TIMSS 2015

Highlights of Mathematics and Science Achievement of Grade 9 South African Learners

Nurturing green shoots

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WHAT IS TIMSS?

The Trends in International Mathematics and Science Study (TIMSS) is an assessment of the mathematics and science knowledge of fourth and eighth grade students around the world. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare students' educational achievement across borders.

TIMSS was first administered in 1995, and every four years thereafter – 1999, 2003, 2007, 2011 and 2015. For participating countries TIMSS provides a series of trend measures. Fifty-nine countries and nations and 425 000 students participated in TIMSS in 2015.

TIMSS is designed to align broadly with mathematics and science curricula in the participating countries. The results, therefore, suggest the degree to which students have learned the mathematics and science concepts and skills likely to have been taught in school. TIMSS also collects background information on students, teachers and schools to allow cross-national comparison of educational contexts that may be related to student achievement.

TIMSS estimates mathematics and science achievement and attempts to explain students' performance using contextual information. The TIMSS design also offers participating countries an opportunity to measure changes over time. The goal of the study is to help countries make informed decisions about how to improve teaching and learning in mathematics and science.

TIMSS assessment framework

TIMSS uses the curriculum as the major organising concept in considering how educational opportunities are provided to students and the factors that influence the way students use these opportunities. The TIMSS Assessment Model has three aspects: the intended curriculum, the implemented curriculum, and the attained curriculum. The intended curriculum refers to the mathematics and science that students are expected to learn as defined in countries' curriculum policies, which are referred to as the Curriculum Assessment Policy Statements (CAPS) in the South African context. The implemented curriculum refers to the way the educational system should be organised to facilitate this learning (what is actually taught in classrooms, the characteristics of those teaching the learning content, and how it is delivered) and the attained curriculum refers to what students have learned and what they think about learning these subjects.

TIMSS 2015 in South Africa

The TIMSS 2015 sample for South Africa was drawn from the 2013 Department of Basic Education list of all schools in South Africa, which comprised 10 009 schools (9 099 public and 910 independent schools), that offered Grade 9 classes. Statistics Canada drew the South African sample by using the province, school type (public and independent) and language of learning and teaching (Afrikaans, English and dual medium) as stratification variables. A total of 300 schools were sampled, of which 292 agreed to participate in the study. A total of 12 514 learners, 334 mathematics and 331 science teachers participated in the study conducted by the Human Sciences Research Council.

Internationally, TIMSS is tested at the Grade 8 level. However, the earlier South African data showed that a high number of learners did not attempt to answer many of the items, which made estimating achievement scores extremely difficult. To provide better estimates, in 2003 South Africa assessed Grade 8 and 9 learners, and in TIMSS 2011 and 2015 we assessed Grade 9 learners.

Why TIMSS for South Africa?

Mathematics and science competence is important for social and economic development. It is therefore important for a country to measure and monitor the performance of its learners in these key subject areas in order to assess the health of the educational system.

TIMSS is a widely recognised international testing programme aimed largely at assessing whether countries are making progress in education over time. Trend data from TIMSS questionnaires provide a dynamic picture of changes in the implementation of educational policies and practices and help to raise new issues relevant to improvement efforts.

1. SOUTH AFRICAN MATHEMATICS AND SCIENCE ACHIEVEMENT IN RELATION TO PARTICIPATING COUNTRIES

Thirty-six countries participated in TIMSS 2015 at the Grade 8 level and three countries at the Grade 9 level (Norway, Botswana and South Africa). We will describe the achievement scores using three measures, namely (i) average mathematics and science scale scores in TIMSS 2015 for participating countries; (ii) change in mathematics and science achievement scores for countries which participated in TIMSS 2003 and TIMSS 2015 and (iii) the TIMSS benchmarks to present the mathematics and science achievement profile of selected countries.

South African mathematics and science achievement

Tables 1 and 2 describe the TIMSS mathematics and science scale scores and standard errors for the 39 participating countries in rank order. The TIMSS achievement scale has been set with a centrepoint of 500 and a standard deviation of 100.

For mathematics, the top five ranked countries were from East Asia – Singapore (621), the Republic of Korea (606), Chinese Taipei (599), Hong Kong SAR (594) and Japan (587). The five lowest performing countries were Botswana (391), Jordan (386), Morocco (384), South Africa (372) and Saudi Arabia (368). Of these five countries, the only country with a statistically significantly different score to that of South Africa was Botswana.

For science, four of the top five ranked countries were from East Asia – Singapore (597), Japan (571), Chinese Taipei (569), the Republic of Korea (556) and Slovenia (551). The five lowest performing countries were Saudi Arabia (396), Morocco (393), Botswana (392), Egypt (371) and South Africa (358).

The top-performing countries were from Asia and the Northern Hemisphere and the lowest performing countries were Middle-Eastern and African.

Change in TIMSS performance from 2003 to 2015

We analysed the change in TIMSS mathematics and science scores for the 25 countries that participated in TIMSS 2003 and TIMSS 2015. Bars to the right in Figure 1 indicate the increase in scores from TIMSS 2003 to TIMSS 2015, and bars to the left show a decrease in scores. The length of the bar represents the amount by which the country score has changed.

Of the 25 countries included in the analysis, 19 improved in mathematics scores between the two cycles and five decreased (New Zealand by 1 point, Egypt by 14 points, Hungary by 15 points, Jordan by 38 points, and Malaysia by 43 points). For science, there was decrease in the achievement scores of 12 countries.

South Africa has shown the biggest positive change, with an improvement of 90 points in science and 87 points in mathematics. South Africa started with very low performance scores in 2003 and this upward shift translates to an overall performance improvement by approximately two grade levels between 2003 and 2015.

Mathematics and science achievement profile using the TIMSS 2015 benchmarks

TIMSS created a set of international benchmarks to provide countries with more meaningful descriptions of what learners know. TIMSS defines four categories of benchmarks, namely: scores between 400 and 475 points are classified as achievement at a low level, scores between 475 and 550 points as achievement at an intermediate level, scores from 550 to 625 points as achievement at a high level and scores above 625 points as achievement at an advanced level.

Figure 2 describes the performance profile using the TIMSS international benchmarks for a selection of countries that participated in TIMSS 2015. We illustrate the performance of the five highest performing countries, five countries around the centrepoint and the five lowest performing countries. Each set of countries has a different performance profile.

In the five highest performing countries, almost all learners scored above the low TIMSS benchmark of 400 points. Over three-quarters of these learners achieved scores above 550 (high benchmark) points.

In the five countries performing close to the centrepoint, between 9% and 16% of learners performed below the 400 point mark. Close to 30% of these learners achieved scores above 550 points (high benchmark). In the five lowest performing countries, between half and two-thirds of the learners scored below 400 points (they did not

achieve the minimum competency). In these countries, less than 20% of learners scored above 475 points (intermediate benchmark). While South Africa is one of the lowest performing countries, it is pleasing to note that 1% of learners scored in the advanced category (>625 points). None of the other lowest performing countries have learners scoring at the advanced level.

Table 1: Mathematics performance across TIMSS 2015 countries

Country	Average Scale Score	SE
Singapore	621	(3.2)
Korea, Rep. of	606	(2.6)
Chinese Taipei	599	(2.4)
Hong Kong SAR	594	(4.6)
Japan	586	(2.3)
Russian Federation	538	(4.7)
Kazakhstan	528	(5.3)
Canada	527	(2.2)
Ireland	523	(2.7)
United States	518	(3.1)
England	518	(4.2)
Slovenia	516	(2.1)
Hungary	514	(3.8)
Norway (9)	512	(2.3)
Lithuania	511	(2.8)
Israel	511	(4.1)
Australia	505	(3.1)
Sweden	501	(2.8)
TIMSS Scale Centrepoint	**500**	
Italy	494	(2.5)
Malta	494	(1.0)
New Zealand	493	(3.4)
Malaysia	465	(3.6)
United Arab Emirates	465	(2.0)
Turkey	458	(4.7)
Bahrain	454	(1.4)
Georgia	453	(3.4)
Lebanon	442	(3.6)
Qatar	437	(3.0)
Iran, Islamic Rep. of	436	(4.6)
Thailand	431	(4.8)
Chile	427	(3.2)
Oman	403	(2.4)
Kuwait	392	(4.6)
Egypt	392	(4.1)
Botswana (9)	391	(2.0)
Jordan	386	(3.2)
Morocco	384	(2.3)
South Africa (9)	372	(4.5)
Saudi Arabia	368	(4.6)

