CHAPTER 11

Key findings and implications

Introduction

TIMSS 2003 looked at the mathematics and science achievements of 50 participating countries. Data for southern-hemisphere countries, including South Africa, was collected in the latter part of 2002; for the northern-hemisphere countries participating, data was collected in the first half of 2003.

This report describes the achievements (at an international and national level) in mathematics and science of South African learners in TIMSS 2003. Around 9 000 South African Grade 8 learners participated in TIMSS 2003. In addition to mathematics and science achievement data, information relating to learners, teachers, classrooms and schools was also collected. This allowed a contextual analysis of achievement results to be made and relevant improvement strategies to be suggested. This chapter provides the key findings from the TIMSS research, as well as implications for policy, practice and research.

Key findings

1. Benefits and limitations of comparative studies

- The principal benefit of cross-national studies is that a country's academic performance, in this instance, South Africa's, can be benchmarked against the performance of other countries displaying similar characteristics. This comparative analysis is useful in generating or eliminating hypotheses seeking to explain and understand a country's performance.
- A limitation of TIMSS for South Africa is that the achievement scores of learners are low and the distribution of scores is skewed toward the left (the 'floor effect'). This skewed distribution makes it much more difficult to generate and develop models explaining performance using the available data.

2. South African TIMSS achievements in an international context

- The top performing TIMSS countries for mathematics and science achievements were Singapore, Republic of Korea, Hong Kong (SAR), Chinese Taipei, Japan and Estonia. The lowest performing countries were Lebanon, the Philippines, Botswana, Saudi Arabia, Ghana and South Africa.
- South Africa had the lowest performance scores in mathematics and science compared to the other TIMSS participants.
- The international average scale score for mathematics was 467 (SE = 0.5), and for science, 474 (SE = 0.6). The South African scores were 264 (SE = 5.5) and 244 (SE = 6.7) respectively.
- South Africa had the largest variation in scores, ranging from a preponderance of very low scores to a few very high scores, so skewing the score distribution to the left (the abovementioned 'floor effect').
- South African performance in mathematics and science at the international benchmarks is disappointing, with only around 10 per cent in mathematics and 13 per cent in science achieving scores higher than 400 points. This means that

South Africa, in conjunction with Ghana, had the highest percentages of learners scoring less than 400 points (that is, below the LIB).

3. Gender analysis

- In most countries, including South Africa, there were equitable participation rates in mathematics and science classes between girls and boys. This was also the pattern in all the South African provinces, except in Eastern Cape and Gauteng where about 8 per cent more girls than boys participated.
- The international average mathematics scale score for girls and boys was not significantly different, but the average science scale score for boys was statistically higher than for girls by six points.
- In South Africa, the difference in the national average mathematics and science scale scores for girls and boys was not statistically significant.
- Although there are differences in the provincial average mathematics and science scale scores for boys and girls, this difference was not statistically significant.
- In TIMSS 2003, the difference between the achievement scores of boys and girls in schools categorised by ex-racial departments was not statistically significant.
- In TIMSS 1999, the mathematics and science scores of girls in the ex-African schools were statistically lower than the boys. While it is a positive sign that there is no difference in the TIMSS 2003 scores for boys and girls, the remaining concern is that both groups still present low scores.

4. Participation patterns at Grade 8 level

- 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 in TIMSS 1999 (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.

5. Performance patterns at Grade 8 level

By province

- The average achievement scores in mathematics and science of the provinces showed great variation.
- The top performing provinces were Western Cape and Northern Cape and the lowest performing provinces were Eastern Cape and Limpopo.
- The top performing provinces had scores which were almost double those of the lowest performing provinces.
- The socio-economic conditions in the provinces differ; the top performers having a higher GDP than that of the poorer performing provinces.

By schools categorised by ex-racial department

- There were differences in the average mathematics and science achievement scores of learners in schools categorised by ex-racial department.
- Learners who were in ex-HoA school (previously only for white learners) achieved an average mathematics and science score that was close to the international average.
- The average score of learners in African schools was almost half that of learners in ex-HoA schools.
- There has been a migration of better performing and financially resourced African learners to ex-HoA schools (where more resources are available). This means

that African schools have to contend with both the negative repercussions of apartheid's separatist education policies, *and* the migration of better performing learners – leaving these schools in the difficult position of having to produce good results under poor conditions.
- These achievement scores of the different school types (categorised by ex-department) indicate that attendance of learners at different school types is an important determinant in influencing learner achievement outcomes.

