Educational outcomes: Pathways and performance in South African high schools

Authors:
Vijay Reddy[1]
Servaas van der Berg[2]
Dean Janse van Rensburg[1]
Stephen Taylor[2]

Affiliations:
[1]Human Sciences Research Council, Education and Skills Development Research Programme, Durban, South Africa

[2]Department of Economics, University of Stellenbosch, Stellenbosch, South Africa

Correspondence to:
Vijay Reddy

Email:
vreddy@hsrc.ac.za

Postal address:
Private Bag X07, Dalbridge, Durban 4014, South Africa

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We analysed the pathways and performances in mathematics of high (secondary) school students in South Africa using a panel-like data set of Grade 8 students who participated in the 2002 Trends in International Mathematics and Science Study (TIMSS) and who were tracked to Grade 12 examination data sets. We examined the relationship between TIMSS mathematics performance and reaching Grade 12, the selection of and performance in Grade 12 mathematics, and success rates in the matriculation examination. The progression of students from schools serving middle-class (Subsystem M) and poorer students (Subsystem P, the majority) was compared. Firstly, mathematics achievement scores in South Africa are low and different performance patterns were shown between the two subsystems. Secondly, students who started with similar Grade 8 mathematics scores had different educational outcomes 4 years later. In Subsystem M schools, Grade 8 mathematics scores were a good indicator of who would pass matric, whilst this relationship was not as strong in Subsystem P schools. Thirdly, there was a stronger association between TIMSS Grade 8 scores and subject choice of matric mathematics in Subsystem M schools than in Subsystem P schools. Fourthly, there was a strong correlation between Grade 8 mathematics performance and matric mathematics achievement. Mathematics performance in the earlier years predicted later mathematics performance. To raise exit level outcomes, mathematics scores need to be raised by Grade 8 or earlier. To improve educational and labour market outcomes, the policy priority should be to build foundational knowledge and skills in numeracy.

Introduction

The hope and aspiration for any parent, society or government is that children and youth receive a good education and that the capital, capabilities and skills gained from schooling lead to personal development, citizenship and readiness for the labour market. South Africa, like other economically unequal countries, has prioritised improving access to and quality of education, and thus to improving education outcomes. Mathematics and science are key areas of knowledge and competence, and government has emphasised the centrality of mathematics and science as part of the human development strategy for South Africa.[1] Whilst there have been successes in increasing access to education, the stagnation of, especially mathematics, test scores over time suggests that resolving quality and outcome issues remains elusive.[2,3,4,5,6]

Given the persistent pattern of low achievement scores for students from low-income households, the research and policy challenge is how to improve the schooling system to break this cycle of poor achievement in mathematics, as well as in other problem areas, namely, languages and sciences. We need to move beyond the legacy questions to understand why, despite many efforts of government and other key role players, we have not been successful in improving these educational outcomes. This analytic–descriptive study reports on an analysis of students' pathways and performances in the high school phase.

To create the sample population, we used a unique panel-like data set which identified a group of students who participated in 2002 in the Grade 8 Trends in International Mathematics and Science Study (TIMSS 2002) and were also in the Grade 12 (matriculation) examinations data set. This group provided a good example of a longitudinal data set with achievement scores at both the Grade 8 and Grade 12 levels. Using these two data sources, it was possible to examine the associations between Grade 8 mathematics performance in TIMSS and the selection of mathematics as a matric subject, Grade 12 mathematics performances, and patterns of passing matric.