Table 2: Science performance across TIMSS 2015 countries

Country	Average Scale Score	SE
Singapore	597	(3.2)
Japan	571	(1.8)
Chinese Taipei	569	(2.1)
Korea, Rep. of	556	(2.2)
Slovenia	551	(2.4)
Hong Kong SAR	546	(3.9)
Russian Federation	544	(4.2)
England	537	(3.8)
Kazakhstan	533	(4.4)
Ireland	530	(2.8)
United States	530	(2.8)
Hungary	527	(3.4)
Canada	526	(2.2)
Sweden	522	(3.4)
Lithuania	519	(2.8)
New Zealand	513	(3.1)
Australia	512	(2.7)
Norway (9)	509	(2.8)
Israel	507	(3.9)
TIMSS Scale Centrepoint	**500**	
Italy	499	(2.4)
Turkey	493	(4.0)
Malta	481	(1.6)
United Arab Emirates	477	(2.3)
Malaysia	471	(4.1)
Bahrain	466	(2.2)
Qatar	457	(3.0)
Iran, Islamic Rep. of	456	(4.0)
Thailand	456	(4.2)
Oman	455	(2.7)
Chile	454	(3.1)
Georgia	443	(3.1)
Jordan	426	(3.4)
Kuwait	411	(5.2)
Lebanon	398	(5.3)
Saudi Arabia	396	(4.5)
Morocco	393	(2.5)
Botswana (9)	392	(2.7)
Egypt	371	(4.3)
South Africa (9)	358	(5.6)

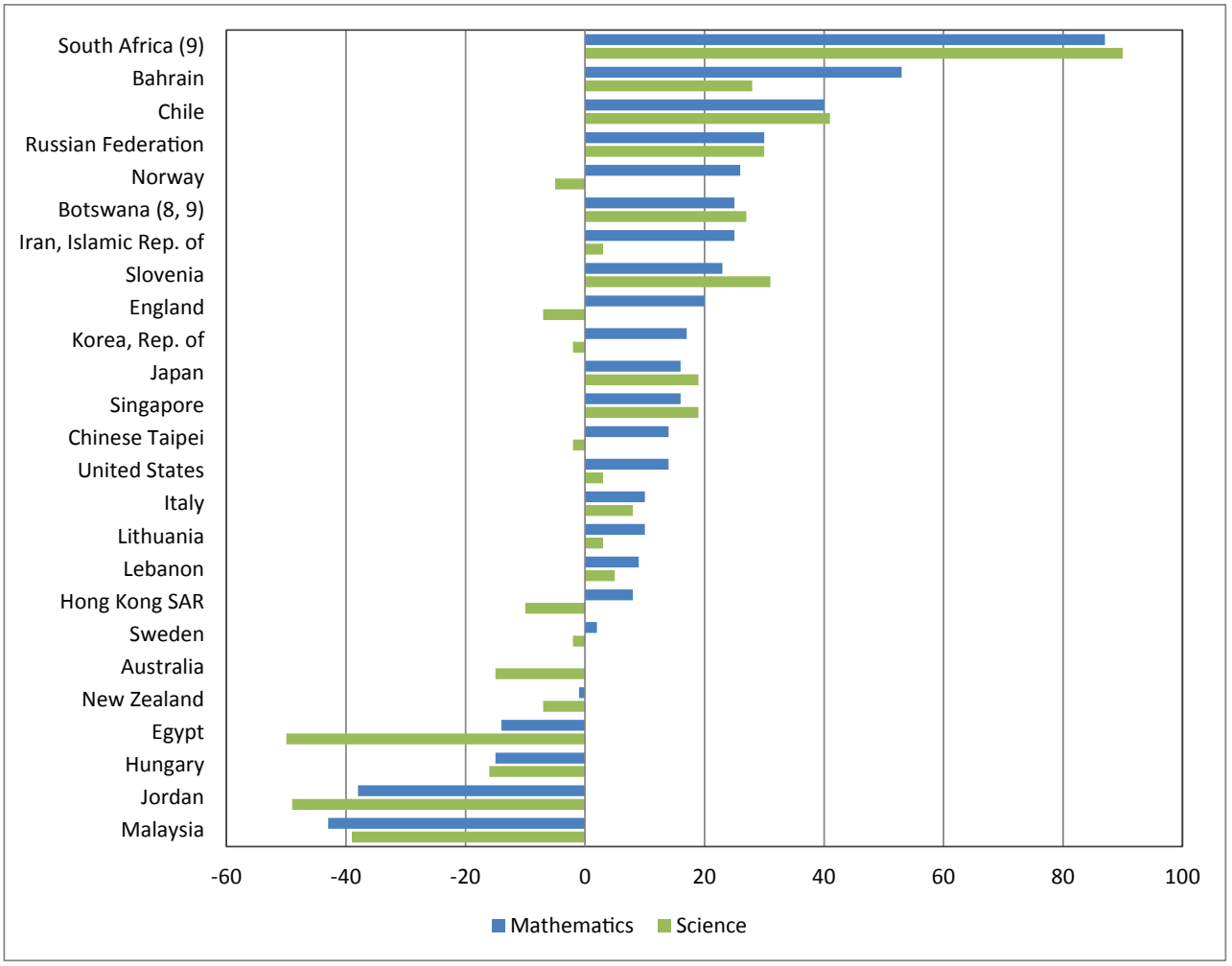


Figure 1: Change in average score of selected countries from 2003 to 2015

**South Africa participated at Grade 9 level in both years and Botswana tested at Grade 8 in 2003 and Grade 9 in 2015.*

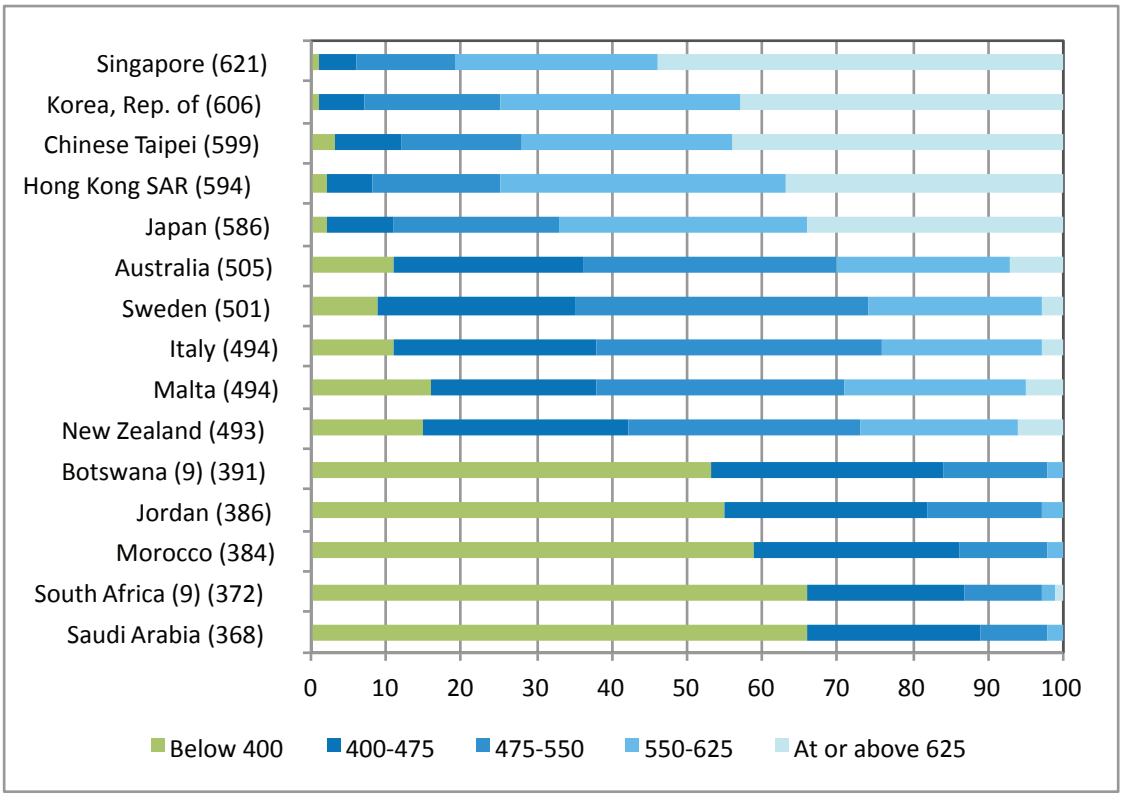


Figure 2: Mathematics achievement profile of selected countries, 2015

2. SOUTH AFRICAN TIMSS 2015 PERFORMANCE AND CHANGES FROM TIMSS 2003 TO TIMSS 2015

We describe (i) South Africa's mathematics and science performance in TIMSS2015; (ii) the changes in the South African average scale score performance between TIMSS2003 and TIMSS2015 and (iii) the South African mathematics and science achievement profile in TIMSS2003, 2011 and 2015, using TIMSS benchmarks.

