Beyond Benchmarks

What twenty years of TIMSS data tell us about South African education

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Table of contents

List of figures

List of tables

Introduction

South Africa has participated in a number of local and international educational achievement studies over the past 20 years. Their main purpose has been to monitor and evaluate the quality of schooling in specific areas of the curriculum at given points in time. Typically, these projects have involved collecting information from learners and school representatives that describe the learning environment in different parts of the country. Although many of these studies have focused on educational issues at the foundation and intermediate phases, a few have targeted the senior phase. The Trends in International Mathematics and Science Study (TIMSS) is an example of such an assessment. It evaluates mathematics and science knowledge at the Grades 4, 5, 8 and 9 levels (Reddy 2006). Data are available for four South African TIMSS Grade 8 and Grade 9 surveys over the past 20 years. The first round of TIMSS South Africa took place in 1995 and the most recent survey took place in 2011 (Mullis et al. 2012).

A race to the bottom?

There are broadly two types of response to education survey results that are released in South Africa. The predominant response is that very little has improved in the South African education landscape since 1994, and that resources are going to waste. The simple ranking of countries from top to bottom performers generally lends support to this perspective. As part of this narrative, South Africa's expenditure on education is contrasted with that of top-ranking developing countries that appear to be making more rapid progress. It is argued that South Africa has abandoned any educational aspirations and is effectively in a race to the bottom of virtually every educational ranking.

A second common response to studies of educational achievement is to dismiss the results entirely, and to question the purpose of participating in international assessments. After all, it is argued, the majority of countries have a vastly different educational history from that of South Africa.

A less frequently expressed response acknowledges that for better or worse educational outcomes can change over time, sometimes dramatically (Ripley 2013), and international assessment results can be useful at many different levels of policy and planning, especially when studies are repeated across time (Best et al. 2013; Postlethwaite & Kellaghan 2008). In their most immediate form, they can prompt debate about the direction in which the education system is heading. More specifically, they can provide valuable information about which educational inputs are most strongly linked to better performance and a more equitable system.

The purpose of this report is to provide a measured assessment of what has been achieved over the past 20 years based on the evidence provided by TIMSS, to redefine what 'good' progress means in the light of South Africa's developmental pathway, and to recommend what evidence-based interventions can be considered as the next realistic steps in South Africa's educational development. In the first section of this report we will provide an overview of educational achievement derived from 20 years of TIMSS data, using national and provincial results. We will also consider achievement differences among learners of different backgrounds. The second section focuses on results derived from differences in the school environment. The report concludes by making a case for a selection of policy alternatives based on key concerns that emerge from the data analysis.

Part A

Twenty years of educational reform: how are we doing?

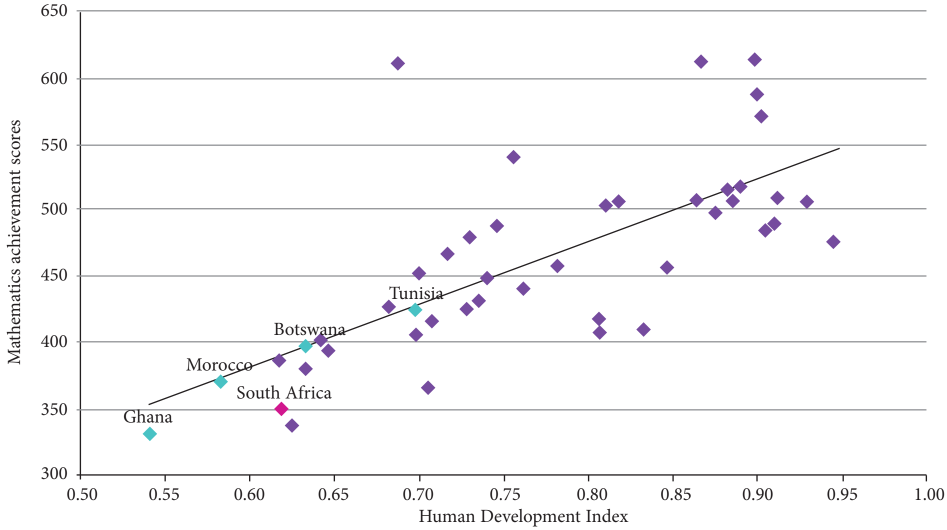
National policies and practices

Education policies have undergone numerous reviews and challenges over the past 20 years. In the 1990s, the White Paper on Education and Training (Department of Education 1995), the National Education Policy Act (No. 27 of 1996) and the South African Schools Act (No. 84 of 1996) focused on addressing past imbalances in the South African system. From the early 2000s, policy reforms have focused on improving resource distribution across schools (Department of Education 2001a) and narrowing gaps in primary enrolment between the rich and the poor (Department of Education 2006). High priority has also been given to increasing the mastery levels of learners (Department of Basic Education 2011a; Department of Education 2009; National Planning Commission 2011). Some policies have been targeted specifically at improving mathematics and science education; these include the National Strategy for Mathematics, Science and Technology Education (Department of Education 2001a), the Dinaledi Schools Initiative (Department of Education 2001b) and the Youth into Science Strategy 2006 (Arends et al. 2014). The overriding objective of all these plans has been to improve the quality of educational delivery, particularly for historically under-served groups, and to achieve steady improvements in educational outcomes that will support other areas of growth and development. With the emergence of rich survey data such as TIMSS, evidence-based interventions can be planned and reviewed more reliably.

Education for development

Some economies achieve relative wealth but do so without this leading to a sustained increase in quality of life. Other economies may be relatively poor in terms of Gross Domestic Product (GDP) per capita, but still achieve high levels of social development, as measured by access to health and education (UNDP 2014). The Human Development Index (HDI) is a composite measure designed to capture both the economic and the social aspects of development, such as life expectancy, average years of schooling and GDP per capita. Figure 1 compares the 2012 HDI for TIMSS countries with their achievements in mathematics as measured in TIMSS 2011 (Mullis et al. 2012).

Figure 1: *Comparison of 2011 HDI and TIMSS 2011 mathematics achievement for all participating countries.*



Note: Data presented in all figures and tables in this report are based on calculations done by the authors, drawing on the TIMSS database (IEA 2013).

The data show that there is a strong positive correlation between the HDI and mathematics achievement based on the TIMSS 2011 data (shown by the diagonal line); a higher HDI is related to higher levels of achievement in mathematics. The direction of the relationship between the HDI and mathematics probably runs both ways. Higher HDI means that a country has more resources to devote to education. Presumably other non-school factors that impact on education, such as socio-economic status of the learners, nutrition, and parental education levels, will also move positively with HDI, resulting in better mathematics achievement. Similarly, better mathematics achievement over time is likely to result in a better educated workforce, which would be able to carry out more sophisticated tasks, resulting in higher GDP per capita. More sophisticated statistical tests would be needed to identify whether there is in fact a cause-and-effect relation involved, or whether this is merely a correlation.

The data point for mathematics in South Africa (shown in pink in Figure 1) lies below the line representing the average relationship between HDI level and achievement in mathematics. This suggests that South African learners perform below what would be expected, given South Africa's HDI level. Data points for most African countries (shown in blue) fall on the line, which implies that their national achievement scores are as expected, given their HDI. Again, more sophisticated analysis would be needed to reveal whether or not this is indeed a meaningful relationship.

Decisions based on data

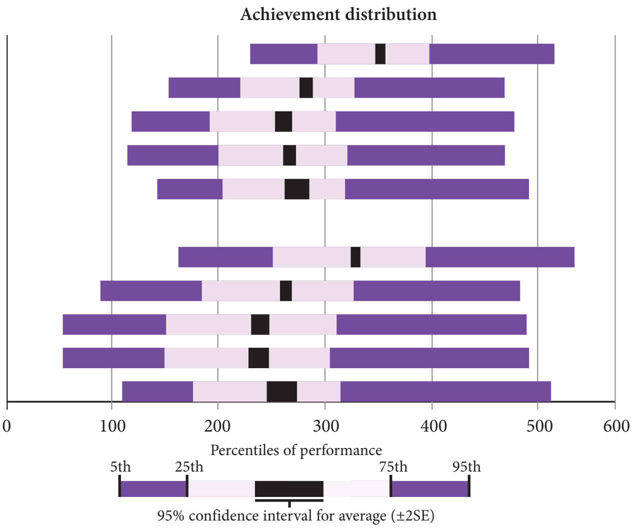
To date, South Africa has participated in four TIMSS assessments: 1995, 1999, 2002 and 2011.[1] In 1995 and 1999, the survey targeted learners in Grade 8 – the first year of secondary school. The 2002 study included both Grade 8 and Grade 9 learners in its sample, while the most recent round of TIMSS (2011) was undertaken at the Grade 9 level. The reason for changing the testing grade from Grade 8 to Grade 9 was because of South Africa's overall low performance in previous rounds of the study. A shift from testing Grade 8 learners to testing Grade 9 learners was judged to enable a better match between the content knowledge presented to learners in TIMSS and the curriculum coverage in South Africa. In 2011, 285 out of a possible 10 085 South African schools were selected to participate in the TIMSS study. In total, 11 969 learners were included in TIMSS 2011.

It is apparent that the greatest improvements in national test scores for both mathematics and science occurred in the past 10 years.

Figure 2 summarises the TIMSS achievement results for South Africa throughout the period that the country has participated in the study. In order to ease comparison across countries and across time, TIMSS data are scaled to an international midpoint and standard deviation of 500 and 100 respectively. This means that a score of 500 reflects the midpoint for all TIMSS country average scores.

Figure 2: *Trends in South African mathematics and science achievement, 1995–2011 (with standard errors)*

Mathematics	Ave. scale score
Grade 9 TIMSS 2011	352 (2.5)
Grade 9 TIMSS 2002	285 (4.2)
Grade 8 TIMSS 2002	264 (5.5)
Grade 8 TIMSS 1999	275 (6.8)
Grade 8 TIMSS 1995	276 (6.7)
Science	
Grade 9 TIMSS 2011	332 (3.7)
Grade 9 TIMSS 2002	268 (5.5)
Grade 8 TIMSS 2002	244 (6.7)
Grade 8 TIMSS 1999	243 (7.8)
Grade 8 TIMSS 1995	260 (7.9)



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1 TIMSS data collection takes place during October of the survey year in the southern hemisphere and in May of the subsequent year in the northern hemisphere. We refer to the years of South African surveys in this report.

Although improvements have been made, progress has not been experienced equally by learners from different backgrounds.

A number of trends emerge from these results. It is apparent that the greatest improvements in national test scores for both mathematics and science occurred in the past 10 years. For both subjects, there was an increase of more than 60 points between 2002 and 2011 for Grade 9 learners. Prior to that (and noting that assessment was conducted at Grade 8 in earlier surveys), there was very little change in average test scores across surveys.

Beyond the national trends related to average test scores, we note that although there was a slight decrease in the spread of scores between 2002 and 2011, the variation in scores remained extremely high, especially for science. Wide variation in test scores means that acquisition of mathematics and science knowledge remains highly unequal. Although improvements have been made, progress has not been experienced equally by learners from different backgrounds.

Stuck at the shallow end

There is another finding that stands out from the TIMSS standardised test scores across an extended period of time. In 2002, the year when adjacent grades were tested in South Africa (Grades 8 and 9), the average difference in test scores between Grade 8 and Grade 9 participants was roughly 20 points. Internationally, when TIMSS results have been compared across two grade levels, the difference between grades has been found to be about 40 points. As a result, 40 points has been taken to be a good estimate of the increased knowledge that learners acquire when they move from one grade to another (Martin et al. 2011). In other words, it is a loose estimate of the additional skills acquired in a given year.

South Africa's measure of educational effort was half that of the international norm in 2002; this suggests that although South African learners were acquiring mathematics and science knowledge, they were doing so at a slower pace than learners in other countries. Therefore, children were learning, but the amount that they were learning in a given year was far below international norms. Figure 3 shows that this has continued to be the case, and gives striking international benchmark results from TIMSS 2011. TIMSS test scores are divided into four international benchmarks. Learners who achieve a test score of 625 are at an 'advanced' international benchmark. Learners who achieve at least 550 and 475 are at the 'high' and 'intermediate' benchmarks respectively. The 'low' international benchmark identifies learners who have achieved a score of 400. Learners who score below 400 have not demonstrated knowledge of the most basic skills in mathematics and science.

