TIMSS 2015

Highlights of Mathematics Achievement amongst Grade 5 South African Learners

Nurturing green shoots

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WHAT IS TIMSS NUMERACY?

The Trends in International Mathematics and Science Study (TIMSS) is an assessment of the mathematics and science knowledge of fourth grade 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 achievement across borders. The main aim of the TIMSS study is to determine the nature and extent of learner achievement as well as understand the context in which it occurs. The goal is to determine the factors linked to learning that could impact policy.

TIMSS Numeracy (TIMSS-N) was introduced in 2015 to assess the foundational mathematical knowledge, procedures and problem-solving strategies of learners at the end of primary school. TIMSS-N asks learners to answer questions and work out problems similar to those posed in TIMSS, except that easier numbers and more straightforward procedures are used. 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. The TIMSS-N results are reported on the TIMSS Mathematics scale.

South Africa's participation in TIMSS Numeracy

The IEA applied explicit and implicit stratified random sampling techniques by using the province, school type (public and independent) and language of learning and teaching (Afrikaans, English and dual medium) as stratification variables. For TIMSS Numeracy 2015 in South Africa, the Human Sciences Research Council conducted the study in 2014 at 297 schools with 10 932 learners. As this is the first time South Africa is participating at the Grade 5 level, this assessment serves as a base line against which future results can be compared. In addition, including an assessment at the Grade 5 level allows more time for appropriate interventions to be introduced into the schooling system.

TIMSS assessment framework

TIMSS is designed to align broadly with mathematics curricula in the participating countries. 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. TIMSS also collects background information on the participating learners, their families, teachers and schools to allow cross-national comparison of educational contexts that may be related to student achievement. TIMSS uses the curriculum as the organising principle of how educational opportunities are provided to learners. The curriculum model consists of three aspects: (i) the intended curriculum, (ii) the implemented curriculum, and (iii) the attained curriculum.

It is possible to explore how achievement scores translate into what learners can do by examining country performance at the international benchmarks. TIMSS test scores are divided into four international benchmarks. For the South African context, a fifth benchmark was introduced to identify the group of learners that could be targeted to "pull up" to the higher benchmarks, the so-called "potentials".

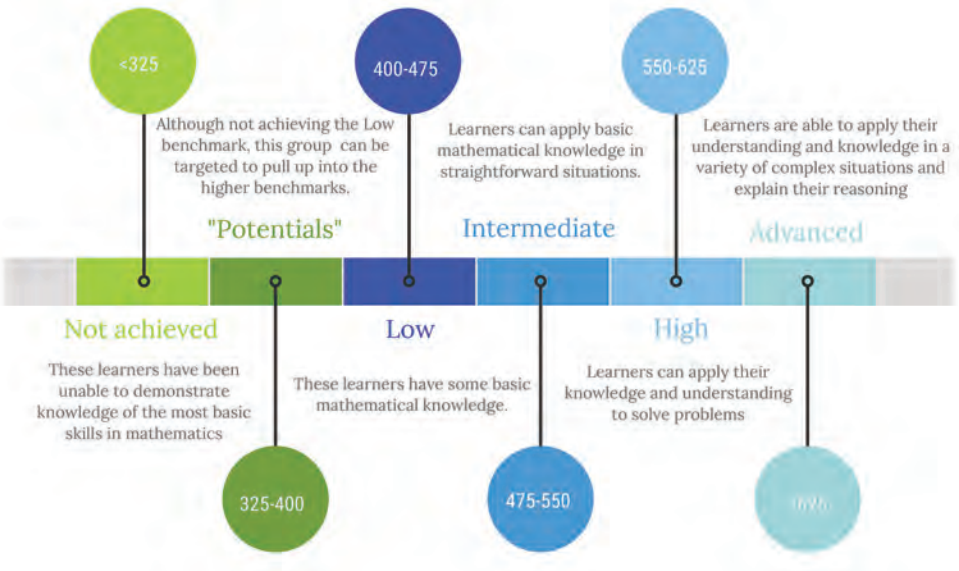

Figure 1: TIMSS benchmarks

SOUTH AFRICAN MATHEMATICS ACHIEVEMENT

The achievement scores are described by: (i) average mathematics scale scores in TIMSS 2015 for participating countries; and (ii) the mathematics achievement profile of selected countries using the TIMSS benchmarks.

South African mathematics performance in relation to that of other countries

For the purposes of cross-country comparison, the TIMSS achievement scale is set with a centre point of 500 and a standard deviation of 100. All data are rescaled from one cycle to another using concurrent calibration to ensure that all country data are on the same scale to allow for comparability.

Forty-eight countries participated in TIMSS 2015 at the Grade 4 or 5 levels. Of these, seven countries (Bahrain, Indonesia, Iran, Jordan, Kuwait, Morocco and South Africa) participated in TIMSS Numeracy. TIMSS and TIMSS-N scores are reported on the same scale.

Table 1 ranks the participating countries according to the average scale scores for mathematics from highest to lowest.

The top five ranked countries are from East Asia – Singapore (618), Hong Kong SAR (614), Korea (608), Chinese Taipei (596), and Japan (593). The bottom five countries are Jordan (389), Saudi Arabia (384), Morocco (378), South Africa (376) and Kuwait (354). The score differences between South Africa, Morocco and Saudi Arabia are not statistically significant.

Thirty-one of the 48 countries performed above the centre point of 500 points. While there were small differences from one country to the next, there was a considerable range of achievement from the top-performing to the lowest performing countries.

A further description of performance is provided by using the TIMSS international benchmarks. Figure 2 compares

Country	Ave Score	SE[1]
Singapore	618	3.8
Hong Kong SAR	614	2.9
Korea	608	2.2
Chinese Taipei	596	1.8
Japan	593	1.9
Croatia	505	2.5
Spain	502	1.7
International centre point	500	
Slovak Republic	498	2.5
New Zealand	491	2.3
France	488	2.9
Jordan	389	3.0
Saudi Arabia	384	4.0
Morocco	378	3.0
South Africa (5)	376	3.4
Kuwait	354	4.6

