CHAPTER 5

National analysis: TIMSS 2003 mathematics

Chapter 3 of this report provided information on international mathematics achievement and on South Africa's performance in relation to the other participating countries. The value of TIMSS could be enhanced with further analysis aimed at providing information to policymakers and practitioners within South Africa, that is, by offering a national analysis. For the national analysis we used the TIMSS international dataset and added the following variables: name of province where the school is located and the ex-racial department of the school.[1] In the national analysis, disaggregated scores were calculated, scores linked to available contextual information, and there was an analysis of change of performance over time (TIMSS 1999 and 2003). The following elements comprised the national analysis undertaken:

- National mathematics participation and performance in TIMSS 1999 and 2003;
- Performance by province;
- Performance by ex-racial department of schools;
- Performance by gender;
- Performance by language of the test; and
- Performance by content area, cognitive domain and question type.

National mathematics participation and performance in TIMSS 1999 and 2003

The average age of South African learners in TIMSS 2003 (administered in November 2002) was 15.1 years. This is 0.4 years lower than the average age of 15.5 years of the TIMSS 1999 sample (administered in 1998). This drop in the average age, from 1998 to 2002, implies that there is either less repetition in the system or fewer learners leave the system and then re-enter. This would suggest that participation patterns in the system are improving.

The TIMSS 2003 national average mathematics scale score was 264 (SE = 5.5). The score in TIMSS 1999 was 275 (SE = 6.8). The 11 point decrease in the average mathematics scale score is not significant (see Chapter 3 for details).

The scores of learners were categorised at the different performance benchmarks. In TIMSS 1999, 13 per cent of the learners scored more than 400 points in the mathematics test, and this decreased to 10 per cent in TIMSS 2003. The low number of learners scoring higher than 400 points in both studies is cause for concern. Without achieving high scores at Grade 8 level, it is unlikely that learners would go on to attain high scores at Grade 12, so restricting their opportunity to pursue tertiary-level studies in science and/or engineering. The second concern is that the percentage of learners who scored higher than 400 has decreased from 13 per cent in TIMSS 1999 to 10 per cent in TIMSS 2003.

Performance by province

In South Africa, the national Department of Education is responsible for developing educational policies. The provincial departments of education are responsible for

1 The ex-racial department of school refers to the categorisation of schools during the apartheid era.

ensuring the implementation of these policies and supporting the delivery of a quality education. Each of the provinces has a different resource base and distinct advantages and disadvantages. It is important to compute the achievement scores for each of the provinces so that provincial policy-makers remain informed about the state of education in their area, and can then introduce strategies designed to improve matters. Appendix 2 provides a description of schools in the TIMSS 2003 sample, by province and by ex-racial department of the school.

Provincial scores

In South Africa, we oversampled the number of schools for the TIMSS national sample, so that there would be a sufficient number of cases to ensure the calculation of provincial scores. Table 5.1 indicates the average provincial mathematics scale score in TIMSS 2003.

Table 5.1: Average mathematics scale score by province

Province	Average mathematics scale score (SE)	Score range
Western Cape (n = 813)	389 (25.3)	96–677
Northern Cape (870)	333 (13.5)	70–673
Gauteng (774)	304 (19.1)	64–579
Free State (867)	265 (8.6)	45–630
National average (8 952)	264 (5.5)	5–690
Mpumalanga (962)	261 (22.4)	24–650
KwaZulu-Natal (1 632)	255 (13.7)	5–690
North West Province (946)	251 (17.2)	17–572
Eastern Cape (943)	223 (8.3)	5–570
Limpopo (1145)	217 (5.6)	5–455

The top three performing provinces were Western Cape, Northern Cape and Gauteng and the three lowest performing provinces were North West, Eastern Cape and Limpopo. The average provincial score ranges from 389 for the top performing province, Western Cape, to 217 for the lowest performing province, Limpopo – a difference of 172 score points. Three provinces – Western Cape, Northern Cape and Gauteng – scored significantly higher than the national average, and four provinces – KwaZulu-Natal, North West, Eastern Cape and Limpopo – scored significantly lower than the national average. Free State and Mpumalanga scored the same as the national average.

Provincial scores and the Human Development Index

The socio-economic conditions, and thus the conditions for teaching and learning, are different in each of the provinces. The HDI of each province (calculated by GDP per capita, literacy rate – measured by the adult literacy rate and combined primary, secondary and tertiary gross enrolment rates – and life expectancy at birth) provided an indication of socio-economic conditions. Figure 5.1 illuminates the provincial mathematics scale score and the provincial HDI.