Taking this analysis of learners' knowledge a step further, if we consider the mathematics assessment as an example, learners at the low international benchmark (400–475) have a basic knowledge of whole numbers, decimals, operations and basic graphs. Learners at the intermediate benchmark (475–550) are capable of more complex skills such as applying their mathematics knowledge to situations, problem-solving, and working with graphs. Learners who are positioned at the high and advanced benchmarks (550–625) have the ability to problem-solve at a high level, reason with geometric figures and analyse graphical data (Mullis et al. 2012). In the case of science, the range of skills begins with identifying basic facts in physical and life sciences at the low benchmark (400–475) and extends to demonstrating an understanding of abstract concepts at the advanced level (625).

Three-quarters of South African learners had not acquired even the minimum set of mathematical or science skills by Grade 9.

The benchmarked results for South Africa are quite telling. On the one hand, it is encouraging that between 2002 and 2011 the number of learners scoring above the 400 threshold almost doubled. Table 1 shows that between 2002 and 2011 the number of learners scoring above 400 increased by 13.5 per cent for mathematics and 12.0 per cent for science. In addition, 1.0 per cent of South African learners were categorised at the advanced levels for mathematics and science. On the other hand, a source of grave concern is that only one-quarter of learners had achieved above the low benchmark score of 400. Even though 1.0 per cent of learners had achieved the advanced benchmark, the vast majority of benchmarked learners were at the lowest level where only a basic knowledge of mathematics and science had been acquired. Most crucial, though, was the percentage of learners who were below even the minimum benchmark. Three-quarters of South African learners had not acquired even the minimum set of mathematical or science skills by Grade 9. This is worrying. These learners are stuck at the shallow end of skills acquisition. The acquisition of skills in mathematics and science is cumulative. Emphasis needs to be placed on improving the fundamentals of instruction in earlier grades in order to reduce the large number of learners who lack basic knowledge of mathematics and science in grades 8 and 9.

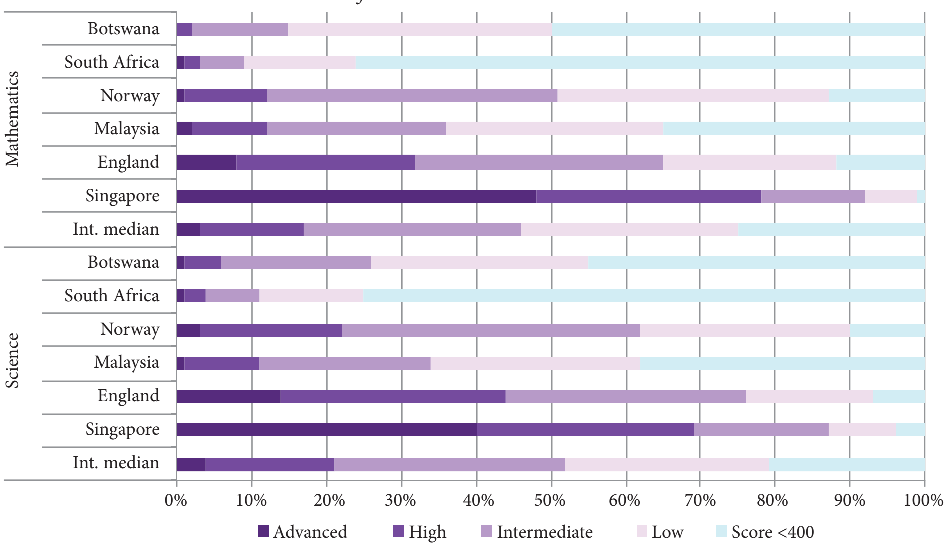
Table 1: *TIMSS performance at international benchmarks of mathematics and science achievement, 2002 and 2011*

	Advanced >625	High 625–550	Intermediate 550–475	Low 475–400	Total >400
	Percentage of total South African learners assessed				
Mathematics TIMSS 2011	1.0	2.0	6.0	15.0	24.0
Mathematics TIMSS 2002	0.6	1.5	2.8	5.6	10.5
Science TIMSS 2011	1.0	3.0	7.0	14.0	25.0
Science TIMSS 2002	1.0	2.0	3.0	7.0	13.0

Figure 3 compares international benchmarks for a selection of countries that have participated in the TIMSS surveys. Botswana and South Africa are among a handful of African participants in TIMSS. Both shifted to Grade 9 testing during this period. These neighbouring countries both have high levels of income inequality and youth unemployment in spite of their status as middle-income African countries (Carnoy et al. 2012; Leigh et al. 2012), but we note that their patterns of progress in mathematics and science education have been very different. One per cent of South African learners were benchmarked at the advanced level by 2011 (shown in blue on the graph) but none of Botswana's learners had achieved this level of competence. Although small, this group can be viewed as a pool of future thought leaders with the potential to contribute to research, national development and innovation. The share of top performers in South Africa is comparable to the share in countries like Norway and Malaysia.

Although fewer gains were made at the advanced level in Botswana compared to 2002, there was greater improvement for Botswana's learners at the low and intermediate levels and a considerable reduction in learners who were achieving results below 400. In 2002, more than 60 per cent of Botswana's learners and close to 90 per cent of South African learners achieved scores *below* 400. In 2011, half of Grade 9 learners in Botswana achieved a score *above* 400, compared with one-quarter of their South African peers.

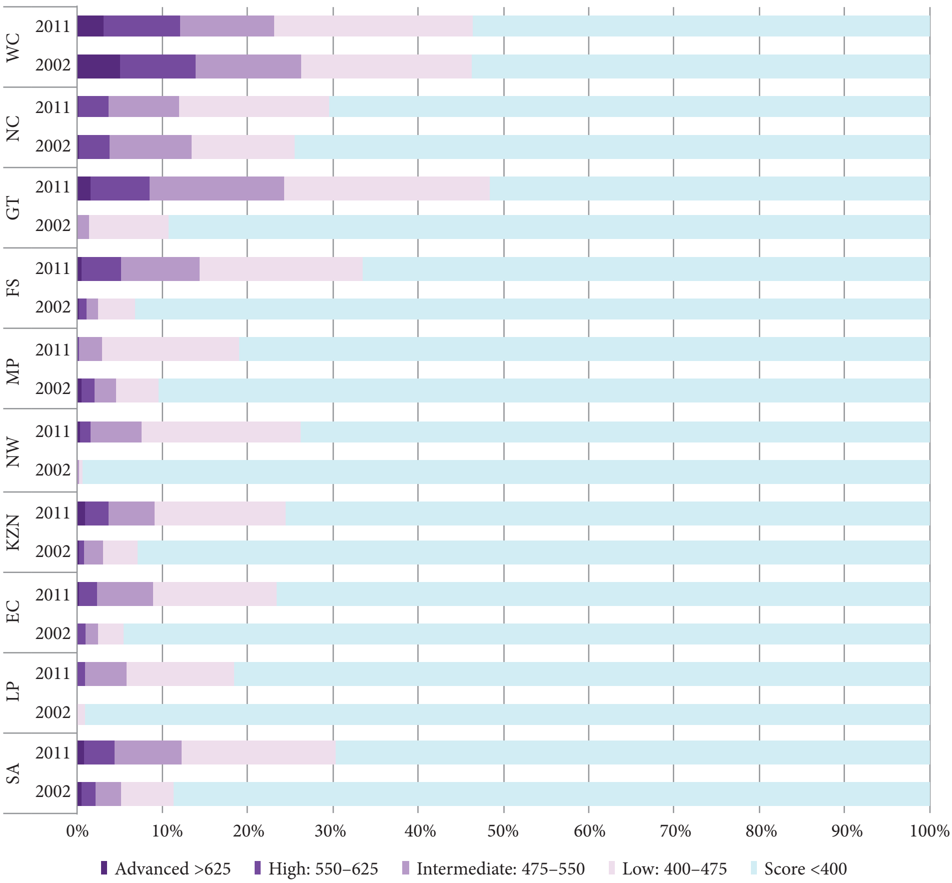
Figure 3: *TIMSS 2011 performance at international benchmarks for mathematics and science achievement in a selection of countries*



Provincial trends

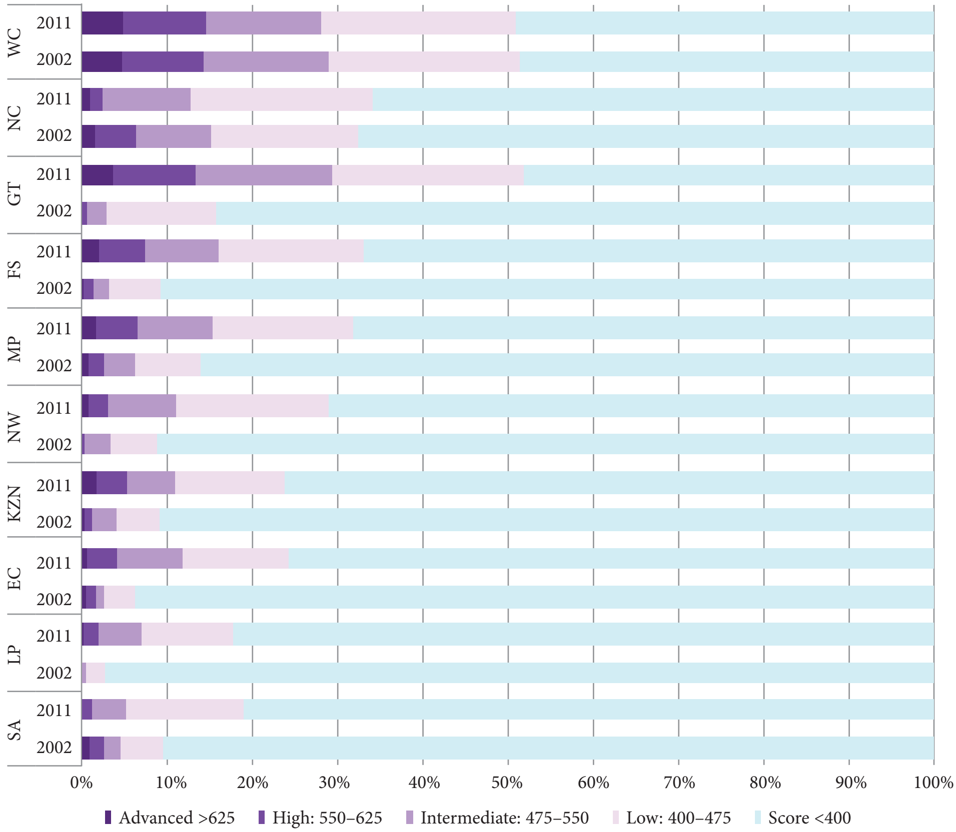
Figures 4 and 5 show provincial mathematics and science achievement against performance benchmarks. The first important observation from these graphs is that with the exception of the Western Cape, which maintained its proportions of benchmarked learners, *all* provinces showed notable improvements between 2002 and 2011. Some provinces (such as Limpopo and the Eastern Cape) were starting from a very low base, with virtually all learners achieving below the benchmark threshold in 2002. Others (including Gauteng and the Free State) showed notable increases. Improvements in these provinces were the main drivers of positive shifts in national trends. A key question is why such differences arose provincially, given that sampling procedures and data collection were consistent and conformed to international standards. One potential explanation is that pro-poor investment policies have targeted the most disadvantaged schools and households and therefore had their most immediate impact on the poorest-performing provinces.