South Africa's mathematics and science performance in TIMSS 2015

South Africa achieved a mathematics score of 372 (SE 4.5) and a science score of 358 (SE 5.6) in TIMSS 2015. South Africa is one of the lower performers of the 39 participating countries.

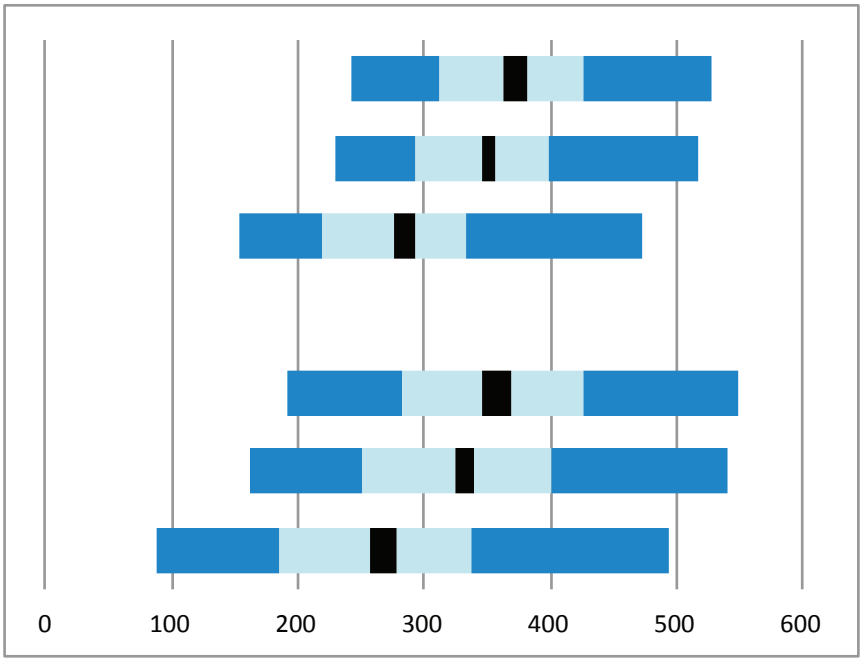
The score distribution for mathematics and science, from the 5th to 95th percentiles, was 286 points and 358 points respectively. South Africa has a wide score distribution, reflecting high educational inequalities which mirror the societal inequalities. The range of scores is greater for science than for mathematics, indicating higher inequalities for science than for mathematics.

Performance trends from TIMSS 2003 to TIMSS 2015

The TIMSS methodology provides an opportunity for a country to measure change in its own performance over time. Figure 3 summarises the South African performance for TIMSS 2003, 2011 and 2015 for both mathematics and science.

In the TIMSS 2011 reports we showed that the South African performance for mathematics and science was the same for the 1995, 1999 and 2003 cycles (Reddy et al., 2012; Reddy et al., 2015). Between TIMSS 2003 and 2011, the mathematics and science scores improved by 67 and 64 points respectively. Between 2011 and 2015 the mathematics and science scores improved by a further 20 and 26 points respectively.

MATHEMATICS	Average scale score (SE)
TIMSS 2015	372 (4.5)
TIMSS 2011	352 (2.5)
TIMSS 2003	285 (4.2)
SCIENCE	
TIMSS 2015	358 (5.6)
TIMSS 2011	332 (3.7)
TIMSS 2003	268 (5.5)



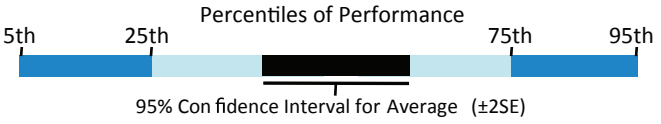


Figure 3: Trends in Grade 9 mathematics and science performance, 2003, 2011 and 2015

Three findings are particularly noteworthy when considering the TIMSS performance from 2003 to 2015.

- Over this period, there was an improvement of 87 points for mathematics and 90 points for science, more than for any other country with comparable data. This is equivalent to an improvement in performance of approximately two grades.
- The highest gains were achieved at the lower end of the achievement distribution, which means that those with the lowest levels of achievement are improving.
- The percentile graph (shown in Figure 3) provides information regarding the overall shape and size of the achievement distribution. The longer the line, the wider the variation in scores, which, in turn, suggests big educational inequalities. The distribution of scores is still wide, but has narrowed from 2003 to 2011, and again to 2015, showing a narrowing of the gap between the top and the bottom performers. This is true for both mathematics and science. Educational inequalities are decreasing, albeit slowly.

Mathematics and science achievement profile at the TIMSS benchmarks

To provide a more textured picture of South African performance, in addition to the four international benchmarks described above, we have included a fifth South African category. The fifth category refers to the percentage of learners who achieved between 325 and 400 score points. We call this group the *potential* group, as these learners have the potential to improve their scores to above 400 points. Figure 4 illustrates the South African profile at the different TIMSS benchmarks (including the South African potential group) for mathematics and science for 2003, 2011 and 2015.

In 2015, 34% of mathematics learners and 32% of science learners achieved a score of over 400 points. This means that only one-third of South African Grade 9 learners demonstrated achievement at the minimal level in mathematics and science. These learners form the pool who could choose mathematics and science as a school subject in the post-Grade 9 phase. The encouraging news is that 3.2% of mathematics learners and 4.9% of science learners can be categorised at the high levels of achievement (i.e. scoring over 550).

However, it is an interesting exercise to examine the change in the percentage of South African learners who performed above the 400 point TIMSS benchmark for mathematics and science between 2003 and 2015.

In 2003, a mere 10.5% of mathematics learners achieved a score above 400 points. This increased to 24.5% in 2011 and to 34.3% in 2015. Therefore, between 2003 and 2015 there was an increase of 24 percentage points in the number of learners scoring above 400. Science scores followed a similar pattern. In 2003, 13.1% of science learners achieved a score of over 400. This percentage increased to 25.2% in 2011 and to 32.3% in 2015. Between 2003 and 2015 there was an increase of 19 percentage points.

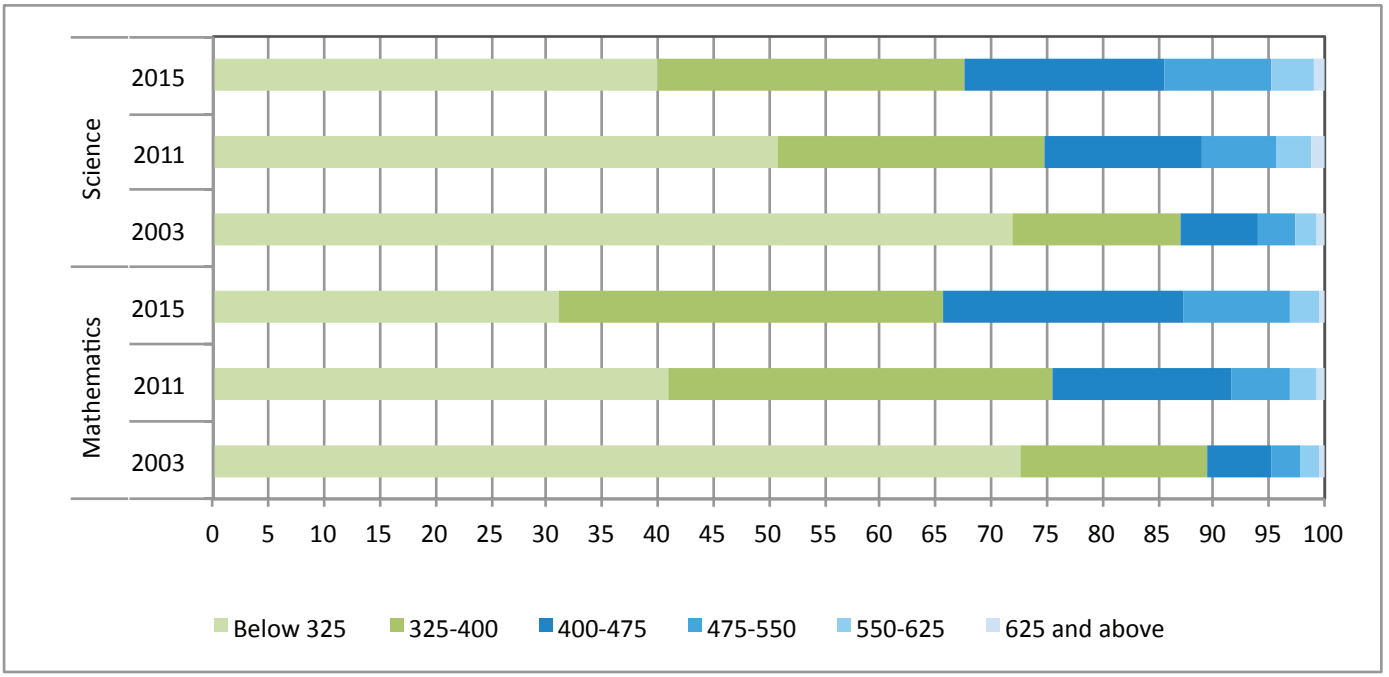


Figure 4: Percentage learners performing at the benchmarks, 2003, 2011 and 2015

It is also interesting to observe the changes in the proportion of learners scoring below 325 points (the South Africa defined benchmark). In 2003, 73% of Grade 9 mathematics learners and 72% of Grade 9 science learners scored below 325 points. This has decreased to 31% of mathematics learners and 40% of science learners in 2015. Performance in mathematics and science appears to have shifted from a *very low level to a low level*.

