CHAPTER 6

National analysis: TIMSS 2003 science

Chapter 4 provided information on international science 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 science 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 science participation and performance in TIMSS 1999 and TIMSS 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 science scale score was 244 (SE 6.7). The score in TIMSS 1999 was 243 (SE 8.8). The one point increase in the average science scale scores is not significant (see Chapter 4 of this report for details).

The scores of learners were categorised at the different performance benchmarks. In TIMSS 1999, 13.9 per cent of the learners scored more than 400 points in the science test, and this decreased to 12.4 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 13.9 per cent in TIMSS 1999 to 12.4 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 ensuring the implementation of these policies and supporting the delivery of a quality

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

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 6.1 indicates the average provincial science scale score in TIMSS 2003.

Table 6.1: Average science scale scores by province

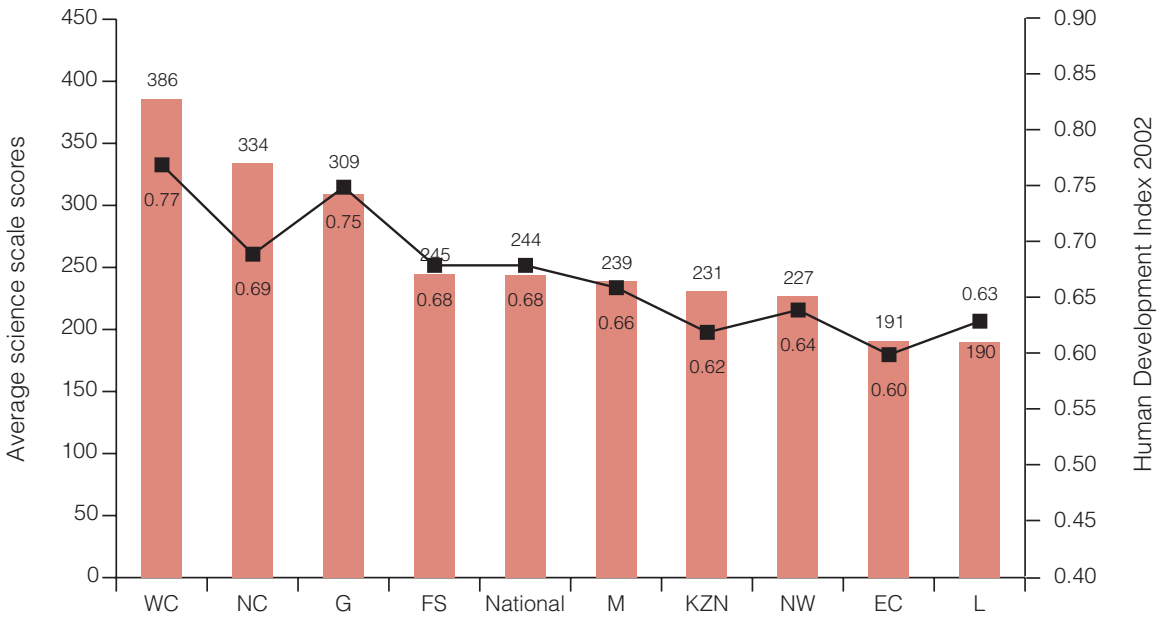
Province	Average science scale score (SE)	Score range
Western Cape (n = 813)	386 (28.1)	5–707
Northern Cape (n = 870)	334 (13.9)	5–687
Gauteng (n = 774)	309 (22.9)	11–666
Free State (n = 867)	245 (9.3)	5–622
National average (n = 8 952)	244 (6.7)	5–707
Mpumalanga (n = 962)	239 (28.5)	5–621
North West Province (n = 946)	231 (21.5)	5–571
KwaZulu Natal (n = 1 632)	227 (16.5)	5–684
Limpopo (n = 1 145)	191 (6.6)	5–506
Eastern Cape (n = 943)	190 (10.0)	5–527

The top three performing provinces were Western Cape, Northern Cape and Gauteng and the three lowest performing provinces were KwaZulu-Natal, Limpopo and Eastern Cape. The average provincial score ranges from 386 for the top performing province, Western Cape, to 190 for the lowest performing province, Limpopo. This means that the top performing province had double the score of the lowest performing province. Three provinces – Western Cape, Northern Cape and Gauteng – scored significantly higher than the national average, and three provinces – KwaZulu-Natal, Limpopo and Eastern Cape – scored significantly lower than the national average.