Figure 4: *Provincial mathematics achievement, by performance benchmarks, 2002 and 2011*



WC = Western Cape NC = Northern Cape GT = Gauteng FS = Free State MP = Mpumalanga
NW = North West KZN = KwaZulu-Natal EC = Eastern Cape LP = Limpopo SA = South Africa

Figure 5: *Provincial science achievement, by performance benchmarks, 2002 and 2011*



WC = Western Cape NC = Northern Cape GT = Gauteng FS = Free State MP = Mpumalanga
NW = North West KZN = KwaZulu-Natal EC = Eastern Cape LP = Limpopo SA = South Africa

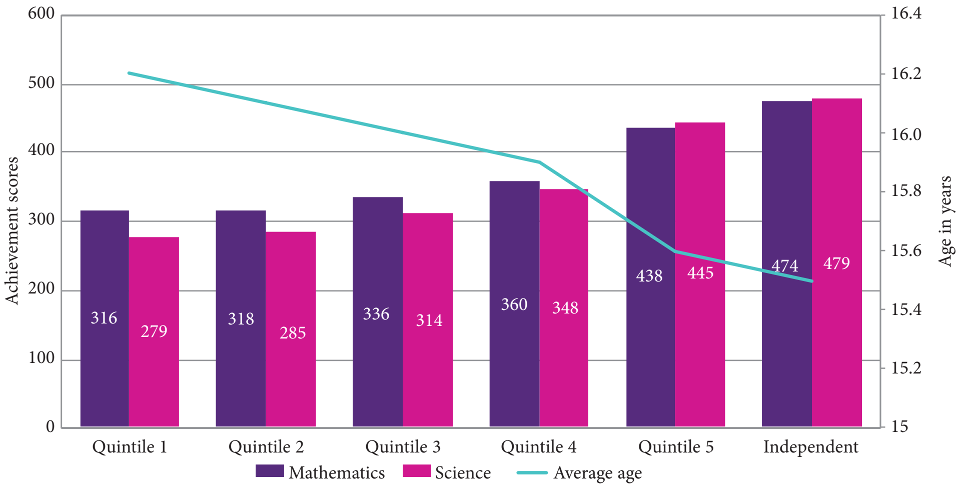
School poverty index

Schools in South Africa vary with respect to level of infrastructure and resources. Furthermore, there are often vast differences between communities where schools are situated. Many schools are located in areas with high levels of poverty and unemployment and have to contend with a lack of basic resources. In order to determine how achievement scores varied with resource availability at schools, the Department of Basic Education calculated a poverty index for each state-owned school.[2] Schools were grouped into one of five bands or quintile ranks. The most economically disadvantaged and resource-poor schools were grouped into

2 The poverty score for each school assigns it to a quintile rank (Q1–Q5) based on a predetermined formula. The quintile ranking also determines the allocation of funding to schools by the department. The quintile rank for each school is calculated based on the poverty level of the community in which the school is located. Quintiles 1 and 2 were declared no-fee schools in 2007, and in 2010 quintile 3 schools were added to the no-fee category.

quintile 1, and the most affluent schools were assigned a quintile 5 ranking. In addition, all schools in quintiles 1 to 3 are no-fee schools. The quintile ranking does not apply to independent schools. In general, these schools have access to a substantially greater level of private resources because of the tuition fees paid by parents, although some of these schools do receive state subsidies. Because schools with high concentrations of poverty have access to fewer quality resources for teaching and learning, we expected to find an achievement score difference between the lower and higher quintile schools. Figure 6 plots the difference in performance across schools in the different quintile ranks, with independent schools grouped separately.

Figure 6: *TIMSS 2011 achievement scores and average age of learners, by school poverty index*

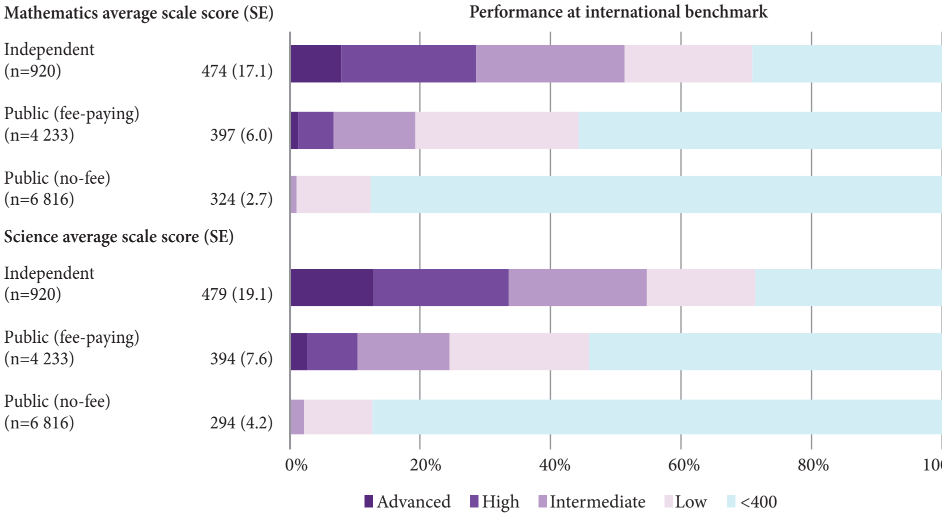


The first point to note from these graphs is that although economically advantaged learners clearly had an edge over children who were poor, results for quintiles 1 to 4 were very similar. This pattern is in line with earlier studies of South African education conducted for different phases of the schooling system (Van der Berg 2005, 2008). In contrast, quintile 5 schools achieved results that were comparable to results for independent schools. It is also worth mentioning that age and quintile rankings moved in opposite directions. On average, children from more affluent schools and independent schools were younger than children from poor schooling environments. This age differential seems to point to higher levels of grade repetition among learners attending resource-poor schools.

International benchmarks: public and independent schools

Figure 7 summarises TIMSS 2011 performance benchmarks by school type, distinguishing the performance of independent schools, public no-fee schools (quintiles 1 to 3) and public fee-paying schools (quintiles 4 and 5).

Figure 7: *Average scale score and performance at benchmarks by school type, TIMSS 2011*



Fifty per cent of learners in independent schools achieved above the 400 benchmark or better.[3] The highest-achieving learners in independent schools performed at the same level as average learners in the best-performing education systems, such as Chinese Taipei, Singapore and South Korea. In contrast, the majority of learners attending public schools achieved scores below 400. However, about 10 per cent of learners in public fee-paying schools achieved at the high and advanced competency levels. None of the learners at public no-fee schools achieved high- or advanced-level scores. The top achievers in no-fee South African schools were at the intermediate level internationally.

Mathematics and science performance by gender and age

The TIMSS 2011 sample had a relatively even distribution between boys and girls. It consisted of 48 per cent girls and 52 per cent boys. In this section we consider gender differences in mathematics and science results. We also discuss age differences for girls and boys, and how age and gender intersect with achievement scores.

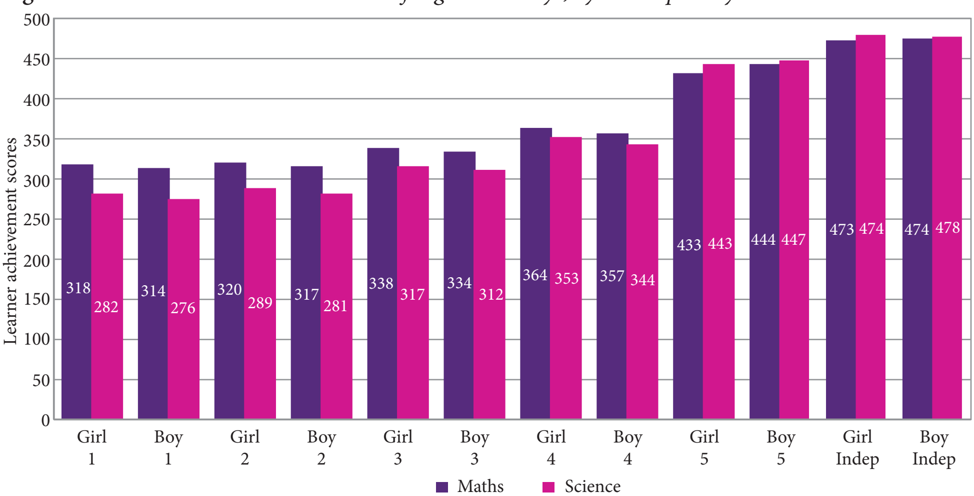
International evidence on gender and academic performance is somewhat mixed, not only across countries but within countries at different points in time (Baker & Jones 1993). It has been suggested that the size of the gender gap tends to reflect the relative status of men and women in different societies (Else-Quest et al. 2010). There are notable exceptions, however. The gender gap favouring girls in mathematics and science in Arab-speaking countries in the Middle East was first detected in 2007, and remained present in the 2011 TIMSS study (Martin et al. 2012). An area that is receiving increased attention is how extensive the gender gap

3 Independent school learners represented 3 per cent of the learner population.

is at different points in the achievement distribution (Penner & CadwalladerOlsker 2012). For example, the gender gap between high-achieving girls and boys might be different from the gender gap for low-achieving learners. Similarly, patterns in resource-rich and resource-poor settings may differ considerably.

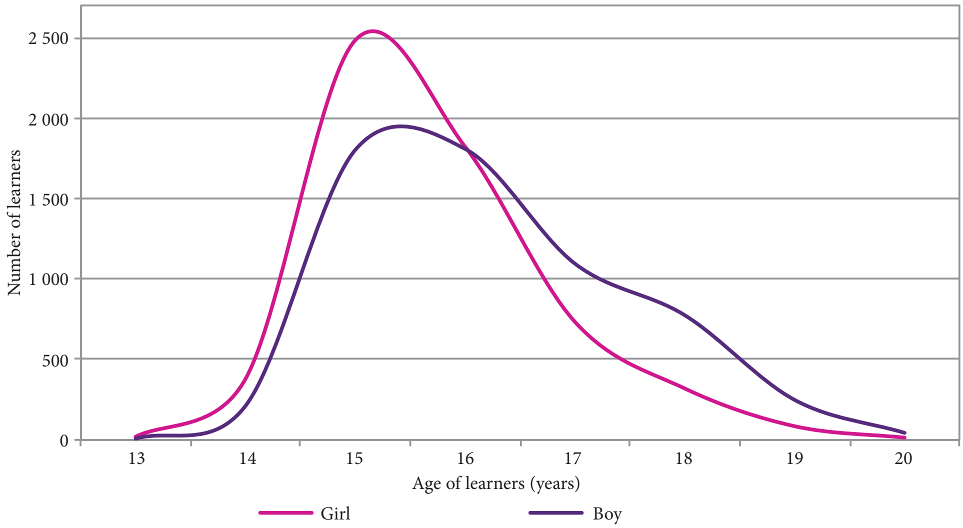
Historically, researchers have found that, where they existed, gender gaps in mathematics and science achievement tended to favour boys over girls (Fennema & Sherman 1978; Maccoby & Jacklin 1974; Zuze 2008). However, according to some studies (Lindberg et al. 2010) these gaps have all but disappeared, while other studies (Riggle-Crumb & Moore 2013) suggest that the gaps might even have been reversed. New complexities within gender inequalities have emerged recently. In TIMSS 2011, South African girls outperformed boys in both subject areas, but this difference was not statistically significant. The average mathematics scores for girls and boys were 354 (SE 3.0) and 350 (SE 3.4) respectively. Similarly for science, the average score for girls was 335 (SE 4.1), while for boys it was 328 (SE 4.5). Figure 8 shows the 2011 TIMSS results by gender, broken down by schools' differential access to resources. The gender patterns for learners based on wealth quintile are remarkably similar. It is certainly not the case that gender gaps are wider or narrower in poor, wealthy or independent schools. They appear to be quite uniform across quintiles.

Figure 8: *TIMSS 2011 achievement scores for girls and boys, by school poverty index*



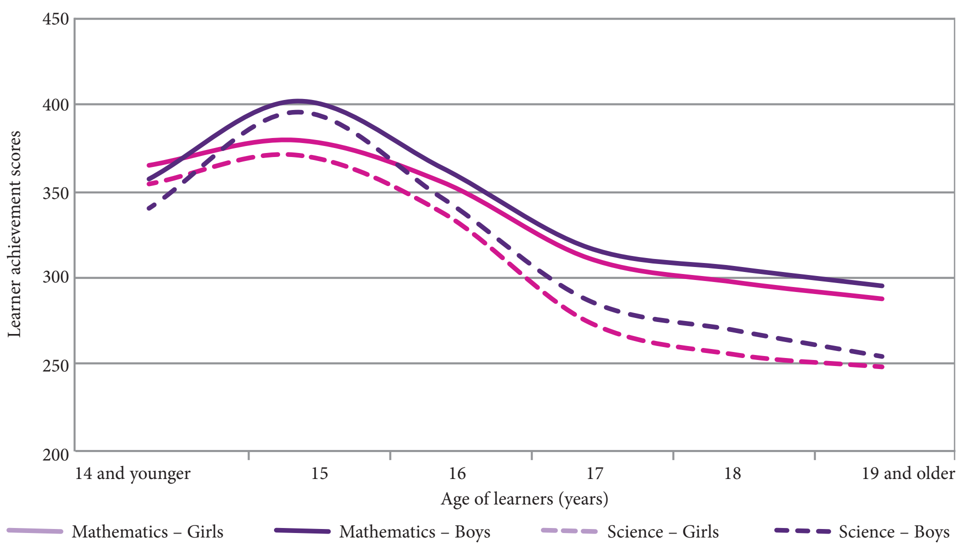
South African learners who participated in TIMSS 2011 were aged between 13.0 and 19.9 years, with an average age of 16 years. The average age of Grade 9 girls and boys was 15.8 and 16.3 years respectively. The age distribution by gender is shown in Figure 9. The gender age gap suggests that either boys started school later than girls or that boys repeated grades more frequently. It is also possible that boys left and returned to school more often. However, several studies have found that repetition is higher among South African boys than girls (Branson et al. 2013; Lee et al. 2005; Zuze & Reddy 2014).

