23 *TIMSS in South Africa: Making global research locally meaningful*

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Introduction

The Trends in International Mathematics and Science Study (TIMSS) is anassessment of the mathematics and science knowledge of fourth and eighth grade learners[1] around the world. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare their learners' educational achievement across borders. TIMSS was first administered in 1995, and subsequently every four years. TIMSS provides a seriesof trend measures, allowing countries to measure and monitor the health of their education systems over time. Demographic and contextual information collected from learners, teachers, parents and schools provides a rich dataset to explain theobserved achievement levels. South Africa participated in TIMSS at the Grade 8 or9 level in 1995, 1999, 2003,[2] 2011, 2015 and 2019, and at the Grade 5 level in 2015
and 2019.

South Africa's participation in this international assessment study was initiated and facilitated by the Human Sciences Research Council (HSRC) in the 1990s. TIMSS1995, 1999 and 2003 were funded by the HSRC's parliamentary grant allocation. In 2011, the Department of Basic Education (DBE) adopted the TIMSS measures asone of the key indicators of educational performance in the country, and this study was included in the DBE's strategic plan. The HSRC has therefore conducted TIMSS2011, 2015 and 2019 for the DBE. One of the authors of this chapter (Reddy) is thePrincipal Investigator and National Research Coordinator (NRC) responsible for conducting TIMSS 2003, 2011, 2015 and 2019.

Since commencing its participation in TIMSS, South Africa has ranked last or second to last out of the set of participating countries, and every four years its low achievement scores have generated dramatic newspaper headlines. Headlines linkedto the TIMSS 1999 results included 'South African pupils are the dunces of Africa'(*Sunday Times*, 16 June 2000) and on the release of TIMSS 2003, 'Bottom of the Class' (*Financial Mail*, 17 December 2004). The headlines changed slightly with the release of the TIMSS 2011 and 2015 results: 'Grade 9 maths scores improve forfirst time since 1995' (*Times Live*, 11 December 2012) and 'South Africa learners getting better at maths and science, but still among worst in world' (*Times Live*, 29 November 2016).

Responses to the TIMSS results, especially in the earlier years, have been mixed, withcritics arguing that participation in international assessments is a pointless exercise

because of the slow (or non-existent) improvement in South African education, and that these assessments are not relevant to the country's social and political history. Supporters of TIMSS have argued that international assessments (especially those that provide trend measures) can be useful at many levels of policy and planning (Reddy 2005). There is now greater acceptance of the robustness of the TIMSS results, and the achievement estimates still provide one of the national performanceindicators used by the DBE (2015a).

This chapter outlines the history and motivations for participation in TIMSS. In the first section of the chapter, we outline the history of South Africa's participation in TIMSS and the relationship among the key actors, as well as changing perceptions towards the study over time. Secondly, we provide a nuanced description of South African mathematics achievement[3] from 1995 to 2015. Thirdly, we discuss the impact of TIMSS research on knowledge generation and evidence-based policy- making. We conclude the chapter reflecting on future directions for TIMSS in South Africa.

Education, mathematics and science in South Africa

Numerical and mathematical skills are globally recognised as key competencesfor the development of an individual, a society and an economy. The apartheid education system withheld mathematics from the majority of the population (black African, Indian and coloured)[4] and legislated this in the Bantu[5] Education Act (No. 47 of 1953). The Minister of Education at the time pronounced in Parliament: 'What is the use of teaching the Bantu mathematics when he cannot use it in practice?' [6] The result of this systematic exclusion from mathematics deprived black people fromgaining one of the fundamental competences through the schooling system. Theeffects of that exclusion remain with us.

The release of Nelson Mandela marked the fall of apartheid and the country preparedfor the first democratic elections and the transition to a non-racial society. In 1994, the country reversed the discriminatory policy related to the provision of education that was developed along racial lines and characterised by the differential provisionof resources, and created a single, unified education department by consolidating the 17 apartheid-era educational departments and systems. Up to that point, there were limited national educational statistics available, but rather fragmented statistics,of varying quality, for the different education departments. The only available achievement information was from the exit level Grade 12 examination, but separateexaminations were administered to the different racially based education systems (see Kahn 1993).

Since 1994, the democratic government has emphasised the centrality of education, especially reading, numeracy and mathematics, and science, for development. Performance in school mathematics is one of the key indicators used to describe the health of our educational system. Mathematics under-performance continues to bea contributor to social inequalities in terms of access and income. Changes in school

mathematics performance will provide a measure of the extent of transformation in schools, and in the wider society, since the inception of the democratic state.