Provincial scores and the HDI

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 6.1 illuminates the provincial mathematics scale score and the provincial HDI.

Figure 6.1: Provincial science 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 score. Provinces with a higher HDI attained a higher achievement score than provinces with a lower HDI. Gauteng is an exception, and this may 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 6.2). 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 increase in scores for Northern Cape and Limpopo was statistically significant. In all other cases the scores changes were not statistically significant.

Table 6.2: Provinces where scores increased or decreased between TIMSS 1999 and TIMSS 2003

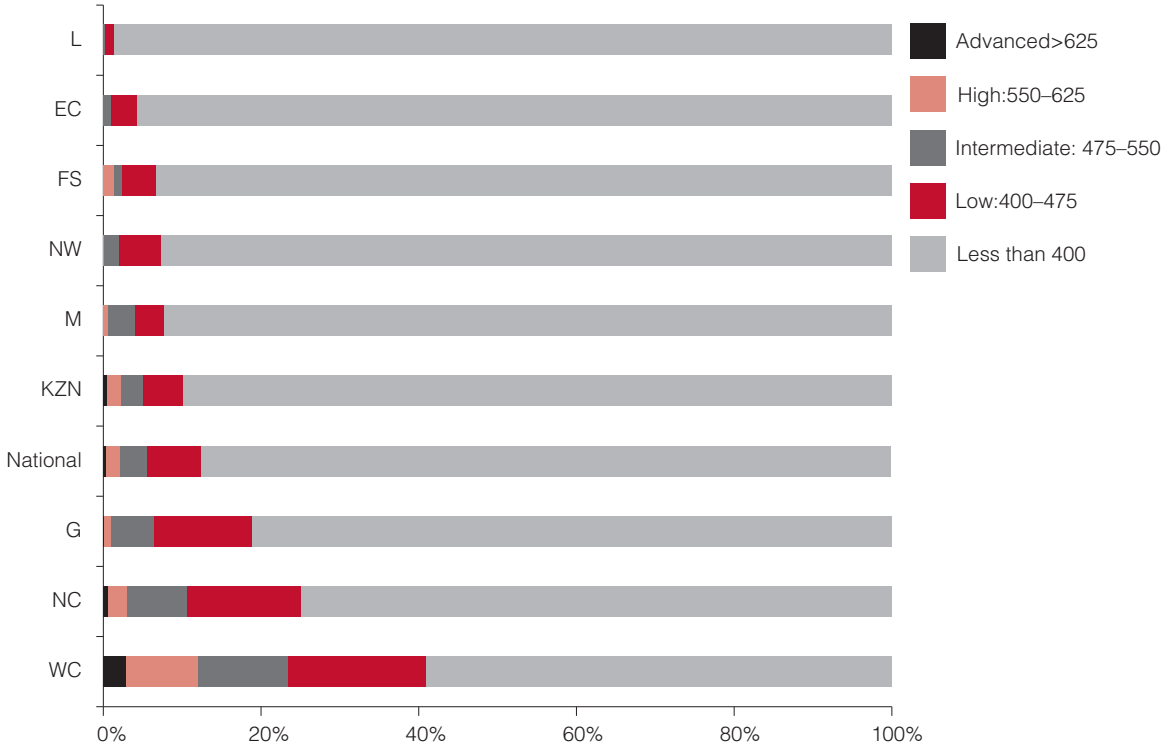
Provinces where average scores increased	Provinces where average scores decreased
Northern Cape (by 51 points)	KwaZulu-Natal (by 31 points)
Limpopo (by 22)	Eastern Cape (by 16)
Mpumalanga (by 7)	Free State (by 10)
	Western Cape (by 7)
	North West (by 4)
	Gauteng (by 3)

There has been a change in the rank order of some of the provinces from TIMSS 1999 to TIMSS 2003. Three provinces improved their rank order: Northern Cape from 3 to 2, Free State from 5 to 4 and Mpumalanga from 7 to 5. Two provinces dropped in rank order: Gauteng from 2 to 3 and KwaZulu-Natal from 4 to 7.

Performance of provinces at the different benchmarks

South Africa had 12.4 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 6.2). As expected, Western Cape had the highest number of learners achieving scores greater than 400, followed by Northern Cape and Gauteng. In Limpopo, none of the learners achieved scores higher than 475.