Figure 9: *TIMSS 2011 age distribution of Grade 9 girls and boys*



For learners who progressed through school without interruption (neither repeating a grade nor dropping in and out of school), the appropriate grade age would be between 14.5 and 15.5 years. The percentage of learners who were age-appropriate for their grade was close to 60 per cent for girls and 40 per cent for boys. Given the wide age range of the learners and the age difference between girls and boys, we explored the relationship between age, gender and academic performance. Figure 10 disaggregates the sample by age and gender and plots the average mathematics score and average science score for each age year.

Figure 10: *TIMSS 2011 average mathematics and science achievement scores, by gender and age*



The patterns of performance by gender and age were the same for mathematics and science achievement; although younger girls outperformed boys of a similar age, the difference was not statistically significant. At age-grade appropriate levels (14.5–15.5 years), boys scored at a statistically significant higher level than girls. This result seems to suggest that boys who were age-appropriate for their grade performed better in mathematics and science than girls who progressed through school at the same pace. For over-age learners, there was no gender difference in mathematics and science scores.

Part B

How learners live and learn

Home environment

The home environment can be viewed in terms of the private resources available to learners outside of school. In this section, the home environment is discussed with reference to home resources, home pedagogical resources and the level of parental education.

Figure 11 reports on the home resources of learners in the last two rounds of TIMSS. The data for 2002 represent public schools. For 2011, information on resources is broken down into categories for learners attending public no-fee schools (quintiles 1 to 3), fee-paying schools (quintiles 4 and 5) and independent schools.

Figure 11: *Reported percentages of learners with home resources in 2002 compared with 2011, by school type*[a]

Resource at home	Public schools (2002)	No-fee (2011)	Fee-paying (2011)	Independent (2011)
Computer	33	23	44	77
Own books		60	68	82
Internet connection		21	38	69
Own cell phone		74	81	92
Dictionary	78	63	81	94
Electricity	80	79	92	98
Running tap water	64	59	80	92
Television	82	82	92	98
Radio	92	79	85	89
Water-flushed toilets	48	31	66	86
Motor car	38	29	47	78
Telephone	54	27	34	56
Fridge	73	71	86	95

Note a: The existence of own books, own cell phone and internet connection at home was not investigated in 2002.

South African GDP per capita was R30 905 in 2002 and this grew to R37 017 in 2011, a 19.7 per cent increase. We would expect this growth to be reflected in greater household resources in 2011 than 2002. Similarly, we would expect that learners at fee-paying and independent schools would come from more affluent backgrounds and that resources in their households would therefore be greater. In many instances, there were marked differences across categories of schools. Virtually all learners attending fee-paying and independent schools had access to electricity at home. More than 20 per cent of learners attending no-fee-paying public schools in 2011 did not have access to electricity at home. Whereas fewer than one-third of learners attending public no-fee-paying schools had access to water-flushed toilets, twice as many learners in fee-paying public schools had access to the same facilities. Nearly 70 per cent of learners in independent schools had access to the internet at home, compared with only 38 per cent in fee-paying public schools and 21 per cent in no-fee-paying public schools. Technological progress has meant that some of the items in the questionnaire for the 2002 study were no longer present in the 2011 questionnaire and vice versa. For example, in 2011 learners were asked whether they had their own cell phone, but this item was not included in the 2002 survey. Similarly, learners were no longer asked about the presence of a calculator in the house in the more recent survey.

The data in Figure 11 largely conform to expectations. The prevalence of some resources had declined over the nine-year period. For example, fewer households had dictionaries and telephones. This could be because these resources had been replaced by more technologically advanced options. Dictionaries can now be accessed online instead of in book form, while landline telephones are gradually being replaced by cell phones.

TIMSS has developed a 'Home Resource for Learning' scale that includes information on the number of books at home, the availability of two home-study resources (own room and internet connection) and the highest level of education of either parent. Table 2 presents findings on the percentages of South African learners in public schools who have access to some of the TIMSS scale resources, and compares these with international averages.

Table 2: *Percentage of learners with access to components of the 'Home Resource for Learning' scale, 2002 and 2011*

	Components of the 'Home Resources for Learning' scale		
	More than 100 books in the home	Own room and internet connection in the home	At least one parent with a university degree or higher
	% of learners (SE)		
South Africa 2002[a]	10 (0.6)		11 (0.8)
South Africa 2011[b]	9 (0.4)	25 (0.7)	19 (0.7)
International average 2011[b]	25 (0.2)	53 (0.2)	32 (0.2)

Notes: a Findings include public-school learners.
b Findings include both public- and independent-school learners.

Only 9 per cent of Grade 9 learners in South Africa had more than 100 books at home, compared with one-quarter of international learners. A comparison of 2002 public-school data on the number of books at home with 2011 data for the same resource showed no improvement. Additionally, although 32 per cent of learners had an internet connection at home in 2011, only 1 in every 4 learners had their own room as well as an internet connection at home – less than half the international average.

The data show an increase in the highest level of education amongst parents of Grade 9 learners between 2002 and 2011. Parental education has been shown consistently to have strong positive links with learner achievement (Case & Deaton 1999; Lee & Zuze 2011; Willms & Somers 2001). Better-educated parents generally earn more and are therefore likely to spend more money on their children's schooling. They may also ensure that their children have additional resources for learning outside of school, such as extra lessons, books and other learning materials. This is not to say that children whose parents are less educated cannot succeed academically. In some circumstances, academic support might be unrelated to parental education or socio-economic circumstances. Children from poor homes will still benefit if they are encouraged to practise what has been learned in school and if the value of education is reinforced regularly (Xu & Corno 2003). In 2002, 11 per cent of public-school learners had at least one parent who had completed a university degree, while by 2011 this had increased to 19 per cent. We will show, in a later section, that although improvements in parental education levels have occurred, there are vast differences in these levels depending on the type of school that children attend.

Table 3 confirms that learners from households with greater access to private educational resources also had better achievement outcomes in TIMSS 2011. In this table, learners were placed in three categories based on their educational resources at home. Achievement on the TIMSS assessment is reported for each group, both in South Africa and overall, and for both mathematics and science. A number of patterns are noticeable. There was a clear link between the level of resources in the home and achievement in the TIMSS 2011 survey. This pattern seems to be even more marked for science than for mathematics. There was a wider distribution of achievement scores for science than mathematics, and these results were also strongly correlated with the resources in the home. South African learners from the best-resourced homes constituted a much smaller share of the population than in other countries but their material advantage was sufficient to align them with roughly the level of the average score for the international sample.

Table 3: *Percentage of learners and average achievement scores, by home educational resources, 2011*

	Home educational resources					
	Many resources		Some resources		Few resources	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics (SA)	3 (0.2)	487 (8.3)	55 (0.8)	362 (2.8)	42 (0.8)	333 (2.7)
Mathematics (int. avg.)	12 (0.1)	530 (1.2)	67 (0.2)	470 (0.6)	21 (0.2)	415 (1.0)
Science (SA)	3 (0.2)	504 (9.9)	55 (0.8)	347 (4.0)	42 (0.8)	305 (4.1)
Science (int. avg.)	12 (0.1)	540 (1.1)	67 (0.2)	480 (0.6)	21 (0.2)	424 (1.0)

The middle category of home resources shown in Table 3 was by far the largest, both in South Africa and internationally. South African learners in this category performed substantially worse than their counterparts in other countries (more than one standard deviation worse in both subjects). In fact, South African learners in the middle category of home resources had lower levels of achievement than the global average for learners from homes with *few* resources.

South Africa's share of learners from homes with few resources was roughly double the global average. These learners had very low levels of achievement and, as noted above, this was especially true for science, where their achievement was more than one standard deviation below that of the international average for learners from a similar resource background. As mentioned earlier, South Africa is typically grouped with middle-income countries but the country has higher levels of poverty and inequality than many emerging economies. South African learners in the lowest resource category are likely to be from more acutely deprived circumstances than learners in the same category in other countries.

Table 4 restates some of the findings discussed earlier in this report, but in this case the distinction made is by the type of school, rather than the resources in the home. Learners from independent schools would be expected to have access to a greater number of private educational resources. This table shows that learners at independent schools had materially higher levels of mathematics and science achievement than public-school learners in general. As the table indicates, the most distinct differences between school types were in levels of parental education and home language. Learners from independent schools had access to better pedagogical resources at home and their parents were more likely to have a tertiary qualification than their contemporaries in fee-paying public schools. Just over half of independent-school learners enjoyed the benefit of writing the test in their home language, compared with one-third of fee-paying public-school learners and close to 20 per cent of the no-fee-paying group.

Table 4: *Profiles of learners in public and independent schools, 2011*

School type	Mathematics score 2011 (SE)	Science score 2011 (SE)	Age in years	% of learners with no or few books in the home (SE)	% of learners with maternal education above Grade 12 (SE)	% of learners always speaking the language of the test at home (SE)
Independent	474 (17.1)	479 (19.1)	15.4	21 (3.0)	68 (4.2)	33 (5.8)
Public fee-paying	397 (6.0)	394 (7.6)	15.8	35 (1.4)	39 (1.8)	27 (2.4)
Public no-fee-paying	324 (2.7)	294 (4.2)	16.2	47 (1.0)	18 (2.0)	8 (0.5)

Physical resources at school

In earlier sections of this report, we have shown that poor children have limited access to reading material in their homes. Usually, their parents have lower levels of education and they often live in communities that lack public libraries or learning centres. Research suggests that children from impoverished homes in South Africa begin school at a distinct disadvantage, perform systematically worse at school and have fewer career opportunities beyond school (Branson & Zuze 2012). Early patterns of disadvantage may remain if not addressed appropriately. One potential area of improvement is in the school infrastructure. Although the presence of modern facilities cannot guarantee that children will learn better, it is absolutely critical that basic services are in place. Some South African schools are already equipped with modern facilities but many school facilities remain inadequate. According to the National Education Infrastructure Management Systems Report (Department of Basic Education 2011b), nearly 80 per cent of schools are without library or computer facilities and nearly 15 per cent do not have access to electricity.

In Table 5, schools are divided according to the principal's assessment of the socio-economic status of the learners at the school at the time of TIMSS 2011. As before, a clear difference is evident in performance based on resources, although this measure of resources was based entirely on the principal's account. Schools with learners from more privileged backgrounds achieved better results. South Africa's most affluent schools performed at roughly the global average, about as well as those in other countries.

Table 5: *Principals' assessment of the socio-economic composition of their schools, 2011*

	School composition					
	More affluent		Neither more affluent nor more disadvantaged		More disadvantaged	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics (SA)	8 (1.3)	487 (14.4)	12 (2.6)	356 (15.0)	80 (2.7)	339 (3.2)
Mathematics (int. avg.)	32 (0.5)	494 (1.4)	33 (0.6)	471 (1.2)	36 (0.5)	448 (1.3)
Science (SA)	8 (1.3)	502 (17.0)	12 (2.6)	336 (21.0)	80 (2.7)	317 (4.9)
Science (int. avg.)	32 (0.5)	501 (1.3)	33 (0.6)	481 (1.2)	36 (0.5)	458 (1.3)

Based on the principals' views, the wealthiest South African schools were on par with affluent schools in other countries, but middle-class and resource-poor schools were more than 100 points adrift from comparator schools globally. The difficulty with interpreting the information in Table 5 is that it is perfectly reasonable to assume that what international respondents view as disadvantage is materially different from local conditions in South Africa. Therefore a measure of caution is required when comparing local and international definitions of wealth.

Table 6 examines whether school resource constraints were viewed as a barrier to performance by the school principal, with schools grouped according to the extent to which principals believed that they were affected by these constraints.