Figure 5.1: Provincial mathematics scale scores and HDI, by province

Note: WC = Western Cape; NC = Northern Cape; G = Gauteng; FS = Free State; M = Mpumalanga; KZN = KwaZulu-Natal; NW = North West; EC = Eastern Cape; L = Limpopo.

There seems to be a correlation between the provincial HDI and the provincial achievement scores. Provinces with a higher HDI attained a higher achievement score than provinces with a lower HDI. Gauteng is an exception, and this may be due to the economic inequalities and variances existing across its population.

Comparison of TIMSS 1999 and TIMSS 2003 provincial scores

TIMSS is a trend study and it is useful to compare the provincial average scores over the two periods – 1999 and 2003 (see Table 5.2). Average provincial scores and the rank order of provinces changed. There was an increase in the scores of three provinces, while the others experienced a decrease. The provincial change in scores from TIMSS 1999 to TIMSS 2003 is not statistically significant.

Table 5.2: Provinces where scores increased or decreased between TIMSS 1999 and TIMSS 2003

Provinces where average scores increased	Provinces where average scores decreased
Western Cape (by 11 points)	KwaZulu-Natal (by 37 points)
Northern Cape (by 13)	Eastern Cape (by 26)
Mpumalanga (by 8)	Gauteng (by 14)
	Free State (by 11)
	North West (by 8)
	Limpopo (by 3)

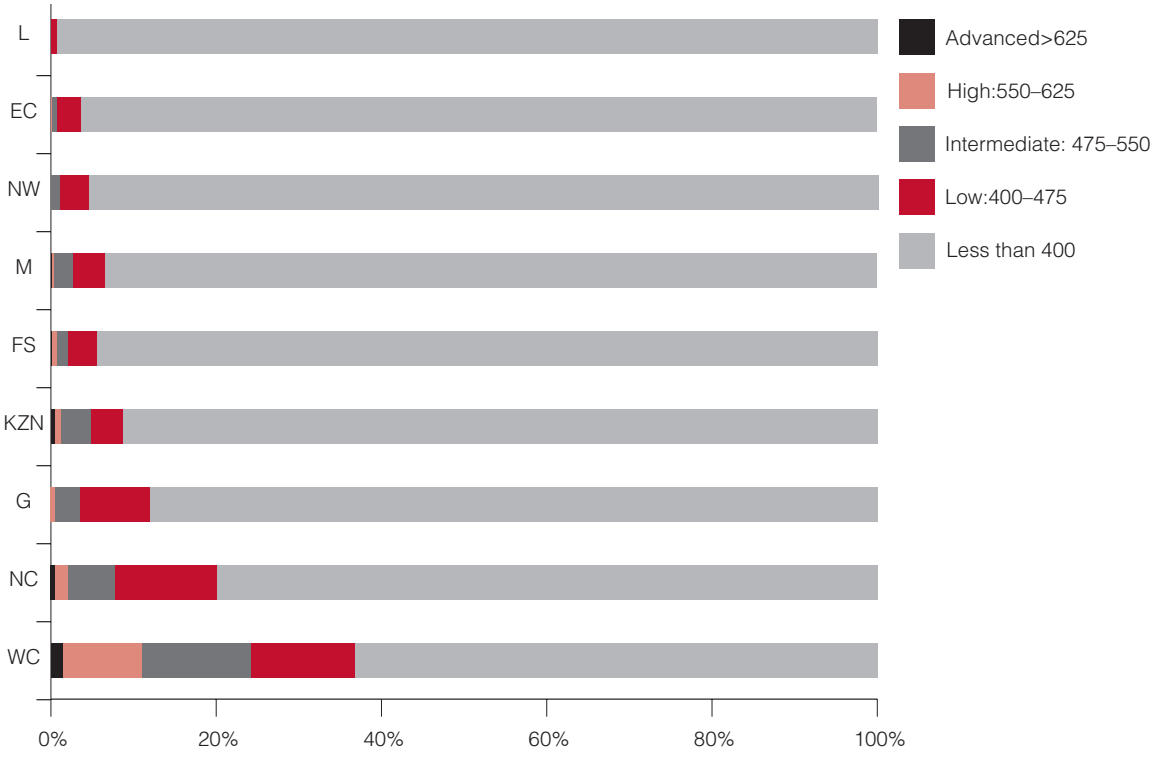
There has been a change in the rank order of some of the provinces from TIMSS 1999 to TIMSS 2003. Two provinces improved their rank order: Free State from 5 to 4 and

Mpumalanga from 7 to 5. Two provinces dropped in rank order: KwaZulu-Natal from 4 to 6 and North West from 6 to 7.