Figure 6.2: Provincial profile of science 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 6.3. There were significant differences in the average scores of learners attending different school types. Learners who were in ex-HoA schools had an average score that was just above the international average. The average science scale score (and SE) for schools of the ex-racial departments were as follows:

- ex-DET schools 199 (3.9);
- ex-HoR schools 311 (9.9);
- ex-HoD schools 371 (27.3); and
- ex-HoA schools 483 (17.3).[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 6.3: Average science scale score of learners from the different school types

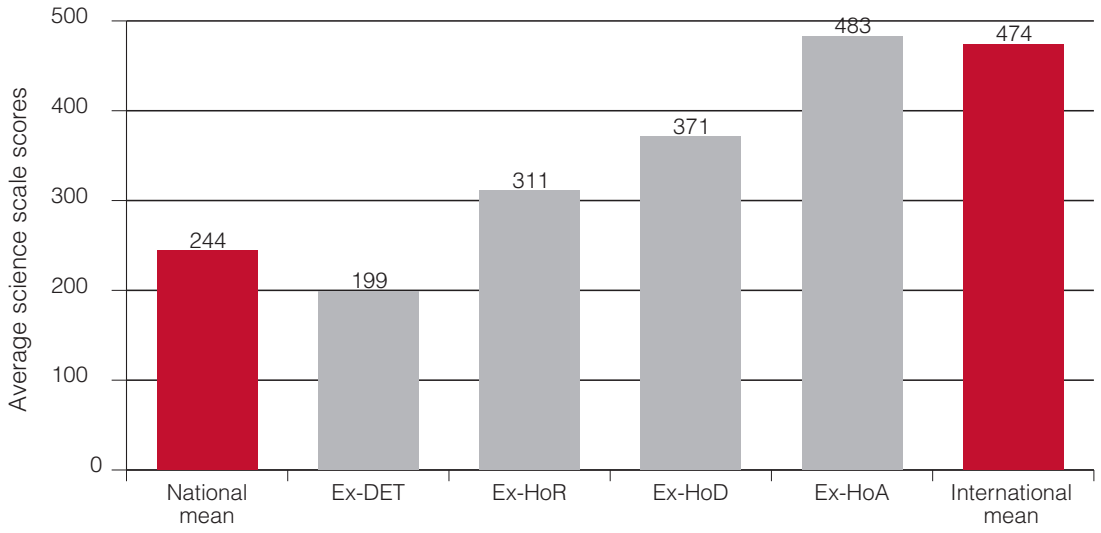
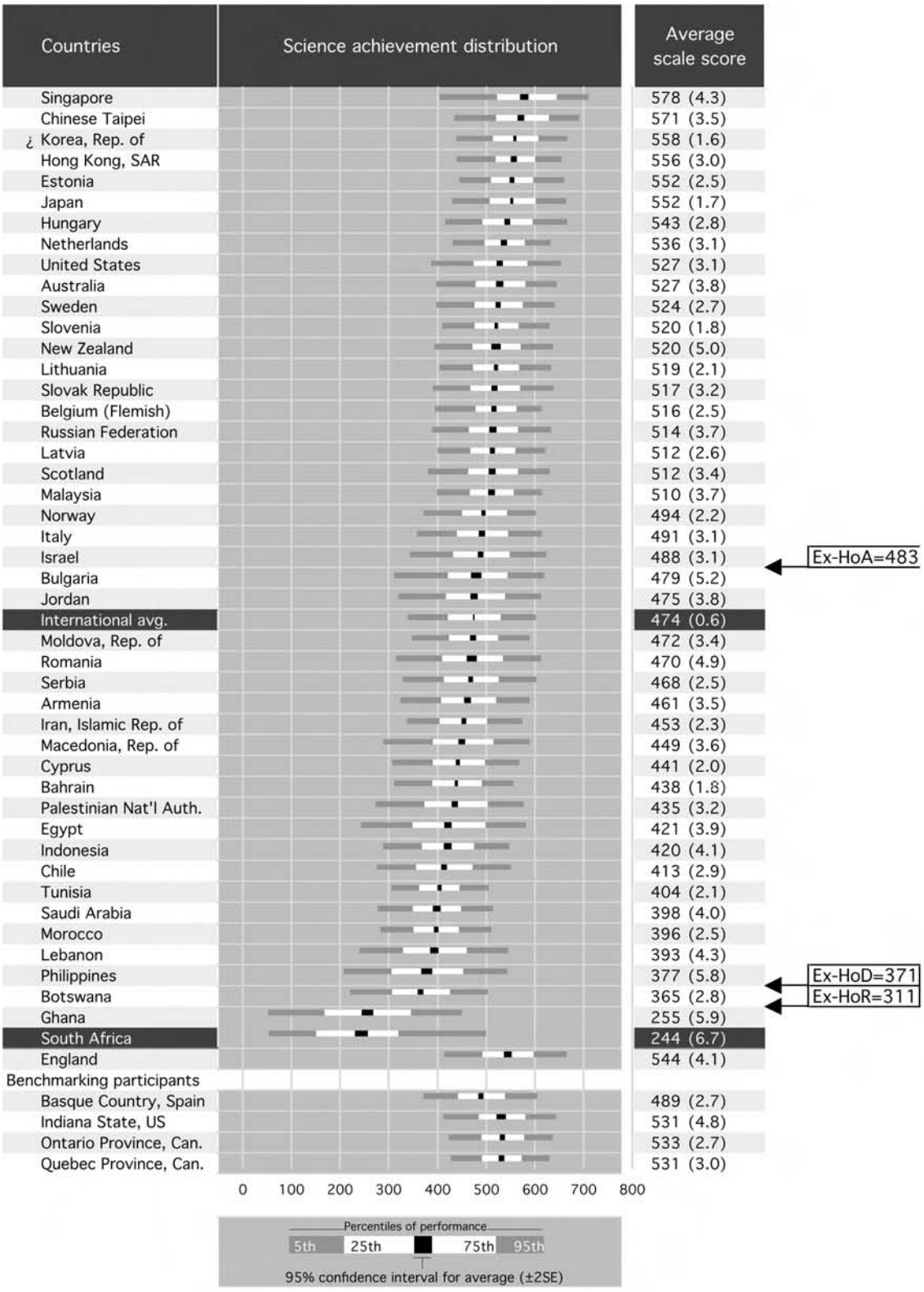