The South African school system can be seen as being made up of two historically and persistently differently functioning subsystems,[4,5,6] and it is appropriate to disaggregate the data and outputs for these two subsystems. The study categorises the schools which largely serve students from poorer homes as Subsystem P and those which largely serve middle-class students as Subsystem M. Subsystem P schools, which are the majority (80%), refer to schools which historically served Black African students in South Africa during the apartheid era. These schools were provided with the fewest resources and still bear the scars of that legacy; they are located in areas occupied by low-income households. These schools cater for a majority of students for whom the language of instruction (English) is their second or third language. By contrast, schools which were categorised as Subsystem M schools were historically attended by White and Indian students (we use the race terms in this article to reflect the historical resourcing patterns to different groups). These schools were better resourced under apartheid, are generally located in higher-income areas, and the majority of their students study in English as their first language. These schools constitute about 14% of the schools in the country. Because of their heterogeneity, and because they did not fit well into the two categories, for this analysis we ignored the schools that were attended historically by Coloured students.

Education outcomes: Student pathways and performances

Through an analysis of students' mathematics pathways and performances in the high school phase, this article provides new insights into educational outcomes in an unequal system. Firstly, we reviewed research analysing large-scale achievement data sets which identified determinants of educational quality and outcomes and, secondly, we reviewed research using panel data sets containing cognitive scores to examine student pathways and performances over time.

Since the 1970s, the availability of large-scale representative data sets, with information on student academic achievement, has provided an opportunity to undertake statistical or econometric analyses that can identify variables subject to policy control which can influence student cognitive achievement. Analyses to identify these key determinants using education production–function models[7,8,9,10] or school effectiveness or school improvement models[11,12,13,14] for a quality education, have been undertaken in both high-income and low-income country contexts.

Although these studies have advanced our understanding of the education process, there are limits to how they can advance our understanding of the determinants to improve education outcomes. These limitations apply even in high-income countries with good quality data and less extreme educational inequality, and where the basic inputs are in place.[15] In developing country contexts, where achievement scores are low and where the basic educational components are not in place, results from these statistical analyses are sometimes less informative regarding what could make a difference in achieving quality education.[15] There are limitations to statistical analyses and modelling from large achievement data sets: they can only show a 'snapshot' of a school at any particular time[16]; there is a lack of agreement on the determinants of educational quality[15]; there is a danger of reductionism and invalid specification of causality inherent in school effectiveness studies[17,18]; the determinants of improved education quality identified are more effective in already well-performing schools[19]; and there is a concern that these studies do not deal adequately with social class in the analysis.[12] Extending the analysis, especially in low-income countries, from a snapshot to a longitudinal framework, provides possibilities for a different insight on how to improve achievement outcomes.

There have been only a few investigations of the pathways and performances of school students over time. However, with an increasing number of large and representative panel data sets, a body of literature is developing. Panel studies have been undertaken on student pathways in relation to progression through an educational system[20,21,22]; to educational and career aspirations[23,24,25,26,27]; to aspirations, performance and transition from school to post-school institutions; and to labour markets and employment.[10,28,29,30,31,32] The few panel studies that have included cognitive or academic performance data have been used to analyse academic performance patterns over time, thus predicting patterns of future performance.[33,34,35,36,37]

The main findings that emerged from the review of panel data sets which included cognitive and achievement data were, firstly, that performance in earlier years predicts later performance; and, secondly, that gaps in cognitive ability emerge during early childhood as a consequence of differences in family background and, over time, these gaps widen.[34,36,38] Thirdly, children with educated and wealthy parents who score poorly in the early tests tend to catch up, whereas children with lower educated and lower-income parents who score poorly are unlikely to catch up.[33,35]

The early years of one's life are an important phase for promoting cognitive development and the acquisition of foundational knowledge and skills. Many poor children fail to reach their potential cognitive development because of deficiencies in their early development. Heckman[38] reports that, in the USA:

> going across income groups, gaps in cognitive ability emerge early in the life cycle and widen slightly in the early years of schooling. They stay constant after the age of eight, and school environments play only a small role in accounting for, narrowing or widening the gaps.