3. MATHEMATICS AND SCIENCE PERFORMANCE BY PROVINCE AND SCHOOL TYPE

Achievement by school type: Public fee-paying schools, public no-fee schools and independent schools

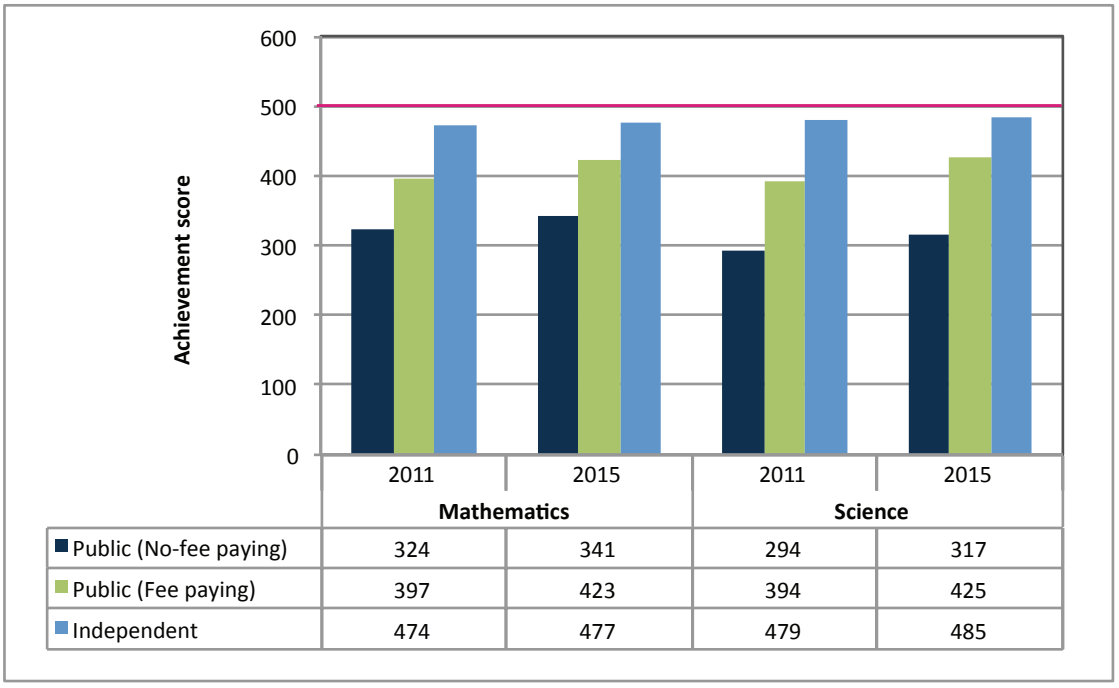
The South African schooling system is made up of 7% independent schools and 93% public schools. South Africa is a highly unequal society and there is high variation in the physical conditions of schools and the contexts in which they are located. This variation is captured by the poverty index of schools (quintile ranking 1 to 5). As part of the government's pro-poor strategy to support education, schools in Quintiles 1, 2 and 3 receive subsidies that make it possible to exempt learners from paying fees. Thus, public schools are differentiated into fee-paying schools and no-fee schools. Of the learners who participated in TIMSS 2015, 65% attended public no-fee schools, 31% public fee-paying schools and 4% independent schools.

Figure 5 shows the average learner scores in mathematics and science for learners in the three school types for TIMSS 2011 and TIMSS 2015.

The average mathematics and science scores for each of the school types are significantly different, with public no-fee schools recording the lowest performance. In TIMSS 2015, the mathematics scores and standard errors for the different school types are: public no-fee schools 341 (3.3) points, public fee-paying schools 423 (10.0) and independent schools 477 (11.5). For science the average scores are: public no-fee schools 317 (4.2), public fee-paying schools 425 (11.9) and independent schools 485 (11.8).

Figure 5 also shows how the increases in TIMSS scores from 2011 to 2015 play out differently across the different school types, with learners in public schools achieving the larger gains:

- The achievement scores of learners who attended public no-fee schools increased by 17 and 23 points for mathematics and science, respectively.



	Mathematics		Science	
	2011	2015	2011	2015
Public (No-fee paying)	324	341	294	317
Public (Fee paying)	397	423	394	425
Independent	474	477	479	485

Figure 5: Performance by school type, 2011 and 2015 (with centrepoint of 500)

- Learners who attended public fee-paying schools increased their scores by 26 and 31 points for mathematics and science, respectively.
- Learners who attended independent schools increased their scores by 4 and 6 points for mathematics and science, respectively. This difference is not statistically significant.
- It is particularly noteworthy that the average scores of the more affluent school types (the independent and the public fee-paying schools) did not reach the centrepoint score of 500.
- The gap between the average mathematics performance of public fee-paying and independent schools narrowed from three-quarters of a standard deviation in 2011 to half a standard deviation in 2015. The gap between public fee-paying and no-fee schools remains at three-quarters of a standard deviation for mathematics and one standard deviation for science.

School type profiles described by international benchmarks

Figure 6 shows the percentage of learners who performed at the different TIMSS benchmarks for mathematics and science by school type for 2011 and 2015.

In 2015, more learners reached the low benchmark of 400 score points in both subjects than in 2011. Nineteen percent of learners in public no-fee schools; 60% of learners in public fee-paying schools; and 81% of learners in independent schools performed at or above the 400 point benchmark in mathematics. Similar figures for science were 16%, 58% and 81% of learners in public no-fee schools, public fee-paying schools and independent schools, respectively. It is a major concern that less than one in five learners in no-fee schools achieved a score of over 400.

Forty percent of mathematics learners and 30% of science learners who attended no-fee public schools achieved a score of between 325 and 400 points. These learners make up the potential category and could move up to a score of 400.

While the profile of the mathematics and science performance levels changed in all school types from 2011 to 2015, it is clear that the public no-fee schools still need the most interventions to improve their performance.

Mathematics and science achievement by province

In South Africa, the national Department of Basic Education (DBE) shares responsibility for basic schooling with