Figure 6.4 provides an indication of how the different school types would have fared in the international comparison.

2 There were 8 952 cases in total. 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 schools in these categories.

Figure 6.4: Distribution of science 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 6.3 provides information of how the performance of learners in schools, categorised by ex-racial department, changed between TIMSS 1999 and TIMSS 2003.

Table 6.3: Change in science performance from TIMSS 1999 to TIMSS 2003, by ex-racial department

	1999 average scale score (SE)	2003 average scale score (SE)	1999–2003 difference
Ex-DET schools	195 (3.8) (n = 6 166)	199 (3.9) (n = 6 697)	4
Ex-HoR schools	348 (17.1) (n = 1 059)	311 (9.9) (n = 1 211 059)	-37
Ex-HoD schools	420 (16.7) (n = 212)	371 (26.3) (n = 303)	-49
Ex-HoA schools	457 (25.1) (n = 709)	483 (17.3) n = 741	26
National average	243 (7.8)	244 (6.7)	1

There was a decrease in the average science score in the ex-HoR (with the difference being 'not quite' significant) and ex-HoD schools. There was an increase in average science scores in ex-DET schools (by 4 points) and in ex-HoA schools (by 26 points), but none of these changes are 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. The result of these interventions has been that some schools have shown an increase in performance, while others display decreased performance levels.