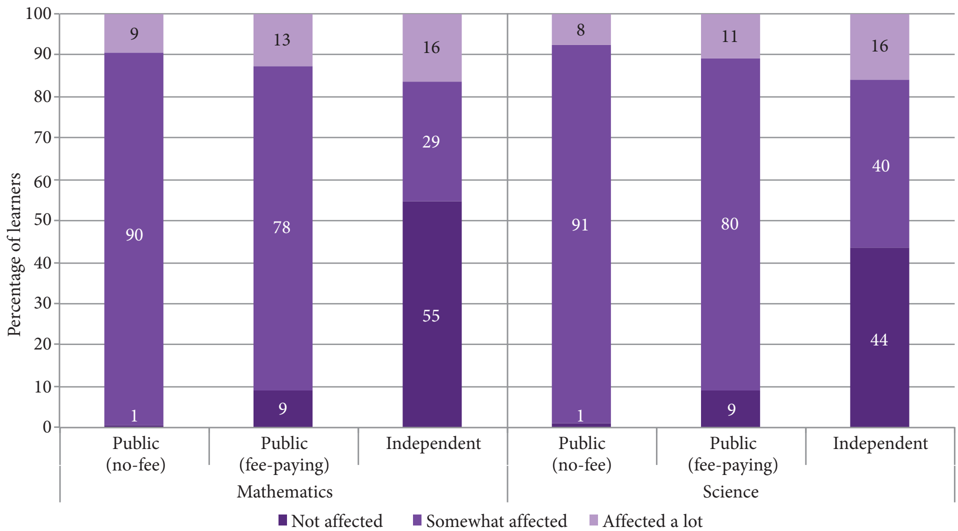
Table 6: *Principals' assessment of resource shortages as barriers to performance, 2011*

	Instruction affected by resource shortages					
	Not affected		Somewhat affected		Affected a lot	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics (SA)	5 (0.9)	510 (15.2)	85 (2.2)	342 (3.0)	10 (2.1)	350 (7.7)
Mathematics (int. avg.)	25 (0.5)	488 (2.2)	69 (0.5)	464 (0.7)	6 (0.3)	453 (2.9)
Science (SA)	5 (1.0)	499 (24.0)	87 (2.2)	321 (4.3)	9 (2.1)	333 (13.6)
Science (int. avg.)	22 (0.4)	494 (1.9)	71 (0.5)	474 (0.7)	7 (0.3)	464 (3.3)

Internationally, resource constraints were associated with lower achievement. The same was roughly true in South Africa, although there was a wider gap in performance between schools that were poorly resourced, according to principals, and those that did not face any resource constraints. Surprisingly, the schools that characterised themselves as most affected by a resource deficit performed slightly better than those that were only somewhat affected, although this difference is not statistically significant. As before, South Africa is notably different from the rest of the world in terms of the distribution of resources. In other countries, one-quarter of schools claimed to be unaffected by shortages but this was only the case in 5 per cent of South African schools. Ten per cent of schools were severely affected by shortages, compared with only 6 per cent in the global sample. As stated earlier, school principals can have very different views of what constitutes a resource shortage. Because these indicators are based on a principal's assessment, their comparability across countries, or indeed even within countries, is somewhat limited.

Figure 12 shows the data breakdown for resource constraints by type of school. It would be expected that as independent schools are generally wealthier than public schools, they would have fewer problems with resource shortages. Instead, we see that 1 in 5 school heads of independent schools perceived that their learners were seriously affected by resource shortages. This underscores the limitations of using subjective data in comparing school quality.

Figure 12: *Percentage of learners affected by resource shortages according to principals, by type of school, 2011*



Textbooks and other instructional materials are critical resources in mathematics and science classrooms. The use of textbooks as the basis of mathematics and science instruction in South Africa has changed significantly since 2002 and is now reflecting international practice more closely (Table 7). In 2002 just more than one-third of the learners used textbooks as a basis for instruction in both mathematics and science; for the majority of learners textbooks were used for supplementary teaching. In 2011 more than two-thirds of the learners received instruction that relied on textbooks, with mathematics/science resources and computer software being used for supplementary purposes in teaching.

Table 7: *Percentage of learners by resources teachers used for teaching mathematics and science, 2002 and 2011*

	Percentage of learners whose teachers use each resource type							
	Textbooks (SE)		Workbooks or worksheets (SE)		Mathematics / science resources[a] (SE)		Computer software for mathematics and science instruction (SE)	
	Basis for instruction	Supple-mentary	Basis for instruction	Supple-mentary	Basis for instruction	Supple-mentary	Basis for instruction	Supple-mentary
Mathematics 2002	34 (4.0)	60 (3.9)						
Mathematics 2011	71 (3.5)	27 (3.4)	43 (3.7)	51 (3.7)	16 (3.0)	71 (3.7)	5 (1.7)	19 (2.9)
Mathematics (int. avg.)	77 (0.4)	21 (0.4)	34 (0.5)	62 (0.5)	23 (0.5)	71 (0.5)	7 (0.3)	55 (0.5)
Science 2002	36 (3.3)	56 (3.5)						
Science 2011	66 (3.6)	28 (3.2)	39 (3.8)	52 (3.7)	20 (3.0)	69 (3.6)	3 (1.0)	17 (2.9)
Science (int. avg.)	74 (0.4)	24 (0.4)	35 (0.5)	60 (0.5)	43 (0.5)	54 (0.5)	16 (0.4)	61 (0.5)

Note a: Mathematics resource categories include, for example, concrete objects or materials that help learners understand quantities or procedures. Science resource categories include, for example, science equipment and materials.

School environment and climate

The TIMSS database contains an index to measure perceptions of the school environment. The data are grouped according to the views of principals and teachers. In 2011, South African school principals reported less emphasis on academic success, on average, than other countries. Using principals' perceptions of emphasis, only 35 per cent of South African schools placed a high or very high emphasis on academic success, compared with 60 per cent in the global sample. Similar results were obtained based on teachers' perceptions of emphasis (Table 8).

Table 8: *Percentage and average achievement of learners, by principals' and teachers' reports of emphasis on academic success, 2011*

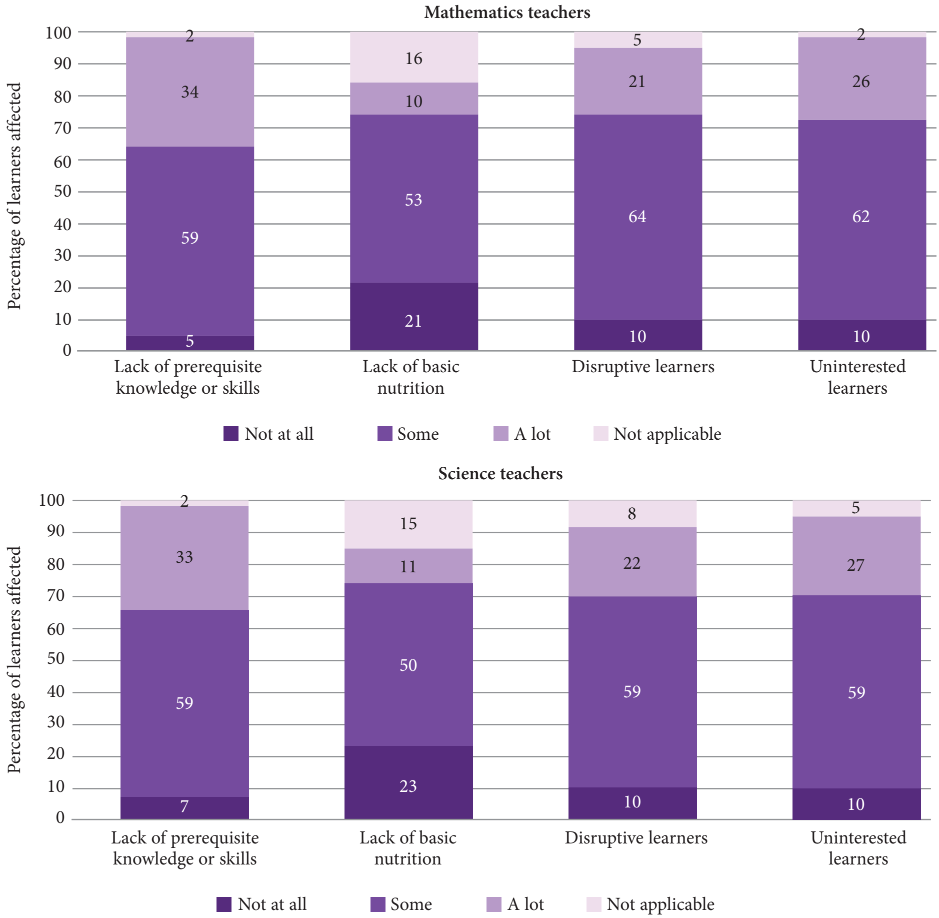
	Emphasis on academic success					
	Very high		High		Medium	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Principals' report						
Mathematics (SA)	4 (1.0)	470 (45.6)	31 (3.1)	371 (7.6)	66 (3.0)	335 (3.2)
Mathematics (int. avg.)	7 (0.3)	495 (3.1)	53 (0.6)	477 (0.9)	41 (0.5)	449 (1.0)
Science (SA)	4 (1.0)	470 (57.6)	31 (3.1)	359 (11.1)	66 (3.0)	310 (4.7)
Science (int. avg.)	7 (0.3)	504 (2.8)	53 (0.6)	486 (0.9)	41 (0.5)	460 (1.0)
Teachers' report						
Mathematics (SA)	2 (0.6)	~ (~)[a]	39 (3.6)	368 (5.9)	59 (3.6)	339 (3.7)
Mathematics (int. avg.)	5 (0.3)	506 (3.4)	48 (0.6)	478 (0.9)	47 (0.5)	452 (0.9)
Science (SA)	5 (1.6)	329 (25.3)	31 (2.9)	366 (9.0)	64 (3.1)	312 (5.2)
Science (int. avg.)	5 (0.2)	504 (3.2)	50 (0.5)	487 (0.8)	46 (0.5)	463 (0.9)

Note: a ~ indicates insufficient data to report achievement.

Achievement appeared to be correlated with the emphasis placed on academic success, although this relationship held more strongly in other countries than in South Africa. When using teachers' perceptions of the school's emphasis on academic success, schools with only a 'high' emphasis outperformed those that had a 'very high' emphasis for science. However, this is the only counter-intuitive example. In the case of a principal's perception of emphasis on academic success, there was a stark difference in achievement between schools with a 'very high emphasis' on success and those with only a medium emphasis. The difference in achievement was 135 points, compared with only 46 points in the international sample.

Figure 13 reports data on factors that teachers perceived to be hindering learners' educational attainment. The results are relatively similar for both mathematics and science.

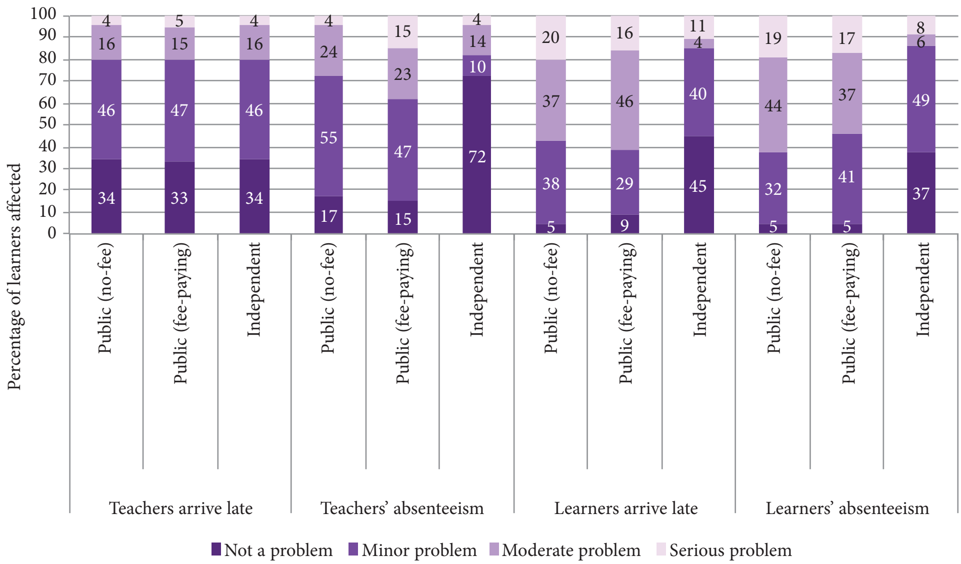
Figure 13: *Factors affecting learner performance as reported by mathematics and science teachers, 2011*



According to teachers, a lack of prerequisite knowledge among learners had a serious effect on learner achievement in about one-third of cases. Nearly 60 per cent of learners were also affected *to some degree* by a weak academic background based on teacher reports. Teachers estimated that lack of nutrition was a serious problem for 10 per cent of learners, and less so for about half of all learners. Additionally, about 1 in 5 learners attended schools where there were disruptive learners and nearly one-quarter were seriously affected by uninterested learners. Overall, lack of prerequisite skills seemed to be the most important factor limiting academic performance according to teachers.