By language of the test
- Learners answered the test in either Afrikaans or English.
- Those learners who took the test in Afrikaans achieved an average mathematics score of 370 and an average science score of 376. Learners who took the test in English achieved an average mathematics score of 253 and an average science score of 231.
- Learners taking the test in Afrikaans were first-language users and their score would place this group just above the average score for Botswana on the international table.
- Most learners taking the test in English would be attending African schools and English would not be their first language.
- While the language of the test and learner 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 also influencing performance.

By what learners know and can do
- South African learners performed poorly on almost all test items.
- In most MCQs, less than 30 per cent of the learners achieved the correct answer.
- The average per cent correct on all mathematics and science items was just below 20 per cent.
- In mathematics, South African learners performed relatively well in the domains of measurement and data and performed most poorly in geometry.
- In science, they performed better in the chemistry domain, while performance was weakest in physics and earth science.

6. Trends in mathematics and science achievement

- The national achievement scores for mathematics and science were not significantly different, statistically, between TIMSS 1999 and TIMSS 2003. During this period there had been curriculum restructuring in the country.
- There were no statistically significant changes in the provincial mathematics scores in these two periods.
- In science, the increase in scores from TIMSS 1999 to TIMSS 2003 for Northern Cape and Limpopo is statistically significant.
- The mathematics score for African schools decreased 'significantly' from TIMSS 1999 to TIMSS 2003.

7. Performance at Grade 9 level

- The Grade 9 performance in mathematics and science mirrors that of Grade 8.
- A disappointing feature of the results is that the average score for Grade 9 learners is only around 20 points higher than for Grade 8 learners.

8. Curriculum

- The TIMSS instruments were administered during a period of curriculum change and restructuring.
- During this period, teachers referred to different curricula to determine what and how they taught in their classrooms – NATED 550, C2005, and the RNCS.
- The philosophy underpinning the restructured curriculum was that of an outcomes-based education.
- The official curriculum in 2002 was C2005, and this was characterised by an under-specification of basic knowledge and skills in all learning areas, including mathematics and science.
- South Africa is one of the countries where there is the least overlap with the TIMSS assessment frameworks. While this may have had an effect on achievement scores, analysis of performance on topics teachers said had been covered revealed scores as remaining very poor, with learners achieving only around 20 per cent correct on those items.

9. Learners

Home background

- About one-tenth of South African learners had parents who had completed university or a university-equivalent education, while approximately 30 per cent of learners had parents with no more than a primary education.
- About 10 per cent of South African learners had more than 100 books in the home and about 40 per cent (one of the highest percentages in this category in the international dataset) had fewer that than 10 books in the home.
- Eighteen per cent of South African learners indicated that they 'always' speak the language of the test at home, and 15 per cent indicated that they 'never' speak the language of the test at home.
- These three resources (parental level of education, the educational resources in the home, and the extent to which the language of the test is spoken at home) were examined to establish what effect they had on mathematics and science achievement scores. The findings indicated that, within the country, the learners who had these resources performed better than those who did not.
- Comparisons across countries revealed a new dimension. Even when these resources (high parental education, and so on) are in place, the South African TIMSS mathematics and science average score for this group of learners is lower than the corresponding groups' scores in other countries.
- None of these factors on its own can explain performance – it is an examination of the interaction of many factors, embedded within a context, that will generate hypotheses of why performance may be high or low.

Attitudes

- In general, the attitude of South African learners to mathematics and science is positive – they have high self-confidence; they enjoy and value the subjects.
- The responses of learners to questions on attitudes could, however, be socially desirable answers, and there is a need to probe further to determine the 'real' attitudes of learners.
- Internationally, and in South Africa, no significant variations in achievement scores were detected between learners who indicated high positive attitudes to mathematics and science and those who did not.

10. Science and mathematics teachers

Profile of the teachers

- The majority of mathematics and science teachers were aged between 30–39, and their average teaching experience was 11 years (for mathematics teachers) and 10 years (for science teachers).
- In South Africa, about 40 per cent of mathematics learners and 50 per cent of science learners were taught by female teachers.
- Over 95 per cent of the TIMSS learners were taught by mathematics and science teachers who indicated that they had completed a post-secondary qualification.
- Around two-thirds of mathematics and science learners were taught by teachers who indicated that they had at least three years of teacher training and that the initial training included either mathematics or science. These teachers can be classified as qualified and knowledgeable in their subject matter.
- Internationally, most teachers have at least a four-year degree as their teaching qualification. The comparison with an international cadre of TIMSS teachers showed South African mathematics and science teachers to be one of the least qualified groups.