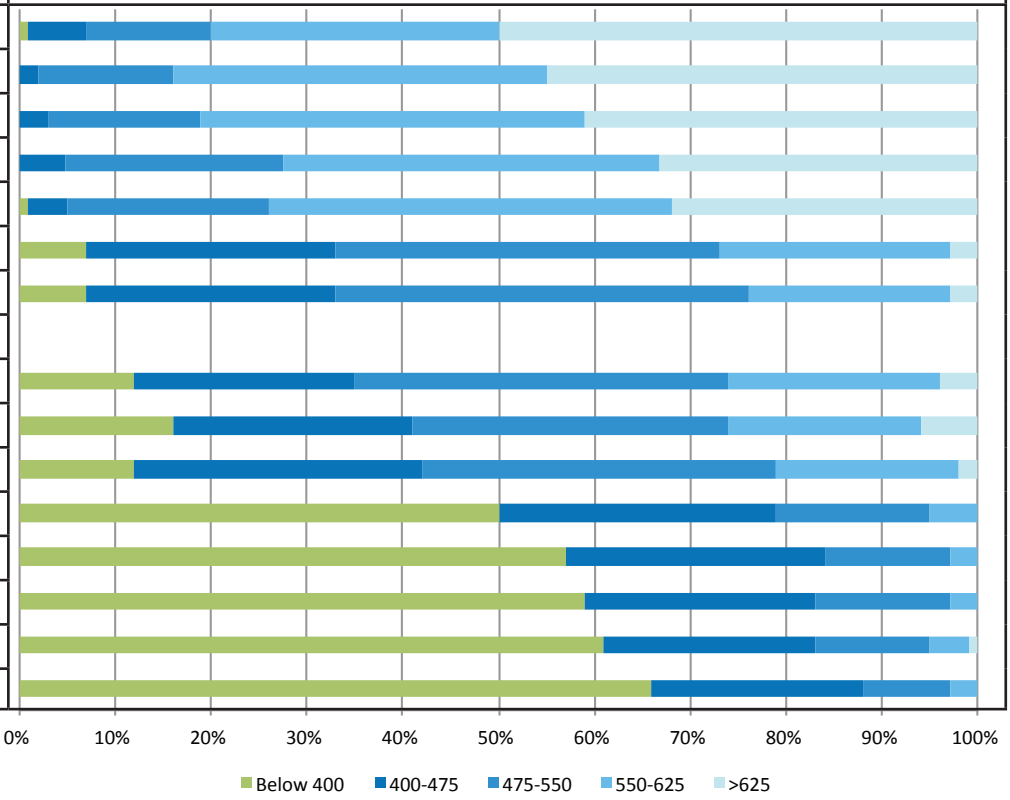

Figure 2: Grade 4/5 TIMSS 2015 performance by TIMSS benchmarks for mathematics achievement in a selection of countries

1 Standard Error: a statistical term that measures the accuracy with which a sample represents a population

Table 1: Average mathematics achievement

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 (5)	549	2.5
Ireland	548	2.2
England	546	2.9
Belgium (Flemish)	546	2.1
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 CENTREPOINT 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 Rep. 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 (5)	376	3.4
Kuwait	354	4.6

performance at TIMSS international benchmarks for a selection of countries that participated in TIMSS 2015. The figure illustrates the performance of the five highest performing countries, five countries around the centrepoint and the five lowest performing countries.

In the five highest performing countries – Singapore, Hong Kong SAR, Korea, Chinese Taipei, and Japan – almost all learners scored above the 400-point mark, the low benchmark set by TIMSS for learners demonstrating the minimum mathematics competencies. Over three-quarters of these learners achieved scores above 550 points (the high benchmark).

For the five countries performing around the centrepoint – Croatia, Spain, the Slovak Republic, New Zealand and France, between 7% and 16% of learners performed below the low TIMSS benchmark.

The profile of the five lowest performing countries – Jordan, Saudi Arabia, Morocco, South Africa and Kuwait – shows that between 50% and 65% 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% of learners scored in the advanced category. South Africa stands out in this regard as the other four lowest performing countries did not have learners performing at the Advanced benchmark.

Mathematics achievement in South Africa

TIMSS mathematics items are designed to measure learner knowledge and proficiency, which can vary widely from one learner to another. The TIMSS benchmarks attempt to provide more meaningful descriptions of what learners know (see Figure 1 for more detail). According to the TIMSS categorisation, approximately two-fifths of learners (39%) achieve above the 400 TIMSS point mark. Three-fifths of South African learners (61%) do not exhibit the minimum competency in basic mathematical knowledge required at the Grade 5 level, that is they score below the 400 mark.

Overall, 1.3% of South African learners were benchmarked at the 'Advanced' level (above 625 points). Learners in this small "pocket of excellence" possess the potential to participate in postgraduate studies.

TIMSS describes performance according to four benchmarks where learners have achieved minimum level competences. All learners who score below 400 points are considered not to have achieved this. South Africa is a very diverse country and the home and school resources are vastly unequal across the group of learners. In order to understand this performance in a more textured manner, it is necessary to disaggregate the results into the policy-

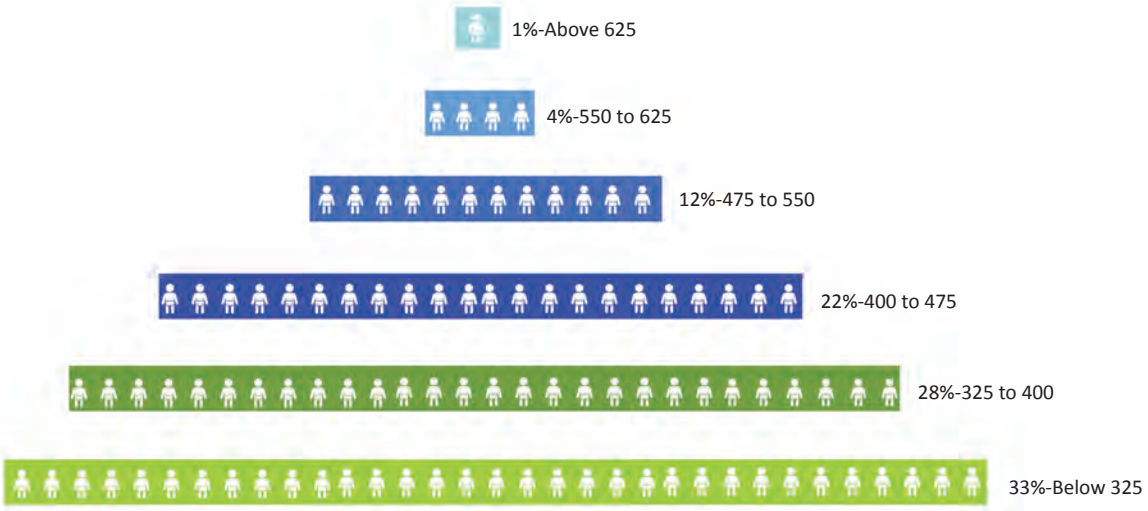

Figure 3: TIMSS mathematics achievement by TIMSS benchmarks for South Africa

relevant categories. Participants scoring below the level of the TIMSS benchmarks are further broken down into two categories: 325 to 400 and below 325. As noted in Figure 1 above, those learners scoring between 325 and 400 can be viewed as a "potential" success group, in that they could, given the right support and interventions, move above the 400 point achievement mark. In this disaggregation, one-third of all learners scored below 325 and 28% scored between 325 and 400.

Provincial mathematics achievement

In South Africa the national Department of Basic Education (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 of education and the varied levels of resources, it is useful to report on provincial performance.

Figure 4 sets out the provincial TIMSS mathematics performance by TIMSS benchmarks. The provinces are ranked by average achievement score. The three top-performing provinces were the Western Cape, Gauteng and Mpumalanga. The three lowest performing provinces were the North West, Limpopo and the Eastern Cape.

The highest performing province, the Western Cape, achieved an average scale score 65 points above the national average, while the Eastern Cape scored 33 points below the national average. This makes the difference between the highest and lowest performing provinces 98 points (one standard deviation).

