unit increase is with reference to the base case. Thus, when comparing learners younger than 10.3 years old with those that are the correct age for their grade (10.3 to 11.6 years), learners who are the correct age score an additional 50.6 points on average; while those who are over 12 years old score 16.7 points less.

Table 13.1: Summary regressions of single independent variable relationship with achievement

	Relationship	Coefficient	Standard Error	Significance
	A profile of learners			
Learner is a girl	+	15.4	(1.9)	***
Age blocks: *(ref under 10.3 years old)*				
10.3 – 11.6 years ("correct" age for grade)	+	50.6	(4.2)	***
11.7 – 12 years	+	18.6	(4.7)	***
Over 12 years old	–	-16.7	(4.4)	***
Frequency test language is spoken at home: *(ref: never)*				
Sometimes	+	47.1	(3.2)	***
Always/almost always	+	132.3	(3.4)	***

Authors' own calculations

*Table notes: *** p<.001; ** p<.005; * p<.01; † p<0.1*

When all the variables examined are considered jointly in a single regression, the resulting coefficients are conditional correlations: they show associations between all the different variables, when all the other factors examined in the report are simultaneously taken into account. Note, however, that given that all the factors considered were measured at the same time, this analysis cannot show either a causal or developmental, i.e. change over time, relationship. That said, the joint regression does permit an insight into how all these variables might operate together and which associations hold even when other salient features of the learner's environment are taken into account. The conditional estimates are then likely to better reflect both the size and direction of the relationships summarised than the unconditional estimates, but the "effect sizes" themselves cannot be directly compared.

[28] *The term "effect" is used here for ease of descriptive purposes only and does not imply any kind of causal association between variables, but rather is shorthand for describing the unconditional association between variables of interest.*

[29] *This is the "same" amount as in the descriptive analysis which shows that girls score an average of 16 additional points. The slight difference here reflects rounding differences in summary results presented in section 5.*

The tables below (13.2 – 13.9) show the estimated coefficients for both the unconditional (column 1, results from individual variable regressions on TIMSS achievement) and conditional (column 2, single regression with all variables entered simultaneously) associations. For ease of presentation, we show the tables separately across the same broad results sections in the descriptive chapters above, but for each table, column 2 reports the conditional estimates for all variables considered across all tables.

Note also that these variables are not standardised and reflect the association between the independent variable of interest and achievement for each unit change in the "predictor" variable and the corresponding average increase/decrease in TIMSS numeracy achievement points. These coefficients are then not directly comparable with each other per se, but rather presented in the same way they are discussed in the descriptive sections of the report above and must be understood in conjunction with the metric of each separate variable considered (see Appendix Table A4.1 for full details of all summary statistics).

13.1 A profile of learners

Even when all the factors are considered together, girls still outperform boys at Grade 5, even though the size of the association is considerably attenuated in the conditional model: the unconditional correlation falls from 15.4 points (column 1) to 2.3 points (column 2) in the full model, but remains significant at the 10 per cent level.

Table 13.2: Unconditional and conditional correlations with learner attributes

	Unconditional		Conditional	
	A profile of learners			
Learner is a girl	15.4	***	2.3	†
Age blocks: *(ref under 10.3 years old)*				
10.3 – 11.6 years	50.6	***	7.6	**
11.7 – 12 years	18.6	***	-7.7	*
Over 12 years old	-16.7	***	-17.2	***
Frequency test language is spoken at home: *(ref: never)*				
Sometimes	47.1	***	12.2	***
Always/almost always	132.3	***	25.9	***

Authors' own calculations

*Table notes: *** p<.001; ** p<.005; * p<.01; † p<0.1*

As noted above (in section 5), learners who are the "correct age" for their grade score higher than either those who are slightly under age for their grade (the reference group) or those who are over 12 years old. In the conditional model, this relationship holds but we see that those who are slightly older than the "correct age", i.e. learners who are between 11.7 and 12 years old, also perform less well than the reference group. This group, roughly 13 per cent of the Grade 5 cohort, perform better than those who are over 12 years old but their lower scores possibly reflect an interruption in progress earlier in the system and highlight that any grade repetition must be met with appropriate remediation to ensure that learners do not fall further behind as they move through the system.

The importance of the language of test administration remains significant when all other factors are taken into account in model 2, with those who always or almost always speak the test language at home scoring, on average, 26 points more than those who never do. Compare this coefficient from the single variable regression that shows an unconditional association of 132.3 additional points for learners who frequently speak the language of the test when compared to those who never do. The reason the conditional association is so much smaller reflects the inclusion of collinear relationships, such as household demographic factors and school characteristics; for example, learners from more advantaged and higher SES homes go to better-resourced schools where they are more likely to regularly speak, learn and be proficient in the test language. Such results begin to highlight the

complex interplay between factors affecting achievement: no one silver bullet can "fix" South Africa's low levels of performance, rather it is the combination of changes through a multi-pronged approach to the whole system that will gradually improve achievement across all learners.

13.2 Resources in the home

Resources in the home and indicators of SES play an important role in learner achievement, each having an individual positive association with TIMSS numeracy performance. School-level characteristics often mediate most of the association between family demographics and academic attainment: learners from more advantaged households live in more affluent areas, with better access to highly resourced schools, and the financial capital available to enable the children to be sent to these schools. Yet even in our fully comprehensive model which includes indicators of school resources, school climate and the type of school learners attend, the importance of family background remains significant.

Table 13.3: Unconditional and conditional correlations with home resources

	Unconditional		Conditional	
	Resources in the home			
Assets				
Learner has own computer	8.2	***	-10.7	***
Internet connection	46.3	***	5.6	***
Water-flush toilets	59.9	***	0.6	
Fridge	63.8	***	7.7	***
Electricity	73.5	***	19.7	***
Number of social grants received	-18.3	***	-2.4	***
Indicators of socioeconomic status				
Household education *(low to high)*	27.9	***	5.7	***
Total number of books in the home	15.9	***	3.4	***
Highest household occupation	18.3	***	3.5	***

Authors' own calculations
*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

Interestingly, in the conditional model, learner access to their own computer at home shows a negative association with numeracy performance. This demonstrates the complexity of a model trying to capture concurrently measured predictors of attainment and the nuances of how resources in the home are clustered amongst different families: the raw relationship is positive, as would be expected, but when considered in conjunction with a host of other factors, some of which measure similar underlying features of social status and income, the collinearity between different indicators becomes problematic. Note also that having access to a computer has a far smaller relationship with performance in TIMSS numeracy than the other assets at home considered here, having basic amenities such as water-flush toilets and electricity shows far larger associations reflecting the pervasive level of inequality across South Africa.

13.3 The early educational environment and early academic skills

We observe similarly counterintuitive, negative relationships between parents' early educational engagement with the learner and with learners finding their educator engaging: while the unconditional association is positive for both, when other factors are considered jointly with these factors, the association changes, possibly reflecting that the relationship operates differently for different learners or in different school contexts. A developmental model using longitudinal data that is able to include timing of a factor's influence is needed to tease apart these more complex relationships.

Table 13.4: Unconditional and conditional correlations with early learning and school readiness

	Unconditional		Conditional	
	The early educational environment			
Frequency parent engages in early literacy and numeracy activities before school	11.6	***	-1.3	***
Attended preschool	13.2	***	1.4	*
	Early academic skills			
Level of literacy and numeracy skills at school entry	16.8	***	6.8	***
Proportion of learners entering school with good learning ready skills	6.3	***	-0.5	

Authors' own calculations

*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

As in the descriptive analysis presented above, the positive relationships between both preschool attendance and strong early academic skills in literacy and numeracy in Grade 1 and mathematics performance remain conditional on the host of other measures. That principal reports of the proportion of learners entering school with good levels of early literacy and numeracy skills is no longer associated with performance in mathematics in the conditional model suggests that parents are more reliably able to rate their child's skill level. While this may seem like a very obvious statement, it matters because parents with lower-performing children should also then be able to alert schools and educators when additional support is anticipated.

13.4 Educational expectations and beliefs

Educational expectations and learner academic beliefs are also significantly associated with mathematics performance in the conditional model. The size of the estimated relationship between parents' expectations of the level of education their child will achieve and performance in TIMSS numeracy falls from 10.1 to 2.0, more so than for either the learner's own reported liking of mathematics or their confidence in their ability in the subject, suggesting that this association is mediated by other features of the learner's world. That is, the "effect" of higher educational expectations likely operates through factors such as learners liking mathematics more and having greater confidence in their ability to learn the subject, as well as parents creating more cognitively stimulating home environments.

Table 13.5: Unconditional and conditional correlations with educational expectations and beliefs

	Unconditional		Conditional	
	Educational expectations and beliefs			
Parents' educational expectations	10.1	***	2.0	***
Learner likes maths	22.1	***	8.4	***
Learner confident in maths	26.2	***	11.2	***
Learner finds maths educator engaging	11.2	***	-1.1	**

Authors' own calculations

*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

As in the descriptive analysis, there appears to be a particularly strong association between confidence in mathematics and performance in mathematics. Again, while this may on the surface appear to be an obvious relationship, international literature on the importance of self-concept of ability in mathematics highlights that this association holds for learners across the achievement distribution, meaning that improving how learners feel about their ability to learn mathematics, even where they are really struggling, can improve performance. As noted in our introductory sections, a solid grounding in mathematics is essential for all young people, providing them

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with critical thinking skills and key problem-solving abilities. If improving learner confidence can simultaneously improve performance, then teaching strategies, particularly for those in need of remediation, should work to include practices that boost learners' self-concept of their own ability.

13.5 School resources

School resources matter for learner achievement and continue to do so when considered in conjunction with all the other variables included in our comprehensive, conditional model 2, albeit to a lesser extent: having a place at school for learners to do schoolwork and the total number of computers are positively associated with performance, while schools providing free lunches, i.e. those that have a higher proportion of more economically disadvantaged learners, and where instruction is affected by resource shortages, have lower average levels of numeracy achievement.

Table 13.6: Unconditional and conditional correlations with school resources

	Unconditional		Conditional	
	School resources			
School has a place for learners to do schoolwork	12.6	***	2.4	†
School provides free lunch	-78.4	***	-20.8	***
School has a library	68.9	***	0.7	
Total number of school computers	1.6	***	0.6	***
Learner has a workbook *(ref: no)*				
Own	67.9	***	36.1	***
Shared	9.2		18.6	***
Instruction affected by maths resource shortages *(Higher score = Less affected)*	11.3	***	3.4	***

Authors' own calculations

*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

Interestingly, once other school-level characteristics are taken into account, having a school library no longer has a significant association with mathematics achievement. This result possibly reflects the very low proportion of no-fee schools that actually have a library: just a quarter of learners in no-fee schools have access to a school library in comparison to 80 per cent of those in fee-paying schools and 81 per cent in independent schools. This result might also change if our achievement measure was a subject such as reading, history, or science, where access to a wide range of books might be more important for raising performance than it is for mathematics.