Teacher and learner attendance have been identified as important factors for academic success (Gottfried 2009; Miller et al. 2014). Learners with good attendance records achieve better results and learner attendance has even been used to represent the quality of the school (Coutts 1998). Figure 14 examines the data on absenteeism and late-coming in more detail. Learners attending public schools, irrespective of whether they were fee-paying or no-fee schools, were more likely to be exposed to serious levels of absenteeism and late-coming than learners at independent schools. Teacher punctuality was viewed as a less serious concern than learner punctuality according to the school principals.

Figure 14: *Percentage of learners affected by absenteeism and late-coming, by school type, 2011*



As reflected elsewhere in this report, the conditions in public and independent schools differed substantially. Only 14 per cent of independent-school learners, as opposed to 54 per cent of public fee-paying and 63 per cent of public no-fee school learners, attended schools where learner absenteeism was a serious or moderate problem. Whereas fewer than 10 per cent of public-school learners attended schools where learner punctuality was not a problem, 45 per cent of learners in independent schools did not face this challenge. The gap between public and independent schools was even greater when teacher absenteeism was compared. For just under one-fifth of independent-school learners this was a moderate or serious problem, compared to 28 per cent of no-fee public-school learners and 38 per cent of fee-paying public-school learners. It was only in the case of teacher punctuality that relative uniformity was reflected for different types of school. Across schools, this was a moderate or serious problem for 20 per cent of the learners.

School safety

Violence is a widespread phenomenon across South Africa and can pose a major challenge to the physical and emotional development of children (Barbarin & Richter 2001). Exposure to violence is commonplace for a large number of South

African learners and can begin very early in life. Victims in nearly half of all reported cases of rape and indecent assault in South Africa are children (Richter & Dawes 2008). Unsafe conditions can surface in family and community settings but their pervasiveness in schools is particularly worrisome because of the severe impact that these risk factors can have on academic development. The negative effects of violent behaviour can manifest in many ways, including increased absenteeism, reduced participation in school activities and poor cognitive development (Kirk & Sampson 2011). Beyond the negative impact on academic progress, additional damage can be experienced by children who are repeatedly exposed to bullying behaviour. In a study of eight African countries, exposure to bullying was linked to a multitude of negative health-risk behaviours including increases in attempted suicide and in alcohol and drug abuse (Brown et al. 2008).

Key pieces of legislation have been introduced over the years to ensure the safety of the school environment. The extent to which these laws are enforced remains an area for further scrutiny. The South African Schools Act forbids the use of corporal punishment. Yet corporal punishment continues to be used widely. Both the Children's Act (No. 38 of 2005) and the Criminal Law (Sexual Offences and Related Matters) Amendment Act (No. 32 of 2007) underscore the need to report cases of abuse and to ensure that educators do not pose a risk to children. In 2011 alone, over 2.6 million children reported experiencing different forms of violence in schools, including sexual abuse and bullying (Martin 2014). The Department of Basic Education is finalising its School Safety Framework (Department of Basic Education 2012), which emphasises a multidimensional approach to addressing school safety. Both perpetrators and victims of violence need to be addressed, as do schools, families and communities.

In 2011, one-third of Grade 9 learners reported that they had been exposed to bullying on a weekly basis compared with just over 1 in 10 in the international sample.

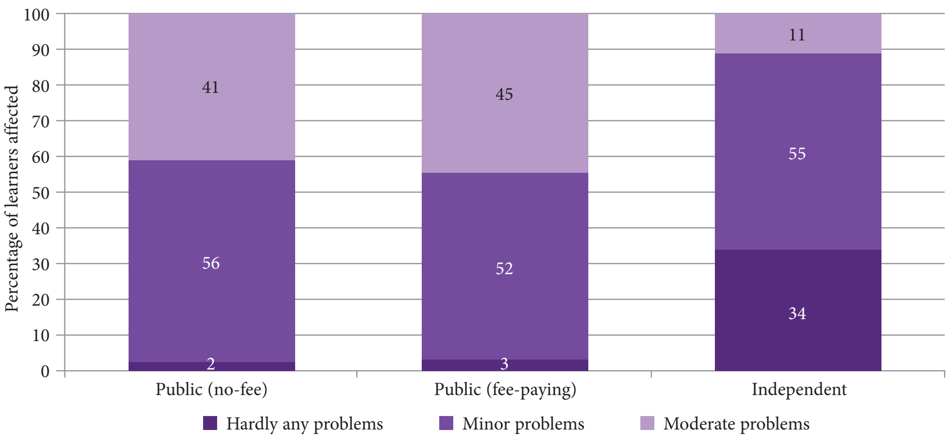
Data on school safety collected during the 2011 TIMSS study came from three different sources: school principals, teachers and the learners themselves. The school discipline and safety index captured the school principals' perspective on this issue in terms of whether schools had 'hardly any', 'minor' or 'moderate' problems as concerns about school safety increased. Although this is a fairly subjective measure and captures the potentially biased viewpoint of the principal, it nonetheless provides an understanding of how seriously the issue of school safety was viewed from a school-leadership perspective. According to the TIMSS results, 41 per cent of South African Grade 9 learners attended schools where there were moderate problems of school safety (Table 9). This was more than twice the international average, which was 18 per cent. Higher mathematics and science scores appeared to be related to safer school environments. Of course, as we have noted on many occasions in this report, the relationship could flow in either direction. Safer environments could nurture better learning but equally, better learners might be drawn to safer schools.

Table 9: *Mathematics and science achievement scores, by principals' perspectives on school discipline and safety, 2011*

	Index of school discipline and safety					
	Hardly any problems		Minor problems		Moderate problems	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics (SA)	4 (1.2)	406 (26.9)	55 (3.6)	352 (4.1)	41 (3.4)	345 (4.6)
Mathematics (int. avg.)	16 (0.4)	483 (1.7)	66 (0.5)	467 (0.7)	18 (0.4)	437 (1.8)
Science (SA)	4 (1.2)	391 (34.6)	55 (3.6)	329 (6.4)	41 (3.4)	326 (6.3)
Science (int. avg.)	16 (0.4)	492 (1.7)	66 (0.5)	477 (0.7)	18 (0.4)	452 (2.0)

Safety concerns were very different in public and independent schools. According to the 2011 study, heads of independent schools reported having a far safer environment than heads of public schools (Figure 15).

Figure 15: *Principals' perspectives on percentage of learners affected by school discipline and safety conditions, by school type, 2011*



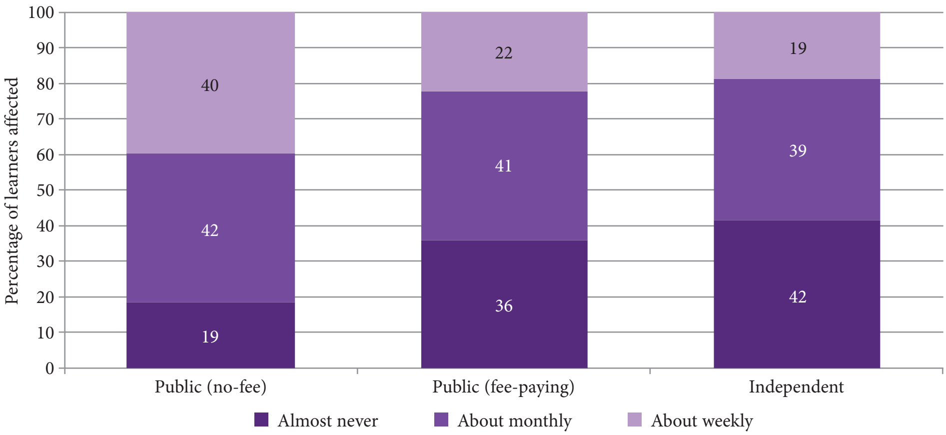
Teachers' reports on school safety were also collected during the study. The results followed similar patterns to the school principals' reports and are not discussed here. The learners' perspective on school safety was unique because it focused on questions about exposure to bullying. The results were quite alarming, particularly if we consider that there is always a level of under-reporting of violent behaviour (Table 10). In 2011, one-third of Grade 9 learners reported that they had been exposed to bullying on a weekly basis compared with just over 1 in 10 in the international sample. Both in South Africa and internationally, learners who experienced regular bullying were among the weaker performers in both mathematics and science. However, the gap in test scores between those who were bullied weekly and those who were bullied on a monthly basis was far wider, on average, in South Africa. This seems to suggest the severity of the impact of incessant bullying on learning. Where exposure to violence is frequent, learning is affected.

Table 10: *Learners bullied at school, 2011*

	Almost never		About monthly		About weekly	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics (SA)	25 (0.7)	393 (3.9)	42 (0.8)	362 (2.3)	33 (1.0)	322 (3.0)
Mathematics (int. avg.)	59 (0.2)	473 (0.6)	29 (0.1)	467 (0.7)	12 (0.1)	441 (1.0)
Science (SA)	25 (0.7)	392 (5.1)	42 (0.8)	346 (3.4)	33 (1.0)	287 (4.4)
Science (int. avg.)	59 (0.2)	483 (0.6)	29 (0.1)	478 (0.7)	12 (0.1)	452 (1.1)

Bullying was less of a concern in independent schools but even in these somewhat safer environments, 1 in 5 learners was bullied on a weekly basis (Figure 16).

Figure 16: *Percentage of learners affected by bullying, by school type, 2011*



Attitudes and aspirations

Data from the two most recent TIMSS studies included information about learner attitudes towards their subject matter. While no one disputes that positive attitudes towards mathematics and science are beneficial for an understanding of the subject matter, less is known about how different attitudes compare and how attitudinal patterns have shifted over the years. Results from the TIMSS learner questionnaires were used to create three separate attitude indices. Intrinsic value reflects learners' enjoyment of the subject. Extrinsic motivation relates to the value attached to studying mathematics and science, and belief in ability represents the level of self-confidence about learning in these areas.

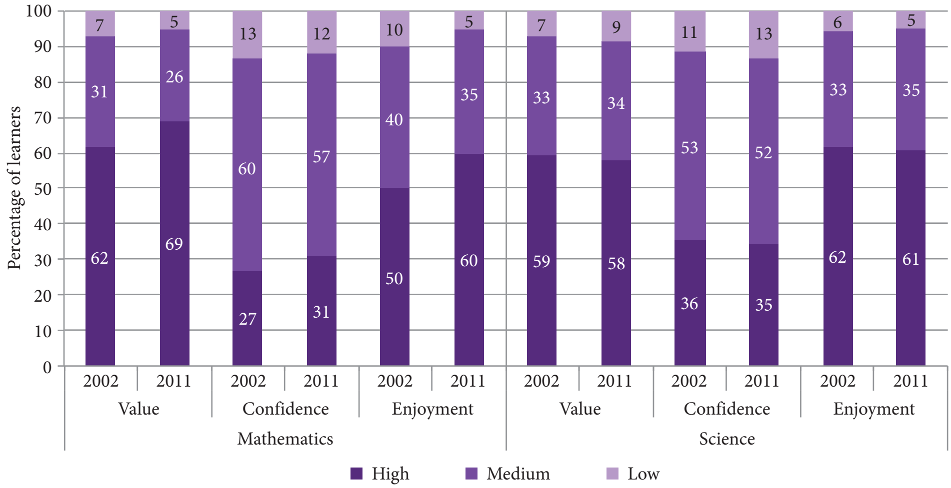
Table 11 compares average achievement scores by grouping learners into three different levels of motivation – high, medium and low. Many interesting points emerge from this table. South African learners' enjoyment and valuing of mathematics and science (the intrinsic and extrinsic indicators) were far higher than international norms. In contrast, confidence in mathematics and science was lower than the global average. Internationally, on average, learners with more positive attitudes on any of the three attitude indicators tended to achieve better mathematics and science scores. In South Africa, the difference in achievement results was most pronounced between the highest category and the middle and bottom categories.