The provinces with the widest range of scores were Gauteng (348 points) and the Eastern Cape (340 points). This is a reflection of the high variation in learner ability. North West (246) and Limpopo (267) showed the narrowest range

Figure 4: Provincial achievement distribution

School type	Score (SE)
Public (no-fee)	344 (3.4)
Public (fee-paying)	445 (7.7)
Independent	506 (11.9)

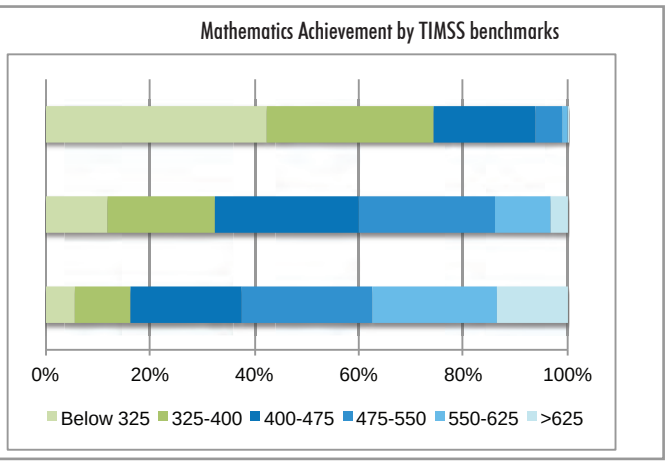

Figure 5: Average mathematics achievement by school type

of scores. As these provinces also exhibited the lowest average score, this means that the majority of leaners are performing equally poorly.

The provincial analysis by TIMSS benchmarks shows that while 60% of the Grade 5 learners scored below 400 TIMSS points nationally, the provincial patterns exhibited vast inequalities. Thirty-one per cent of the learners in the Western Cape and 43% in Gauteng scored below 400 points, while 76% of the learners in Limpopo performed at that level. In the remaining six provinces, between 60% and 74% of learners scored below 400. These provinces have a huge amount of work to do to raise the level of inputs so that there are improved outcomes.

Learners who achieved the advanced benchmark (above 625 points) are predominantly from Gauteng (3.1%), the Western Cape (3%) and KwaZulu-Natal (1.5%).

Mathematics achievement by school type

The South African schooling system comprises independent schools (9%) and public schools (91%). 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 was calculated by the Department of Basic Education. Schools were divided into five groups called the quintile rank of the school. The most economically disadvantaged are grouped into Quintile 1 and the most affluent schools assigned a Quintile 5 ranking. All schools in Quintiles 1 to 3 are no-fee schools. Thus, the categories "no-fee", "fee-paying" and "independent" are used to differentiate between school types. Of the learners who participated in the TIMSS 2015, 70% attended public no-fee schools, 27% public fee-paying and 4% independent schools. Figure 5 summarises the average mathematics scale score and performance benchmarks by school type.

At independent schools, over 60% of learners reached the Intermediate benchmark (475 points) or did even better, with 14% achieving the Advanced benchmark of 625 points. In contrast, three-quarters of the learners attending public no-fee schools scored below 400. About 14% of learners at public fee-paying schools achieved the High (11%) and Advanced (3%) competency levels.

Mathematics achievement by 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. The South African Grade 5 TIMSS 2015 sample showed a relatively even distribution of boys (48%) and girls (52%). Girls outperformed boys by a statistically significant average of 16 points (Figure 6). Internationally, girls outperformed boys in 21 of the participating countries (eight of these differences were statistically significant). Although South African girls outperformed boys in the Grade 9 TIMSS, the difference was not statistically significant.

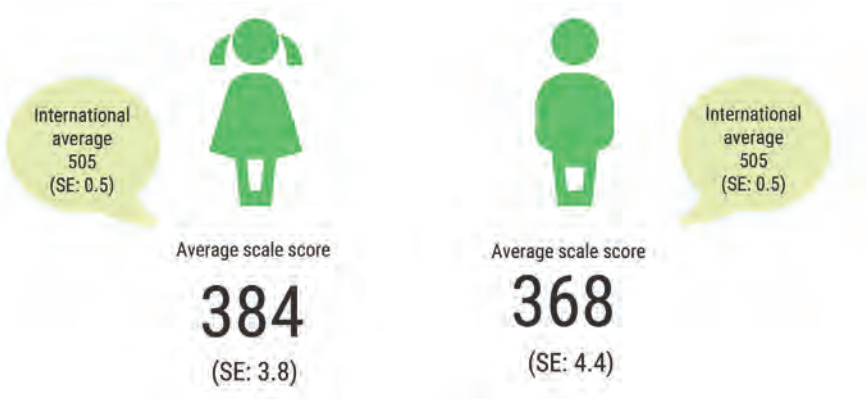

Figure 6: Average mathematics achievement scores for boys and girls

CURRICULUM ANALYSIS

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.

Table 2 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.

Learners performed slightly better than the overall mean in the numbers (by 5 points) and data display (by 3 points) content domains and underperformed in the geometric shapes and measures domain (by 16 points).

Knowing, applying and reasoning are the hierarchical order of cognitive demand. 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 16 points higher than the male average, and 8 points higher than the full sample mean. Female achievement in the areas of numbers, shapes & measures, and data display, for example, is 15, 14 and 20 points higher than the male average respectively.

Figure 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.

Table 2: 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[2]	Mean	SE	Difference from overall mean
Overall	**100%**	**88%**	**376**	**(3.5)**	
Content domain:					
Numbers	50%	88%	379	(3.4)	+ 3
Shapes & measures	35%	86%	359	(3.7)	- 16
Data display	15%	100%	381	(4.0)	+ 5
Cognitive domain:					
Knowing	50%		378	(3.6)	+ 2
Applying	35%		377	(3.4)	+ 1
Reasoning	15%		369	(3.5)	- 7

2 Degree of match calculated as a proportion of topics (for each content area) covered by the Grade 5 South African curriculum. There are a total of 17 topics: 8 in numbers; 7 in geometric shapes and measures and 2 in data display.

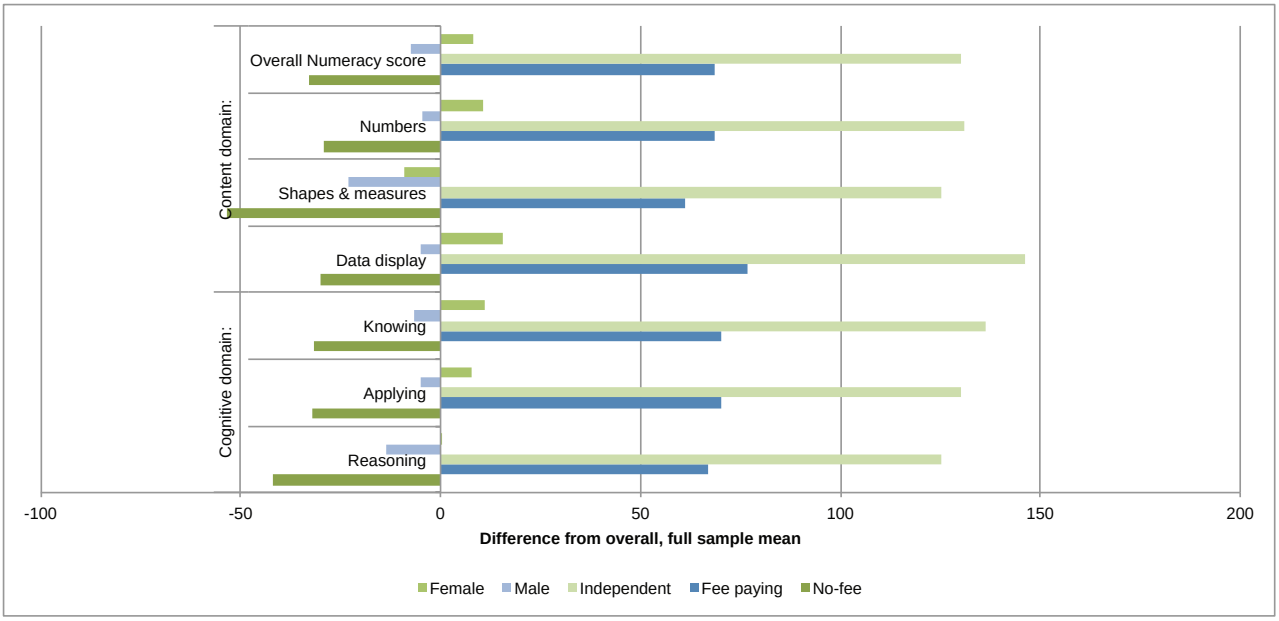

Figure 7: Achievement scores by content and cognitive domains, by sex and school type