The relationship between learner access to workbooks and mathematics performance is important here. The raw, unconditional association between access and achievement is only significant for learners who have their own workbook, with those sharing having no advantage over those who do not have any access to workbooks at all. In the conditional model, shared access is positively associated with learner achievement, but given the absence of a significant relationship in the single variable regression, it is very likely that this association again reflects collinearity with other resources and school-level characteristics. Since all Grade 5 learners are meant to have access to their own workbook, ensuring that this objective is met for all learners is likely to result in very real gains for those in the most under-resourced of schools, particularly since in the conditional model, having individual access to a workbook is associated with a 36-point increase in TIMSS numeracy compared to a learner without access, roughly equivalent to a whole grade of learning. This result also sits in parallel with the finding reported in section 10 that learners without their own access to a workbook also attend schools affected by more general resource shortages. Thus focus on improving resources in general in those schools most affected by shortages should also be a focus of ongoing policy initiatives.

13.6 School climate

In the conditional correlation model, model 2, all school climate variables remain significantly associated with TIMSS mathematics achievement except for the school's emphasis on academic success. Rather the measures of safety and discipline, alongside the level of bullying experienced by learners, seem to be more salient features of the school climate as it relates to performance in mathematics.

Table 13.7: Unconditional and conditional correlations with school climate

	Unconditional		Conditional	
	School climate			
School emphasis on academic success	9.0	***	0.1	
School safety and discipline problems *(Higher score = Fewer problems)*	9.6	***	5.2	***
Learners' sense of school belonging	7.9	***	0.9	**
Bullying score *(Higher score = Less bullying)*	14.8	***	4.2	***
Parents' perceptions of the school	22.9	***	7.6	***

Authors' own calculations
*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

As was shown in the descriptive analyses above, better parental perceptions of the school are positively associated with TIMSS numeracy scores, the size of the association falling by approximately two-thirds in the conditional model.

13.7 A profile of educators

The relationship between educators and learner performance in the Grade 5 TIMSS assessments is complicated. The results below reflect that, as noted above, educator and principal responses to the questionnaires are not nationally representative but indicative of those sampled in the study. In column 1, the raw, unconditional associations between the four aspects of educators considered all operate in the expected direction: higher educator satisfaction is positively associated with learner performance, and greater challenges and limitations faced by educators, and more problematic educator absenteeism are negatively associated with achievement.

Table 13.8: Unconditional and conditional correlations with educator attributes

	Unconditional		Conditional	
	A profile of educators			
Educators' job satisfaction	8.7	***	-3.4	***
Level of challenges facing educators	-10.3	***	-1.8	†
Level of limitations facing educators	-8.9	***	-7.6	***
Level to which educator absenteeism is a problem	-9.2	***	2.7	**

Authors' own calculations
*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

When other factors are taken into account in the joint model, the picture is less clear: while more challenges and limitations remain negatively related to mathematics attainment, educator satisfaction is now negatively associated with performance and educator absenteeism. These counterintuitive relationships again highlight the complexity of understanding the influences on attainment and possibly reflect school-level variations that cannot be fully explored here due to the non-nationally representative sample of educators available. For example, educator absenteeism is more problematic in public schools, both no-fee and fee-paying, than in independent schools, and

more educators in no-fee schools report being less than satisfied in their jobs than in fee-paying or independent schools. It may be that in schools where educator absenteeism is more problematic, job satisfaction amongst other educators is very low. There may also be aspects of social desirability guiding some of these responses. These data are not sufficient to unpack these issues in more detail.

13.8 School type and province

The conditional associations between school type and TIMSS performance are roughly a third of the size of their unconditional relationships, again showing how much of the "school type effect" is mediated by other variables such as household demographics and the population of a school's learners, as well as its own resources, climate and educators.

As in the provincial descriptive analysis in section 4, the Eastern Cape and Limpopo are seen here as the lowest-performing provinces. Interestingly, when all the other variables are included in the joint model, Limpopo actually performs lower than the Eastern Cape, possibly reflecting a higher proportion of lower-performing and/or poorly resourced schools, alongside a greater number of more disadvantaged households.

Table 13.9: Unconditional and conditional correlations with school type and province

	Unconditional		Conditional	
	School type			
School type *(ref: No-fee)*				
Fee-paying	101.6	***	39.5	***
Independent	163.1	***	55.6	***
	Province			
Province *(ref: Eastern Cape)*				
Free State	30.8	***	33.5	***
Gauteng	77.5	***	5.6	*
KwaZulu-Natal	23.9	***	16.6	***
Limpopo	0.8		-15.3	***
Mpumalanga	40.9	***	21.7	***
Northern Cape	30.0	***	18.1	***
North West	12.5	**	19.6	***
Western Cape	98.8	***	50.3	***

Authors' own calculations
*Table notes: ***p<.001; ** p<.005; * p<.01; † p<0.1*

Section summary

These summary tables show the comparative reduction in point estimates between the unconditional and conditional models and clearly demonstrate the complexity of varying factors as they are associated with mathematics achievement in Grade 5. Our attempt at summarising these relationships demonstrates that there is no one "silver bullet" that will fix low performance and rebalance years of social imbalance throughout the system, but rather that there are many issues that can be improved upon. The system is unequal, but it is eminently treatable.

PART E

IMPROVING MATHEMATICS ACHIEVEMENT

Improving mathematics achievement

14. A focus on "potentials"

South Africa is one of the lowest-performing countries in mathematics when compared to others participating in TIMSS, and the national average of 376 points falls short of even the lowest international benchmark. With only two in five (39 per cent) learners achieving above the lowest TIMSS performance benchmark and thus showing minimum competencies in basic mathematical knowledge required at the Grade 5 level, what would it take for South Africa to improve mathematics scores and move up the rankings? What is realistic? And where is the best place to intervene (i.e. "biggest bang for the policy buck")?

At the Grade 9 level, there has been slow but steady improvement in South Africa's average performance in both mathematics and science. Indeed, between 2003 and 2015 across all participating TIMSS countries, South Africa showed the greatest overall gain, improving by 86 points in mathematics and 90 in science (see Reddy et al., 2015 and Zuze et al., 2017, for further detail here), equivalent to more than two academic grades over a 12-year period. Across the last two rounds specifically, 2011 and 2015, the average score in mathematics has improved by 20 points (from 352 to 372 points) and the corresponding proportion of learners scoring above 400 points, the low end of the bottom TIMSS performance benchmark, increased from 23 per cent to 34 per cent of learners. Granted, this increase at the Grade 9 level was from an initially very low base in 2003, but it nevertheless underscores the substantial and continuing learning gains made across South African youth in recent years.

To bring the *Grade 5 national average* above the 400-point mark, learners would need to improve by an average of 25 points, over half a school grade higher than their current level of performance. Given the 20-point increase in Grade 9 scores over the four-year period from 2011 to 2015, an improvement of 25 points for the Grade 5s sets the bar quite high, but is not beyond the realms of possibility for the 2019 survey.

To improve the *overall proportion of learners scoring above the low benchmark*, one strategy could be to focus instead on the "potentials" group highlighted throughout this report, i.e. those who score just below the 400-point threshold[30]. Just under a fifth of Grade 5 learners (19 per cent) score between 350 and 400 points: if this group were specifically targeted and able to raise their score by 25 points, half would then score above the 400-point mark and push the total proportion of learners scoring above the TIMSS threshold to 47 per cent, an overall increase of 8 percentage points (see Table 14.1 below).

Table 14.1: Impact simulations: National and benchmark level changes with points increases

Points increase	Impact on national average	% above 400 with "points increase" for the *Potentials*
5	381	40
10	386	42
20	396	45
25	401	47
40	416	53

Authors' own calculations

When we consider that the proportion scoring above 400 points rose from 11 per cent of the Grade 9 population in 2003 to 23 per cent in 2011, and 34 per cent in 2015, an increase of less than 10 percentage points in those achieving higher than the basic level of competency could be within reach if this group were effectively targeted and resourced.

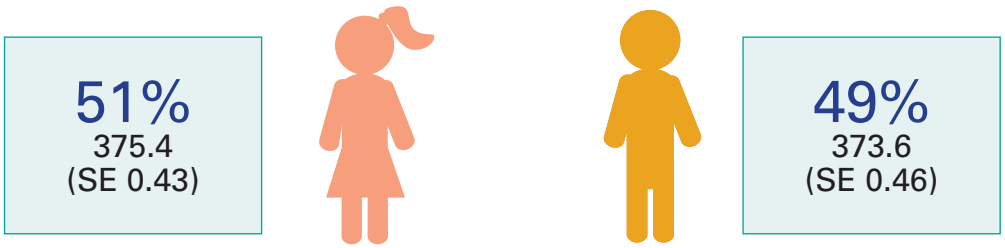
[30] *Improving the scores of those at the top of the achievement distribution also needs to be part of the whole system shift, particularly since, as was highlighted in section 4 above, nearly half of learners (46 per cent) in the most well-resourced schools, the independent schools, are performing below the centre point of the TIMSS assessment, 16 per cent of whom are below the level of the test. However, raising the scores of only those already above the low benchmark does nothing to increase the overall proportion of learners who score below it.*

14.1 Who are the so-called "potentials"?

If our interest lies in lifting those scoring just under the threshold to achieving above it, then a better understanding of who the "potentials" are and where they go to school is useful.

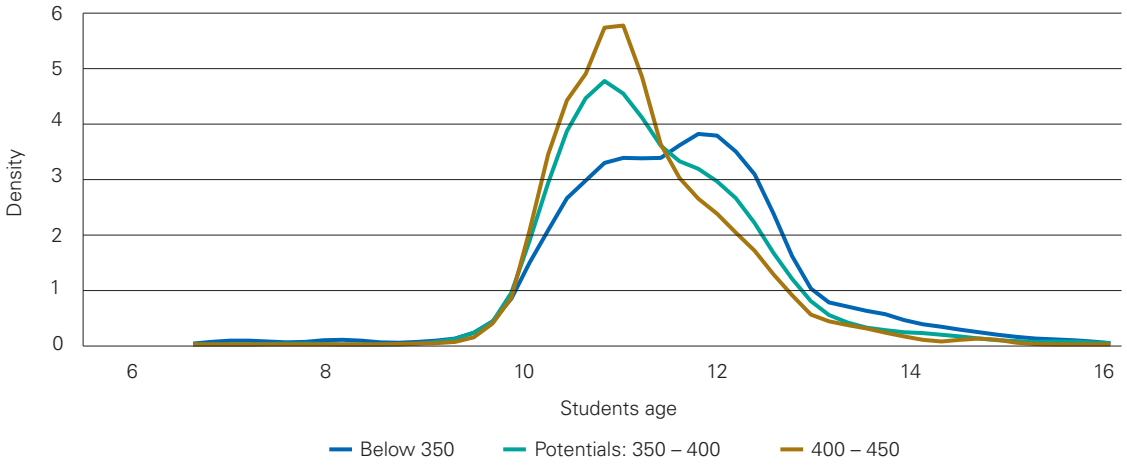
In terms of a gender split in the group, there is no difference between those scoring between 350 and 400 points, and any other group.