Performance of provinces at the different benchmarks

South Africa had 10 per cent of learners who achieved a score higher than 400 (that is, above the Low Performance Benchmark). Disaggregating the scores by provinces provided the following profile of performance (Figure 5.2). As expected, Western Cape had the highest number of learners achieving scores greater than 400, with just over one-third of learners achieving this. Western Cape is followed by Northern Cape and Gauteng. In Limpopo, none of the learners achieved scores higher than 475.

Figure 5.2: Provincial profile of mathematics performance at different benchmarks



Note: WC = Western Cape; NC = Northern Cape; G = Gauteng; FS = Free State; M = Mpumalanga; KZN = KwaZulu-Natal; NW = North West; EC = Eastern Cape; L = Limpopo.

Performance by ex-racial department of schools

Under apartheid, education was administered separately and unequally to the different racial groups. African schools were the most disadvantaged and white schools the most advantaged. It is important to include an analysis of learners' performance in schools categorised by ex-racial departments of education, as this indicates the performance of schools operating under different conditions, such as infrastructure, management and governance, educational culture, resource base, socio-economic status of learners, and so on. African schools are located in areas where mostly Africans live and these areas are characterised by high levels of poverty and unemployment. Ex-HoA schools, previously for white learners, exist in the better socio-economic conditions associated with a predominately white demographic.

Scores by ex-racial departments of schools

The disaggregated scores of learners in schools categorised by ex-racial departments in TIMSS 2003 are provided in Figure 5.3. There were large differences in the average scores of learners attending different school types. Learners who were in ex-HoA schools had an average score that was close to the international average. The average mathematics scale score (and SE) for schools of the ex-racial departments were as follows:

- ex-Department of Education and Training (DET) schools 227 (2.9);
- ex-House of Representatives (HoR) schools 314 (8.6);
- ex-House of Delegates (HoD) schools 366 (24.9); and
- ex-House of Assembly (HoA) schools 468 (20.3).[2]

Presently, the racial profile of learners in the ex-HoR, ex-HoD and ex-HoA schools indicates that there is racial integration, and that in ex-DET schools the learner population is essentially African.

Figure 5.3: Average mathematics scale scores of learners from the different school types