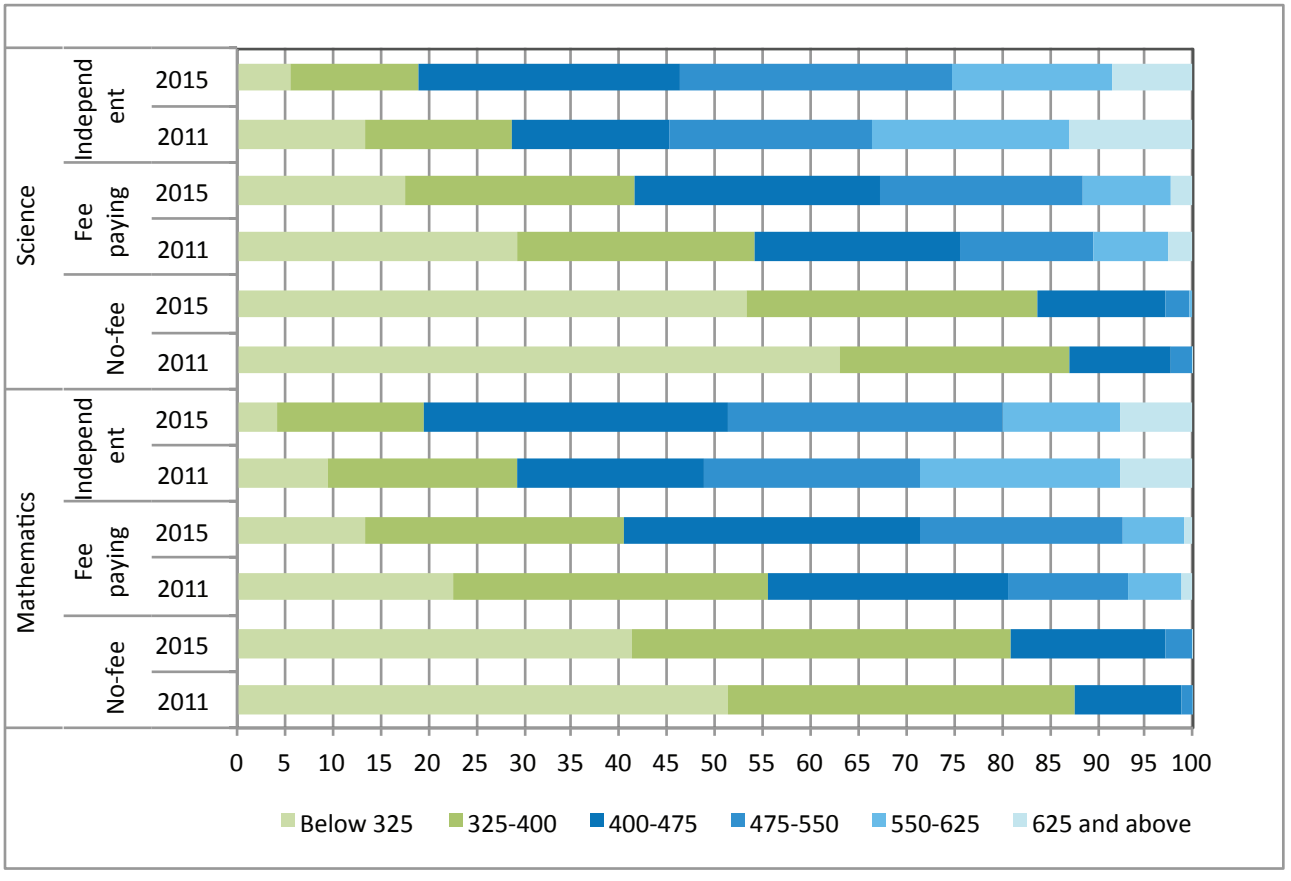


Figure 6: Percentage learners performing at the TIMSS benchmarks for mathematics and science by school type, 2011 and 2015 (including SA highest potential group)

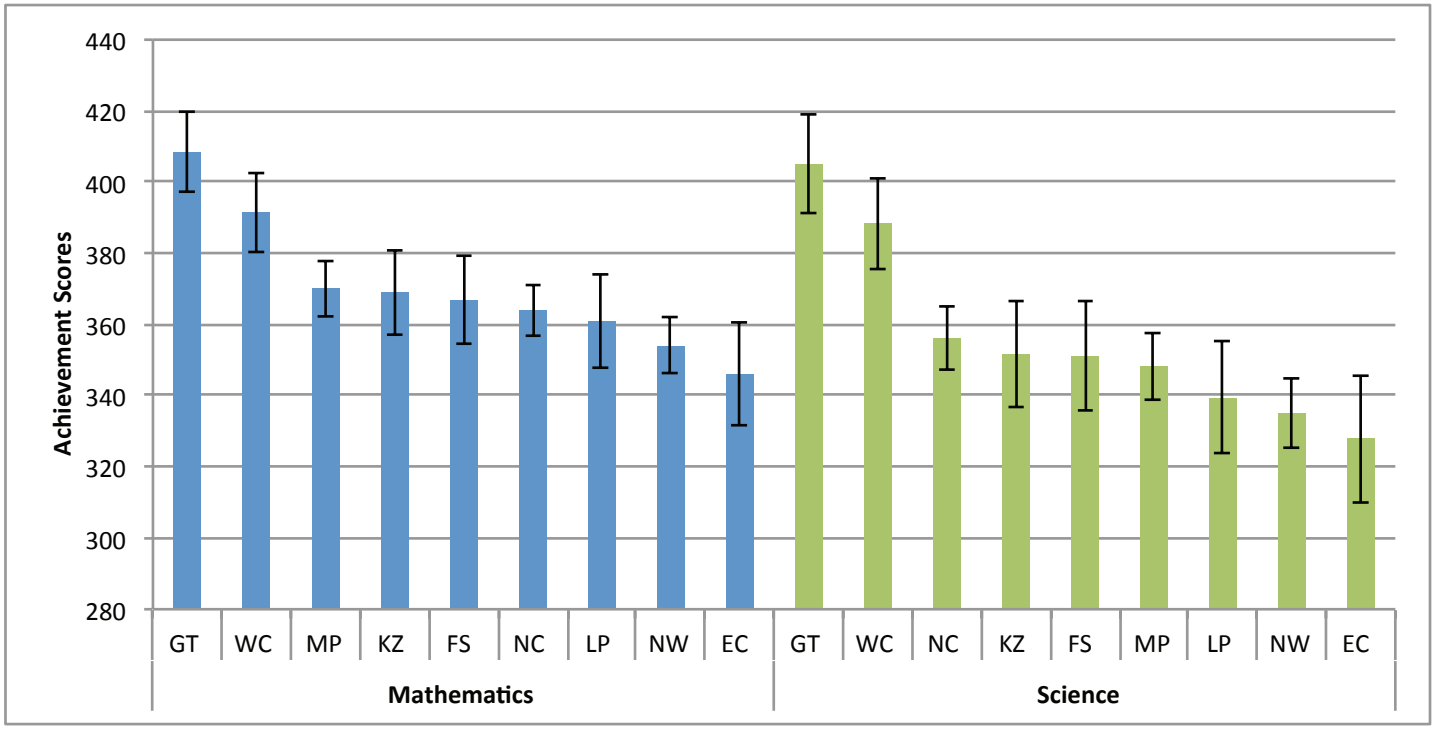


Figure 7: TIMSS 2015 provincial mathematics and science performance, with standard error

provincial departments, as it is the task of each provincial department to finance and manage its schools directly. Given the responsibilities of the provincial departments of education, it is useful to report on provincial performances. TIMSS oversampled the number of schools and learners so that reliable estimates of provincial performances could be provided. The TIMSS 2015 provincial mathematics and science performance is shown in Figure 7.

The rank order of the provinces for TIMSS 2015 mathematics was: Gauteng with a score of 408 (11.4), Western Cape 391(11.0), Mpumalanga 370 (7.8), KwaZulu-Natal 369 (11.8), Free State 367 (12.5), Northern Cape 364 (7.2), Limpopo 361 (13.4), North West 354 (7.9), and Eastern Cape 346 (14.4).

The rank order of the provinces for TIMSS 2015 science was: Gauteng with a score of 405 (13.8), Western Cape 388 (12.7), Northern Cape 356 (8.9), KwaZulu-Natal 352 (14.7), Free State 351 (15.3), Mpumalanga348 (9.6), Limpopo 339 (15.8), North West 335 (10.0), and Eastern Cape 328 (17.6).

Changes in mathematics and science scores from TIMSS 2003 to TIMSS 2015

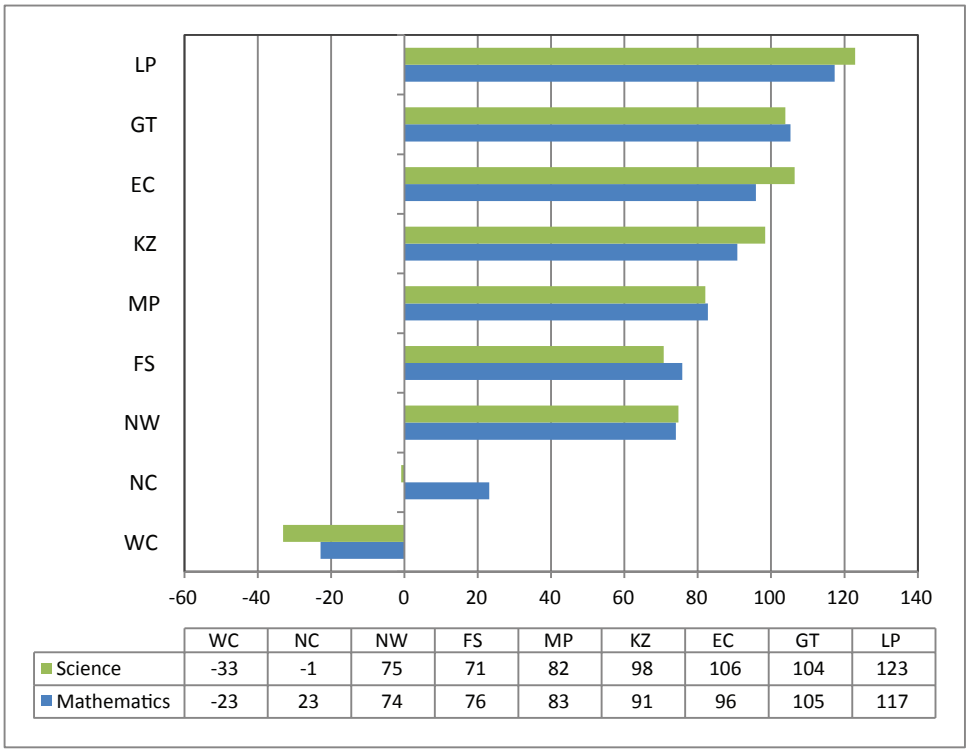
The increase in the national average mathematics and science scores from TIMSS 2003 to TIMSS 2011 to TIMSS 2015 is reflected by an increase in the scores of most provinces. The change in mathematics and science performance from TIMSS 2003 to TIMSS 2015 is shown in Figure 8.