Figure 14.1: Average mathematics achievement for "potentials" by gender



The average age of a learner in the "potentials" group is 11.5 years, the upper end of the "correct age" for a Grade 5 learner, but statistically no different from those scoring above 400 points. Figure 14.2 shows the age distribution for learners in the "potentials" group, against those in the benchmark category 400-450. Note that, as reported in section 5, older learners perform less well in mathematics.

Figure 14.2: Age distribution by benchmarks



"Potentials", like those scoring below 350, are more likely to attend no-fee schools: 77 per cent of the "potentials" group are in no-fee schools, with a further 22 per cent in fee-paying schools and just 2 per cent from independents. Figure 14.3 shows the steady rise in the proportion of learners in fee-paying and independent schools as the points for each benchmark group increase as we move higher on the achievement scale benchmarks.

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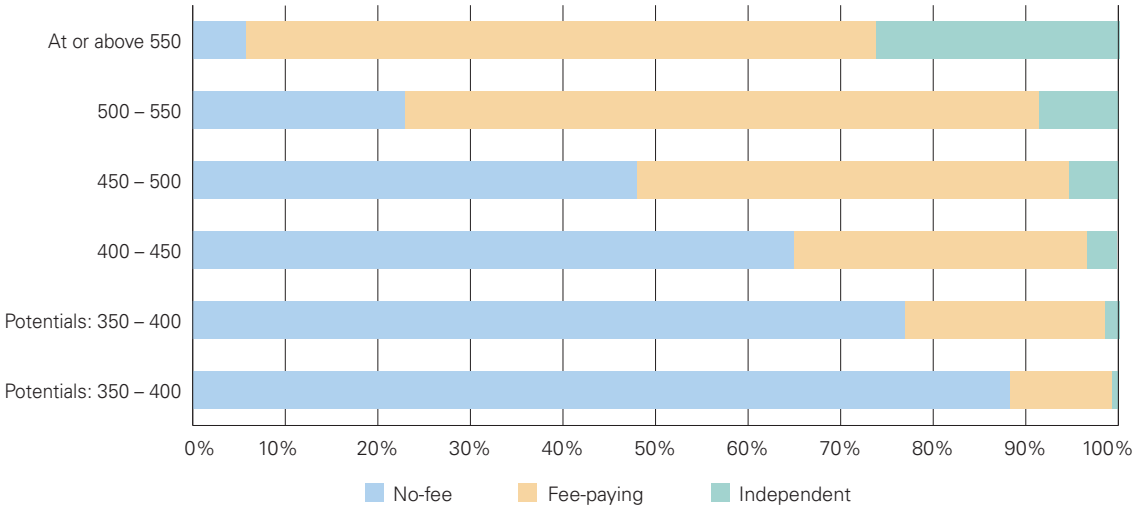
Figure 14.3: TIMSS and local benchmark groups, by school type



Authors' own calculations from TIMSS 2015 learner background dataset

Given that those in benchmark groups directly above and below the "potentials" group are most similar in performance at least, we can conduct analysis to highlight differences between individuals scoring at these three different levels in order to better understand what might be done to lift those falling just short of the 400-point mark. Table 14.2 attempts to capture how the relationships between the indicators of home, family background and school contexts differ between learners scoring above and below the "potentials". We use multinomial logistic regressions to show the statistically significant associations predicting membership of those scoring below 350 and those scoring between 400 and 450 points in comparison with learners scoring 350-400 points.

For simplicity in Table 14.2 only the direction of statistically significant coefficients is given, where a "-" means less likely than the potentials group, and "+" means more likely[31]. For example, girls are less likely to be in the "Below 350 points" group than in the "potentials" group, while those who are older are more likely to be in the "Below 350 points" group than the "potentials".

Table 14.2 shows several predictable relationships in distinguishing these groups also evident in the descriptive sections above: learners scoring less than 350 points are less likely to frequently speak the language of the test at home than those scoring 350-400 points, come from more disadvantaged households (less likely to have a fridge or electricity, though interestingly, more likely to have a computer, lower household education and parental occupation levels), have lower levels of literacy and numeracy skills at entry to school, less resourced school environments with greater levels of bullying, more safety and discipline problems, greater limitations facing educators, and lower school belonging and parental satisfaction. Interestingly, learners scoring below 350 points are more likely to find their mathematics educator engaging than those in the "potentials" group, despite being less confident in and enjoying mathematics less. Liking and feeling engaged by an educator may then be an important protective factor against early dropout, with learners who are doing less well academically but are engaged by their educator possibly being more likely to stay in school than leave school early. This also highlights again the need for appropriate remediation of learners falling behind and at risk of grade repetition, as well as the value of targeting school academic beliefs as a means to improving learning outcomes for learners across the achievement spectrum.

[31] *Learners scoring higher than 450 points are excluded from this analysis.*

The apparent preschool disadvantage may be due to poor quality experience for those going on to no-fee schools or being lost along the way through the failure of poorly resourced and more disadvantaged Q1-Q3 schools to be able to develop the early gains realised during the preschool period.

For those in the 400-450 points group, these learners are more likely to frequently speak the language of the test at home than "potentials", come from more educated households with parents of higher occupational status, have stronger literacy and numeracy skills in Grade 1 as rated by parents, are more confident and happy in mathematics instruction, as well as attend better-resourced, more affluent schools with fewer safety and discipline problems.

There are also provincial differences suggesting that Limpopo in particular is more likely to have learners scoring in the "potentials" range than below 350 points or between 400 and 450 points when all other measures are considered. This result is in line with the unconditional and conditional summary results discussed above (see Table 13.9): in the full model where all variables are considered simultaneously, Limpopo actually performs worse than the Eastern Cape, possibly reflecting this greater likelihood of having learners scoring between 350 and 400 points. Reflecting its top rank provincially, the Western Cape is more likely to have learners scoring 400-450 points than 350-400 points.

The analysis presented here also speaks to several of the other salient associations noted in the descriptive sections of this report, including the particular importance of preschool: we saw above that preschool attendance is very high in South Africa, with 89 per cent of learners having some experience of formal early learning settings before starting Grade 1, but that the gain in mathematics performance associated with attending preschool is not realised for all children equally, specifically those in no-fee schools. Here too, the results suggest that those who attended preschool are more likely to be in the 400-450 points group than the "potentials." The apparent preschool disadvantage may be due to poor quality experience for those going on to no-fee schools or being lost along the way through the failure of poorly resourced and more disadvantaged Q1-Q3 schools to be able to develop the early gains realised during the preschool period.

Similarly, 95 per cent of all learners have access to workbooks in class, either their own (87.5 per cent) or shared (8 per cent), with a positive relationship between access and achievement observed at all school types (see Figure 10.4 above for further detail). However, those scoring below 350 points are less likely than the "potentials" group to have access, either sole use or shared, suggesting again that achieving a full roll-out of the workbook initiative as soon as possible might be an easy policy lever to improve performance for those with the very lowest scores.

Finally, we note that those in the "potentials" group appear to attend schools where there are greater problems with staff absenteeism, even when controlling for other school-level characteristics. This may suggest underlying issues with school climate that are linked to lower levels of learner performance. Analysis at the Grade 9 level, for example, which attempts to parse the different layers of associations with learner achievement, highlights the particular importance of school climate in explaining differences within schools (see Zuze et al., 2017, for more detail here). The authors show that when other features of learner background and school resourcing are taken into account, dimensions of school climate such as experience of discipline and safety problems, challenges faced by educators, and frequency of learner bullying contribute to higher school average achievement. They also note that differences in school climate also explained the differences in average test scores between no-fee, fee-paying and independent schools.

Table 14.2: Multiple logistic regression predicting membership of "below 350 points" and "400-450 points" groups against "potentials"

Compared to "Potentials: 350 – 400"	Below 350 points		400 – 450 points	
A profile of learners				
Learner is a girl	–	†		
Age blocks: *(ref under 10.3 years old)*				
10.3 – 11.6 years				
11.7 – 12 years	+	**		
Over 12 years old	+	**		
Frequency test language is spoken at home: *(ref never)*				
Sometimes	–	***		
Always/almost always	–	***	+	*
Resources in the home				
Assets				
YP has own computer	+	***		
Internet connection				
Water-flush toilets				
Fridge	–	**		
Electricity	–	***		
Number of social grants received				
Indicators of socioeconomic status				
Household education *(low to high)*	–	***	+	**
Total number of books in the home				
Highest household occupation	–	***	+	
The early educational environment				
Frequency parent engages in early literacy and numeracy activities before school	+	***		
Attended preschool			+	†
School readiness				
Level of literacy and numeracy skills at school entry	–	***	+	***
Proportion of learners entering school with good learning ready skills	+	†		
Educational expectations and beliefs				
Parents' educational expectations				
Learner likes maths	–	***	+	***
Learner confident in maths	–	***	+	***
Learner finds maths teacher engaging	+	*		
School resources				
School has a place for learners to do schoolwork				
School provides free lunch			–	*
School has a library				
Total number of school computers	–	**	+	*
Learner has a workbook *(ref: no)*				
Own	–	***		
Shared	–	***		
Instruction affected by maths resource shortages				

Compared to "Potentials: 350 – 400"	Below 350 points		400 – 450 points	
School climate				
School emphasis on academic success			–	**
School safety and discipline problems *Higher score = Fewer problems)*	–	***	+	*
Learners' sense of school belonging	–	†		
Bullying score *(Higher score = Less bullying)*	–	***		
Parents' perceptions of the school	–	**		
A profile of teachers				
Teachers' job satisfaction				
Level of challenges facing teachers				
Level of limitations facing teachers	+	*		
Level to which teacher absenteeism is a problem	–	***	–	**
School type				
School type *(ref: No-fee)*				
Fee-paying	–	***	+	***
Independent	–	***	+	*
Province				
Province *(ref: Eastern Cape)*				
Free State	–	***		
Gauteng	–	**		
KwaZulu-Natal	–	*		
Limpopo	+	**	–	***
Mpumalanga	–	***		
Northern Cape				
North West	–	***		
Western Cape	–	***	+	***

****p<.001; ** p<.005; * p<.01; † p<0.1*

PART E

Section summary

Slow but steady improvement in mathematics achievement in TIMSS at Grade 9 shows an increase in the national average from 352 to 372 points between 2011 and 2015; the corresponding improvement in the proportion of learners scoring above the 400-point low benchmark threshold rising from 23 per cent to 34 per cent.