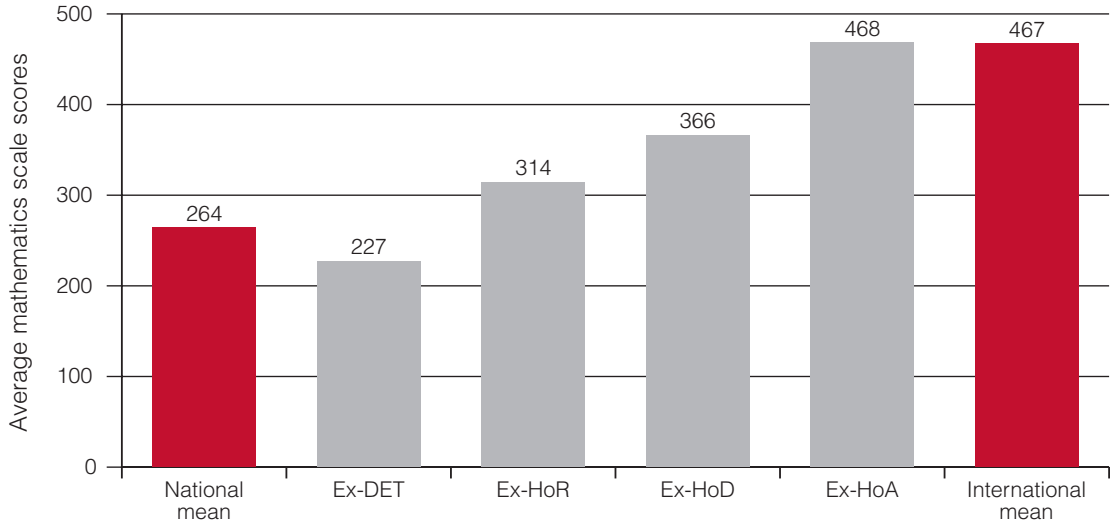
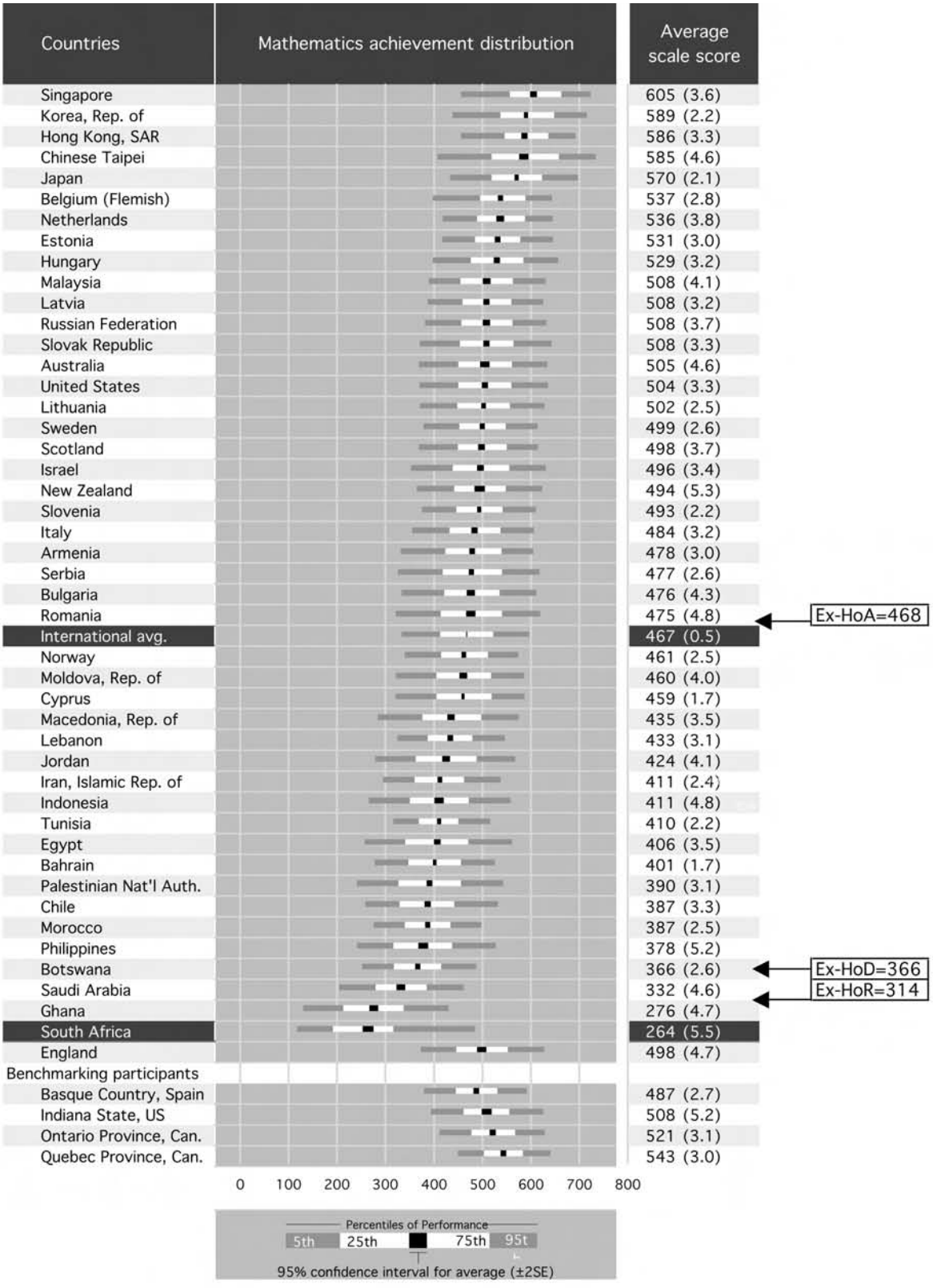


Figure 5.4 provides an indication of how the different school types would have fared in the international comparison.

2 There were 8 952 cases. Of these, 6 697 learners were in ex-DET schools (for African learners); 1 211 learners were in ex-HoR schools (previously for coloured learners); 303 learners were in ex-HoD schools (previously for Indian learners), and 741 learners were in ex-HoA schools (previously for white learners). Although the numbers for ex-HoD and ex-HoA schools are low, the scores can be considered as indicative of performance in these schools.

Figure 5.4: Distribution of mathematics achievement



Comparison of scores of schools from ex-racial departments for TIMSS 1999 and 2003

TIMSS 1999 data was collected in 1998 and TIMSS 2003 data was collected in 2002. The racial profile of learners in the different school types changed from TIMSS 1999 to TIMSS 2003. The profile of racial integration is provided in Table 9.2 in Chapter 9. Table 5.3 provides information of how the performance of learners in schools, categorised by ex–racial department, changed between TIMSS 1999 and TIMSS 2003.