Performance by gender

National scores

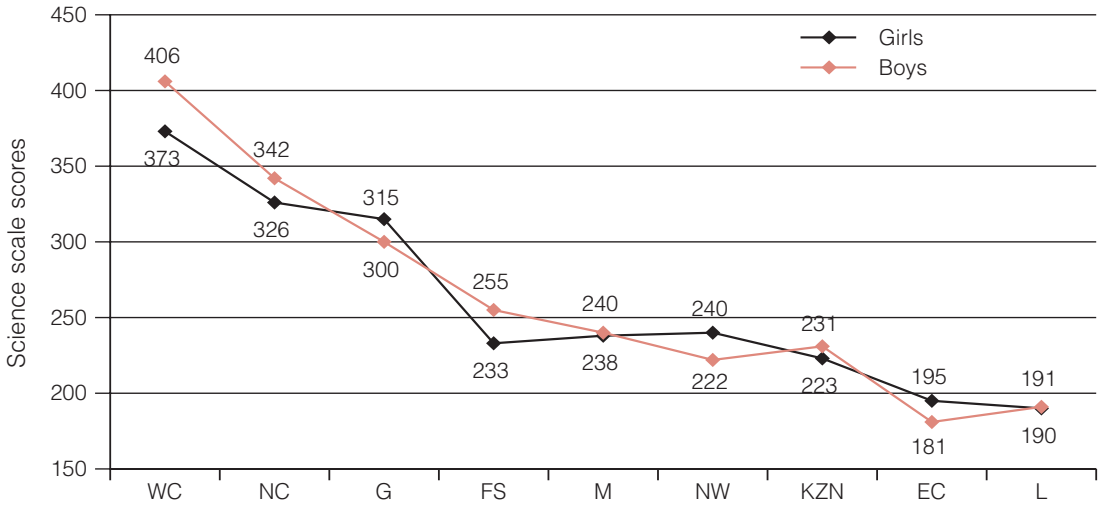
In the national sample, there was an almost equal participation by girls and boys. Nationally, the performance between girls and boys is similar, with the girls scoring 242 (SE = 7.2) and the boys scoring 244 (SE = 7.7) in TIMSS 2003. This two-point difference is not significant. There has, however, been a change in the scores of the girls and boys since TIMSS 1999, when the girls score was 234 (SE = 9.2) and the boys score was 233 (SE = 7.7). In neither year has the difference in score between girls and boys been statistically significant. The scores of the girls increased by 8 points from TIMSS

1999 to TIMSS 2003 and the scores of the boys decreased by 9 points over the same time period. These across-year differences are not statistically significant.

Provincial performance by gender

Figure 6.5 provides a picture of provincial science achievement scores for girls and boys, by province.

Figure 6.5: Science 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 the Western Cape (by 33), Free State (22), Northern Cape (16), KwaZulu-Natal (8), Mpumalanga (2) and Limpopo (1). The scores of girls were higher in North West (18), Gauteng (15) and Eastern Cape (14). 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 12 and 13 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 science 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 science scores for the different groups was calculated. Table 6.4 indicates the performance of girls and boys, in TIMSS 2003 and TIMSS 1999, by school type.

Table 6.4: Science performance in schools categorised by ex-racial department, for TIMSS 1999 and TIMSS 2003, by gender

Ex-dept	Gender	TIMSS 1999			TIMSS 2003		
		No.	Score (SE)	Difference: boy–girl	No.	Score (SE)	Difference: boy-girl
Ex-DET	Girl	3 260	186 (4.4)	19*	3 401	200 (4.3)	-3
	Boy	2 906	205 (3.9)		3 267	197 (4.3)	
Ex-HoA	Girl	365	441 (31.2)	34	350	475 (15.7)	16
	Boy	344	475 (18.6)		390	491 (21.8)	
Ex-HoR	Girl	551	351 (23.1)	-6	601	307 (10.4)	7
	Boy	508	345 (13.9)		528	314 (13.5)	
Ex-HoD	Girl	114	424 (15.1)	-9	126	366 (26.7)	9
	Boy	98	415 (23.8)		177	375 (28.6)	
Total	Girl	4 290	234 (9.2)	19	4 362	242 (7.2)	2
	Boy	3 856	253 (7.7)		4 478	244 (7.7)	

** 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 19 points lower than those of boys and this difference was statistically significant. In ex-HoA schools girls scored 34 points fewer than the boys, but the difference was not statistically significant. The TIMSS scores indicate that the gender difference in science achievement scores, from TIMSS 1999 to TIMSS 2003, has decreased in ex-DET and ex-HoA schools.

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 of this report 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 6.5.

Table 6.5: Average science score by language of instruction

Language of instruction	Science scale score (SE)
English (n = 7 912)	231 (6.9)
Afrikaans (n = 1 040)	376 (26.4)

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

- *Life sciences (30%).* This domain included understanding, amongst other elements, types, characteristics and classification of living things; structure, function and life processes in organisms; cells and their functions; and the development and life cycles in organisms.
- *Chemistry (15%).* This domain included classification and composition of matter; particulate structure of matter; properties and uses of water; acids and bases; and chemical change.
- *Physics (25%).* This domain included physical states and changes in matter; energy types, sources and conversions; heat and temperature; light; sound and vibration; electricity and magnetism; and forces and motion.
- *Earth sciences (15%).* This domain included earth's structure and physical features; earth's processes, cycles and history; and earth in the solar system and the universe.
- *Environmental sciences (15%).* This domain included changes in population, uses and conservation of natural resources, and changes in environments.