To bring the Grade 5 national average above the 400-point mark, learners would need to improve by an average of 25 points, over half a school grade higher than their current level of performance. In particular, a focus on the so-called "potentials" – learners scoring just under the 400-point threshold – is one avenue to consider. Just under a fifth of learners at Grade 5 score between 350 and 400 points and are:

- more likely to be found in no-fee schools;
- less likely to speak the language of the test at home;
- more likely to come from disadvantaged, lower-resourced and lower SES households; and
- more likely to have experienced bullying and attend schools with greater safety and discipline problems, as well as resource shortages and problems with staff absenteeism.

Again, the importance of early school experience plays a role in boosting learners above the low threshold cut-point: learners who attended preschool are more likely to score in the 400-450 point range, than below it. There is also some evidence to suggest that Limpopo has a particularly high proportion of learners scoring in the "potential" range and might then particularly benefit from a focus on this group specifically.

What distinguishes this group, then, is similar to the story seen throughout this report of compounding disadvantage and the summary results presented in section 13: there is no one thing that will improve average attainment, rather a system-wide approach that tackles features of both school and home life is needed to raise the bar for learners who are struggling. What this also means, however, is that targeting the "potentials" group specifically through, for example, improving school climate and resourcing (especially in no-fee schools), should also yield gains for all learners regardless of where they are along the continuum of mathematics achievement.

PART F

KEY FINDINGS, POLICY IMPLICATIONS AND RECOMMENDATIONS

Key findings, policy implications and recommendations

This study provides baseline information regarding mathematics achievement at the Grade 5 level and is a new indicator of the health of the South African educational system. In addition to the achievement data we also have detailed information of school and home learning contexts. South Africa is one of the lowest-performing countries in mathematics in comparison with other participating countries; achievement is highly unequal and socially graded.

Three in five South African learners (61 per cent) do not exhibit the minimum competencies in basic mathematical knowledge required at the Grade 5 level. Analysis of achievement and contextual data lead to a number of key findings. Given the low performance, focusing on the negatives, however, does nothing to move us forward or narrow the achievement gaps.

So what are the findings and how can schools and the state set about tackling manageable issues so that learner performance improves across the board and inequalities can begin to be redressed?

1. *Inequality in the South African education system remains a huge problem and exists throughout the entire system*. When broken down by school type, the depth of inequalities in achievement is only amplified. Schools often further exacerbate many of the inequalities that begin at home, compounding early disadvantage with a lack of resources and poor educational climates. Provincially too there are large discrepancies in average levels of attainment that need addressing.

   The diversity in educational achievement suggests differentiated strategies for those at different points on the achievement scale; and this is best exemplified through the categorisation of no-fee and fee-paying schools. For those at the lower end of the achievement spectrum, mostly in no-fee schools, improved home and school resources and experiences can help contribute to better achievement. For those performing at the higher achievement end, mostly in fee-paying and independent schools, the focus should be on improving in-school and classroom experiences and challenging learners for excellence in performance.

2. The results presented in this report *retell the predictable story* seen before in South Africa of advantage begetting advantage at one end of the distribution, and compounding disadvantage at the other. In fee-paying and independent schools, improving the proficiency in the language of instruction for all learners and decreasing the frequency of bullying experienced by learners should help improve achievement scores. Far more interventions are required for learners in no-fee schools, starting from shifting home engagements from play to mediated play which promotes learning and improving school awareness of learner abilities and academic readiness, school resources and school climate.

3. *Grade R participation* has been increasing from 20 per cent of the population participating in ECD programmes in 1996 to 90 per cent of the TIMSS-N sample indicating they had attended preschools for varying durations. Those that attended preschools scored higher than those who did not do so. However, as with research by van der Berg et al., (2013), learners in no-fee schools appear not to gain the same advantage from attending preschool settings as their counterparts in fee-paying and independent schools. This may reflect that the quality of education they receive in early settings is of a lower standard or that poorly resourced Q1 to Q3 no-fee schools cannot sustain, and build on, the early learning gains.

Just having "a place to go" in terms of a childcare environment is not enough. *Early learning settings need to be cognitively rich and stimulating for all children,* particularly those who are already more likely to come from disadvantaged and poorly resourced households, to help learners start school with the best possible chances. ECD practitioners need to be adequately trained, but service delivery in the form of improved resources learning materials, funding, security for children while at the ECD facility, and toilet amenities are vital to ensure high quality provision and a benefit to all learners, regardless of school or province (see Atmore, van Niekerk & Ashley-Cooper, 2012 for a comprehensive discussion of factors impacting ECD provision and quality).

Future studies must track the impact of learners attending Grade R in ordinary public schools vs those who attend in stand-alone centres.

4. Mathematical knowledge is hierarchical and builds on strong foundational knowledge, thus ensuring the basics are in place is a key part of academic success. However, learners enter school with different levels of early literacy and numeracy skills and if they are not "school ready" at Grade 1, the disadvantage is likely to continue, deepening along the way.

   Moreover, since the greatest challenge reported by teachers is that *learners lack the prerequisite knowledge,* the importance of educational quality and the need to build up knowledge and skills from Grade R is paramount.

   Grade 1 classes should therefore spend the first two weeks of school implementing the School Readiness Baseline Assessment programmes to identify how learners perform and targeted investments should be made in Grades 1 and 2 to remediate those at risk of falling behind.

5. Overall, 87 per cent of all learners have their own workbooks and conditional correlations with *achievement scores show positive associations with sole access to a workbook.* The quickest and easiest change that should be acted on with immediate effect based on the results presented here is to ensure that all learners have individual access to a workbook. Those with no, or shared, access do less well in TIMSS mathematics achievement than learners with their own workbook. Increasing access from its current level of 87 per cent to 100 per cent as soon as possible, and understanding where this resource is lacking may also help in terms of more equitable distribution of resources in the most deprived schools: learners without sole access to a workbook are more likely to be in schools where general resource shortages are greater.

6. *Grade repetition is not working for the vast majority of learners.* By Grade 5, 39 per cent of learners are at least a few months "over-age" for their grade, with a quarter having repeated at least one grade (at least six months older than the oldest possible "correct" age for the grade). While some of those who are older may reflect younger learners who are held back from the beginning of the grade system, our results show that both over- and under-age Grade 5 learners perform significantly worse academically.

   Research on grade repetition shows that early instances of grade repetition are associated with an increased likelihood of further grade repetition: grade repetition becomes even more marked in the later grades (Branson, Hofmeyr & Lam, 2013) and that with each instance of grade repetition, the likelihood of reaching Grade 12 and matriculating reduces (Isdale et al.; 2016, forthcoming). Assessment practices within schools that determine whether a learner advances to the next grade need to accurately reflect ability. Where being held back is appropriate, for grade repetition to be effective, learners falling behind and at risk of having to repeat need proper remediation and teaching strategies sufficiently adapted so as to accommodate the necessary remedial action required.

7. *School climate, bullying and school safety issues pose real threats to learner achievement.* School climate is related to individual achievement in mathematics – schools with fewer discipline problems, learners feeling safe in a school and fewer teacher absences contribute to better achievement.

   Learner experience of bullying in Grade 5 is more than double that at Grade 9 and is higher than in any other participating TIMSS country. Those who experience bullying not only perform less well academically, but are more likely to themselves become bullies. High levels of safety and discipline problems in schools are also negatively associated with achievement, and often go in tandem with bullying behaviours. The relationship between bullying and achievement appears stronger for learners in fee-paying and independent schools than in no-fee schools, possibly indicating it has become normalised in the most disadvantaged schools.

   Issues around bullying and school safety and discipline need to be tackled and seriously dealt with and the importance of safe school environments is made explicit in the National Development Plan (NDP), the South African Government's Vision for 2030. National policies, such as the NSSF, and/or legislative changes can go some way to tackling the problems of bullying and safety, but schools have to tackle the issues particular to their learners at a school-by-school level in order to foster an overall climate of inclusion, warmth, and respect, and promote the development of core social and emotional skills among both learners and teachers.

8. *Language proficiency* in the language of the test is associated with individual achievement and literacy development and meaningful reading both at home and in schools must be encouraged and supported. The common practice is to either use English from Grade 1 or to switch from an African instructional language to English from Grade 4 onwards (Pretorius et al., 2016). This acts as a disadvantage for learners who have gained proficiency in African languages from birth, with English being a second or even third language. Understandably this impacts learner achievement.

   In fee-paying and independent schools, where there are better resources and climate, language proficiency has a stronger association with achievement scores.

9. *Achievement in mathematics is more than just a numbers game.* As noted in our introductory section, early abilities are built on over time, and existing skills and previous strategies are gradually adapted and improved upon. The development of mathematical skills is no exception, and is also related to motivating forces such as how good a learner thinks they are at mathematics and whether they see themselves as capable of understanding and improving. Research here shows that the relationship between achievement and confidence, or self-concept of ability, in mathematics is reciprocal: thinking you are good and seeing yourself as capable of getting better at mathematics improves performance, even for those at the bottom of the achievement distribution (Susperreguy et al., 2017).