Table 5.3: Change in mathematics performance, from TIMSS 1999 to TIMSS 2003, by ex-racial department

School type	1999 average scale score (SE)	2003 average scale score (SE)	1999–2003 difference
Ex-DET	238 (4.9) (n = 6 166)	227 (2.9) (n = 6 697)	-11*
Ex-HoR	348 (16.1) (n = 1 059)	314 (8.6) (n = 1 211)	-34
Ex-HoD	406 (14.3) (n = 212)	366 (24.9) (n = 303)	-40
Ex-HoA	442 (18.0) (n = 709)	468 (20.3) (n = 741)	25
National average	275 (6.8)	264 (5.5)	-11

** Difference is statistically significant.*

There was a decrease in the average mathematics score in the ex-DET, ex-HoR and ex-HoD schools in the period 1999 to 2003. The decrease in ex-DET schools is significant at the 95 per cent confidence level and in ex-HoR schools it is 'not quite' significant. There was an increase in average mathematics scores, of 25 points, in ex-HoA schools, but this is not statistically significant.

Since 1998 (with the introduction of C2005) there have been many professional development courses and programmes for teachers. In addition, numerous interventions by government, private sector, business and non-governmental organisations have been made in schools, especially the African schools, with the objective of improving the state of mathematics and science education. However, it seems that despite these programmes there has been a decrease in mathematics performance in many schools.

Performance by gender

National scores

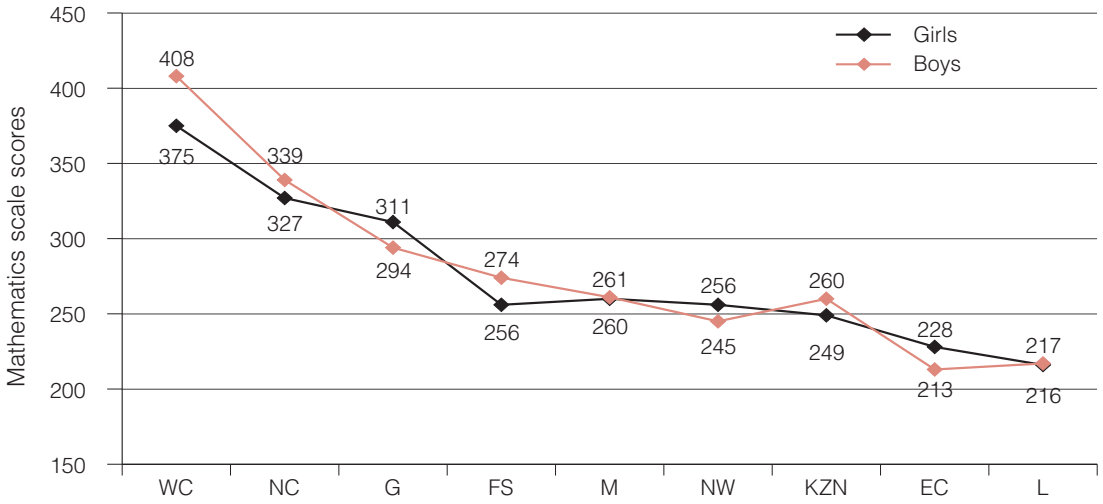
In the national sample, there was an almost equal participation by girls and boys. Nationally, the performance between girls and boys is similar, with the girls scoring 262 (SE = 6.2) and the boys scoring 264 (SE = 6.4) in TIMSS 2003. There has, however, been a change in the scores of the girls and boys since TIMSS 1999, when the girls score was 268 (SE = 7.5) and the boys score was 283 (SE = 7.3). In neither year has the difference in score between girls and boys been statistically significant. The scores of the

girls decreased by 6 points from TIMSS 1999 to TIMSS 2003 and the scores of the boys decreased by 19 points over the same time period. These across-year differences are not statistically significant.

Provincial performance by gender

Figure 5.5 provides a picture of provincial mathematics achievement scores for girls and boys.

Figure 5.5: Mathematics performance of girls and boys by province



Note: WC = Western Cape; NC = Northern Cape; G = Gauteng; FS = Free State; M = Mpumalanga; KZN = KwaZulu-Natal; NW = North West; EC = Eastern Cape; L = Limpopo.

The scores of boys (in order of magnitude) were higher than the girls in Western Cape (by 33), Free State (18), Northern Cape (12), KwaZulu-Natal (11), Mpumalanga (1) and Limpopo (1). The scores of girls were higher in Gauteng (by 17), Eastern Cape (15) and North West (11). As in the national sample, the difference in the scores between boys and girls in the provinces is not statistically significant.