Table 11: *Learners' enjoyment of, value attached to and self-confidence in mathematics and science, by average achievement score, 2011*

	High motivation		Medium motivation		Low motivation	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Enjoyment index	**Like**		**Somewhat like**		**Do not like**	
Mathematics (SA)	41 (0.9)	378 (2.0)	44 (0.7)	339 (2.9)	15 (0.6)	348 (5.3)
Mathematics (int. avg.)	26 (0.2)	504 (0.8)	42 (0.1)	467 (0.6)	31 (0.2)	443 (0.7)
Science (SA)	41 (1.1)	376 (3.0)	45 (0.8)	311 (4.5)	14 (0.6)	313 (6.4)
Science (int. avg.)	35 (0.2)	515 (0.8)	44 (0.2)	472 (0.8)	21 (0.2)	450 (1.1)
Valuing index	**Value**		**Somewhat value**		**Do not value**	
Mathematics (SA)	72 (0.8)	364 (2.3)	21 (0.5)	341 (3.9)	7 (0.4)	309 (5.3)
Mathematics (int. avg.)	46 (0.2)	482 (0.7)	39 (0.1)	463 (0.6)	15 (0.1)	439 (0.9)
Science (SA)	57 (1.0)	344 (3.5)	26 (0.6)	319 (4.7)	16 (0.7)	346 (6.8)
Science (int. avg.)	41 (0.2)	502 (0.8)	33 (0.2)	477 (0.8)	26 (0.2)	457 (1.1)
Confidence index	**Confident**		**Somewhat confident**		**Not confident**	
Mathematics (SA)	10 (0.4)	427 (4.9)	54 (0.8)	349 (2.7)	35 (0.9)	344 (3.0)
Mathematics (int. avg.)	14 (0.1)	539 (0.9)	45 (0.1)	478 (0.6)	41 (0.2)	435 (0.6)
Science (SA)	17 (0.6)	399 (4.1)	59 (0.6)	326 (3.5)	24 (0.7)	323 (5.6)
Science (int. avg.)	20 (0.2)	536 (1.0)	49 (0.2)	482 (0.8)	31 (0.2)	450 (0.9)

Figure 17 shows that across time, attitudes towards mathematics have become more positive. As this is less so for science, this area requires further investigation. It is just as important to determine how attitudes and academic achievement actually interact with each other. Positive attitudes could motivate learners to work harder and achieve better results. Equally, learners' attitudes might be strengthened when their academic output improves.

Figure 17: *Changes in enjoyment of, value attached to and confidence in mathematics and science, 2002 and 2011*



Teacher identity

While emphasis on teacher content knowledge is often a key component in international education studies, less attention is given to the way teachers view their profession and how they perceive their competence. And yet increased commitment levels among teachers are strongly linked to low teacher turnover and positive attitudes among learners (Day et al. 2005). Such factors are also directly related to how committed teachers are to remaining in a profession that is already experiencing critical shortages (Arends & Phurutse 2009). The attitudes, experience and knowledge of teachers who taught mathematics and science to learners in the TIMSS sample were also surveyed in 2002 and 2011.

The average age range for South African TIMSS teachers increased from 30–39 years in 2002 to 40–49 years in 2011. The average teaching experience of mathematics and science teachers increased from 11 years in 2002 to 14 years in 2011. Nearly two-thirds of TIMSS 2011 learners were taught by teachers with more than 10 years' teaching experience. Internationally, 87–90 per cent of learners are taught by mathematics and science teachers with a university qualification. In South Africa, approximately 98 per cent of TIMSS 2011 learners were taught by mathematics and science teachers who indicated that they had completed a post-secondary qualification. More than three-quarters of mathematics and science learners were taught by teachers who indicated that they had studied either mathematics or a science-related topic in their pre-service training course.

Based on the information provided, South African mathematics and science teachers appear to be highly qualified and knowledgeable in their subject areas. South African teachers have attended a higher number of professional-development activities than the international average for activities related to mathematics or science content, mathematics or science curriculum, improving critical thinking, and mathematics or science assessment. Although the quantity of professional-development courses cannot be questioned, the quality of these courses needs to be seriously interrogated. The scheduling of these courses also needs to be called into question. In some provinces, professional-development courses take place during the school holidays but it is not uncommon for teachers to attend courses during the academic year. It is also worth pointing out that the nature of teacher training differs vastly across countries, and this should be considered when comparing teacher qualifications internationally.

Table 12 shows that between 2002 and 2011, positive self-reports on how well prepared teachers felt to teach their assigned subjects more than doubled. By 2011, more than 80 per cent of mathematics teachers and more than 75 per cent of science teachers expressed an overall preparedness to teach their assigned subject. There was some variation in the topics for which teachers felt most adequately prepared. There was near-universal ease among mathematics teachers with teaching topics related to numbers; this was less the case with topics such as geometry and data and chance. Among science teachers, a higher percentage felt prepared to teach biology than subjects like earth science and physics. These results raise interesting questions about why there has been such a positive shift in teachers' sense that they are coping with the demands of their subject. Further work is needed to understand whether the factors driving this shift are related to changes in the professional-development training that teachers undergo, the type of teaching materials now available to teachers, or perhaps the desire to appear self-reliant.

Table 12: *Percentage of teachers who felt 'very well' prepared to teach the TIMSS mathematics and science topics, 2002 and 2011*

		Mathematics topics				
		Numbers (5 topics)	Geometry (6 topics)	Algebra (5 topics)	Data and chance (3 topics)	Overall mathematics (19 topics)
South African avg.	2002	64	39	44	23	43
South African avg.	2011	93 (1.6)	85 (1.9)	92 (1.5)	80 (2.2)	88 (1.3)
International avg.	2011	92 (0.3)	85 (0.3)	87 (0.3)	62 (0.4)	84 (0.3)
		Science topics				
		Biology (7 topics)	Chemistry (4 topics)	Physics (5 topics)	Earth science (4 topics)	Overall science (20 topics)
South African avg.	2002	29	24	22	11	22
South African avg.	2011	84 (2.0)	79 (2.0)	76 (2.3)	57 (3.1)	76 (1.5)
International avg.	2011	77 (0.4)	82 (0.4)	78 (0.4)	47 (0.5)	72 (0.3)

Only 45 per cent of learners attending no-fee public schools were taught by teachers who expressed satisfaction with their profession.

The same trend found for preparedness to teach was observed in relation to Grade 9 learners taught by mathematics and science teachers who were very confident in their ability to teach their respective subjects. The percentage of South African TIMSS 2011 learners taught by very confident teachers was higher than the international average. We have to be cognisant of the self-reporting nature of the TIMSS 2011 teacher questionnaire and need to consider that teachers' responses may be socially desirable ones, or an over-estimation of their teaching capabilities.

Although mathematics and science teachers seemed to view themselves as confident or well prepared, there was a far more subdued response when it came to questions about career satisfaction. Only 45 per cent of learners attending no-fee public schools were taught by teachers who expressed satisfaction with their profession. Table 13 suggests that teachers' job satisfaction did not seem to be a strong indicator of learners' achievement: learners taught by teachers who were more satisfied with teaching didn't necessarily achieve better results. Nonetheless, it remains important to understand why the majority of Grade 9 teachers are not fully satisfied with their career, and when their morale began to decline. Equally crucial is determining what actually motivated them to become teachers.

Table 13: *Percentage and average achievement of learners by teacher career satisfaction and school type, 2011*

	Teacher career satisfaction					
	Satisfied		Somewhat satisfied		Less than satisfied	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics						
No-fee	43 (4.7)	317 (5.3)	45 (4.9)	331 (3.7)	12 (3.4)	323 (5.0)
Fee-paying	38 (7.0)	403 (11.3)	56 (7.4)	396 (10.5)	6 (2.4)	361 (12.8)
Independent	57 (12.1)	509 (18.7)	37 (11.2)	414 (23.7)	6 (4.5)	382 (10.4)
Science						
No-fee	37 (5.1)	282 (8.7)	54 (5.1)	294 (5.4)	9 (2.2)	321 (13.5)
Fee-paying	40 (6.1)	381 (16.6)	54 (6.1)	398 (12.8)	6 (2.5)	406 (57.4)
Independent	56 (8.5)	462 (26.8)	41 (7.9)	475 (30.6)	3 (3.4)	560 (7.2)

Home language

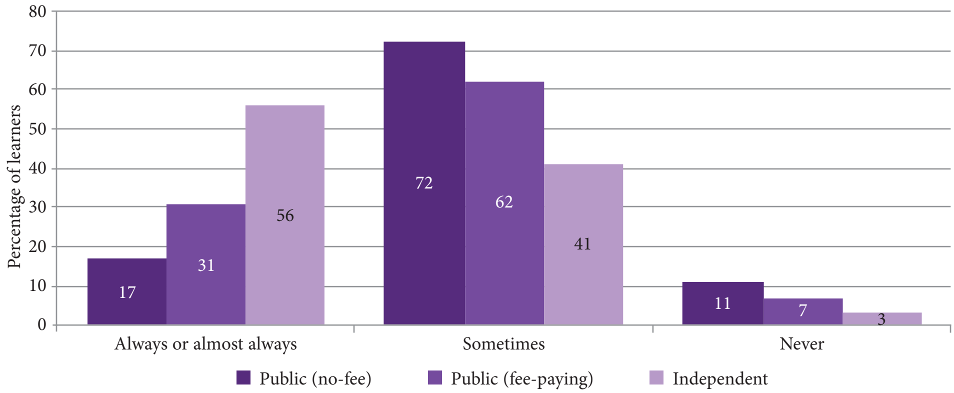
Internationally, almost 80 per cent of the learners spoke the language in which the test was conducted at home 'always' or 'almost always' in TIMSS 2011 – this was three times as many as in South Africa. As would be expected, there was a positive relationship between the extent to which the test language was spoken at home and mathematics and science achievement scores (Table 14). Speaking the test language at home less frequently seemed to be particularly related to very weak science outcomes.

Table 14: *Percentage and average achievement of learners by whether home language was the same as test language, 2002 and 2011*

	Learners speak the test language at home					
	Always or almost always		Sometimes		Never	
	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)	% of learners (SE)	Average achievement score (SE)
Mathematics 2002 (SA)	25 (1.7)	358 (9.1)	64 (1.7)	269 (3.0)	12 (0.8)	226 (6.2)
Mathematics 2011 (SA)	26 (1.0)	405 (4.5)	65 (1.2)	337 (2.2)	9 (0.6)	312 (4.9)
Mathematics 2011 (int. avg.)	79 (0.2)	469 (0.6)	17 (0.2)	443 (1.3)	4 (0.1)	421 (2.4)
Science 2002 (SA)	25 (1.7)	359 (10.9)	64 (1.7)	248 (4.6)	12 (0.8)	192 (6.7)
Science 2011 (SA)	26 (1.0)	412 (5.9)	65 (1.2)	310 (3.4)	9 (0.6)	264 (6.1)
Science 2011 (int. avg.)	79 (0.2)	481 (0.6)	17 (0.2)	448 (1.2)	4 (0.1)	424 (2.3)

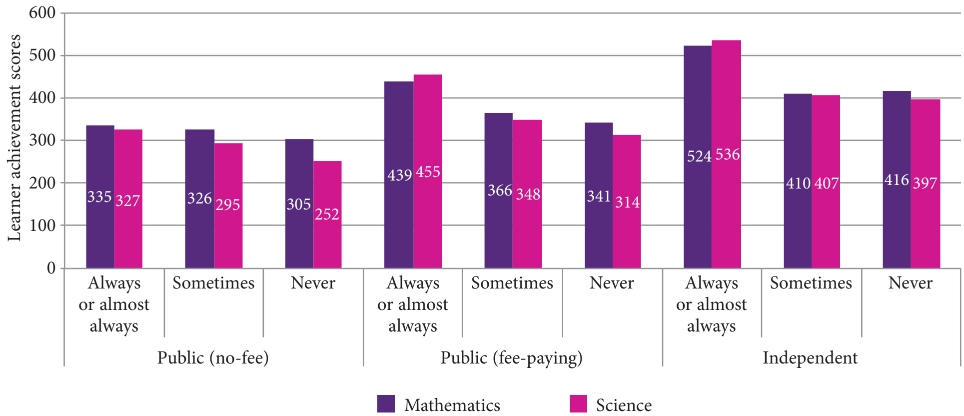
Figure 18 compares patterns across schooling groups in terms of the home language and language of testing. Overall, the gap between public fee-paying and independent schools in this regard was wider than the gap between public fee-paying and no-fee schools. Eighty-three per cent of learners attending no-fee public schools spoke the test language 'never' or 'sometimes', compared with 69 per cent of fee-paying learners and 44 per cent of independent-school learners.