The International Association for the Evaluation ofEducational Achievement and TIMSS

The IEA began in 1958 when a group of largely European scholars, concerned about school effectiveness and student learning, proposed that effective evaluation requires an examination of both the inputs to education and its outcomes (including knowledge, attitudes and participation). They further argued that if research could obtain evidence from a wide range of education systems, the variability would be sufficient to reveal important relationships that would escape detection within a single education system.[7]

Thus, the IEA initiated the First International Study of Mathematics in the 1960sto compare mathematics achievement in twelve countries of similarly high levels of industrialisation. The First International Science Study, conducted in the 1970s, expanded the scope to include 19 countries (adding a few countries at lowlevels of industrialisation). These studies were repeated in the 1980s in order to measure changes in educational achievement over time. The Second International Mathematics Study was conducted in 20 countries between 1980 and 1982, and the Second International Science Study was carried out in 24 countries in 1983 and 1984.The major finding from these studies was that the way a subject was actually taughtin the classroom, in contrast to how it was prescribed in the curriculum, was a good predictor of systematic differences in student performance. Furthermore, the studiesshowed that all school systems experience some inequalities and achievement gaps across different groups of students (Robitaille & Donn 1993).

In the 1990s, the IEA integrated mathematics and science into a single assessmentand embarked on the Third International Mathematics and Science Study (TIMSS1995). This was the first in a four-year cycle of assessments in mathematics and science, and with TIMSS-Repeat conducted in 1999, the Trends in International Mathematics and Science Study (TIMSS) was initiated. Subsequently, TIMSS took place in 2003, 2007, 2011, 2015 and 2019. The TIMSS and PIRLS[8] International Study Centre at Boston College is responsible for directing these studies.

The 1990s witnessed various shifts in the political contexts of many countries. InEastern Europe, the Berlin Wall fell, and the Union of Soviet Socialist Republics (USSR) and many Eastern Bloc countries fragmented into nation states. Many ofthese new countries joined as IEA members in order to participate in assessmentstudies so that they could establish their baseline achievement data, and where their countries' performance stood in relation to others. In addition, these countries wanted the benefit of the technical expertise available in global achievement and trend studies and used their participation in this global network to build their own internal capacity (interview with Dr M Martin 2019).

TIMSS in South Africa

We constructed the story of TIMSS in South Africa through the analysis of TIMSS project notes, research reports, academic publications and interviews with four key actors involved in TIMSS 1995 and 1999, as well as through personal reflections by the present TIMSS NRC. In taking a 25-year historical journey of TIMSS, we apologise for any inadvertent gaps and biases. We also recognise that retrospective accounts could represent the story in a more positive manner than if it were told in real time.

HSRC in the 1990s: Participation in TIMSS

The Human Sciences Research Council, a statutory research agency, was established in 1968 by the apartheid government. Much of its social science research was in support of the apartheid government and its policies, and it was described as the 'handmaiden of government' (Cloete et al. 1986). With the political changes of the 1990s, the HSRC set about repositioning itself in relation to the new democratic government, state and society, thus revising its research agenda. In the early 1990s, the academic boycott of South Africa[9] ended and research institutions, including the HSRC, sought to establish networks with international academic institutions and organisations. The HSRC also set about reconnecting with social science and education communities in South Africa and conducting research that was relevant for the new society. The HSRC took a strategic decision to conduct research that universities may have found difficult or impossible to undertake, viz. large-scale survey research (interview with Professor Rolf Stumpf 2019).

At the same time, an HSRC researcher, the late Dr Derek Gray,[10] through his international networks, was introduced to the TIMSS network. He found resonance between the objectives of TIMSS and the new vision and mission of the HSRC, which included assessing and monitoring educational performance to inform educational policy. Gray saw the link between mathematics and science performance, and economic progress in a technologically based society, and viewed TIMSS as an important project in relation to the 'Reconstruction and Development Plan and to the future planning of the education services' (Gray 1994: 14). He predicted that South African achievement results would be poor, but thought it was important for the country to know where it stood, and work on improving the education system (interview with Dr Dana Kelly 2019).

The HSRC President at the time, Rolf Stumpf, had a good working relationship with the then Director-General of the Department of Education (DoE) (DG Manganyi). The DoE had commissioned the HSRC to conduct the 1996 School Register of Needs survey (DoE 1997) and supported the HSRC in conducting research that would benefit education, including TIMSS. Unfortunately, the DoE was unable to fund the study (interview with Professor Rolf Stumpf – 2019), and the HSRC was unsuccessful in raising the required funding externally (Gray 1994). Due to its perceived importance, the HSRC therefore funded TIMSS 1995[11] (and the

subsequent 1999 and 2003 studies) from their parliamentary grant allocation, with international travel subsidised by the IEA.