Performance at different benchmarks, by gender

There was a similar number of girls and boys, at 10.2 and 10.8 per cent respectively, who achieved scores higher than 400 (the LIB). In both cases, the number of learners is low. An improvement on this situation presents a strong challenge to the education system.

Gender scores by ex-DoE

The national and provincial scores indicated that there was no statistically significant gender difference in the mathematics scores of girls and boys. It is important to investigate gender differences in performance for learners in different socio-economic conditions. Using the ex-racial departments of schools as a proxy for social class, the average mathematics scores for the different groups was calculated. Table 5.4 shows the performance of girls and boys, in TIMSS 2003 and TIMSS 1999, by school type.

Table 5.4: Mathematics performance in schools categorised by ex-racial department, for TIMSS 1999 and TIMSS 2003, by gender

		TIMSS 1999			TIMSS 2003		
Ex-dept	Gender	No.	Score (SE)	Difference: boy–girl	No.	Score (SE)	Difference: boy–girl
Ex-DET	Girl	3 260	231 (4.8)	16*	3 401	228 (3.2)	-2
	Boy	2 906	247 (5.7)		3 267	226 (3.4)	
Ex-HoA	Girl	365	431 (20.8)	24	350	464 (19.0)	8
	Boy	344	455 (16.2)		390	472 (24.3)	
Ex-HoR	Girl	551	349 (19.0)	-2	601	309 (8.3)	10
	Boy	508	347 (14.9)		528	319 (11.2)	
Ex-HoD	Girl	114	409 (15.2)	-8	126	355 (24.8)	18
	Boy	98	401 (15.8)		177	373 (27.5)	
Total	Girl	4 290	267 (7.5)	16	4 478	262 (6.2)	2
	Boy	3 856	283 (7.4)		4 362	264 (6.4)	

** Difference is statistically significant at the 95% confidence level.*

In TIMSS 2003, for ex-DET schools, the scores of girls were higher than those of the boys. The average score of schools of the other ex-departments indicated that the boys achieved higher scores than the girls. In none of the categories was the difference statistically significant. In TIMSS 1999, the score of the girls in ex-DET schools was lower than those of the boys and this difference was statistically significant. In the other school types, there was no statistically significant difference in the scores of girls and boys. The TIMSS 1999 scores suggested that in poorer socio-economic conditions girls experienced the greater disadvantage in mathematics performance. The TIMSS scores over the two periods (1999 and 2003) indicated that the gender difference in mathematics performance had decreased in ex-DET schools. While it is a positive feature that the gender gap in performance is decreasing, the overall performance of both groups is still low, and of concern.

Performance by language of the test

Schools were asked to indicate their language of teaching and learning. Although South Africa has 11 official languages, schools indicated two languages of instruction: English or Afrikaans. Learners were then given the TIMSS instruments in either English or Afrikaans. Appendix 3 provides an analysis of schools who took the TIMSS test in Afrikaans, by province and ex-racial department of the school. The average scale score of the learners for these two groups, according to the language of the instrument, is shown in Table 5.5.

Table 5.5: Average mathematics score by language of instruction

Language of instruction	Mathematics scale score (SE)
English (n = 7 912)	253 (5.7)
Afrikaans (n = 1 040)	370 (23.5)

There were 1 040 learners who answered in Afrikaans. These learners came from different provinces and schools categorised by ex-department. Many of the learners taking the test in Afrikaans attended either ex-HoR or ex-HoA schools, and these schools are mostly in the Northern or Western Cape. These learners would have taken the test in their home language and the average score of 370 would place this learner group just above the score for Botswana on the international table. For the learners who took the test in English, most would be attending ex-DET schools and English would not be their first language. While the language of the test and the learners' proficiency in that language contributed to the achievement scores attained, it is difficult to determine the extent of this contribution as there are other inequalities among the different school types and these also influence performance.

Performance by content area, cognitive domain and question type

Analysis of the percentage of learners who correctly answered each item provides a useful picture of what South African learners know, and can do, in mathematics. The following analyses – by content area, cognitive domain and question type – provide a profile of how learners answered each item.

Performance by content domain

The TIMSS 2003 mathematics tests were designed to enable reporting on five content areas, in accordance with the TIMSS mathematics framework. The five content areas (and % of items in the test) were:

- *Number (30%).* This domain included understanding of counting and numbers, ways of representing numbers, relationships amongst numbers, and number systems.
- *Algebra (25%).* This domain included patterns and relationships among quantities, using algebraic symbols to represent mathematical situations, and developing fluency in producing equivalent expressions and solving linear equations.
- *Measurement (15%).* This domain focused on understanding and demonstrating familiarity with the units and processes used in measuring various attributes.
- *Geometry (15%).* This domain focused on analysing the properties and characteristics of geometric figures, including lines, angles and two- and three-dimensional shapes, and providing explanations based on geometric relationships.
- *Data (15%).* This domain focused on understanding how to collect data, and organising and displaying data in graphs and charts.