Professional development courses

- Internationally, about half the learners were taught by teachers who indicated that they had participated in professional development activities in the past two years.
- The type of professional development activities that most teachers (internationally) participated in related to mathematics or science content and pedagogy.
- The percentage of South African teachers who attended professional development activities was higher than the international average.
- The type of professional development activities that over half the South African teaching group were involved in related to content, curriculum, assessment, and improving critical thinking.
- It is surprising that there was a relatively low percentage of teachers reporting on professional development activities relating to mathematics or science pedagogy or instruction, given that C2005 introduced a different way of organising classroom activities.

11. Classrooms

Class size

- The South African average class size of 45 is the second highest of all TIMSS participants.
- Just over half the South African learners were in classes where there were more than 41 learners in the class.
- Within the country there was a slight association, as expected, between mathematics and science achievement scores and class sizes – the scores were higher when the class size was smaller.

Textbooks

- Internationally, about two-thirds of mathematics teachers, and just over half the science teachers, reported using the textbook as the primary basis for their lessons; the remaining third using the textbook as a supplementary resource.
- In South Africa, the pattern was reversed: one-third of mathematics and science teachers reporting that they used textbooks as the primary basis for lessons, and two-thirds using it as a supplementary resource.

12. Schools

Socio-economic status

- In South Africa, 85 per cent of learners were in schools with more than 50 per cent economically disadvantaged learners. Five per cent of learners attended schools where there were fewer than 25 per cent economically disadvantaged learners.
- Internationally, the average mathematics score for learners in schools with few economically disadvantaged learners was 496; in schools where more than 50 per cent came from economically disadvantaged homes the score was 439 – representing a difference of 57 scale points.
- In South Africa, the average mathematics score for learners in schools with few economically disadvantaged learners was 479; in schools where more than 50 per cent came from economically disadvantaged homes the score was 237. These figures point out the advantage held by economically advantaged learners – their scores were double those of their disadvantaged counterparts.
- In South Africa, economic disadvantage has a severe impact on achievement scores.

School resources, climate and attendance

- About 40 per cent of learners attended schools that teachers and principals classified as having a low resource base for mathematics and science teaching and learning.
- About half the learners attended schools rated by teachers and principals as having a low school climate
- Forty-four percent of learners attended schools rated by teachers and principals as having low school and class attendance.
- The school conditions for about half the learners does not seem to be conducive to experiencing high quality teaching and learning.

Implications

Given the above findings from TIMSS 2003, what then are the implications? The following sections examine some of the implications of TIMSS 2003 for future South African research, policy and practice in education.

Analysis of achievement scores within the country, and a comparison of these scores across several countries, highlights the fact that no single cause can be cited as an explanation for the performance of South African learners. The analysis is conjunctural – a combination of several factors (acting together within particular social, economic, historical and cultural contexts) produced the kinds and levels of performances observed. However, the analysis highlights several leverage points that could be used to raise mathematics and science performance in schools.

1. Improving performance: improve the school

The performance level of learners in mathematics and science in South Africa is very low. However, this poor performance does not exist in isolation; it reflects the inequalities many learners are confronted by within the education system itself. The main challenge for South African education is to improve this system; the aim being, for the purposes of this report, to increase the (currently poor) average achievement scores in the mathematics and science learning areas. In addition, the distribution

of scores needs to move from its present postion – skewed to the left – towards a more normal distribution curve.

The performance scores for schools categorised by ex-racial departments show large variations between learners from different social classes and economic backgrounds. Rather than wait for social conditions to change for the better, a better alternative might be to consider the education system itself (its institutions, resources, and so on) as a leverage point for effecting such change. In poorer communities, schools enact a particularly important service in the provision of educational inputs. As outlined in Chapter 10, the role the school plays in determining or shaping the life trajectories of its learners is critical, as it is very often the main, or only, institution capable of fulfilling this function in less advantaged communities.

An important strategy for the improvement and change of score distribution is to increase the number of South African public schools producing good results. Performance is stratified along race and class lines – performance in much better in ex-HoA schools, which are, typically, better resourced and located in areas of higher socio-economic status. African schools face a daunting task in improving their learners' performance. Not only are these schools located in areas of poor socio-economic status (itself a reason behind poor learner performance at school), but they also suffer from the migration of their better performing and resourced learners to higher achieving, more affluent schools.