HOW LEARNERS LIVE AND LEARN

Education and learning are shaped by home, school and community environments and the interaction between them. Understanding the relationships between the key characteristics from these different contexts and learner achievement provides important signals about how numeracy and mathematical skills develop and the possible angles for policy leverage to improve overall mathematical skills.

Resources in the home

As noted above, South Africa is a very diverse country and home and school resources are vastly unequal across the group of learners. This is reflected in Table 3, which reports that, on average, learners attending fee-paying and independent schools have greater access to a host of different household resources. For example, more than half (51%) of learners in fee-paying schools and over two-thirds (67%) in independent schools have an internet connection at home compared to only 28% of those in no-fee schools. Almost three-quarters (73%) of learners in independent schools have their own cell phones compared with just over half of those (55%) in no-fee schools.

There is also evidence of socioeconomic variation within the different school types: more than a quarter (28%) of learners at independent schools report being in receipt of a government grant, 17% are without access to running water, and 11% do not have access to flush toilets. Contrast this with the no-fee paying schools where 86% receive a government grant, 41% are without access to running water and 59% do not have access to flush toilets.

The *level of maternal education* provides a further indicator of household demographics that are known to relate positively to learner achievement. Table 4 reports that, on average, just under half (46%) of learners in South Africa come from households where mothers have post-Grade 12 education. This breaks down to 37% of learners in public no-fee paying schools, 62% in fee-paying schools and 84% of those in independent schools. As regards the provinces, learners from Gauteng (60%) and KwaZulu-Natal (54%) come from the most educated households, while just one-third (37%) of those from the Free State have mothers with any form of post-matric education. The difference in performance in households where mothers have a post-matric qualification and those with less than a Grade 12 education is 105 points, equivalent to more than two grades.

Table 3: Reported percentages of learners' home assets, by overall average and school type

		School type		
Resource at home	SA Average	No-fee	Fee-paying	Independent
Computer (own)	31	27	39	56
Computer (shared)	45	41	52	59
Own room	53	49	61	73
Internet connection	36	28	51	67
Own Cell phone	59	55	67	73
Flush Toilets	56	41	87	89
Motor car	58	53	67	85
Telephone	30	25	39	53
Fridge	86	82	95	97
Dictionary	67	60	82	87
Electricity	83	78	93	94
Running tap water	64	59	76	83
Television	89	86	95	96
Government grant	74	86	50	28

In terms of the *number of books in the home*[3], just one in five learners (20%) comes from a household with more than 25 books. Again, those in independent schools are more advantaged with half (50%) of all learners having more than 25 books in the home, while only one in six (16%) of those in no-fee schools have such access. As with maternal education, learners from Gauteng report having more books at home, with over one-quarter (27%) having more than 25 books at home, with just 15% of those living in North West reporting similar access. The difference in average performance between those with access to less than 25 books and those with more than 25 books at home is 45 points, roughly equivalent to one school grade.

Across the TIMSS 2015 cohort, just under one-third of learners (31%) always or almost always spoke the *language of learning and teaching* at home, giving them, on average, a 78-point advantage. Unsurprisingly, the provincial comparison reflected in Table 4 shows considerable variation with those in the Western Cape and those in the Northern Cape – 64% and 54%, respectively – most likely to frequently speak the test language at home.

3 Reported by the learner.

Table 4: Indicators of home environment, by province and school type

	% with Maternal education above Gr 12	% with more that 25 books at home	% who always / almost always speak language of the test at home
SA Average	46%	20%	31%
Western Cape	36%	19%	64%
Gauteng	60%	27%	37%
Mpumalanga	48%	22%	20%
Free State	37%	20%	26%
Northern Cape	39%	19%	54%
KwaZulu-Natal	54%	20%	30%
North West	38%	15%	18%
Limpopo	42%	17%	15%
Eastern Cape	36%	18%	30%
No-fee	37%	16%	20%
Fee paying	62%	26%	54%
Independent	84%	50%	55%

Table 5: Proportion of learners and average mathematics achievement scores, by Home Educational Resource index

	Few Resources		Some Resources		Many Resources	
	% learners	*Ave. score*	*% learners*	*Ave. score*	*% learners*	*Ave. score*
South Africa	34 (1.2)	348 (3.2)	65 (1.2)	391 (4.1)	2 (0.4)	599 (10.0)
International	9 (0.1)	427 (1.5)	74 (0.2)	501 (0.4)	17 (0.2)	569 (0.9)

Interestingly, learners in fee-paying schools and those in independent schools are equally likely to frequently speak the language of the test at home, and one in five (20%) of those in no-fee schools do so.

In attempting to summarise the resources present in the home, a scale for measuring the Home Educational Resources[4] has been constructed for each participating country. In South Africa, one-third of learners (34%) come from households considered to have few resources in comparison with an overall international average of 9%, and a corresponding difference in performance of 79 points, the equivalent of almost two grades. Just two per cent of South African learners are considered to come from households with many resources, contrasting with an international average of 17%. Interestingly, however, learners in South Africa from the most highly resourced homes score, on average, 30 points more than their international counterparts.

4 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 (i.e. internet connection, own room) in the home; the number of children's books in the home as reported by the parent; the highest level of education of either parent; highest level of occupation of either parent.

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. That is, what parents have is important, but so too is what they do.

Table 6 shows the proportion of learners whose parents[5] reported often engaging them in certain 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 sometimes or never, is 35 points on average. Where parents frequently play games involving shapes and puzzles, the difference is 40 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.

In total, parents of learners responded to 17 different types of early educational activities, which have been condensed into a single index of early literacy and numeracy activities in the home.

5 Parents, guardians or other primary caregivers

Table 6: Proportion of learners whose parents report "often" engaging in selected early educational activities, by province and school type

	Read books	Play with alphabets	Counting songs	Play with number toys	Games with shapes	Play with building blocks
SA Average	35%	30%	34%	31%	36%	31%
EC	33%	29%	30%	28%	31%	27%
FS	32%	30%	31%	31%	34%	26%
GT	40%	38%	37%	34%	45%	36%
KZ	30%	28%	33%	28%	32%	31%
LP	31%	26%	27%	28%	29%	25%
MP	36%	28%	36%	31%	38%	31%
NC	36%	30%	35%	30%	38%	32%
NW	33%	31%	35%	33%	38%	30%
WC	44%	35%	46%	37%	44%	39%
No-fee	32%	26%	30%	27%	30%	27%
Fee paying	40%	40%	42%	38%	48%	39%
Independent	53%	48%	46%	46%	55%	50%

Table 7: Relationship between literacy and numeracy activities before school, household education and achievement in TIMSS

				Household educational level					
				Below grade 12		Completed grade 12		Post-secondary	
				45		33		22	
Frequency of activities:	%	Average score:		343	(3.0)	380	(4.2)	451	(6.3)
Never or 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)

Table 7 shows the positive association between both household education and the early educational environment on the one hand, and learner achievement on the other. As each contextual indicator increases, so too does learner achievement, with learners in households where there is frequent use of literacy and numeracy activities before school alongside parents with post-secondary education scoring, on average, 170 points higher than those from households where early educational activities are a rarity and household education is below Grade 12.