In 1994, the HSRC was accepted as an IEA member and one of the TIMSS participating countries. Gray attended his first NRC meeting in Italy in 1993 andthe next meeting at Boston College, USA in 1994. At these meetings, the NRCs provided feedback on design, instruments, analysis and research implementation tothe TIMSS Study Centre.[12] It was a time of very limited e-mail communication and documents had to be couriered to and from the NRCs.

The TIMSS network had started off as a group of industrialised nations at similar levels of educational development. As more countries at lower levels of industrialisation and educational development joined, challenges emerged, related to how to accommodate a wide range of country performances and the power differentials that existed between the countries at different stages of development. Gray commented: 'I became aware of the fact that the needs and facts of developingnation members of TIMSS were to some extent being marginalised. Assumptions were made and decisions approached based on first world availability of informationand equipment.' He went on to say: 'There is NO malice, spite or other agendas in these tendencies, but I was very strongly aware of them though' (Gray 1994). This observation has repeated itself in the experiences of subsequent NRCs.

In 1995, the HSRC administered the TIMSS achievement study in 150 schools with Standard 5 and Standard 6 learners (now Grades 7 and 8).[13] Data collection was operationally and logistically a massive and complex exercise. The first methodological challenge was to establish a database containing the names of all schools in the country, and to then select a nationally representative sample of schools. Pre-1994, the HSRChad established contact with the 17 education departments and began constructinga Database of Schools in South Africa. Using this database, though imperfect, the HSRC selected a sample of schools in which to administer the study. Using the HSRC'ssurvey arm, MarkData, the data was collected between August and December 1995. The extended duration of data collection was a result of the limited information regarding schools' locations or usable maps, particularly in rural areas, and the associated difficulty in finding and accessing schools. The research team had no prior experience in conducting large-scale national assessments, and it was thereforea learning experience for all (Howie 2000). Despite this, the data was submitted tothe TIMSS Study Centre using courier services. Pierre Foy, an IEA statistician at the time, characterised the efforts of Dr Gray and the team as 'valiant and heroic'(interview 2019). South Africa was one of 41 countries that participated in TIMSS1995 and was the first African country to take part. However, due to gaps in the data and low sampling participation, the IEA could not provide robust estimates, and in the international reports, the South African results were categorised as 'unapprovedsampling procedure at the classroom level and not meeting other guidelines' (Gonzalez & Smith 1997: 10).

Despite the incomplete dataset, the HSRC team analysed the data and completed theresearch report outlining the first national achievement estimates for the country,

and speculated about the reasons for South African learners' poor performance (Howie 1997). Howie (2011: 301) described the reaction to the release of the TIMSS 1995 results in the following way:

> The results of TIMSS 1995 produced outrage in different circles starting with the Department of Education, which had difficulty accepting the very low performance of the South African learners. The business community and public were shocked that the top-performing learners in the country did not compare with the average learners of the top-performing countries.

Participation in TIMSS 1995, even with its methodological limitations, provided the first indicative estimate of South African mathematics and science achievement, and hence an indication of the quality and outcomes of the educational system. The Third International Mathematics and Science Study conducted in 1995 was repeated in 1999. Two other African countries (Morocco and Tunisia) joined South Africa as part of the 38 participating countries. The HSRC, with Sarah Howie as the NRC for South Africa, funded and conducted TIMSS 1999 at the Grade 8 level. With slightly improved, but still challenging conditions, the Database of Schools in South Africa was again used to draw the South African sample. This time the sample was expanded to 225 schools, with 25 schools selected from each of the provinces in order to provide provincial achievement estimates. South Africa complied with all the data collection requirements and the IEA was consequently able to estimate the national mathematics and science scores.

The TIMSS 1999 achievement scores were again very low, and South Africa was ranked as the lowest performing country. These results provided further evidence of the poor quality and outcomes of the South African education system. Scepticism regarding the value of TIMSS still existed, and the Minister of Education at the time lamented that international studies like TIMSS and the Monitoring of Learning Achievement (coordinated by Unesco) were not set by ourselves as South Africans 'but by external agents who might not necessarily share our own worldview' (Asmal 2003). The academic community was also divided in their support, or rejection, of the TIMSS findings. The scepticism emerged in the context of poor achievement outcomes, and an academic community with limited statistical and quantitative skills.