The content area scores were scaled to compare the relative performances. South Africa's performance in each of these areas is indicated in Table 6.6.

Relative to the other content areas, South African learners performed well in the chemistry domain. Performance was weakest in the physics and earth science domains.

Table 6.6: Relative science scale scores (and SE) in the content domains

Life sciences	Chemistry	Physics	Earth sciences	Environmental science
250 (6.0)	285 (5.9)	244 (6.2)	247 (6.3)	261 (6.6)

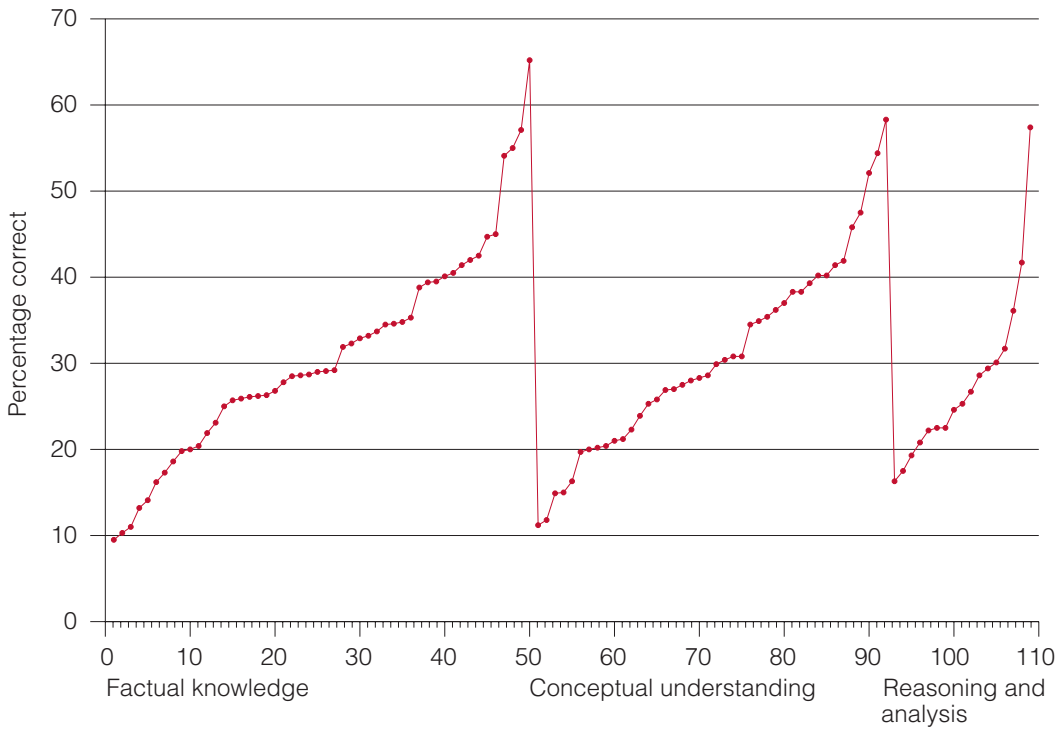
Performance by cognitive domain

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

- *Factual knowledge (30%).* This refers to the learners' knowledge base of relevant science facts, information, tools and procedures. In order to solve problems and develop explanations in science, learners must possess a strong knowledge base.
- *Conceptual understanding (35%).* This means having a grasp of the relationships explaining the physical world and relating the observable to more abstract, or general, scientific concepts.
- *Reasoning and analysis (35%).* A major purpose of science education is to prepare learners to engage in scientific reasoning to solve problems, develop explanations, draw conclusions, make decisions, and extend their knowledge to encompass new situations.

Figure 6.6 provides a profile of how South African learners answered each MCQ item, categorised according to the three cognitive domains.