Taken together, these results highlight that:

- the majority of parents engage in early educational activities with their children before school
- as noted in above, the more early literacy and numeracy activities parents engage in at home before the child enters school, the higher the child's achievement in numeracy
- learners from better educated households achieve higher scores

Table 7 also shows a positive, incremental relationship between these two contextual inputs in terms of achievement in TIMSS. The results do not indicate evidence of interactions between these two contextual inputs, where one "good" context, e.g. often engaging in literacy and numeracy activities before school, can make up for a "poor" one, e.g. low parental education. Rather, the pattern of results simply suggests that the more good inputs, the better.

Can other positive early contexts support or boost poor early home environments?

Pre-school attendance in South Africa is almost universal with almost nine out of every ten learners (88.9%) having some form of schooling prior to Grade 1. Both in South Africa and internationally the more preschool instruction received by learners, the higher their average mathematics score in Grade 5.

Is this contextual advantage realised across all learners? Figure 8 shows that when examined by school type, a similar pattern of incremental advantage emerges. However, those

Table 8: Average mathematics achievement by preschool attendance, for South Africa and international average

	South Africa			International average		
Preschool attendance	%	Ave. mathematics score	S.E.	%	Ave. mathematics score	S.E.
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)

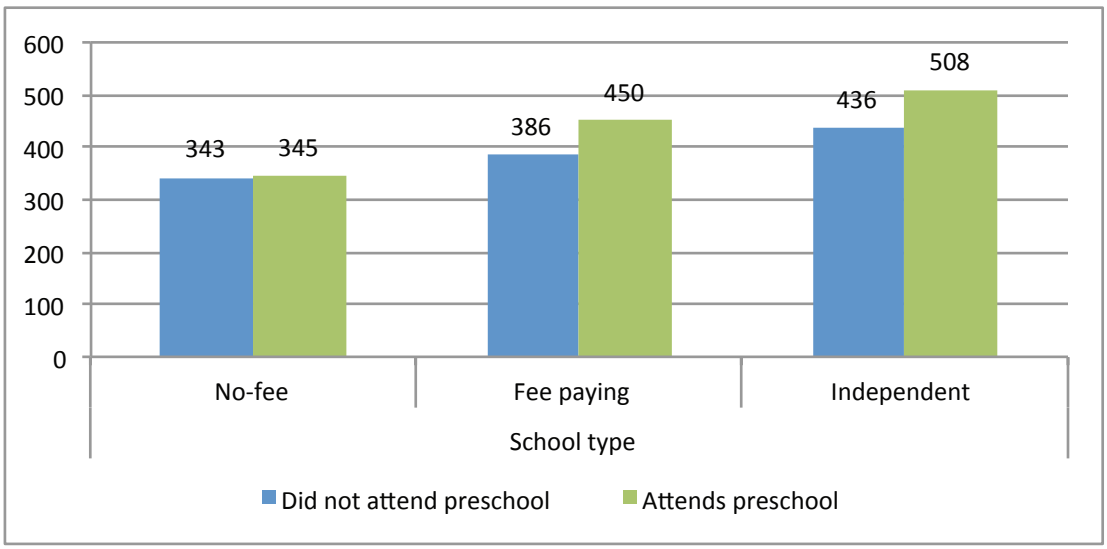

Figure 8: Mathematics achievement and preschool attendance, by school type

in Q1-Q3 no-fee schools do not appear to get the same "boost" from attending preschools that those in fee-paying and independent schools do. This is probably an indication that the quality of preschool education available to those who go on to Q1-Q3 schools is not as high as that of the pre-schooling available to those who subsequently attend fee-paying and independent schools.

School readiness

Further highlighting the role of good quality preschool education, learners who start school ready to learn perform better in mathematics in Grade 5. Across a range of measures, learners who had a solid foundation in literacy and numeracy skills prior to Grade 1 outperformed those with only minimal competencies by an average of 84 points, the equivalent of two grades. Approximately half

Table 9: Proportion of learners with strong literacy skills prior to grade 1, by province and school type

	Recognise most letters of Alphabet	Read some words	Write letters
	Very well	Very well	Very well
SA Average	49%	35%	43%
EC	45%	32%	41%
FS	50%	39%	44%
GT	57%	40%	51%
KZ	50%	37%	42%
LP	44%	31%	41%
MP	50%	34%	42%
NC	43%	30%	40%
NW	46%	37%	44%
WC	47%	34%	42%
Public (No-fee paying)	46%	35%	43%
Public (Fee paying)	54%	35%	44%
Independent	62%	41%	51%

Table 10: Proportion of learners with strong numeracy skills prior to Grade 1, by province and school type