TIMSS in the 2000s: Encouraging government to own the study

South Africa continued its participation in TIMSS 2003, with the HSRC coordinating and funding the study. The TIMSS sample was drawn from the School Register of Needs database, and the HSRC decided to administer the test to both Grade 8 and 9 learners in each school. Two hundred and fifty-five (255) schools, and close to 9 000 Grade 8 learners and 4 300 Grade 9 learners, participated in TIMSS 2003 (Reddy et al. 2006). Vijay Reddy was the NRC, and Reddy (2005: 64) declared that her own role as the NRC was neither 'straightforward [n]or unproblematic', and highlighted that she had to grapple with how TIMSS data could be analysed in a way that provided

more helpful information to local policy makers and practitioners. She further argued that while there are limitations and power differentials related to large- scale achievement studies, benefits for lower income countries would be realised if participating countries shaped the analyses to meet their own needs. Reddy (2005) proposed that the findings from TIMSS would be more useful if the analyses (i) used a simplified and transparent methodology to report information; (ii) paid greater attention to the categories of poverty and inequality in shaping the analysis;

(ii) disaggregated achievement scores to explore the performance of relevant local groups; and (iv) developed a time-series analysis (trend) of achievement scores to establish whether, and why, performance is changing over time.

Thus, the analysis of the TIMSS 2003 data was informed by the fact that the story of South African performance cannot be told through the single national score, but through appropriate demographic disaggregation. In reporting the results of TIMSS 2003, we disaggregated the achievement scores by province, gender and school type (ex-racial school education departments). The analysis confirmed the link between provincial achievement scores and the human development index of provinces (Reddy et al. 2006: 48). The disaggregation of the achievement scores by the ex-racial school types revealed the strong correlation between socioeconomic status and achievement. Black Africans, the group most disadvantaged by the apartheid policies, exhibited the lowest performance. Schools attended by this group were located in areas characterised by high levels of poverty and unemployment (Reddy et al. 2006: 50). An important, but overlooked, finding was that the range of performance between the 5th and 95th percentiles was widest for South Africa, compared to other participating countries. This reflects the wide disparities in society and in schools, and is evident in the educational outcomes of the learners. The wide variation in the South African mathematics scores led to the observation that there were two systems of education in the country, and the achievement scores in TIMSS were reflective of South African inequalities (HSRC 2004). This characterisation of the schooling system as being made up of two historically and persistently different and unequally functioning subsystems (Reddy 2005, 2006; Fleisch 2008) continues to this day.

The HSRC analyses acknowledged the role of poverty, a lack of resources and infrastructure, low teacher qualifications, poor teaching cultures and poor English language proficiency as factors contributing to low achievement scores. Our recommendation for improving the achievement outcomes was to target schools for educational improvement. Given the high levels of poverty in the country, the home and societal contributions needed to be enhanced by schools to effect change for the majority of learners (Reddy 2005, 2006). Schools needed to improve with respect to their environment, culture, and teaching competences, among other factors.

Another recommendation made after TIMSS 2003 was that South Africa should not participate in the 2007 round of TIMSS. The South African education system had undergone radical restructuring, and many new initiatives and interventions had been introduced. It was therefore argued that, considering the strain that the

interventions put on the education system (and, more pertinently, the educators), South Africa should rather participate next in 2011, as this would allow the intervention programmes to become embedded within the education system. 'This achieved, it would then be more reasonable to measure performance in TIMSS 2011 to see how the country has progressed' (Reddy et al. 2006: 120). This decision wascriticised within some quarters, particularly newspapers, suggesting that the reason for non-participation was that government did not want to 'expose itself to further humiliation' (Howie 2011: 302). Howie (2011: 302) further indicated that 'members of the broader education community regretted this decision as a missed opportunityto continue the external monitoring of the quality of education'. While South Africa's non-participation in TIMSS 2007 meant missing that data point, allowingeducational interventions time to become embedded in the system before assessing was considered a better option for education.

TIMSS in the 2010s: The institutionalisation of TIMSS into government

The majority of countries participating in TIMSS are supported by their national Ministry of Education, and the study may be conducted by the ministry itself oran appointed independent research agency. After the release of the TIMSS 2003 results, the HSRC engaged in discussions with the DoE for TIMSS to be included in the DoE's plans as one of the international achievement studies that could provide educational monitoring data for the country.