In 2003, the difference in performance between the highest and lowest performing provinces was 170 points for mathematics and 205 points for science. This difference decreased in 2011, to 88 points for mathematics and 127 points for science. In 2015, the difference decreased further to 62 points for mathematics and 77 points for science. This improvement by the lower performing provinces points to a move towards more equitable achievement across the provinces.

Since 2003, the average scale score has increased in eight provinces for mathematics and seven provinces for science. Limpopo has shown the highest average score increase in mathematics and science, namely 117 points and 123 points, respectively. The Western Cape has shown a statistically significant decline in the average scores in both mathematics and science of 23 points and 33 points, respectively. Later, we see how the profile of learners has changed, which could provide an explanation for the changes in the performance of the provinces.

Performance at the TIMSS benchmarks by province

In Figure 9, the provincial mathematics achievement is described in terms of the TIMSS benchmarks. In 2015, the list of provinces, in order of highest to lowest percentage of learners who performed above the 400 TIMSS points mark for mathematics was: Gauteng (49% of learners), Western Cape (44%), KwaZulu-Natal (34%), Free State (32%), Mpumalanga (31%), Limpopo (29%), Northern Cape (28%), North West (25%) and Eastern Cape (24%).



	WC	NC	NW	FS	MP	KZ	EC	GT	LP
Science	-33	-1	75	71	82	98	106	104	123
Mathematics	-23	23	74	76	83	91	96	105	117

Figure 8: Difference in provincial performance in mathematics and science from 2003 to 2015

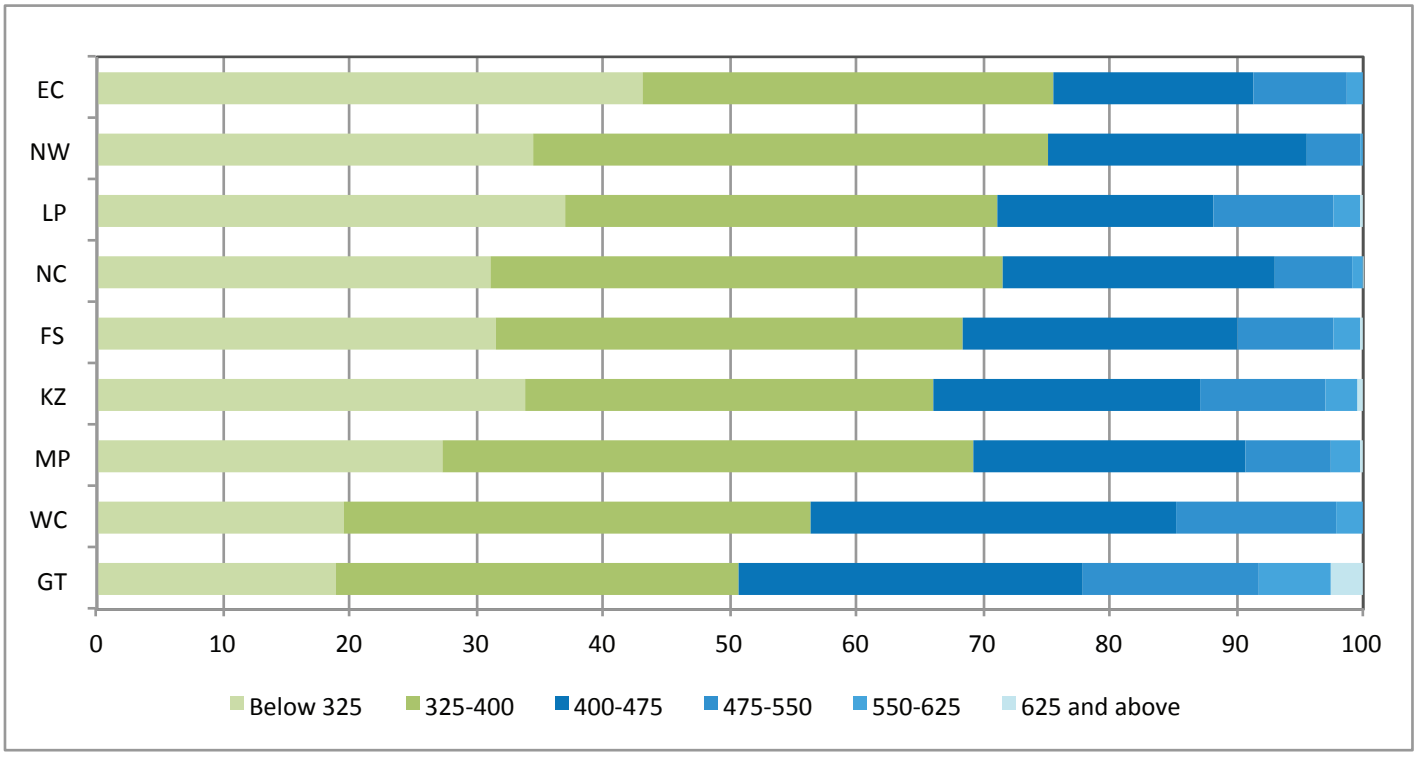


Figure 9: Percentage of learners performing at the TIMSS benchmarks in mathematics by province, 2015

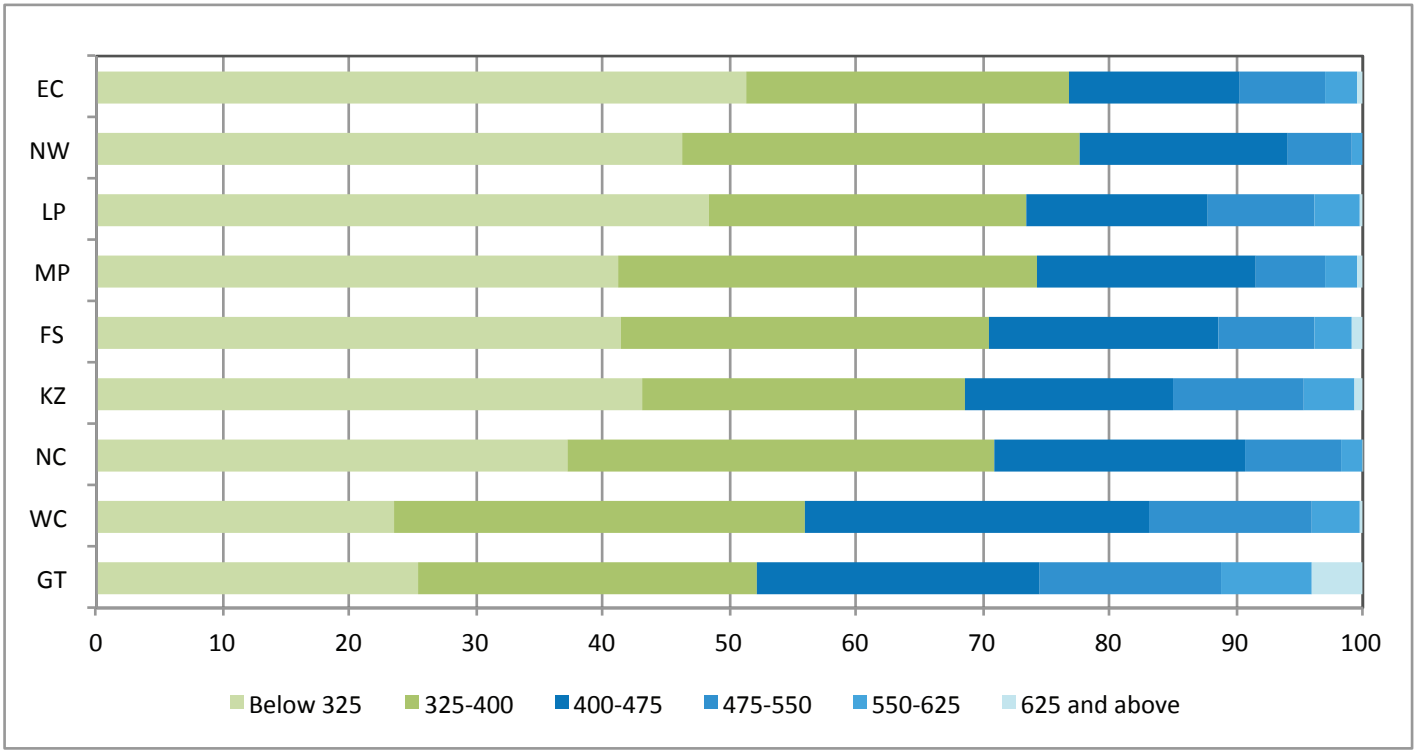


Figure 10: Percentage of learners performing at the TIMSS benchmarks for science by province, 2015