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

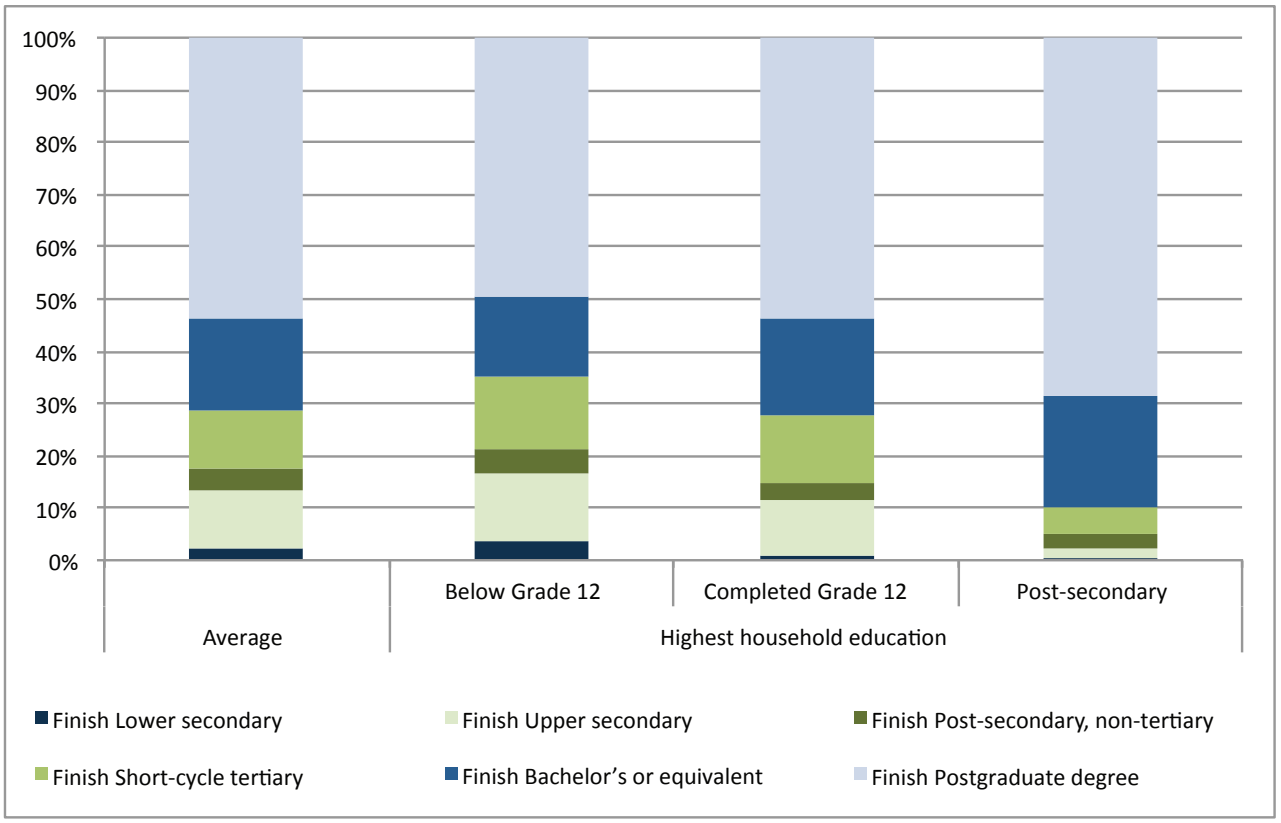

Figure 9: Parents' educational expectations for learners, by overall average and highest household education

(49%) of all learners were able to recognise most of the letters of the alphabet very well on beginning Grade 1, with just over one-third (35%) able to read some words very well and more than four in ten (43%) able to write letters very well. Those in independent schools again fared better than those in the public sector, but the differences in early literacy skills across the provinces were less pronounced.

Only one-quarter of learners (26%) were, on average, able to count to 100 or higher on their own prior to starting Grade 1, with this number rising to one-third (35%) of learners in fee-paying public schools and just over four in ten (41%) in independent schools. Fewer learners were able to recognise written numbers up to 100 (21% of all learners, 27% of those in fee-paying schools and 30% of those in the independent sector) and write numbers up to 100 (24% on average, with 23%, 27% and 29% in no-fee, fee-paying and independent schools respectively). Across all three measures of early numeracy, learners in Gauteng showed the highest proficiency.

Finally, in terms of the educational environment of the home, *parents' expectations* for their child's educational career are also positively associated with learner achievement: learners whose parents want them to go on to higher education achieve higher mathematics scores, on average. For example, learners whose parents expect their child to leave after finishing lower secondary school (2%) score, on average, 27 points lower than those whose parents want them to leave after completing Grade 12 (11%). The majority of parents have exceptionally high expectations, with over half (54%) of learners' parents wanting their child to finish a postgraduate degree, where the difference in average performance for those with the lowest parental expectations is 62 points.

Parents' own level of education is also positively associated with their expectations regarding how far their child should go: better-educated parents expect higher levels of education from their children. But there is also evidence of a general upward shift in expected education, with the vast majority of parents wanting their offspring to achieve higher qualification levels than they were able to.

WHERE LEARNERS GO TO LEARN

The school context

Table 11 presents findings on selected school characteristics. Over three-quarters of learners (77%) attend schools where a free lunch is provided and just over half (52%) attend schools where a place is offered to do work before or after school. Just over four in ten learners (42%) attend schools with a library, more so in fee-paying (80%) and independent (81%) schools. As regards the provinces, learner access to a school library in Gauteng is on a par with access in independent schools (82%), with learners in Limpopo having the lowest reported library resources (17%).

There is a strong positive association between learners' achievement and the *emphasis placed on academic success* by the school. Nationally, 7% of learners are in schools where the emphasis on academic success is very high, a figure which rises to 31% in independent schools. There are interesting provincial differences, with the Free State (18%) and Mpumalanga (17%) faring the best. 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 moderate emphasis on success.

Schools with *disciplinary and safety problems* are not conducive to either teaching or learning. Just over one in five learners (22%) attend schools reported to have severe disciplinary problems, with Gauteng having almost double the national average (43%). A stable environment in which teachers and learners feel safe and where poor discipline does not occur is strongly associated with high performance: learners in schools with severe disciplinary problems scored, on average, 41 points lower than those in schools were there were hardly any problems.

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

Table 11: 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 school which have a library	% learners attending schools that placed high/very high emphasis on academic success	% learners attending schools with severe dicipline problems
Overall	SA Average	77%	52%	42%	7%	22%
Province	EC	69%	47%	34%	11%	19%
	FS	77%	41%	38%	18%	19%
	GT	73%	73%	82%	8%	43%
	KZ	75%	45%	34%	1%	13%
	LP	90%	54%	17%	4%	15%
	MP	77%	59%	50%	17%	14%
	NC	58%	65%	28%	0%	21%
	NW	80%	45%	29%	6%	23%
	WC	88%	38%	50%	5%	27%
School type	No fee	89%	52%	25%	7%	22%
	Fee	56%	48%	80%	4%	25%
	Independent	20%	82%	81%	31%	3%

Table 12: Principal's assessment of resource shortages

	Not affected		Somewhat affected		Greatly affected	
	% Learners	Average achievement score (SE)	% Learners	Average achievement score (SE)	% Learners	Average achievement score (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)

Workbooks

Overall access to workbooks for Grade 5 learners is excellent with almost 95% of students in total having access to either their own (87.5%) or a shared (7.9%) workbook in class. Learners in schools without access to workbooks scored significantly lower than those with access, which probably reflects a generally lower level of school resources.

Teachers

Mathematics teachers' and principals' responses to the questionnaires are not nationally representative but indicative of those sampled in the study. At the primary school level, the majority of learners were taught by female teachers (66%) between the ages of 40 and 49 (49%). In terms of qualifications, 46% of learners were taught by teachers who had completed at least a Bachelor's degree with 1% having finished a Master's programme. Sixty-six per cent of learners were taught by teachers with 10 or more

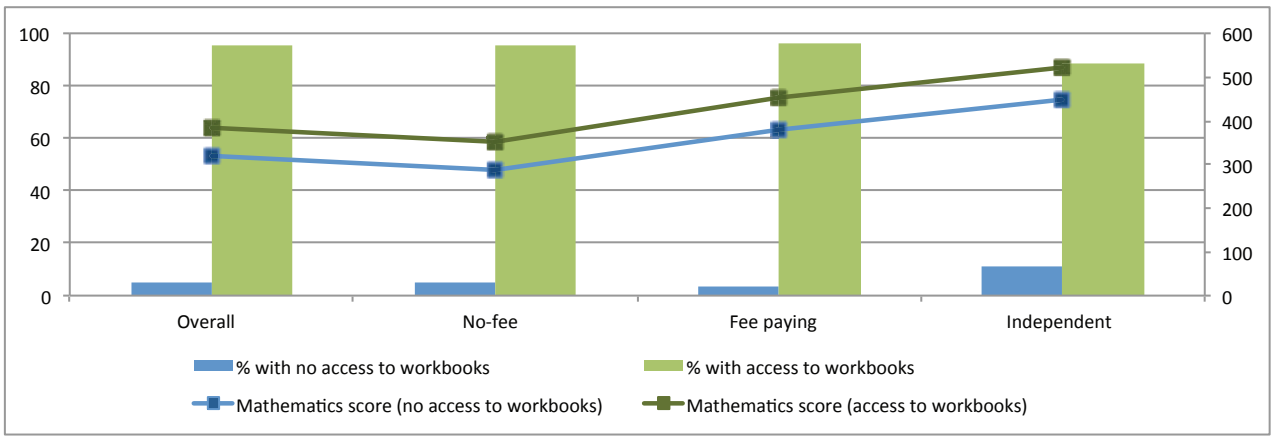

Figure 10: Proportion of learners with access to a workbook and related mean mathematics score, by overall average and school type