In Britain, Feinstein[33] found that pre-school development tests provided a strong indication of a child's later educational success and that this success was largely attributable to family background. Children with educated and wealthy parents who scored poorly in the early tests tended to catch up, whereas children with lower educated and lower-income parents who scored poorly were unlikely to catch up, and were an at-risk group. A subsequent study by Blanden and Machin[35] corroborated these findings. Children born in 2000 to the lowest income households who had scored some of the best results in tests at age three had, by the age of five, lost much of their early advantage. By age seven, these youngsters were overtaken by children from the wealthiest homes who were bottom in the tests at age three. The gap in the average percentile ranking in the tests between high achieving children from poor backgrounds and low achieving children from affluent backgrounds had shrunk from more than 70 percentiles at age three to 20 percentiles by age five.

In the unequal South African school system, the rate of grade progression is considerably higher amongst students within historically White schools (Subsystem M) than amongst those in historically Black schools (Subsystem P). For example, Lam et al.[37] found that 84% of White students who were in Grades 8 and 9 in 2002 successfully advanced three grades by 2005 compared with only 32% of Black African students. Furthermore, Lam et al.[37] demonstrated that grade progression in the schools typically attended by Black students was poorly linked to actual ability (as measured by assessment items) and learning. They found that baseline literacy and numeracy scores strongly predicted grade progression between Grades 8 and 11 for White and Coloured students, but weakly predicted progression for Black students. In contrast, no racial differences were found in the relationship between baseline scores and passing the matric examination, which is nationally standardised. They therefore propose that grade progression within schools attended by Black children is characterised by a considerable degree of randomness, with the consequence of high enrolment despite high rates of failure.

We know little about the patterns of cognitive development and mathematical performance over time. Given the limited literature in South Africa that uses panel data to track student academic performance, this study adds to the literature by using mathematics achievement data from two different time periods in two grades, as well as aggregate performance data from Grade 12, and analyses the pathways (subject choices) and performance patterns of students in school.

Methodology

Panel studies measure the same sample of respondents at different times, and can reveal shifting attitudes or patterns of behaviour over time. They are thus useful in predicting long-term or cumulative effects.[39] This panel-like study tracks the sample of Grade 8 students who participated in TIMSS 2002 to the Grade 12 examination data set.

South Africa participated in the TIMSS in 2002. The study collected mathematics and science achievement data from 8952 Grade 8 students in the country[5] and created a record of the name, date of birth and school attended in 2002 for each student who participated in the study. Grade 12 is the last year of schooling, during which students sit for a public, common examination (called matric). For the purposes of this study, the Department of Education allowed access to the matriculation 2006 and 2007 databases; these were searched for TIMSS 2002 participants. A total of 2734 (30.1%) unique student records from the TIMSS 2002 Grade 8 data set were found in the matric 2006 and 2007 data sets (repeaters were found in both the 2006 and 2007 matric databases). The General Household Surveys (GHS) of 2005 and 2006 calculated the progression rate from Grade 8 to Grade 12 as approximately 57%. This rate provides an indication of how many students were mistakenly not tracked to matric as a result of the imperfect matching process. Similarly, expected progression rates for each race group in our data were obtained from the GHS data. These progression rates were then used to weight up those students identified in matric and to weight down those students not identified in matric. This weighting was done separately for each race group. The weighting procedure ensured that the proportions within our matric sample were broadly representative of the entire population of matriculants in South Africa. In our subsequent analysis, where appropriate, we present the weighted information.

We used the TIMSS 2002 and matric mathematics scores as the proxy measure of analytical skills. These analytical skills are highly valued and are important for an individual's personal, social and economic development. Students who were in Grade 8 in 2002 made a range of subject choice selections and could have traversed one of four pathways: not continued with schooling after Grade 8; continued to Grade 12 without mathematics; continued to Grade 12 with mathematics at standard grade; and continued to Grade 12 with mathematics at higher grade.

Results

The panel-like achievement score data set provided a unique opportunity to examine (1) the relationship between Grade 8 and Grade 12 mathematics performance; (2) the extent to which TIMSS mathematics scores correlated with matric pass rates; and (3) the extent to which TIMSS mathematics scores informed matric mathematics selection and correlated with matric mathematics performance.