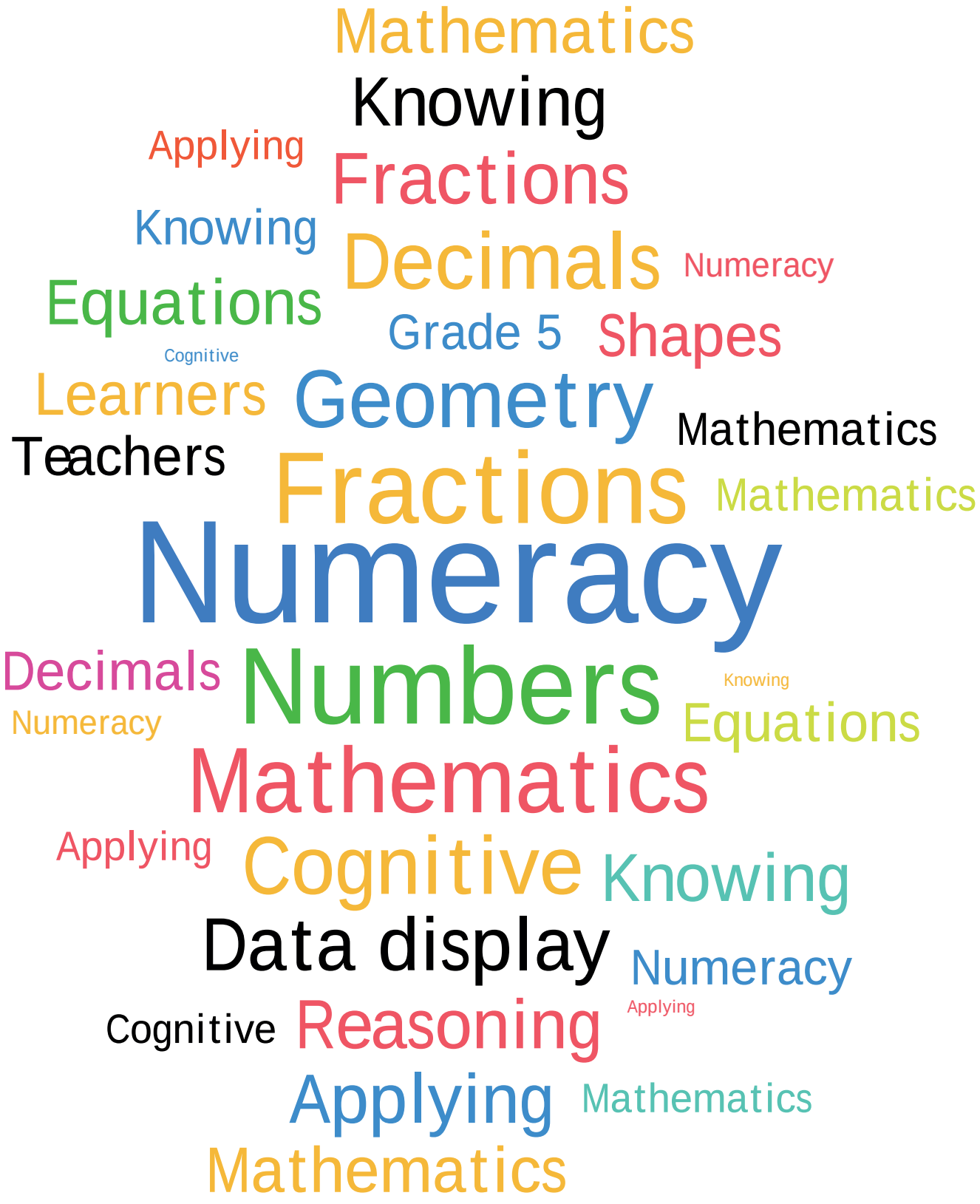
   Teaching strategies for mathematics should therefore include skills and practices that boost learner confidence, motivation and self-concept of their ability in mathematics.

10. *Easing educator limitations: Spillover effects.* Addressing these areas may improve learner achievement and yield gains in national averages and our global ranking. In addition, the combined effect of tackling issues such as these should also go some way towards reducing the very high proportion of educators reporting that their biggest limitation to teaching on a day-to-day basis is that learners do not have the prerequisite skills necessary for educators to effectively do their jobs.

    In the longer term, improving the building blocks of numeracy development will also help to improve educational throughput into and successful participation in post-secondary education. The prevailing reason for underperformance in higher education results from the high proportion of students being underprepared for study at university level (van Broekhuizen, van der Berg & Hofmeyr, 2017), the major cause of which is identified as poor schooling.

Policy and programme recommendations for different role players

National	• Strengthen the capacity of schools to implement literacy and numeracy strategies to develop the reading, writing and numeracy abilities of learners • Focus on the implementation of the Integrated Early Childhood Education policy • Prioritise the provision of pedagogical infrastructure (e.g. libraries and laboratories) and pedagogical resources (e.g. workbooks and textbooks) to learners in public schools, especially no-fee schools • Monitor and support schools with the implementation of the NSSF to create a safe, violence- and threat-free, supportive learning environment • Develop a school climate strategy as well as an implementation, monitoring and evaluation plan for public schools • Continue to use international assessments to track progress towards literacy and numeracy targets
Provincial	• Ensure that pedagogical infrastructure and resources (especially workbooks) are provided to schools and used effectively • Continue to emphasise the importance of foundational knowledge and quality of teaching and learning from Grade R • Promote awareness about the importance of a healthy school climate • Maintain efforts to recruit and retain literacy and numeracy teaching professionals in public schools • Maintain efforts to recruit and retain Grade R teaching professionals in public schools
District	• Design appropriate interventions for improving the use of language in literacy and numeracy teaching • Monitor teacher and learner attendance and punctuality • Monitor the availability of learning (especially workbooks) and teaching support materials and evaluate how effectively these materials are used • Promote and encourage the implementation of the NSSF • Monitor incidences of bullying in schools
School	• Implement the School Readiness Baseline Assessments in the first two weeks of school in Grade 1 • Increase the opportunities for in-service training of Grade R/ECD teachers • Ensure that the focus of teaching and learning at the Foundation Phase is on reading and numeracy • Continuous monitoring of time on task within primary schools • Ensure safety, discipline and order • Monitor and manage rates of absenteeism among teachers and learners • Encourage an academic culture in schools • Encourage and nurture parent and community engagement
Teachers and classrooms	• Emphasise punctuality among teachers • Evaluate and improve on teacher subject matter knowledge and pedagogy • Introduce strategies to boost learner confidence, motivation and self-concept of their literacy and numeracy abilities • Integrate social and emotional learning during lessons • Provide learners with practice examples and regular feedback
Learners	• Emphasise punctuality and attendance among learners • Improve proficiency in the language of the test • Regular practice of literacy and numeracy (mathematics) examples with written homework • Introduce study skills at the Intermediate Phase to assist learners in planning their learning tasks
Communities	• Motivate and mentor young children about the importance of education • Collaborate with schools to support efforts to improve the school climate • Monitor teacher and learner attendance at schools • Instil a culture of zero tolerance of violence
Households	• Engage young children in literacy and numeracy activities • Support and monitor homework and school reports • Ensure learner attendance and punctuality at schools • Engage with teachers and school officials about education delivery, school climate, learner support programmes and performance • Instil a culture of zero tolerance of violence


Mathematics
Knowing
Applying
Fractions
Knowing
Decimals
Numeracy
Equations
Grade 5
Shapes
Cognitive
Learners
Geometry
Mathematics
Teachers
Fractions
Mathematics
Numeracy
Decimals
Numbers
Knowing
Numeracy
Equations
Mathematics
Applying
Cognitive
Knowing
Data display
Numeracy
Applying
Cognitive
Reasoning
Applying
Mathematics
Mathematics

APPENDIX

APPENDIX A1:
TIMSS-Numeracy 2015 design and methodology

A1.1 Introduction

TIMSS 2015 was the sixth cycle of the International Association for the Evaluation of Educational Achievement (IEA) series of large-scale assessments of learner achievement dedicated to improving teaching and learning in mathematics and science.

Forty-nine countries participated in TIMSS 2015 at the Grade 4/5 level; where diversities ranged from economic development, geographic location to population size. Of these, seven countries (Bahrain, Indonesia, Iran, Jordan, Kuwait, Morocco and South Africa) participated in TIMSS-Numeracy.

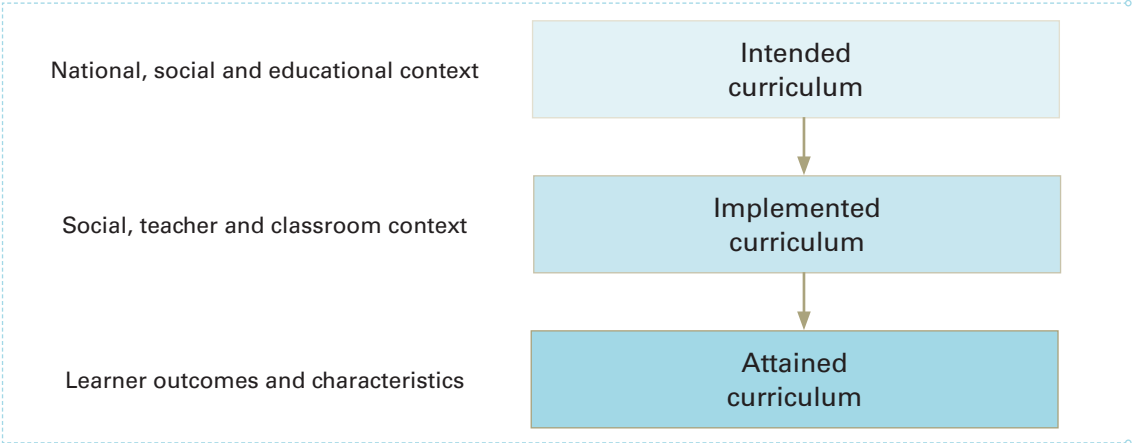
Drawing on the TIMSS 2015 Assessment Framework[32] we will explain the design and implementation of the study. The main stages in the design and planning for TIMSS are:

- TIMSS conceptual framework
- Instruments
- Sampling
- Field testing
- Main administration
- Scoring of constructed responses
- Data capture and cleaning
- Reporting TIMSS achievement scores

A1.2 TIMSS conceptual framework

TIMSS uses the curriculum as the major organising concept in considering how educational opportunities are provided to learners and the factors that affect how learners use these opportunities. The TIMSS Curriculum Model has three aspects: the intended curriculum, the implemented curriculum and the attained curriculum (Appendix figure A1.1). These represent the mathematics and science that learners are expected to learn as defined by countries' curricula policies and publications, how the educational system should be organised to facilitate this learning, what is actually taught in classrooms, the characteristics of those teaching it, how it is taught and, finally, what it is that learners have learned.

Appendix figure A1.1: TIMSS Curriculum Model



The three content domains assessed for mathematics are described in Appendix table A1.1.

[32] *Mullis, IVS & Martin, MO (Eds.) (2013). TIMSS 2015 Assessment Frameworks. Retrieved from Boston College, TIMSS & PIRLS International Study Center website:http://timssandpirls.bc.edu/timss2015/frameworks.html.*

Appendix table A1.1: TIMSS Grade 5 content domains for mathematics

Mathematics			
Content domain	Whole numbers	Shapes and measures	Data
% of assessment	50%	35%	15%
Summary	Whole numbers Expressions, simple equations, and relationships Fractions and decimals	Measurement Geometry	Reading, interpreting, and representing data Using data to solve problems

In order for learners to correctly complete the TIMSS assessment items they need to draw on a range of cognitive skills. These skills are addressed in terms of three cognitive domains set out in the Appendix table A1.2.

Appendix table A1.2: TIMSS Grade 5 cognitive domains for mathematics

Mathematics			
Cognitive domain	Knowing	Applying	Reasoning
% of assessment	50%	35%	15%
Skills assessed	Recall Recognise Classify Compute Retrieve Measure	Determine Represent Model Implement	Analyse Integrate Synthesise Draw conclusions Generalise Justify

A1.3 Instruments

A set of research instruments pertaining to learner achievement items and background information is developed by the IEA with input from the various countries participating in the study. These instruments will be discussed in the following sections.

A1.3.1 Achievement booklets

The TIMSS Achievement Booklets contain both trend items, which form the anchor, to impute and estimate trend achievement score measures and new items are generated for each new round of TIMSS. The new items are generated in National Research Coordinator meetings and are subjected to extensive validation processes.