In Figure 10 the science achievement of the various provinces is described in terms of performance at the TIMSS benchmarks. In 2015, the list of provinces, in order of highest to lowest percentage of learners who performed at or above the 400 TIMSS points mark for science was: Gauteng (48% of learners), Western Cape (44%), KwaZulu-Natal (31%), Free State (30%), Northern Cape (29%), Limpopo (27%), Mpumalanga (26%), Eastern Cape (23%) and North West (22%).

A high proportion of learners, especially for mathematics, scored between 325 and 400 points, and could be encouraged, with the appropriate interventions, to move above the 400 point mark.

4. HOW LEARNERS LIVE AND LEARN

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

Figure 11 shows the provincial profile of selected home characteristics for TIMSS 2003, 2011 and 2015.

Home environment

The *number of books at home* is an indication of the socio-economic status of learners. Having more books at home is positively related to higher performance. The difference in the average performance of learners with fewer than 25, versus more than 25, books at home is 47 points for mathematics and 58 points for science. Only one-fifth of the learners reported having more than 25 books at home in 2015.

The *highest educational level of the household* is positively associated with learner performance. The difference in performance for households with a post-matric qualification and those without is 43 points for mathematics and 55 points for science. The educational level of parents is reported to have improved considerably between 2003 and 2015 (cautionary note: this measure was reported by the learners with 17% indicating '*I don't know*'). This pattern was observed in all provinces except the Western

	% of learners with more than 25 books at home			% of learners with either of their parents or caregivers having an education above Gr 12			% of learners who always or almost always speak the language of the test at home		
	2003	2011	2015	2003	2011	2015	2003	2011	2015
WC	39	30	17	34	33	26	74	68	65
GT	22	30	25	26	37	48	27	36	39
NC	24	24	17	19	29	30	77	68	58
FS	21	20	21	22	30	40	23	25	24
NW	29	25	19	23	29	36	15	20	22
MP	23	23	23	25	26	37	16	17	19
KZ	24	17	16	25	28	45	23	17	27
LP	22	23	21	24	30	40	11	13	18
EC	17	14	18	16	25	34	18	16	29
Independent		50	40		60	63		56	57
SA	24	23	21	24	31	41	25	26	31

Figure 11: Findings on selected home characteristics, 2003, 2011 and 2015

Cape, where household educational levels above Grade 12 decreased by eight percentage points between 2003 and 2015.

If a learner's *language of learning and teaching* (LOLT) corresponds to the language frequently spoken by the learner, a positive association with performance is noted, especially in language-intensive subjects like science. The difference in the average scores of learners who always/almost always spoke the LOLT at home and those who *sometimes* spoke the LOLT at home is 60 points for mathematics and 84 points for science. In 2015, almost one-third (31%) of learners used the LOLT at home. This is evidence of a slight improvement since 2003, when only one-quarter of learners spoke the LOLT at home. The comparison between provinces over the period 2003–2015 shows that in all provinces, except the Western Cape and the Northern Cape, more learners were speaking the LOLT at home by 2015. A decrease of nine and 19 percentage points was recorded for the Western Cape and the Northern Cape, respectively.

Individuals

A *positive attitude* towards school, learning and teaching is important in achieving success at school. Learners responded to questions about their self-concept regarding their ability to learn mathematics and science. There is a positive relationship between learners' belief in their ability and their performance. In 2015, the difference between

	% of learners who are very confident in mathematics		% of learners who are very confident in science		% of learners who are never or almost never absent from school
	2011	2015	2011	2015	2015
WC	13	14	18	20	66
GT	13	10	23	24	69
NC	12	9	20	22	64
FS	11	9	23	23	63
NW	9	7	20	21	59
MP	7	10	19	22	70
KZ	7	8	14	15	63
LP	11	12	14	24	73
EC	10	6	12	19	61
Independent	19	16	23	27	71
SA	10	10	17	21	66

Figure 12: Findings on selected individual characteristics, 2003, 2011 and 2015

the scores of confident learners and those of non-confident learners was 89 points in mathematics and 65 points in science. Confidence levels in science increased in all provinces and independent schools from 2011 to 2015.

Absence from school has a negative effect on learner performance. Learners in the TIMSS 2015 were asked how frequently they were absent from school. The differences in the average performance of learners who were frequently absent (once a week or more) versus those who were never or almost never absent were 64 points in mathematics and 84 points in science. Two out of every three learners reported never or almost never being absent from school.

School context

Schools with *discipline and safety problems* do not provide environments that are conducive to either teaching or learning. A stable environment in which teachers and learners feel safe and where poor discipline does not occur is strongly associated with high performance. On average, learners who have almost never experienced bullying scored 68 points more for mathematics and 97 points more for science than learners who were bullied on a weekly basis. Close to one in five learners (17%) experienced bullying on a weekly basis. Western Cape learners reported the lowest exposure to bullying.

One of the goals of the Department of Basic Education's *Action Plan to 2019* is to ensure that all learners have *access to their own textbooks*. Nationally, 82% of the learners reported having their own mathematics textbooks, compared with 69% for science textbooks. Learners who had their own textbooks scored 24 points higher for mathematics and 31 points higher for science than those who did not have a textbook. In KwaZulu-Natal, only 42% of learners reported having a science textbook.

There is a strong positive association between learners' achievement and the *emphasis placed on academic success* by the school. Learners who attended schools that placed a high emphasis on academic success scored 34 points higher on average for mathematics and 38 points higher for science than those who placed moderate emphasis on academic success. In 2011, 41% of mathematics learners were taught by teachers who placed high or very high emphasis on academic success and this increased to 44% in 2015.

Teachers

Mathematics and science teachers' responses to the questionnaires are not nationally representative, but are indicative of the views of the teachers sampled in the study. In 2015, 46% of TIMSS mathematics and 48% of science learners were taught by female teachers. In terms of qualifications, 73% of mathematics learners and 61% of science learners were taught by teachers who had completed a degree – this is an improvement on the position in 2011. Fifty-six per cent of mathematics learners and 62% of science learners were taught by teachers with 10 or more years of teaching experience. This is in line with the international average.

Professional satisfaction for South African mathematics teachers was high in 2015, with 48% of mathematics learners and 59% of science learners being taught by teachers who are very satisfied with their profession. Internationally, 50% of mathematics learners and 49% of science learners are taught by teachers who are very satisfied with their profession.

	% of learners who reported being bullied often at school			% of learners who have their own mathematics textbook	% of learners who have their own science textbook	% of learners attending schools that placed high/very high emphasis on academic success (maths teachers' response)		% of learners attending schools with moderate to severe problems with mathematics resources and conditions	
	2003	2011	2015	2015	2015	2011	2015	2011	2015
WC	4	18	11	91	87	56	33	58	18
GT	8	21	14	88	79	47	31	50	46
NC	2	19	16	82	65	18	22	56	53
FS	7	35	22	85	83	27	44	47	40
NW	7	32	20	84	75	37	25	50	66
MP	10	32	18	80	69	32	36	69	69
KZ	20	31	20	71	42	45	40	74	54
LP	23	33	19	86	80	32	60	84	65
EC	20	25	17	77	66	36	52	71	70
Independent		17	8	85	82	82	87	10	10
SA	16	28	17	82	69	41	44	64	53

Figure 13: Findings on selected school characteristics, 2003 and 2015

The curriculum

The TIMSS curriculum and assessment framework is organised around the mathematics content domains of number, algebra, geometry, data and chance and the science content domains of biology, chemistry, physics and earth science. A comparison between the intended South African curriculum and the TIMSS assessment framework reveals 95% mathematics coverage and 91% science coverage.