The DBE's[14] Strategic Plan (2010–2013) incorporated this recommendation, stating that:

> participation in international testing programmes will continue, partly so that the country's educational performance can be compared to that in other countries, and partly to improve capacity within the country in theapplication of the latest assessment methods. The DBE commits through itsstrategic plan to participate in the TIMSS and PIRLS. (DBE 2010: 21)

In 2010, given the HSRC's institutional history with TIMSS, the DBE requested that the HSRC conduct TIMSS 2011. The low TIMSS 2003 Grade 8 scores and thedifficulties for imputations and estimations prompted the International Study Centreto suggest that South Africa (with Botswana and Honduras) conduct the survey at the Grade 9 level.

In 2011, data was collected from 12 000 Grade 9 learners in 285 schools across the country. Independent schools were explicitly oversampled in order to estimate learner achievement in these schools. We reported achievement scores by province, school type (public and independent), gender and age. Fifteen years after the end ofapartheid, schools were now ranked by a poverty quintile index and poorer schools were subsidised for their school fees.[15] We thus also reported on achievement scores for fee-paying and no-fee schools. In addition, we reported on contextualrealities and their influence on learning, including home environments and support; physical resources; school climate (environment, safety); and learners' attitudes. We

also recommended that educational policy focus on both low and high performers, thereby simultaneously responding to the agendas of equity and excellence in mathematics achievement (Reddy et al. 2012; Reddy et al. 2016).

The country breathed a sigh of relief when we reported that the TIMSS 2011 Grade9 mathematics achievement scores improved by 67 TIMSS points between TIMSS 2003 and TIMSS 2011. This was the first piece of robust evidence to demonstratethat educational quality and outcomes were improving. DBE's Action Plan to 2019 called these results 'the most significant news about the system in recent years' (DBE 2015a: 10). TIMSS achievement scores were included in Indicator 9 of the Action Plan,[16] and the TIMSS mathematics performance targets were set at 361 for 2015, 401 for 2019, 441 for 2023 and 472 for 2027 (DBE 2015a: 52). While SouthAfrican mathematics achievement was 372 in 2015 (Reddy et al. 2016; Reddy, Visser,Winnaar et al. 2016), the HSRC is more conservative in its projections, and speculatea Grade 9 TIMSS score of 389 in 2019, 420 in 2023 and 440 in 2027.

TIMSS is now firmly embedded in the South African assessment landscape, andthe achievement trend measures are considered to be robust. The DBE again commissioned the HSRC to conduct TIMSS 2015, which at the Grade 9 level provided an additional data point on the achievement trend line over 20 years (1995to 2015).

In 2015, in addition to conducting the study at the Grade 9 level, we also conducted the mathematics assessment at the Grade 5 level. In the earlier TIMSS, we did not assess learners at the Grade 4/5 levels as we were concerned about the limitedEnglish language proficiency of learners at this level. With the improvement in the quality of education in the country, we felt this an appropriate time to includethe Grade 5 study. TIMSS at the Grade 5 level provides us with information about early mathematical proficiency so that interventions can be implemented earlier. In addition to information from learners, educators and schools, the Grade 5 study collected information from parents about home educational activities. The analysis illuminated the vastly differing socioeconomic conditions in the country (Isdale et al. 2017; Reddy et al. 2016) and its impact on mathematics achievement.

In line with the four-year TIMSS cycle, South Africa again participated in TIMSS2019 at the Grade 5 and Grade 9 levels. Officials from some of the provincial education departments had expressed reservations about the provincial estimates and high standard errors in previous rounds.[17] In consultation with the IEA, we therefore boosted the sample sizes for the Western Cape and Gauteng Provinces[18]to 150 schools each. These provinces are recognised as benchmark participants inTIMSS 2019. At the time of writing this chapter, we had completed data collection, and cleaning and preparing the data for analysis and release of the results in December 2020.

Mathematics achievement and the health of the South African education system

The Grade 8 achievement estimates from TIMSS 1995, 1999 and 2003 categorised South Africa as achieving *very low* scores in mathematics and science, and in fact, only one in 10 learners achieved a score above 400 TIMSS points, which denotes having basic mathematical knowledge. There was no statistically significant difference in achievement over this period. The achievement gap between the highest and lowest performing provinces was around 1.6 SD,[19] with the Western Cape and Gauteng being the higher performing provinces, and Eastern Cape and Limpopo the lowest performing (Howie 1997, 2001; Reddy et al. 2006). The achievement scores for learners by the categorisation of their schools into ex-racial departments of education computed a 2.4 SD difference between learners in ex-House of Assembly schools (designated for white learners) and the Department of Education and Training (then and now almost exclusively for black African learners) (Reddy et al. 2006).