Table 13: Sense of student belonging and related numeracy achievement, by South African and international averages

	South Africa		International average	
Sense of school belonging index:	%	Numeracy score	%	Numeracy score
Little sense of school belonging	5	330 (8.0)	4	482 (1.2)
Some sense of school belonging	27	356 (5.0)	30	499 (0.6)
High sense of school belonging	68	391 (3.4)	66	510 (0.4)

years of teaching experience, with 39% of the teachers having served over 20 years in the teaching profession.

South Africa was ranked 12th highest amongst participating countries in terms of teachers' levels of job satisfaction: 62% of learners were being taught by teachers who were very satisfied with their profession. Internationally, 52% of learners were being taught by teachers who were very satisfied with their profession.

The school learning environment

The majority of learners have a strong sense of loyalty to their school and there is a positive association between enjoying and being comfortable in the learning environment and mathematics achievement. Interestingly, there is little difference between South African learners and the international average in terms of student sense of belonging at Grade 5 level.

Nearly one-quarter (23%) of all learners report experiencing bullying on a weekly basis, with those who almost never experience bullying scoring, on average, 72 points higher than those who were bullied weekly. Boys are more likely to be bullied than girls, with almost half of all male learners (47%) reporting being bullied on a weekly basis, compared with 40% of girls. Bullying is also far more common in public schools, particularly no-fee schools, with almost half (48%) of learners in no-fee schools reporting being bullied on a weekly basis compared with just a quarter of those in independent schools.

Across all three indicators of learners' feelings about mathematics there is a positive relationship between higher levels of enjoyment, confidence and reports of teacher engagement and achievement in the Grade 5 mathematics assessment. While the majority of learners enjoy mathematics and reported finding their teacher engaging, far fewer learners reported being confident in their ability to learn mathematics: less than one in five (16%) said they were very confident in their ability to learn mathematics with one-third of learners stating that they had low levels of confidence in their mathematical ability. And in line with international literature on the importance of self-concept of ability, confidence in one's skills set appears to be particularly important in terms of achievement scores.

Learner self-confidence in mathematics is highest among those in independent schools. One-third (33%) of those in independent schools rate themselves as being very

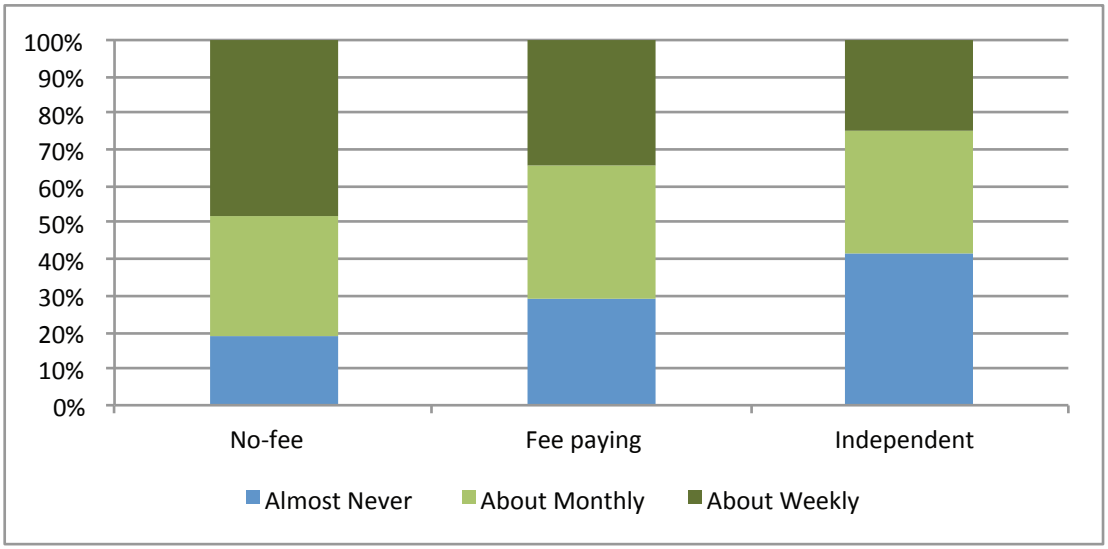

Figure 11: Proportion of learners experiencing bullying, by school type

Table 14: Learner feelings about mathematics and related achievement

	Learner enjoyment of mathematics			Learner confident in mathematics			Learner finds teacher engaging		
	%	Mean	S.E.	%	Mean	S.E.	%	Mean	S.E.
Low	8	350	6.7	33	341	3.5	6	314	5.6
Medium	46	345	3.9	51	376	3.2	25	345	4.1
High	46	416	3.5	16	460	6.0	68	396	3.8

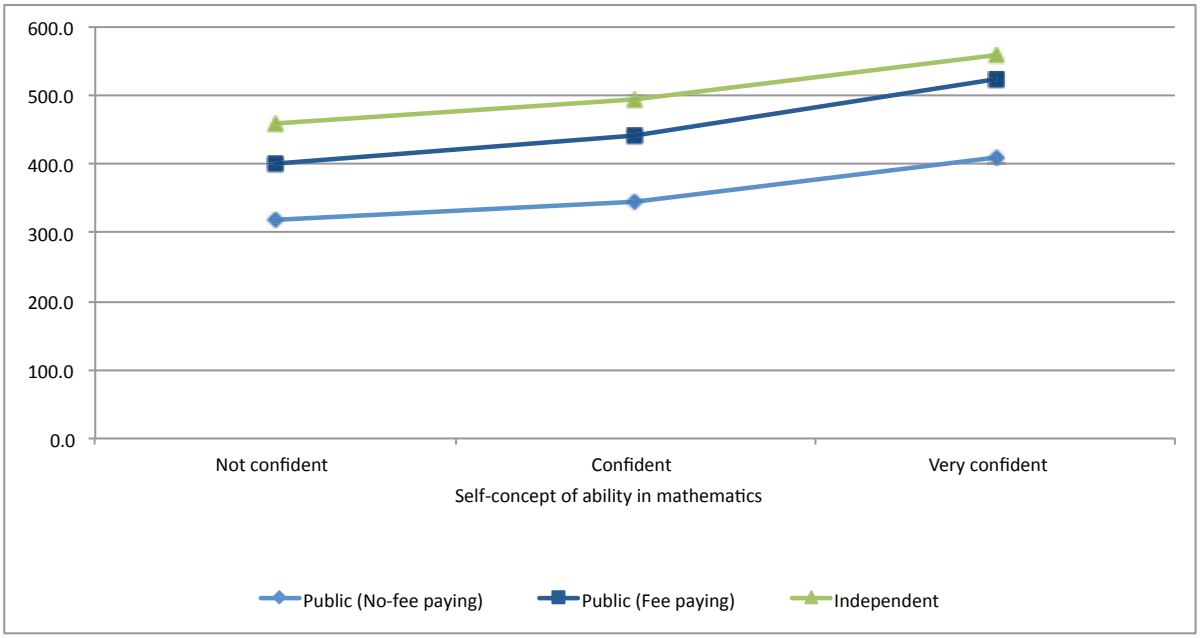

Figure 12: Learner achievement by self-concept of ability in mathematical skills and school type

confident in mathematics in contrast to just 21% and 13% in fee-paying and no-fee public schools respectively. It is important to note, however, that:

- learners in no-fee public schools with very high levels of confidence in their mathematics skills score, on average, higher than those with low levels of confidence in fee-paying public schools; and similarly
- learners in fee-paying public schools with very high levels of confidence in their mathematical skills have higher scores than those in independent schools who only have moderate levels of self-confidence.