For mathematics, performance in the number and geometry content areas was close to the overall mean, higher for algebra (by 22 points) and lower for data and chance (by 15 points). For science, performance in the biology and physics content areas was close to the overall mean, higher than the mean for chemistry (by 11 points) and lower in earth science (by 28 points). The earth science topic area is not covered in the natural science curriculum but is included in the geography curriculum.

Almost equal proportions of the TIMSS items test the cognitive domains of knowing, applying, and reasoning. Performance on knowledge items in mathematics was similar to the mean score, lower than the mean on application items (by 9 points) and, surprisingly, South African learners performed higher than the mean on reasoning items (by 11 points). It is concerning that there was a much lower performance than the mean on science knowledge items (by 21 points) and on reasoning items (by 8 points). Surprisingly, South African learners performed better than the mean score on application items (by 10 points).

Achievement by gender

Nationally, in both mathematics and science, girls outperformed boys but this difference is not statistically significant. However, new complexities with regard to gender are emerging. There is a clear boy disadvantage with boys experiencing high levels of bullying and grade repetition.

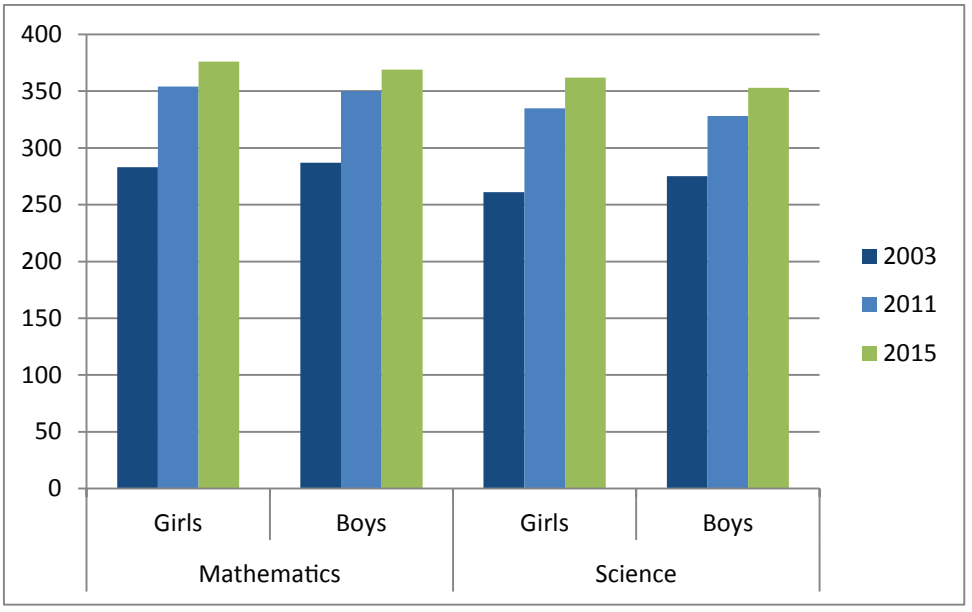


Figure 14: Learner performance by gender, 2003, 2011 and 2015

5. KEY FINDINGS AND IMPLICATIONS

South Africa is one of the lower performing countries in mathematics in comparison to other participating countries. The trend data from 2003 to 2011 highlights the improvements in mathematics and science achievement scores and contexts. This points to potential "green shoots" to nurture in order to reach higher levels of mathematics and science achievement.

Key findings: Unearthing the "green shoots"

- **South African mathematics and science achievement scores have improved from a 'very low' (1995, 1999, 2003) to a 'low' (2011, 2015) national average.** South Africa is still one of the lower performing countries in mathematics and science in comparison to other participating countries. However, from 2003 to 2015 the country has shown the biggest positive improvement of all participating countries in both mathematics (by 90 points) and science (by 87 points), which is equivalent to an improvement in achievement by two grade levels.
- **South African achievement continues to remain highly unequal.** Like other low-performing countries, only one-third of South Africa learners achieved a mathematics and science score above the benchmark of 400 points, a score denoting the minimum level of competence. When the achievement scores are broken down by school type, the patterns reveal vast inequalities. Approximately 80% of learners attending independent schools, 60% of learners at public fee-paying and 20% of learners at public no-fee schools achieved mathematics scores above the minimum level of competency. It is encouraging to note that 3.2% of South African mathematics learners and 4.9% of science learners achieved mathematics and science scores at the high level of achievement (above 550 points).
- **There has been a decrease in provincial inequalities with the lower performing provinces demonstrating the biggest improvements in achievement**. The top performing provinces are Gauteng and the Western Cape while the lowest performing provinces are Limpopo, North West and the Eastern Cape. Between 2003 and 2015, the difference in achievement scores between the highest and lowest performing provinces decreased from 170 points to 62 points for mathematics and from 205 points to 77 points for science.
- **Home conditions conducive to learning are still lacking.** The level of parental education, the number of books in the home and the extent to which the language of the test is spoken at home improved slightly between 2003 and 2015.
- **The availability of school resources has improved.** Eighty-two percent of mathematics learners and 69% of science learners reported having their own textbooks, and teachers reported improved availability of resources for the teaching of mathematics.
- **The condition of schools and the school climate is an ongoing concern.** School safety continues to be a concern, but there have been slight improvements between the TIMSS 2011 and 2015 cycles. However, levels of bullying are still alarmingly high among South African grade 9 learners.
- **Achievement scores and the conditions and climate for learning in homes and schools have been improving but the pace of change is slow.** From 2003 to 2011 the average score improvement for mathematics and science was 30 points for each of the two TIMSS cycles. From 2011 to 2015 the improvement was 20 points. However, while the upward trend is commendable, the rate of change is insufficient to meet the educational expectations and needs of the country. The slow change of contextual conditions contributes to the persistent levels of poverty in the country and the intergenerational nature of inequality.

Nurturing the "green shoots": Learnings to improve mathematics and science achievement

- **Change is possible.** We can identify a number of groups, which will be able to accelerate the pace of change with the appropriate support. These groups include learners who achieved scores of between 325 and 400 points in no-fee schools. This group represents the immense potential that exists among our learners to achieve excellence, given sufficient support. Although many teaching and learning elements are in place, these learners require an improved school climate and better classroom engagement. Higher quality inputs by educators will be required to improve the scores of this group to over 400. Another group to focus on includes the high-performing learners and schools. We need targeted interventions to improve the scores of high performers (550 and above benchmark) and to increase the 3.2% of mathematics learners and 4.9% of science learners who scored above 550 in TIMSS 2015 by at least one percent in TIMSS 2019.

- **We must accelerate the pace of change in achievement.** TIMSS provides an opportunity to evaluate South Africa's performance relative to that of other countries and it offers an opportunity for us to chart our performance trajectory based on our reality. In the next four years multiple strategies must be developed and implemented to improve the TIMSS achievement scores by 40 points and to increase the percentage of learners who achieve the low benchmark in each of the subjects to 45 percent.
- **We need to continue to remove educational inequalities.** Learners who attended no-fee, fee-paying and independent schools were exposed to different home and school environments which are associated with achievement. Differentiated interventions for each of the groups must therefore be developed and implemented. The provincial departments of education must set their provincial mathematics and science achievement target for TIMSS 2019, and then identify a set of intervention strategies to improve provincial performance.
- **Accelerate the provision of pedagogical resources to schools.** While basic resourcing has improved (and must continue to do so), resources for schools must also include pedagogical resources like libraries, laboratories and computers.
- **The environment of learning remains persistently poor, so teaching and learning interventions must focus sharply on what happens inside schools and classrooms.** The school climate must be improved to make it conducive to teaching and learning and teachers with the requisite content knowledge must organise their classrooms in ways that build the knowledge base and competence of learners in mathematics and science.
- **The more "good" elements within both the home and the school contexts that a learner experiences, the better.** These effects are additive, and learners that receive more positive inputs will perform better in mathematics and science.
- **Reinforcing the value of education** must become the national narrative if we wish to push the boundaries and see substantial improvements in the performance of our education system.

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.

TIMSS was first administered in South Africa in 1995, and has continued to be administered in 1999, 2003, 2011 and 2015. This publication reports on South Africa's performance in TIMSS, 2015 at the Grade 9 level, relative to other countries and the trends in mathematics and science achievement from 2003 to 2015.

Mathematics and science competence is important for social and economic development. It is thus important for a country to measure and monitor the performance of its learners in these key subject areas in order to assess the health of the educational system. Learners need to develop mathematical and scientific understandings to manage successfully in school, society and later in workplaces. Technological innovation is driving global competitiveness so the demand for people with mathematical and scientific skills is critical for accelerating growth.

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

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

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.

Reddy, V (Ed). (2006). *Mathematics and Science Achievement at South African Schools in TIMSS 2003*. 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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