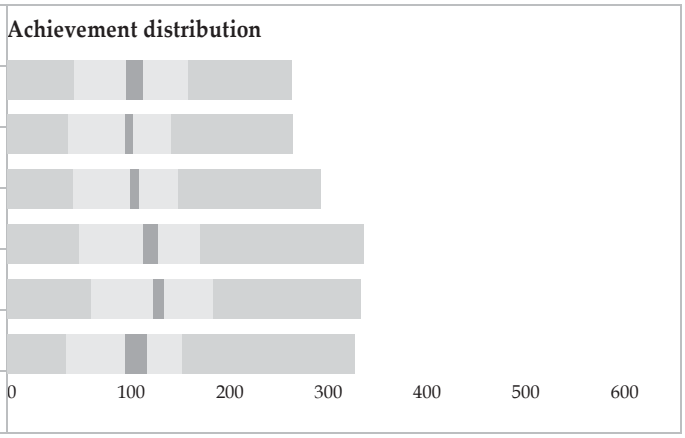
The improvement of 67 TIMSS points for mathematics and 64 TIMSS points for science between TIMSS 2003 and 2011 was followed by further improvement in TIMSS 2015. From 2003 to 2015, there was an improvement of 87 TIMSS points for mathematics and 90 TIMSS points for science, the highest increase out of all countries participating in both rounds (albeit starting from a low base) (Reddy et al. 2016; Zuze et al. 2017). In 2015, one third of learners achieved above the score of 400 points (Mullis et al. 2016). While this is laudable, on the other hand, two-thirds of learners do not have the basic mathematical knowledge for that grade. Similarly, the change in our overall achievement from 'very low' (1995 to 2003) to 'low' (2011, 2015) is applauded, but the progress in learning gains seems to be slowing down. In addition to improvements in educational outcomes, there was also a decrease in educational inequalities, with the best improvements occurring at the bottom end of the distribution, i.e. the poorest groups.

The provincial contexts in South Africa are vastly different in their socioeconomic conditions. It is not surprising, then, that Gauteng and the Western Cape, with the highest provincial GDPs, achieved the highest scores, and Limpopo and Eastern Cape, as the poorest provinces, exhibited the lowest performances. However, a pleasing result was that the provincial achievement gap decreased from 1.6 SD in 2003 to 1 SD in 2015 (Isdale et al. 2017; Reddy et al. 2016; Zuze et al. 2017).

School type (fee-paying or no-fee) serves as a proxy for a school's socioeconomic status. There was an achievement gap of close to 1 SD between fee-paying and no-fee schools in 2015, illustrating the continuing inequality in achievement between poor and affluent learners. While the reality of low achievement in no-fee schools is well recognised, it is noteworthy (and concerning) that the average mathematics score of learners in 500 fee-paying schools was still not as high as expected, being below the centre-point (Isdale et al. 2017; Zuze et al. 2017).

Figure 23.1 *Trends in mathematics achievement in TIMSS 1995, 1999, 2003, 2011 and 2015*

Mathematics	Average scale score
Grade 9 2015	372 (4.5)
Grade 9 2011	352 (2.5)
Grade 9 2003	285 (4.2)
Grade 8 2003	264 (5.5)
Grade 8 1999	275 (6.8)
Grade 8 1995	276 (6.7)



Sources: Reddy et al. 2016; Zuze et al. 2017

Figure 23.1 plots South African mathematics achievement for TIMSS 1995, 1999, 2003, 2011 and 2015. The percentile graph plots the trend in mathematics achievement distribution between the bottom and upper ends at the 5th and 95th percentile at the Grade 8 level (1995, 1999, 2003), and at the Grade 9 level (2003, 2011, 2015).

An important dynamic in any description of educational achievement is related to gender achievement patterns. The gender achievement story is complex, and the mathematics scores for girls and boys at the Grade 5 and 9 levels signal this complexity. The 2015 TIMSS data showed that at the Grade 5 level, girls (statistically significant) outperformed boys (Isdale et al. 2017). These findings are in contrastto the Grade 9 results where there were no significant gender differences in mathematics or science performance (Zuze et al. 2017). It is concerning that the mathematics performance advantage exhibited by girls at the Grade 5 level decreasesover time, and this apparent advantage is lost by Grade 9.

In an equal world, one's educational achievements would be determined by ability and talent. However, in an unequal society the differentiated conditions for learning affect educational performance. The South African demographic and contextual conditions are less favourable for learning than for those in other participating countries (Mullis et al. 2016). In-country, while the racial demographics of fee- paying schools have changed over time, with around 60% of black African learners in fee-paying schools in 2015, the achievement changes from 2003 to 2015 continue to reflect inequalities and socially graded differences within both homes and schools(Reddy et al. 2019).