To facilitate higher national performance, the strategy would be to identify African schools that perform well, then set up an appropriate intervention programme for them. The programme's aim(s) would be to improve the schools' environment and climate; provide more resources for the teaching of mathematics and science; and ensure that there are knowledgeable and competent teachers in place. Higher performing schools are targeted initially because it is likely that only minimal intervention will be needed to increase their performance.

To improve the performance in all schools, the strategy would be; firstly, to ensure that the school environment and climate improves and that there is good school and class attendance. Establishing a good school climate should help improve performance in all learning areas; after this, it will then be possible to focus on issues directly related to mathematics and science.

The key strategy for the improvement of mathematics and science performance is whole-school development, starting with a few targeted sites then gradually expanding the number of schools.

2. Quality of the professional development courses

South African teachers attend a high number of professional development courses. These courses (offered by the Ministry of Education, universities, and non-governmental organisations) are an opportunity to provide a high quality input, and something which could facilitate improving the classroom teaching and learning. Given that this is a high-cost opportunity (the programme costs and the cost of having teachers away from the classroom) and that, so far, there is no clear evidence of the impact these courses have on performance, much more attention must be given to the quality of this intervention. Professional development courses need continual evaluation to ensure a quality input. Furthermore, it would be necessary

to measure the affect these courses have upon the classroom, bearing in mind that inputs of this, or any, nature must be directly aimed at improving learner knowledge and skills.

3. Teaching qualifications

The longer-term objective of (and challenge to) the education system should be to raise the qualification of the mathematics and science teachers to the equivalent of a four-year university degree. However, the immediate challenge is to ensure that the one-third of teachers who teach mathematics and science without possessing the appropriate knowledge and skills be given the requisite training and qualifications. A parallel challenge is to offer professional development courses introducing teachers to the new curriculum.

While it is acknowledged that the training will take place over a period of time, it is crucial for investments in teacher development to be of high quality; furthermore, the return on such investments must be better than it is at present.

4. Class size

An objective of the South African education system must be to reduce the class size from the present average of 45. To achieve this will require substantial investment in financial and human resources – that is, getting more classrooms and attracting new mathematics and science graduates into the teaching profession. The Ministry of Education should develop both medium- and long-term strategies for this purpose.

5. Language of teaching and learning

There is an observable relationship between learners' lower achievement at school and the fact that they do not speak the language of the test items at home. However, as mentioned elsewhere in this report, there is a complex set of several factors affecting performance in the classroom. Therefore, the impact language proficiency has on achievement scores needs to be seen in relation to these other determining factors.

Comparison of South African scores with other countries' scores, using the category of 'language spoken', suggests that language factors are embedded within other factors – socio-economic variables, the nature of teaching and, importantly, the appropriate level of cognitive demand in classroom interactions. Noting this, it is thus crucial that teaching quality and the cognitive demands made of learners are of a sufficiently high standard, and target language proficiency of learners.

6. Resources

Teachers can be supported in the classroom with the provision of high quality teaching materials. There should be textbooks for learners, paralleling what is taught in classrooms, enabling them to work independently.

7. Participating in international and national systemic studies

It is important for South Africa to participate in studies that incorporate the ability to externally benchmark performance. The choice of which cross-national study to participate in rests on two factors: its benchmarking potential, and the likelihood that it will produce a normal distribution of scores – so allowing for the generation

of a model to explain performance. In addition to eliciting information from large-scale, paper-and-pencil tests, studies examining what happens inside classrooms – the teaching and learning of mathematics and science and what learners know, and can do – are also needed.

TIMSS is conducted every four years. The next study (TIMSS 2007) involves data-collection in southern-hemisphere countries at the end of 2006. The South African education system has undergone radical restructuring in its recent past, as several initiatives and interventions have been introduced – each one sharing the common objective of improving teaching and learning in all areas of the curriculum, but especially in mathematics and science. Bearing in mind the strain this intervention has put upon the education system (and, more pertinently, the educators themselves), it is recommended that South Africa does not participate in TIMSS 2007, but rather does so in 2011, as this will allow the intervention programmes to become embedded within the education system. This achieved, it would then be more reasonable to measure South African performance in TIMSS 2011 to see how far the country has progressed.