The content area scores were scaled to compare the relative performances. South Africa's performance in each of these areas is indicated in Table 5.6.

Table 5.6: Relative mathematics scale scores (and SE) in the content domains

Number	Algebra	Measurement	Geometry	Data
274 (5.4)	275 (5.1)	298 (4.7)	247 (5.4)	296 (5.3)

South African learners performed relatively well in the domains of measurement and data, and scored lowest in the domain of geometry.

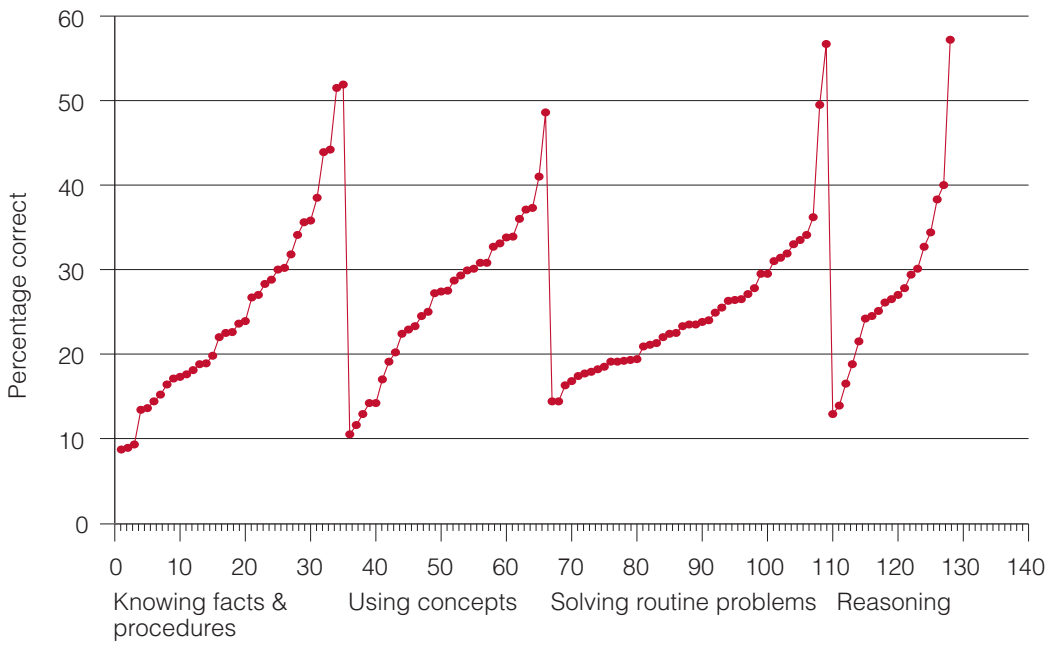
Performance by cognitive domain

The TIMSS 2003 mathematics items were categorised into one of four cognitive domains. The cognitive domains define the behaviours expected of learners as they engage with the mathematics content. The four cognitive domains (and % of items in the test) were:

- *Knowing facts and procedures (15%).* Performing mathematics depends on mathematical knowledge. Facts encompass the knowledge providing the basic language of mathematics, and procedures provide the link to solving routine problems through applying this knowledge.
- *Using concepts (20%).* Knowledge of concepts enables learners to make connections between elements of knowledge that would otherwise be retained as isolated facts.
- *Solving routine problems (40%).* Problem solving is of crucial importance, and often the means of teaching mathematics. In items categorised in this domain, the problem settings are more routine than those aligned with the reasoning domain.
- *Reasoning (25%).* Reasoning mathematically indicates the capacity for logical, systematic thinking, and includes intuitive and inductive reasoning based on patterns and regularities that can be used to arrive at solutions to non-routine problems.

Figure 5.6 provides a profile of how South African learners answered each multi-choice question (MCQ) item, categorised according to the four cognitive domains.

Figure 5.6: Percentage of learners who correctly answered items in each cognitive domain



Although there is a hierarchical nature to the cognitive domains, with the *knowing facts and procedures* domain considered to be at a lower cognitive level than the *reasoning* domain, the performance in each of the domains is similar, that is, there is a similar distribution of correct answers across the domains. In each of the cognitive domains, on most items less than 30 per cent of the learners scored correctly. One would have expected a higher percentage of correct answers on items in the *knowing facts and procedures* and *using concepts* categories. Therefore, performance in the *reasoning* domain is, relatively speaking, good.