The analysis of TIMSS achievement data and conditions for teaching and learning established the extent to which conditions affected learning. Some of the studies investigated the role of language (Howie 2002; Prinsloo et al. 2018); social class (Frempong 1998); curriculum (Ndlovu & Mji 2012); attitudes and self-efficacy (Juan,Hannan & Namone 2018; Juan et al. 2014); home and school resources (Visser &

Juan 2015); school effects (Winnaar et al. 2015); teacher classroom practices (Arends et al. 2017); school climate and bullying (Juan et al. 2018; Winnaar et al. 2018); school leadership (Zuze & Juan 2018); and learners' sense of belonging (Arends & Visser 2019). This is not an exhaustive list, but the consistent findings are that many home and school factors have an influence on learning and achievement.

The impact of South Africa's participation in TIMSS

The HSRC spearheaded the independent monitoring of the quality of our educational outcomes through TIMSS and demonstrated the importance of government adoptingthese measures to periodically monitor the health of the educational system. TIMSS has been institutionalised as a government programme, and the dataset is valuable for both monitoring and determining the predictors of performance.

TIMSS is the only study that provides robust trend achievement estimates and is therefore an important indicator of the health of our education system over time.TIMSS is a trusted measure and the results have been used extensively by politicians,national and provincial governments, policy makers, the media, researchers andthe public. In the 2016 State of the Nation Address, then-president Zuma said: 'We are encouraged by recent international test results. The results in the Trends in International Mathematics and Science Study and the Southern and East AfricanConsortium for Monitoring Educational Quality…, show that the performance of South African students is improving' (SONA 2016).

Even though the responses to the TIMSS 1999 results were sceptical, the concernabout the low quality of mathematics and science performance prompted governmentto focus on improvement programmes for these school subjects. The first systematicintervention by government was the Dinaledi Schools Project, which provided support and resources to 500 schools so that they could improve the quality of mathematics and science education. Over the years, government has increasingly recognised the importance of mathematics and science, and there has been continuedallocation of resources and support to these subjects. National Treasury includes a line item in the Education budget to focus on mathematics and science teaching.

The TIMSS data is also widely used to generate knowledge. Researchers from both within and outside South Africa have published a number of journal articles andbook chapters using the South African data. In addition, a number of universitystudents have used the South African TIMSS data for their dissertations and theses.[20] The TIMSS 2011 and 2015 contextual information, and the correlation to mathematics and science achievement, has extensively informed the country's education policy directions. For example, the TIMSS 2015 analysis highlighted an increase in student bullying, and, in response to that finding, the DBE developed theNational School Safety Framework (DBE 2015b).

Communicating the TIMSS results to the practitioner community is a key featureof the programme. The TIMSS research team participated in the DBE's provincial engagements in 2017 across all nine provinces, presenting the results to 28 500

provincial officials and school principals. The periodic TIMSS-SA newsletter translates the academic findings into information for a wider audience.

A further benefit of TIMSS participation is for research systems with limited technical skills, as this participation allows an opportunity to build the country'sresearch capacity, and provides a robust methodology for trend analysis (Reddy 2005). Researchers and research trainees have had the opportunity to participate in TIMSS and improve their technical skills in relation to conducting large-scale assessments and gain a better understanding of South African achievement and the contextual factors that impact educational outcomes.

Going forward in the 2020s

In the last 25 years, the Human Sciences Research Council has built up a research programme that has assessed mathematics and science achievement, and provided national, as well as nuanced achievement estimates in an unequal society. As a result,South Africa has a mathematics and science trend measure at the Grade 8/9 level from 1995, and a mathematics Grade 5 measure from 2015. This is a good point topause and consider how we see the next part of the TIMSS journey.

As TIMSS is the only study that provides trend achievement measures, it is importantthat we continue with these assessments. This is a prudent time to ask whether we continue assessing achievement at both Grade 5 and 9 every four years or alternate between the grades and thereby test a particular grade every 8 years. Since TIMSS provides crucial information about our educational system, participating in TIMSS every four years and administering them to the same grade every eight years will still provide valuable information.

In 2019, in addition to the national study, we included two provincial studies. The sharper estimates and more detailed descriptions and analyses of the provincial contexts for teaching and learning will speak directly to provinces and allow them to use the information to plan appropriate intervention programmes to improve achievement and reduce achievement gaps in mathematics and science. It is advisable that when average provincial estimates reach a score of 400, they are then included as benchmarking provinces.