KEY FINDINGS & IMPLICATIONS

South Africa is one of the lower performing countries in mathematics in comparison to other participating countries. There are improvements that need to be made and valuable lessons to be learned. Building on what we have learnt from the Grade 9 TIMSS with respect to improvements over time, this first round of TIMSS at the Grade 5 level is an important first step in establishing national and provincial benchmarks against which to record progress. Moreover, this new study offers an opportunity to learn more about activities in the pre-Grade 1 period, in terms of both the early home environment and preschool institutions, and their impact on achievement.

Key findings: Unearthing the "green shoots"

- **South Africa is one of the lower performing countries in mathematics in comparison to other participating countries** and the national average falls short of the lowest international benchmark set by TIMSS.
- **South African achievement is highly unequal.** Three in five South African learners (61%) do not exhibit the minimum competencies in basic mathematical knowledge required at the Grade 5 level. When achievement patterns are broken down by school

type, the patterns reveal the depth of the inequalities present in the system. Approximately 84% of learners in independent schools, 67% of those attending public fee-paying schools and 25% of those at public no-fee schools achieved the minimum level of competency.

- On a more positive note, **just over 1% 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.
- **Girls outperform boys.** More than four out of ten girls (41%) scored above the Low benchmark, compared to only 36% of boys. Interestingly this is not the case in the Grade 9 TIMSS assessment in mathematics where no significant gender differences are observed.
- **Provincial performance varies considerably.** The Western Cape is the highest performing province, while the Eastern Cape is the lowest. The difference between the highest and lowest performing provinces is 98 points, nearly one standard deviation.
- **What parents do matters alongside what parent have.** Socio-economic indicators such as parents' level of education and the number of books in the home are positively related to learner achievement: those with more resources have higher mathematics scores. Many features of the early educational environment experienced by learners have also been shown to improve performance, including engagement in early literacy and numeracy activities and having parents with high educational expectations.
- **Good quality preschool settings offer another important contextual boost for learners.** The preschool experience of learners in public fee-paying and independent schools appears to have a positive impact on their performance, while the performance of learners from no-fee public schools does not appear to benefit from this experience.
- **The more "good" contexts learners experience, the better.** The more positive inputs – household resources, educationally rich activities and settings – a learner experiences, the higher their performance in mathematics. However, there does not appear to be any interaction between these different "inputs": that is, one "good" context does not make up for a "bad" one, but rather the positive effects are cumulative.
- **The learning environment matters for individual achievement.** In terms of the learner's own experiences in the classroom, bullying is negatively related to mathematics achievement, while confidence in one's own ability to learn appears to be an important positive contributor.

Nurturing the "green shoots": Policy recommendations

- **There are potential points (or green shoots) at which to improve mathematics scores.** With improved class pedagogical inputs and school climate, all learners can improve their mathematics scores. One third of the learners in no-fee schools scored between 325 and 400 points. With additional "good" inputs and learning contexts, this group has the potential to improve to above the low benchmark of 400 points. Another group to focus on are the high-performing schools and learners. The 5% who scored above 550 points in 2015 must be increased to 6% in TIMSS 2019.
- **Decrease educational inequalities.** The provincial departments of education must set their provincial mathematics achievement targets for TIMSS 2019 and must implement educational strategies suited to their contexts. An acceleration of pro-poor strategies is required to improve the home and school contexts of learners from no-fee schools.
- **Boys, especially those from poorer environments and schools, are a vulnerable group** which must be focused on in order to reduce grade repetition, bullying and other behaviours which impede achievement.
- **Quality investment in the early years is crucial for those most in need.** While it is promising that early years education is approaching universal provision – 9 in 10 children attend some kind of pre-school setting before entering Grade 1 – it appears that the quality of pre-school education that learners receive is far from equal, failing the most disadvantaged and most in–need learners
- **Classroom teaching must emphasise a solid knowledge base** which will form the basis for problem solving activities.
- **Support parents and care-givers by emphasising learning activities** that they could implement with young children at home to improve their school readiness.
- **Highlighting the importance of self-regulatory and socio-emotional skills, and other non-tangible assets** alongside academic achievement may help improve performance by positively influencing the ways young people experience their learning environment, particularly with respect to bullying and their self-concept of ability.
- **Accelerate the provision of pedagogical resources**, like libraries, computers and specialist rooms to schools.
- The national narrative must **reinforce the value of education** and the role of both the home and school in helping to improving learning outcomes.

The South African part of the Trends in International Mathematics and Science Study (TIMSS) was conducted by the Human Sciences Research Council (HSRC). TIMSS is cross-national assessment of the mathematics and science knowledge of fourth Grade and eighth Grade learners. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare learner educational achievement across borders.

South Africa participated in the TIMSS Mathematics assessment at the Grade 5 level. The TIMSS Numeracy instrument was administered to learners. These results are presented on the TIMSS Mathematics scale. As this is the first time that the country is participating at the Grade 5 level, the study serves as a baseline against which future results may be compared. The importance of developing mathematical skills and acquiring the requisite mathematical knowledge cannot be over emphasised as learners are equipped with problem solving and analytical skills, both of which are important aspects of nurturing effective future citizens. TIMSS Numeracy 2015 provides a mechanism to assess mathematical competences of Grade 5 learners in order to make informed decisions about how best to improve teaching and learning in mathematics.

We use the metaphor of "green shoots" in this analysis to highlight the key findings and their implications for policy and programme directions. The emergence of green shoots in nature represents the potential for growth, and, if nurtured, these shoots will produce strong, healthy and resilient plants.

Related Publications

Mullis, I.V.S., Martin, M.O., Foy, P and Hooper, M (2016). *TIMSS 2015 International Results in Mathematics*. Chestnut Hill, MA: Boston College.

Reddy, V., Prinsloo, C., Arends, F., Visser, M., Winnaar, L., Feza, N., Rogers, S., Janse van Rensburg, D., Juan, A., Mthethwa, M., Ngema, M. & Maja, M. (2012) *Highlights from TIMSS 2011: the South African perspective*.

Reddy, V., Zuze, TL., Visser, M., Winnaar, L., Juan, A., Prinsloo, CH., Arends, F. & Rogers, S. (2015) *Beyond Benchmarks: What twenty years of TIMSS data tell us about South African Education*. Cape Town: HSRC Press.

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This study is a collaboration between the Department of Basic Education and the Human Sciences Research Council.

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