Figure 6.6: Percentage of learners who correctly answered items in each cognitive domain

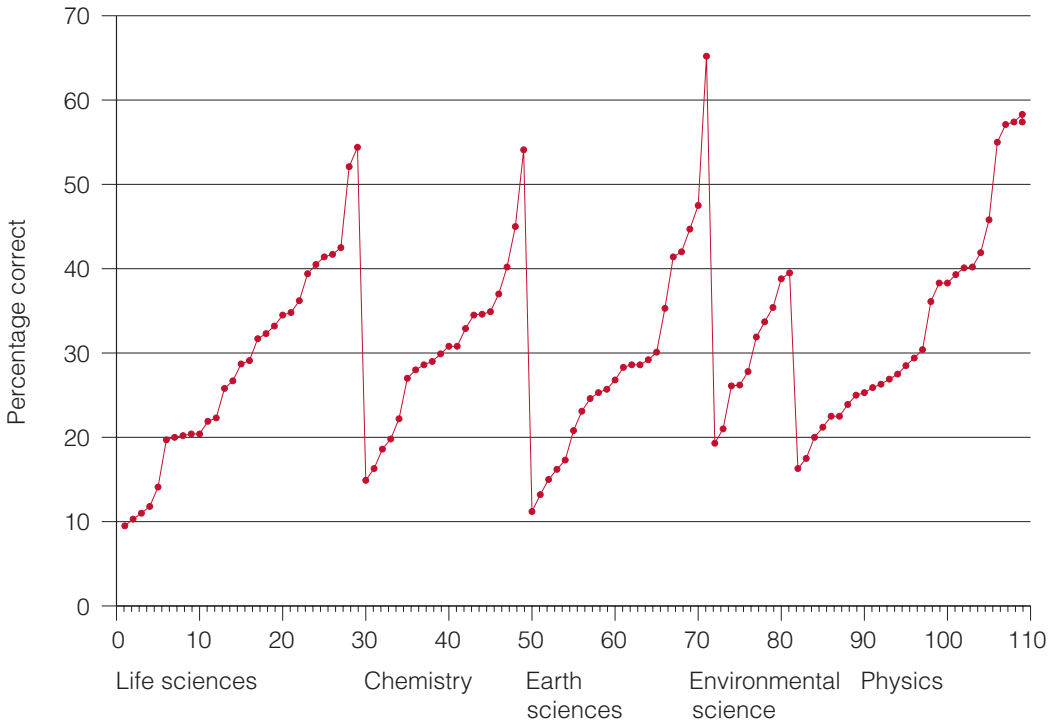


Although there is a hierarchical nature to the cognitive domains, with the factual knowledge domain considered to be at a lower cognitive level than the reasoning and analysis domain, the performance in each of the domains is similar, that is, there is a similar distribution of correct answers across the domains. In each of the cognitive domains, on most items, less than 40 per cent of the learners scored correctly. One would have expected a higher percentage correct on items in the factual knowledge and conceptual understanding categories. Therefore, performance in the reasoning and analysis domain is, relatively speaking, good.

Performance by question type

Learners' knowledge and understanding of science was assessed by MCQs and constructed-response questions. There were 110 MCQ items and 90 constructed-response items. The percentage of correct answers for the MCQ items ranged from 9.5 to 65.5 per cent. In the constructed-response questions, learners performed very poorly, with most of the items being answered correctly by less than 20 per cent of the learners. Figure 6.7 illustrates the percentage of learners correctly answering the MCQ items in the five content areas.

Figure 6.7: Percentage of learners who answered the MCQ items correctly



The graph shows that for most items less than 40 per cent of learners answered correctly. On only five MCQ items did more than half the learners respond correctly. Of the 110 MCQ items, in only eight items did more than half the learners answer correctly. The profile of learners' response rates for each of the content domains is similar.

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 KwaZulu-Natal, Eastern Cape and Limpopo. The score of the Western Cape is almost double the score of Eastern Cape. 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 just above the international average. The average science scale score (and SE) for schools of the ex-racial departments were: ex-DET schools, 199 (SE = 3.9); ex-HoR schools, 311 (SE = 9.9); ex-HoD schools, 371 (SE = 26.3); and ex-HoA schools, 483 (SE = 17.3).

There was a decrease in the average score in ex-HoR schools (with the difference being 'not quite' significant) and ex-HoD schools in the period 1999 to 2003. There was an increase in average score in ex-DET (by 4 points) and ex-HoA schools (by 26 points), but none of the changes are statistically significant.

Nationally, the performance between girls and boys was similar, with the girls scoring 242 (SE = 7.2) and the boys scoring 264 (SE = 6.4). Provincially, there was also no gender difference in science 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 – 231, compared to 376 for learners answering in Afrikaans.

Learners answered relatively well in the domains of chemistry and environmental education. The lower performances were in the domains of physics and earth sciences.