Throughout the TIMSS studies, vast numbers of items have accumulated and with every cycle certain items are released into the public domain and the remainder, which are used as trend items, are not. By releasing items into the public domain, countries are able to use these items as exemplars for preparation for the next TIMSS cycle. The HSRC sent all the released items to the sampled schools on a CD and these items appear on the DBE's Thutong website.

In order to ensure maximum curriculum coverage, TIMSS uses a matrix sampling approach, where items are constituted into blocks and the TIMSS items are spread across five booklets and a single booklet is administered to learners.

APPENDIX A1:
TIMSS-Numeracy 2015 design and methodology

A1.3.2 Background questionnaires

To obtain better insights and explanations for the achievement scores, TIMSS included a number of background questionnaires. Five questionnaires are administered in addition to the assessment instruments:

- The **learner background questionnaire** is completed by the learner who completed the assessment and asks about aspects of the learner's home and school lives, their home environment, school climate for learning and their perceptions and attitudes towards mathematics.
- The **teacher questionnaire** is administered to the mathematics teachers of the learners who wrote the assessment tests. The questionnaire was designed to gather information on teacher characteristics as well as classroom contexts for teaching and learning mathematics.
- The **school questionnaire** is administered to the principal in all sampled schools. It asks about school characteristics like instructional time, resources and technology as well as parental involvement.
- The **home questionnaire** is completed by the parent or guardian of the learner who completed the assessment and asks about the learner's home context for learning on aspects such as pre-Grade 1 educational activities, school readiness of learners, school involvement, ability of parents to assist learners with homework, and perceptions of school safety.
- The **curriculum questionnaire** is completed by the National Research Coordinator who is required to complete information pertaining to the curriculum which is followed by South African public schools.

A1.4 Sampling

A sample of Grade 5 schools was selected to provide a national estimate of mathematics scores. TIMSS 2015 followed the sampling procedures as prescribed in the TIMSS Methods and Procedures Manual[33]. TIMSS follows a two-stage stratified cluster sampling design, where 300 schools were selected at the first stage and at the second stage an intact Grade 5 class was selected within each of the sampled schools.

At stage 1 a representative sample of schools was drawn using the DBE's master list of schools for 2013 as the sampling frame. Schools included in the sampling frame were schools that offered Grade 5 classes and had no missing information on the stratification variables. The sample was explicitly stratified by province, type of school (public and independent schools) and LoLT (English, Afrikaans and dual medium).

Stage 2 involved sampling classes. For classes to be sampled within schools, schools were required to submit class information for all Grade 5 classes. An intact class was randomly selected using sampling software provided by the IEA Data Processing Centre called Windows Within-School Sampling Software (WinW3S). Generally, one class per school was randomly selected; however in dual medium schools two classes were selected. In addition to the sample of participating schools, a first and second replacement school was selected should a school be unable to participate.

[33] *Martin, MO, Mullis, IVS, and Hooper, M. (Eds.). (2016). Methods and Procedures in TIMSS 2015. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/publications/timss/2015-methods.html*

Appendix table A1.3: TIMSS-Numeracy schools sampled

	School sampled	Sampled schools participating	First replacement	Second replacement	Total schools	Total learners
EC	38	37			37	1 194
FS	29	29			29	1 131
GT	46	42	3		45	1 625
KZ	35	35			35	1 173
LP	34	34			34	1 307
MP	29	29			29	1 179
NC	29	29			29	1 026
NW	29	29			29	1 221
WC	31	29		1	30	1 076
Grand total	**300**	**293**	**3**	**1**	**297**	**10 932**

The final realised sample included 297 principals, 298 mathematics teachers, 10 932 learners, and 10 376 parents.

A1.5 Field testing

Pilot studies or field tests in TIMSS are done for a number of reasons, namely:

- To serve as a dress rehearsal for the main survey;
- Provides important information about how well items are functioning; and
- To measure the validity and reliability of the various questionnaire scales/indices.

The sample for the field test was drawn simultaneously with the sample of the main survey; using the same sampling procedures as with the main study. The sample size for the field test was 15 schools (5 per cent of the main sample total) with a target of 600 learners; the sample design ensured that a school drawn for the field test was not selected again for the main survey. The pilot was administered in Gauteng and KwaZulu-Natal. These schools were within a 100-kilometre radius of the Pretoria city centre in the case of Gauteng and Durban in the case of KwaZulu-Natal.

A1.6 Main administration

A substantial amount of preparatory work needed to be done before the study was administered; and the international TIMSS team provided countries with very strict guidelines on how the preparation needed to be done. All these procedures can be found described in detail in the TIMSS 2015 survey operations procedures (unit 1 to 7) documents within the TIMSS 2015 Methods and Procedures report[34].

Pre-administration contact with schools is extremely important as it allowed the HSRC to obtain permission to conduct the study, obtain class lists with learner information as well as arrange appointments with the schools to administer the study.

Consistency between countries is extremely important and the international team developed three basic procedures to guide countries through the data collection phase.

[34] *Martin, MO, Mullis, IVS, and Hooper, M. (Eds.). (2016). Methods and Procedures in TIMSS 2015. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/publications/timss/2015-methods.html*

A1.6.1 Administration of the main survey

The main survey was administered by an external fieldwork company with relevant qualifications and experience in the field of educational assessment. South Africa administered the main study over the last two weeks of October 2015 into the first week of November. The HSRC worked with the DBE and provincial coordinators to ensure that the study was successfully administered.

A1.6.2 Monitoring the quality of the survey administration

Quality assurance in the field is extremely important as it allows for valid learner achievement comparisons between and within countries. Ten per cent of the sampled schools were randomly selected and senior researchers at the HSRC who served as National Quality Control Monitors were required to monitor the TIMSS administration processes. In addition, the International TIMSS team selected an International Quality Control Monitor, who monitored the administration processes in 15 schools in South Africa.

A1.7 Scoring the constructed response items

The constructed response (open-ended) items represent approximately 50 per cent of the TIMSS assessments, hence the reliability and validity of scoring is critical to the quality of the assessment results. In order to achieve reliable and valid scoring the IEA provided training, comprehensive scoring guides and scoring procedures. Learners' responses were scored consistently, regardless of who is assigning the scores. The HSRC employed teachers and tertiary students to conduct the scoring. As a quality control measure, 5 per cent of the booklets were marked twice by different scorers to check for consistency. This is referred to as reliability scoring. Moderating of scoring quality was done by the HSRC staff on an ongoing basis for maintaining accurate and consistent scoring throughout the process.

A1.8 Data capture and cleaning

All data was captured using a software program developed by the IEA called Data Management Expert (DME). The HSRC double-captured all data and verified against the original capture. This ensured that the data remained below the acceptable error rate of 0.1 per cent for assessment data and 1 per cent for contextual data. Once all validation steps are performed on the data; it was sent to the IEA-Data Processing Centre (DPC) in Germany for the final phase of cleaning. The IEA remained in constant contact with data managers at the HSRC once the final stage of cleaning had commenced. This was to ensure that any additional data-related queries the IEA-DPC may have had were solved by the HSRC in a timely fashion, once physical instruments had been checked.

A1.9 Reporting TIMSS achievement scores

Due to the TIMSS item block design, Item Response Theory (IRT) scaling methods use plausible values to obtain estimated proficiency scores in mathematics. Since there are too many items in the TIMSS item bank it would be impossible for all learners to respond to all items. For this, learner scores obtained on completed items are combined with the demographic background of similar learners and estimated scores for learner outcomes are calculated. Five estimates or plausible values for each learner are drawn to account for errors that may occur during the estimation process. With this approach, the advantage of estimating population characteristics is offset by the inability to make precise statements about individuals[35].

The TIMSS 2015 achievement results are summarised using IRT scaling and reported on 0 to 1 000 achievement scales with the SE (the statistical accuracy of the estimate).

[35] *TIMSS and PIRLS Achievement Scaling Methodology Retrieved from https://timssandpirls.bc.edu/methods/pdf/TP11_Scaling_Methodology.pdf*

APPENDIX A2: Curriculum analysis

A2.1 The TIMSS curriculum and assessment

The TIMSS curriculum and assessment framework is organised around the mathematics content domains of numbers, geometry (shapes and measures) and data display. In addition, TIMSS items measure performance in the cognitive domains of knowing, applying, and reasoning.

Appendix table A2.1 below describes the extent of match between the TIMSS and South African curriculum (Curriculum Assessment Policy Statements) and the performance in each of the content areas. The degree of match is calculated as a proportion of topics (for each content area) covered by the Grade 5 South African curriculum. There was a total of 17 topics: eight in Numbers; seven in Geometric shapes and measures and two in Data display.

Appendix table A2.1: Match between TIMSS and South African curriculum and achievement scores by content and cognitive domains

	% of assessment	Degree of match between TIMSS and South African curriculum	Average	SE	Difference from overall mean
Overall	100%	88%	376	(3.5)	
Content domain:					
Numbers	50%	88%	379	(3.4)	+ 5
Shapes and measures	35%	86%	359	(3.7)	- 16
Data display	15%	100%	381	(4.0)	+ 3
Cognitive domain:					
Knowing	50%		378	(3.6)	+ 2
Applying	35%		377	(3.4)	+ 1
Reasoning	15%		369	(3.5)	- 7

Source: Reddy et al., 2016

Learners performed slightly better than the overall average in the Number domain (by 5 points) and Data (by 3 points) content areas and underperformed in the Geometric shapes and measures domain (by 16 points).

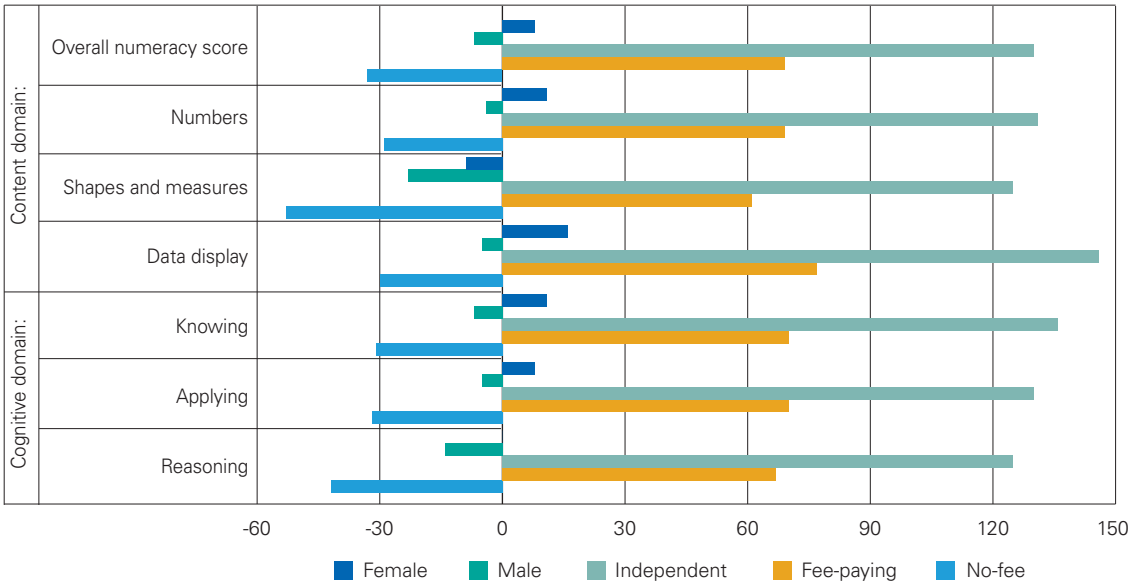
Knowing, applying and reasoning are the hierarchical order of cognitive demand. Figure A2.1 shows that in South Africa, learners are performing at a level similar to the overall average in terms of knowing and applying their mathematical knowledge, but underperforming slightly with respect to their reasoning skills (by 7 points).