With the global shifts towards incorporating technology and e-assessments, about half the TIMSS 2019 participating countries administered an e-TIMSS version, whilethe other half (including South Africa) continued with paper-and-pencil testing. South Africa needs to plan for an e-assessment in 2023. There is, however, limited access to computers and internet connectivity for teaching and learning in our schools. According to the National Education Infrastructure Management Systems Standard Report (DBE, 2019), only 22% of South African schools have internet connectivity for teaching, and one third of the schools have computer centres. Theselow numbers are further exacerbated by provincial differences, with Gauteng and theWestern Cape having the best access – internet access is available in 86% of WesternCape schools and 64% of Gauteng schools, while computer centres exist in 81% of

Gauteng schools and 66% of Western Cape schools. South Africa is therefore faced with enormous challenges in participating in the TIMSS e-assessment.

As a response to countries at lower levels of educational development regarding the demanding nature and appropriateness of some achievement items, TIMSS 2023 willmodify the design and selection of items. A 'group-adaptive design' strategy will beemployed, which means that countries can choose the level of difficulty of the test they administer to their learners. Top-performing countries (e.g. Singapore) maychoose 70% of items with a higher level of difficulty and 30% that are less difficult. Lower performing countries (e.g. South Africa) would construct the assessment with70% less difficult and 30% more difficult items. The TIMSS methodologies make it possible for the achievement score of all countries to still appear on the same scale. This is a major advancement for lower performing countries, where the level of the items has been beyond the ability of the majority of learners, and learners' non- responses have resulted in poor estimates of student learning.

Unlike established economies and educational systems, the South African educational challenge is to understand what happens both inside and outside of schools and classrooms. Many of our analyses to date have focused on measuring learner achievement and explaining achievement gaps based on demographic and contextual variables. We have confirmed findings from other studies relatingto predictors of achievement, as well as illuminated new explanatory variables to explain achievement gaps. Going forward, we need to complement this data with more detailed information related to classroom and school practices, and the teaching and learning relationship between the learner and teacher.

TIMSS is an international achievement study, with both limitations and opportunities.As a low and unequal income country, we have used and must continue to use our voice to inform the modification of the TIMSS design so that it is appropriate fora wider range of countries, and we must use the data infrastructure to include questions that are more relevant to particular country contexts. Our analyses must continue to be locally meaningful. In this way, we can respond to the dual challengeof striving for both global competitiveness and local relevance.

Notes

1 Some countries assess Grade 5 and 9 learners, including South Africa.

2 In 2003, the assessment was conducted at both the Grade 8 and 9 level.

3 While TIMSS measures mathematics and science achievement given the high correlation between the two, in our analysis we will refer only to the mathematics data.

4 The apartheid regime labelled people into one of four population group categories: African, Coloured (people of mixed heritage), Indian/ Asian or White.

5 Black Africans were officially called 'Bantu' by the apartheid regime.

6 Hansard (1954) Debates of the South African Parliament.

7 For full details about the history of IEA see the website: https://www.iea.nl/studies.

8 Progress in International Reading Literacy Study.

9 In 1980 the United Nations passed a resolution of cultural, academic and other boycotts of South Africa. (UN General Assembly Resolution A/RES/35/206E).

10 Gray's HSRC responsibilities at the time included co-ordinating the Science Olympiads programme which sought to promote 'excellence' in mathematics and science.

11 Insiders at the time said this was not without a fight as programmes were competing for financial resources.

12 Subsequently called the TIMSS and PIRLS International Study Centre, Boston College, USA.

13 The HSRC also administered the achievement study to Standard 10 (Grade 12) learners, but without a proper sampling frame the results were not considered reliable.

14 In 2009, the DoE was separated into the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET).

15 70% of schools had their school fees subsidised by the state. The other 30% of schools were categorised as having more resources, and learners living in middle-class suburbs attended schools that were classified as fee-paying schools. Independent schools (constituting about 7% of schools and 4% of learners) are also fee-paying.

16 'Average Grade 9 mathematics score obtained in TIMSS'.

17 With the provincial sample size around 30 schools per province, these standard errors will be high.

18 All provinces were invited to participate in provincial studies but the two provinces agreed for TIMSS 2019.

19 TIMSS scores have a midpoint of 500 and a standard deviation of 100.

20 See http://www.timss-sa.org.za/ for the database of TIMSS-SA publications (journal articles, book chapters, master's and PhD dissertations) compiled by Sylvia Hannan and Vijay Reddy.

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