Figure 18: *Percentage of learners who spoke the text language at home, by school type, 2011*



From Figure 19, it is clear that public fee-paying school learners who spoke the test language 'always or almost always' had average test scores that were similar to independent-school learners who 'sometimes' or 'never' spoke the test language at home. In all types of schools, learners who never spoke the test language at home were disadvantaged. The language-achievement gap was widest in independent schools where, on average, learners who never spoke the test language at home were far behind learners who spoke the test language frequently.

Figure 19: *Learners' achievement scores by school type and whether the test language was spoken at home, 2011*



Summary of results

Table 15 summarises findings from the analysis of TIMSS 2011 data for South African Grade 9 learners.

Table 15: *Summary of results*

	No-fee school	Fee-paying school	Independent school
Learner achievement			
Average mathematics score (SE)	324 (2.7)	397 (6.0)	474 (17.1)
Average science score (SE)	294 (4.2)	394 (7.6)	479 (19.1)
% of learners achieving at or above 400 in mathematics (SE)	12.5 (0.9)	44.3 (2.8)	70.8 (6.7)
% achieving at or above 400 in science (SE)	12.9 (1.0)	46.0 (3.2)	71.3 (6.5)
Age			
Average age of learners in years	16.2	15.8	15.4
Home resources			
% of learners with basic home resources:			
Electricity	79.0	92.0	98.0
Running tap water	59.0	80.0	92.0
Water-flushed toilets	31.0	66.0	86.0
% of learners with pedagogical resources:			
Computer	23.0	44.0	77.0
Internet connection	21.0	38.0	69.0
No or few books at home	45.0	33.0	23.0
% of learners with more educated parents:			
Maternal education above Grade 12	14.7	29.1	49.4
Parent with university education	13.0	28.0	57.0
Language			
% of learners who always or almost always spoke the test language at home	17.0	31.0	56.0

	No-fee school	Fee-paying school	Independent school
School physical resources			
% of learners not affected by resource shortage			
Mathematics	1.0	9.0	55.0
Science	1.0	9.0	44.0
% of learners whose teachers use textbooks as basis for instruction			
Mathematics	70.5	71.1	82.7
Science	71.2	57.5	48.8
% of learners whose teachers use workbooks as basis for instruction			
Mathematics	47.4	34.3	35.5
Science	35.0	46.3	41.3
School environment and climate			
Teachers arriving late: not a problem	34.0	33.0	34.0
Teacher absenteeism: not a problem	17.0	15.0	72.0
Learners arriving late: not a problem	5.0	9.0	45.0
Learner absenteeism: not a problem	5.0	5.0	37.0
School safety			
% of learners affected by school discipline and safety: moderate problems	41.0	45.0	11.0
% of learners who have almost never experienced bullying	19.0	36.0	42.0

Part C

Lessons learned and policy recommendations

Lessons from 20 years of TIMSS: how do we improve the chances for South African learners?

The main purpose of this report has been to provide a realistic overview of South African educational outcomes based on 20 years of participation in TIMSS. In this final section, we draw together the main findings of the report and suggest feasible policy and programme options for different stakeholders moving forward.

1. **South Africa's mathematics and science achievement scores have improved but the level is still very low.** At the national level, improvements in mathematics and science achievement have occurred but at a slower pace than in many countries on the continent and beyond. National average scores remain low in both mathematics and science, but we must keep in mind the very low base from which testing began. National improvements in achievement test scores have been largely the result of dramatic shifts in a handful of provinces and in the lowest-performing category of learners. A systematic review of provincial interventions is required in addition to an evaluation of regional characteristics of teachers and learners.
2. **The South African achievement profile remains highly unequal.** Despite some improvements since 2002, only one-quarter of mathematics and science learners in the 2011 TIMSS study achieved scores above the lowest benchmark of 400, a score denoting the minimal level of competence. Of these learners, only 1 per cent scored at the advanced level. When broken down according to school type, patterns of achievement are particularly revealing. Roughly 65 per cent of learners attending independent schools, 45 per cent of learners at public fee-paying schools and 15 per cent of learners at public no-fee schools achieved mathematics and science scores that were above the minimum level of competency. Granted that the number of learners scoring above the 400 threshold increased by nearly 14 percentage points between 2002 and 2011, it is worrying that such a large percentage of learners are still not acquiring basic skills in mathematics and science.
3. **Addressing the needs of the large numbers of learners who lack basic mathematics and science skills is a high priority.** Part of any strategy to improve overall performance in the future should include strengthening the way mathematics and science are taught in earlier grades. To meet the development

goals of the country and to increase access to science and technology-related careers, a greater number of learners need to acquire advanced technical skills. This improvement can be achieved in a number of different ways. One approach would be to focus on learners who have already grasped the foundations in mathematics and science and to develop their skills further. An alternative and perhaps more demanding strategy would involve shifting learners out of the bottom end of the performance spectrum. Because of the clear differences in achievement patterns between independent, fee-paying and no-fee public schools, differentiated strategies need to be considered.

4. **Many children from high-poverty households lack basic household education resources**. Access to basic amenities such as electricity and modern sanitation remains beyond the reach of learners in the poorest households. Whereas 1 in 5 learners in no-fee schools do not have electricity at home, virtually all learners in fee-paying public and independent schools can rely on an electricity source in the home. Nearly 70 per cent of learners attending no-fee schools do not have access to water-flushed toilets. In terms of the availability of modern technologies at home (such as computers and the internet), learners in no-fee schools are at an even greater disadvantage. In 2011, only 21 per cent of learners attending no-fee public schools had access to the internet compared with 70 per cent of their peers in independent schools. Although the educational levels of parents have generally improved in the past 10 years, TIMSS 2011 indicated that parents whose children attended independent and fee-paying schools were better educated and provided more pedagogical resources in the home. Children in Grade 9 from privileged backgrounds were younger, and more likely to speak the test language regularly. In the past, emphasis has been placed on infrastructure development in schools, but the provision of pedagogical resources is essential for schools where learners cannot acquire them privately. Schools in impoverished areas require a different emphasis in terms of resource provision if their learners are to succeed. How pedagogical resources relate to specific subject areas also needs to be considered, because according to TIMSS 2011 the relationship between resources and achievement was stronger for science than for mathematics.

5. **The school climate needs to be reviewed so that learning can take place in a safe and orderly environment.** In some instances in this report, particularly where resources and learner background were concerned, fee-paying public schools and independent schools were very similar in their profiles (refer to the summary table). Where challenges to the school climate were discussed, fee-paying and no-fee public schools were quite similar when compared with independent schools. Public schools in general, both fee-paying and no-fee, faced high levels of absenteeism and struggled with learner punctuality. They also experienced similar levels of school-discipline and school-safety problems, on average. The level of violence in schools is alarmingly high. Forty-two per cent of learners attending no-fee schools reported being bullied on a weekly basis. Even among learners attending independent schools, 1 in 5 was bullied every week. Although

factors external to schools may be driving the culture of violence, school management and school governing bodies need to devote serious attention to ensuring that schools are safe and provide an environment that is conducive to learning.

6. **Learners and teachers expressed positive attitudes towards teaching and learning, but low morale among teachers needs to be better understood.** It is unclear why teachers viewed themselves as highly competent and effective but at the same time were clearly unhappy with their profession. A number of factors need to be considered more closely, such as their motivation for becoming teachers, opportunities for career progression, their conditions of service and their workload. Compared with teachers in other TIMSS countries, South African teachers spent more time on professional-development activities. Given the high levels of investment in professional-development courses, there need to be higher levels of interrogation of the quality and appropriateness of these training programmes.
7. **New complexities involving gender differences have emerged and need to be investigated further.** There were no significant gender differences in achievement at the national level. Gender gaps across schools with different resource levels were consistently narrow. There were, however, gender differences favouring boys when boys and girls at the age-appropriate levels were compared. Given the under-representation of women in mathematics and science careers, and higher repetition and dropout rates among boys, we need to probe the opportunities and blockages in learning mathematics and science for boys and girls more closely.
8. **Participation in TIMSS and other international assessments has contributed immensely to what we know about the performance of South African learners over time.** International education surveys have allowed us to benchmark the performance of different groups of our learners based on the environment within which they live and learn. These studies have also provided us with an opportunity to view our progress relative to other countries. Education is a key driver for productivity, growth, citizenship and development and remains a priority among policy makers. How policy translates into deliverables needs to be strengthened if education is to be an essential ingredient for the country's long-term development. The number of jobs requiring highly educated workers continues to increase and this trend is unlikely to reverse. Greater effort therefore needs to be made to analyse and disseminate these data sources and to discuss their findings and implications more widely.

Policy and programme recommendations for different role players

Table 16 sets out options and recommendations to address the issues identified above. They are presented in terms of actions appropriate at different levels within the broad education sphere, ranging from national policy initiatives to household support for learners.

Table 16: *Policy and programme recommendations*

National	· Ensure that the delivery of mathematics and science courses in all schools is in line with curriculum requirements. · Work towards an improvement in performance in national and international assessments based on realistic targets. · Embark on a differentiated strategy of interventions and support for improved learning outcomes in fee-paying and no-fee schools. · Improve on the provision of pedagogical infrastructure (e.g. libraries and laboratories) and pedagogical resources (e.g. workbooks and textbooks) to schools. · Use public media to set up programmes in and awareness of mathematics and science. · Revisit the repetition policy and its implementation. · Generate awareness of the full range of career possibilities that can be pursued beyond Grade 9. · Develop policies and guidelines to curb school violence and bullying.
Provincial	· Improve provincial performance of learners achieving above the minimum competency level of 400 points. · Monitor the provision and use of pedagogical infrastructure and pedagogical resources in schools. · Emphasise quality of teaching and learning from Grade R. · Implement policies and guidelines to curb school violence and bullying.

District	· Design appropriate pedagogical interventions for teachers. · Monitor that teachers and learners are in school, on time and learning. · Monitor that textbooks, workbooks and pedagogical resources are in schools and being used. · Investigate teacher job satisfaction and motivation. · Monitor incidences of violence and bullying at schools and support principals/schools in managing school safety.
School	· Emphasise safety, order and academic success. · Monitor and manage rates of absenteeism among teachers and learners. · Emphasise an academic culture in schools. · Provide appropriate support to grade repeaters either during school time or during school holidays.
Teachers and classrooms	· Emphasise punctuality among teachers. · Evaluate and improve on teacher subject knowledge and pedagogy. · Teachers must evaluate their own professional knowledge and pedagogical practices. · Provide learners with practice examples involving written explanations.
Learners	· Emphasise punctuality among learners. · Improve proficiency in the test language. · Ensure regular practice of mathematics and science examples with written homework.
Communities	· Motivate young children to see the importance of education. · Monitor teacher and learner attendance at schools.
Households	· Motivate and inspire young children to value mathematics and science. · Support and monitor homework and school reports. · Monitor learner attendance at schools. · Engage with teachers and school officials about education delivery and performance.

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Beyond Benchmarks

What twenty years of TIMSS data tell us about South African education

South Africa has participated in a number of local and international achievement studies in the field of education over the last 20 years and responses to the results have been somewhat mixed. Critics argue that participation in international assessments is a pointless exercise because of the slow pace of improvement in South African education. Supporters point out that international assessment results can be useful at many different levels of policy and planning, especially when studies are repeated across time. The purpose of this book is to provide a measured assessment of what has been achieved in South African education over the last 20 years based on the evidence provided by Trends in International Mathematics and Science Studies (TIMSS), to redefine what 'good' progress means in light of South Africa's developmental pathway and to recommend what evidence-based interventions can be considered as the next realistic steps in South Africa's educational development.

'The authors of this report conclude that *participation in TIMSS and other international assessments have contributed immensely to what we know about the performance of South African learners over time*. This is indeed true, and this synthesis report thus fulfils the very valuable and important function of making these results available to a wider audience.'

– Professor Servaas van der Berg, Department of Economics, University of Stellenbosch

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