Across the board, girls are outperforming boys: the female overall average is 15 points higher than the male average, and 8 points higher than the full sample mean. Female achievement in the areas of numbers, shapes and measures, and data display, for example, is 15, 14 and 20 points higher than the male average respectively.

Appendix figure A2.1 also shows a clear ranking in terms of achievement by school type with learners in fee-paying (Q4 and Q5) schools outperforming no-fee (Q1-Q3) schools by an average of 102 points, and those in independent schools scoring, on average, 62 points more than those in fee-paying schools.

APPENDIX A2:
Curriculum analysis

Appendix figure A2.1: Difference in achievement scores by content and cognitive domains by sex and school type



Source: Reddy et al., 2016

A2.2 The South African Curriculum Assessment Policy Statement

The South African Curriculum Assessment Policy (CAPS) aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives.

Mathematics in Grade 5 covers five content areas which are:

1. Numbers, operations and relationships
2. Patterns, functions and algebra
3. Space and shape (geometry)
4. Measurement
5. Data handling

Appendix table A2.2 provides a summary of the CAPS content areas and what a learner should be able to do within each content area. The corresponding TIMSS content area is provided for comparison.

Appendix table A2.2: CAPS and TIMSS content areas

Curriculum Assessment Policy (CAPS)			TIMSS
Content area	Topic	Specific areas covered	TIMSS topic
Numbers, operations and relationships	Whole numbers	*Mental calculations involving:* Addition and subtraction units and multiples of 10, 100 and 1 000; Multiplication to at least 10 x 10; Multiplication of units by multiples of 10, 100, 1 000 and 10 000. *Number range for counting, ordering, comparing, representing and place value of digits*: Count forwards and backwards in whole number intervals up to at least 10 000; Order, compare and represent numbers to at least 6-digit numbers; Represent odd and even numbers to at least 1 000; Recognise the place value of digits in whole numbers to at least 6-digit numbers; Round off to the nearest 5, 10, 100 and 1 000. *Number range for calculations:* Adding and subtracting (5 digits), multiplying and dividing) 3-digit by 2-digit). *Calculation techniques:* Using a range of techniques to perform and check written and mental calculations of whole numbers (estimation; adding and subtracting in columns; building up and breaking down numbers; using a number line; rounding off and compensating; doubling and halving; using addition and subtraction as inverse operations; using multiplication and division as inverse operations). *Number range for multiples and factors:* Multiples and factors of 2-digit whole numbers to at least 100. Properties of whole numbers: recognise and use commutative associative distributive properties of whole numbers. Solving problems involving whole numbers in a financial and measurement context and comparing two or more quantities of the same or different kinds.	Demonstrate knowledge of place value, including recognising and writing numbers in expanded form; and represent whole numbers using words, diagrams, or symbols. Compare, order, and round whole numbers. Compute (+, –, ×, ÷) with whole numbers. Solve problems set in contexts, including those involving measurements, money and simple proportions. Identify odd and even numbers; identify multiples and factors of numbers.

APPENDIX A2:
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Curriculum Assessment Policy (CAPS)			TIMSS
Content area	Topic	Specific areas covered	TIMSS topic
Numbers, operations and relationships	Common fractions	Counting forward and backward in fractions, and compare and order common fractions to at least twelfths. *Calculations with fractions:* Addition and subtraction of common fractions with the same denominators and mixed numbers; Fractions of whole numbers which result in whole numbers; Recognise, describe and use the equivalence of division and fractions; Solve problems in contexts involving common fractions, including grouping and sharing; Recognise and use equivalent forms of common fractions (fractions in which one denominator is a multiple of another).	Recognise fractions as parts of wholes, parts of a collection, or locations on number lines, and represent fractions using words, numbers, or models. Identify equivalent simple fractions; compare and order simple fractions; Add and subtract.
	Decimals	Not assessed in CAPS	Demonstrate knowledge of decimal place value including representing decimals using words, numbers or models; compare, order and round decimals; add and subtract decimals, including those set in problem situations.
Patterns, functions and algebra	Numeric patterns	Investigate and extend numeric patterns looking for relationships or rules of patterns; determining input and output values and rules for the patterns and relationships using flow diagrams. Determine equivalence of different descriptions of the same relationship or rule presented.	Identify and use relationships in a well-defined pattern (e.g., describe the relationship between adjacent terms and generate pairs of whole numbers given a rule).
	Geometric patterns	Investigate and extend geometric patterns looking for relationships or rules of patterns; Determine input values, output values and rules for the patterns and relationships using flow diagrams. Determine equivalence of different descriptions of the same relationship or rule presented verbally, in a flow diagram, and/or by a number sentence	Identify and use relationships in a well-defined pattern.
	Number sentences	Write number sentences to describe problem situations. Solve and complete number sentences by inspection, and/or trial and improvement. Check solutions by substitution.	Find the missing number or operation in a number sentence (e.g., 17 + w = 29). Identify or write expressions or number sentences to represent problem situations involving unknowns.

Curriculum Assessment Policy (CAPS)			TIMSS
Content area	Topic	Specific areas covered	TIMSS topic
Space and shape (geometry)	Properties of 2D shapes	Recognise, visualise and name 2D shapes in the environment and geometric setting (regular and irregular polygons – triangles, squares, rectangles, other quadrilaterals, pentagons, hexagons, heptagons; circles; similarities and differences between squares and rectangles). Describe, sort and compare 2D shapes (straight and curved sides, number of sides, lengths of sides, angles in shapes, limited to right angles, angles smaller than right angles, angles greater than right angles). Recognise and describe angles in 2D shapes (right angles, angles smaller than right angles, angles greater than right angles).	Identify, compare, and draw different types of angles (e.g., a right angle, and angles larger or smaller than a right angle). Identify and draw parallel and perpendicular lines.
	Properties of 3D objects	Recognise, visualise and name 3D objects in the environment and geometric settings (rectangular prisms and other prisms, cubes, cylinders, cones, pyramids, similarities and differences between cubes and rectangular prisms). Describe, sort and compare 3D objects (shape of faces, number of faces, flat and curved surfaces).	Use elementary properties to describe and compare common two- and three-dimensional geometric shapes, including line and rotational symmetry. Relate three-dimensional shapes with their two-dimensional representations.
	Symmetry	Recognise, draw and describe line(s) of symmetry in 2D shapes.	Use elementary properties to describe and compare common two- and three-dimensional geometric shapes, including line and rotational symmetry.
	Transformations	Use transformations to make composite 2D shapes (using rotation, translation, reflection). Use transformations to make tessellations (using rotation, translation, reflection). Describe patterns (refer to lines, 2D shapes, 3D objects, lines of symmetry, rotations, reflections and translations when describing patterns).	Use elementary properties to describe and compare common two- and three-dimensional geometric shapes, including line and rotational symmetry.
	Position and movement	Location and directions: Locate position of objects, drawings or symbols on a grid with alpha-numeric grid references; Locate positions of objects on a map by using alpha-numeric grid references; Follow directions to trace a path between positions on a map.	Use informal coordinate systems to locate points in a plane.
Measurement	Length	Practical measuring of 2D shapes and 3D objects (estimating, measuring, recording, comparing and ordering). Calculations and problem-solving involving length (millimetres, centimetres, metres, kilometres).	Measure and estimate lengths.
	Mass	Practical measuring of 3D objects (estimating, measuring, recording, comparing and ordering). Measuring instruments (bathroom scales, kitchen scales and balances). Calculations and problem-solving involving mass.	Solve problems set in contexts, including those involving measurements and simple proportions.

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Curriculum Assessment Policy (CAPS)			TIMSS
Content area	Topic	Specific areas covered	TIMSS topic
Measurement	Capacity/ volume	Practical measuring of 3D objects (estimating, measuring, recording, comparing and ordering). Measuring instruments (measuring spoons, measuring cups, measuring jugs). Calculations and problem solving involving capacity/ volume – converting between litres and millilitres limited to examples with whole numbers and fractions.	Calculate and estimate areas and volumes of geometric figures by covering with a given shape or by filling with cubes.
	Time	Read, tell and write time in 12-hour and 24-hour formats on both analogue and digital instruments in hours, minutes, and seconds. Reading calendars. Solving problems in contexts involving time.	Solve problems involving measurements, including time and money.
	Temperature	Practical measuring of temperature by estimating, measuring, recording, comparing and ordering. Measuring instruments (thermometers). Calculations and problem-solving related to temperature.	Not assessed in TIMSS
	Perimeter, surface area and volume	Measure perimeter using rulers or measuring tapes. Measurement of area – Find areas of regular and irregular shapes by counting squares on grids in order to develop an understanding of square units. Measurement of volume – Find volume/capacity of objects by packing or filling them in order to develop an understanding of cubic units.	Calculate perimeters of polygons; calculate areas of squares and rectangles; and estimate areas and volumes of geometric figures by covering with a given shape or by filling with cubes.
Data handling	Collecting and organising data	Collect data using tally marks and tables for recording. Ordering data from smallest group to largest group.	Read, compare, and represent data from tables, pictographs, bar graphs, line graphs and pie charts.
	Representing data	Draw a variety of graphs to display and interpret data including pictographs and bar graphs.	Read, compare, and represent data from tables, pictographs, bar graphs, line graphs and pie charts.
	Analysing, interpreting and reporting data	Critically read and interpret data (words, pictographs, bar graphs, pie charts). Analyse data by answering questions (data categories/data sources and contexts). Reporting data by summarising data verbally and in short written paragraphs that include drawing conclusions about the data, and making predictions based on the data. Examine ungrouped numerical data to determine the most frequently occurring score in the data set (mode).	Use information from data displays to answer questions that go beyond directly reading the data displayed (e.g., solve problems and perform computations using the data, combine data from two or more sources, make inferences, and draw conclusions based on the data).
	Probability	Probability experiments. Perform simple repeated events and list possible outcomes for experiments such as tossing a coin, rolling a die, and/or spinning a spinner. Count and compare the frequency of actual outcomes for a series of trials up to 20 trials.	Not assessed in TIMSS

APPENDIX A3:
Summary of association results by school type

Throughout the report, one of the key differences influencing the associations observed is school type. Table A3.1 summarises our findings by school type, reporting the average TIMSS mathematics score (and corresponding SE) and proportion of learners experiencing each of the associated variables considered in the report.