Performance by question type

Learners' knowledge and understanding of mathematics was assessed by MCQs and constructed-response questions. There were 128 MCQ items and 66 constructed-response items. The percentage of correct answers for the MCQ items ranged from 8.7 to 57.0 per cent. In the constructed-response questions, learners performed very poorly, with most of the items being answered correctly by less than 10 per cent of the learners. Figure 5.7 illustrates the percentage of learners correctly answering the MCQ items in the five content areas.

Figure 5.7: Percentage of learners who answered the MCQ items correctly

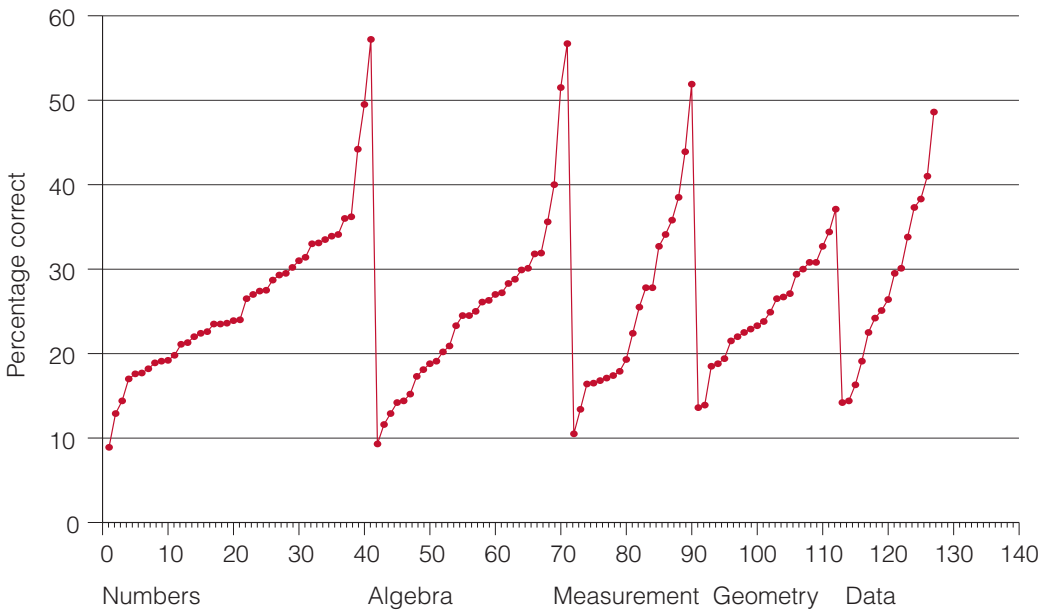


Figure 5.7 shows that for most items less than 30 per cent of learners answered correctly. On only five MCQ items did more than half the learners respond correctly. The profile of learners' response rates for the content domains – number, algebra, measurement and data – is similar. In the area of geometry, however, there were fewer learners who answered correctly.

Summary

From TIMSS 1999, there was a drop in the average age of learners who participated in TIMSS 2003. This implies that there is either less repetition, or fewer learners leave the system and then re-enter – suggesting that participation patterns are improving.

There is a difference in the performance of the country's provinces. The top three performing provinces were Western Cape, Northern Cape and Gauteng, and the three poorest performing provinces were North West, Eastern Cape and Limpopo. With the exception of Gauteng, there was an observable correlation between the provincial mathematics scale scores and the HDI rating.

Learners attending different school types achieved different average scores. Learners who attended ex-HoA schools achieved a score close to the international average. The average mathematics scale score (and SE) for schools of the ex-racial departments were: ex-DET schools, 227 (2.9); ex-HoR schools, 314 (8.6); ex-HoD schools, 366 (24.9); and ex-HoA schools, 468 (20.3).

There was a decrease in the average score in the ex-DET, ex-HoR and ex-HoD schools in the period 1999 to 2003. The decrease is significant in the ex-DET schools. There was an increase of 25 points in average mathematics scores in ex-HoA schools over the period 1999 to 2003.

Nationally, the performance between girls and boys was similar, with the girls scoring 262 (6.2) and the boys scoring 264 (6.4). Provincially, there was also no gender difference in mathematics performance.

Learners who answered the questions in English and Afrikaans achieved different average scores. Many learners who answered in English were not answering in their home language, and this may explain the lower score attained – 253, compared to 370 for learners answering in Afrikaans.

Learners performed relatively well in the content domains of measurement and data. The performance level was lowest in the geometry domain.