Appendix table A3.1: Summary of results by school type

	No-fee	Fee-paying	Independent
Learner achievement			
Average mathematics score (SE)	344 (3.4)	445 (7.7)	506 (11.9)
% of learners achieving at or above 400	25	67	84
Age			
Average age of learners (years)	11.5	11.4	11.3
Home resources			
% of learners with basic home resources			
Electricity	78	93	94
Running tap water	59	76	83
Water-flush toilets	41	87	89
% of learners with pedagogical resources			
Computer (own)	27	39	56
Internet connection	28	51	67
% with more than 25 books at home	37	62	84
% of learners with more educated parents			
Maternal education above Grade 12	37	62	84
Parent whose highest occupation is professional	11	31	55
Language			
% of learners who always or almost always spoke the test language at home	20	54	55
School physical resources			
% of learners not affected by resource shortage	3	6	35
% of learners with access to a workbook (own or shared)	95	96	87
% of schools with no computers	68	28	36
% learners in schools which provide free lunch	89	56	20
% learners in schools which have a place to do schoolwork before or after school	52	48	82
% learners in schools which have a library	25	80	81
School environment and climate			
Educators arriving late not a problem	51	52	70
Educator absenteeism not a problem	38	43	71
Learners arriving late not a problem	24	29	56
Learner absenteeism not a problem	17	26	57
% learners attending schools that placed high/very high emphasis on academic success	7	4	31

APPENDIX A3:
Summary of association results by school type

	No-fee	Fee-paying	Independent
School safety			
% of learners affected by school discipline and safety problems (moderate to severe)	21	25	2
% of learners who have almost never experienced bullying	19	29	41
Early learning activities			
Read books *(Often)*	32	40	53
Write numbers *(Often)*	52	56	54
Watch educational TV *(Often)*	47	56	51
Sing songs *(Often)*	44	56	57
Play with alphabets *(Often)*	26	40	48
Play with number toys (*Often)*	27	38	46
Play word games *(Often)*	26	30	32
School readiness			
Recognise most letters of alphabet *(Very well)*	46	54	62
Read some words *(Very well)*	35	35	41
Write letters *(Very well)*	43	44	51
Count on own *(Up to 100 or higher)*	22	35	41
Recognise written numbers *(Up to 100 or higher)*	19	27	30
Write numbers *(Up to 100 or higher)*	23	27	29

Authors' own calculations

APPENDIX A4: Descriptive statistics for all variables used in the analysis

Appendix Table A4.1: Summary statistics across all variables used in the analysis

	N	Mean	Std. Dev.	Min	Max
TIMSS mathematics achievement score	10 932	375.7	(99.7)	92.5	763.8
A profile of learners					
Learner is a girl	10 932	0.5	(.50)	0	1
Age in Grade 5	10 847	11.5	(.98)	7	15.92
Age blocks: *(ref under 10.3 years old)*					
10.3 - 11.6 years	10 847	0.6	(.50)	0	1
11.7 - 12 years	10 847	0.1	(.34)	0	1
Over 12 years old	10 847	0.3	(.43)	0	1
Frequency test language is spoken at home: *(ref never)*					
Sometimes	9 839	0.1	(.30)	0	1
Almost always	9 839	0.6	(.48)	0	1
Always	9 839	0.1	(.30)	0	1
Resources in the home					
Assets					
Learner has own computer	10 486	0.3	(.46)	0	1
Internet connection	10 369	0.4	(.48)	0	1
Water-flush toilets	9 975	0.6	(.50)	0	1
Fridge	10 083	0.9	(.35)	0	1
Electricity	10 488	0.8	(.38)	0	1
Number of social grants received	10 932	1.1	(1.2)	0	8
Indicators of socioeconomic status					
Household education *(low to high)*	8 852	3.8	(1.6)	1	8
Total number of books in the home	9 974	3.2	(1.7)	2	10
Highest household occupation	8 326	3.9	(2.0)	1	7
The early educational environment					
Frequency parent engages in early literacy and numeracy activities before school	9 606	9.3	(2.1)	1.52	15.30
Attended preschool	9 726	2.0	(1.1)	0	3
School readiness					
Level of literacy and numeracy skills at school entry	10 253	10.0	(1.7)	3.4	14.39
Proportion of learners entering school with good learning ready skills	10 333	9.5	(1.7)	6.26	13.65
Educational expectations and beliefs					
Parents' educational expectations	9 647	4.9	(1.5)	1	6
Learner likes maths	10 532	10.1	(1.5)	4.4	12.7
Learner confident in maths	10 518	9.3	(1.5)	3.1	14.2
Learner finds maths teacher engaging	10 540	10.1	(2.1)	2.3	12.7
School resources					
School has a place for learners to do schoolwork	10 733	0.5	(.50)	0	1
School provides free lunch	9 516	0.8	(.40)	0	1
School has a library	10 702	0.3	(.46)	0	1
Total number of school computers	9 641	12.4	(20.7)	0	200
Learner has a workbook *(ref: No)*					
Own	9 627	0.9	(.33)	0	1
Shared	9 627	0.1	(.27)	0	1
Instruction affected by maths resource shortages	10 800	9.0	(1.5)	2.8	15.3

APPENDIX A4:
Descriptive statistics for all variables used in the analysis

	N	Mean	Std. Dev.	Min	Max
School climate					
School emphasis on academic success	10 808	9.1	(1.8)	4.5	16.7
School safety and discipline problems *(Higher score = Fewer problems)*	10 690	8.8	(1.6)	5.3	12.9
Students' sense of school belonging	10 467	10.1	(2.1)	2.7	12.6
Bullying score *(Higher score = Less bullying)*	10 514	8.5	(1.8)	3.5	12.9
Parents' perceptions of the school	9 543	11.0	(1.7)	3.9	12.5
A profile of teachers					
Teachers' job satisfaction	10 645	1.6	(.61)	0	2
Level of challenges facing teachers	10 803	1.8	(.60)	1	3
Level of limitations facing teachers	10 560	1.9	(.50)	1	3
Level to which teacher absenteeism is a problem	10 626	1.7	(.68)	1	4
School type					
School type (*ref: No-fee)*					
Fee-paying	10 932	0.3	(.44)	0	1
Independent	10 932	0.04	(.19)	0	1
Province					
Province *(ref: Eastern Cape)*					
Free State	10 932	0.1	(.22)	0	1
Gauteng	10 932	0.2	(.38)	0	1
KwaZulu-Natal	10 932	0.2	(.41)	0	1
Limpopo	10 932	0.1	(.34)	0	1
Mpumalanga	10 932	0.1	(.28)	0	1
Northern Cape	10 932	0.0	(.16)	0	1
North West	10 932	0.1	(.25)	0	1
Western Cape	10 932	0.1	(.28)	0	1

APPENDIX A5: Questions used to assess school climate

Principal report

Resource shortages

How much is your school's capacity to provide instruction affected by a shortage or inadequacy in the following?

A. General school resources

a) Instructional materials (e.g. textbooks)
b) Supplies (e.g. papers, pencils, materials)
c) School buildings and grounds
d) Heating/cooling and lighting systems
e) Instructional space (e.g. classrooms)
f) Technology competent staff
g) Audio-visual resources for delivery of instruction (e.g. interactive white boards, digital projectors)
h) Computer technology for teaching and learning (e.g. computers or tablets for student use)
i) Resources for students with disabilities
j) Working toilets

B. Resources for mathematics instruction

k) Educators with a specialisation in mathematics
l) Computer software/applications for mathematics instruction
m) Library resources relevant to mathematics instruction
n) Calculators for mathematics instruction
o) Concrete objects or materials to help students understand quantities or procedures

School emphasis on academic success

How would you characterise each of the following within your school?

a) Educators' understanding of the school's curricular goals
b) Educators' degree of success in implementing the school's curriculum
c) Educators' expectations for learner achievement
d) Educators working together to improve learner achievement
e) Educators' ability to inspire learners
f) Parental involvement in school activities
g) Parental commitment to ensure that learners are ready to learn
h) Parental expectations for learner achievement
i) Parental support for learner achievement
j) Parental pressure for the school to maintain high academic standards
k) Learners' desire to do well in school
l) Learners' ability to reach school's academic goals
m) Learners' respect for classmates who excel in school

APPENDIX A5:
Questions used to assess school climate

School discipline and safety

To what degree is each of the following a problem among Grade 5 learners in your school?

a) Arriving late at school

b) Absenteeism (i.e. unjustified absences)

c) Classroom disturbance

d) Cheating

e) Profanity

f) Vandalism

g) Theft

h) Intimidation or verbal abuse among learners (including texting, emailing, etc.)

i) Physical fights among learners

j) Intimidation or verbal abuse of educators or staff (including texting, emailing, etc.)

Parent report

Your child's school

a) What do you think of your child's school?

b) My child's school does a good job including me in my child's education

c) My child's school provides a safe environment

d) My child's school does a good job informing me of his/her progress

e) My child's school promotes high academic standards

f) My child's school does a good job in helping him/her become better in reading

g) My child's school does a good job in helping him/her become better in mathematics

h) My child's school does a good job in helping him/her become better in science

i) My child is safe from bullying at school

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Understanding mathematics achievement amongst Grade 5 learners in South Africa

The 2015 TIMSS Grade 5 study was administered for the first time in South Africa in August 2015. The study was led by a team of researchers at the Human Sciences Research Council (HSRC) in collaboration with the Department of Basic Education (DBE) and the International Association for the Evaluation of Educational Achievement (IEA).

Providing the first, nationally representative, internationally comparative compendium of data on Grade 5 learners in South Africa, the report is a new indicator of the health of our educational system. The analyses describe in detail the current picture of achievement for learners in the country, highlighting key individual, family, school and provincial differences. The results also include key developments concerning preschool attendance, early learning environments, as well as the importance of educational expectations and academic beliefs, and the damaging effects of bullying. The findings highlight the importance of early achievement and the need to understand the multiple layers of influence on educational pathways, with the conclusions and recommendations highlighting an unequal, yet treatable system.

The Grade 5 study sits alongside the Grade 9 study which has been carried out in South Africa since 1995, recently completing its fifth round.

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