Grade 8 and Grade 12 mathematics performances

The matric pass rate of the Grade 8 group that reached Grade 12 was high at 72%. There was a high participation in mathematics (60%), although only 10% participated at the higher-grade level. Table 1 gives the average mathematics scores in TIMSS and matric for Subsystem P and Subsystem M schools.

Overall, Grade 12 mathematics performance was low, with the average standard-grade mathematics score being 25% and the average higher-grade mathematics score being 43%. The mean score in mathematics in Subsystem M schools was close to double that of students in Subsystem P schools at the standard grade, and more than double that at the higher-grade level. The TIMSS scores were exceedingly low by international standards. The international mean has been set at 500 and the standard deviation across countries at 100. On average, including those who did not reach matric, the South African performance in TIMSS was more than two standard

TABLE 1: Matric mathematics performance by level and school subsystem.

Assessment	Standard grade			Higher grade		
	Average maths score (%)	Average TIMSS score	Correlation	Average maths score (%)	Average TIMSS score	Correlation
Subsystem P schools	25	252	0.29	30	285	0.46
Subsystem M schools	43	425	0.5	63	539	0.47
Overall	28	281	0.45	45	404	0.71

TIMSS, Trends in International Mathematics and Science Study.

deviations below the international mean. Furthermore, there was a fair degree of correlation between the mean TIMSS and matric mathematics scores in the different cells. Notably, the correlation was better in Subsystem M schools and was greater for higher-grade than for standard-grade mathematics. It is also notable that students in Subsystem P schools with low Grade 8 mathematics scores often enrol for mathematics at the higher grade level. The mean TIMSS performance of students from Subsystem P schools who chose to do higher-grade mathematics in matric (TIMSS score 285) was considerably lower even than those Subsystem M students who elected to take standard-grade rather than higher-grade mathematics in matric (TIMSS score 425).

TIMSS score and passing Grade 12 examinations

Our initial hypothesis was that the TIMSS mathematics scores of students who reach matric, select mathematics as a subject and pass matric and mathematics would be higher than the scores of students who are not successful. We identified three distinct groups in the TIMSS data set, (1) those identified in the matric 2006 data set, (2) those identified in the matric 2007 data set and (3) those not identified in either data set (i.e. those that did not reach matric). The kernel density graphs of the TIMSS mathematics scores for the three groups allow a more detailed and nuanced picture of the mathematics starting point of the students (Figure 1).

As expected, the TIMSS modal mathematics score for those identified in the matric data sets was higher than that for those who could not be tracked to matric. The graph for the matric 2006 group displays a wide tail to the right, indicating that, in general, students who reached their matric year with consistent grade progression had higher TIMSS mathematics scores. An unexpected finding was the range of mathematics scores amongst the three groups, and the degree of overlap of the three graphs. It would seem that students starting with similar TIMSS mathematics scores at Grade 8 can have quite different outcomes 4 years later. Disaggregating the kernel density of TIMSS scores for Subsystem P and Subsystem M schools reveals a different pattern for these two sets of schools (Figure 2 and Table 2).

Students in Subsystem P schools, for both those identified and those not identified in matric year, had low TIMSS scores, with the difference of the mean TIMSS scores being 27 points (approximately one-quarter of a standard deviation). As indicated, scores were normalised to an international mean of 500 and a standard deviation of 100. The South African standard deviation is similar in magnitude. Subsystem M schools had higher TIMSS scores, and the difference between the mean TIMSS scores of those who did and those who did not reach matric was 36 points. In general, within both groups, it would seem that TIMSS Grade 8 mathematics scores did not differentiate clearly between those who did and those who did not continue to the matric year. Although, it should be remembered that most of those in Subsystem M reached Grade 12, even though they may not have been identified in the study's data.

TABLE 2: Mean Trends in International Mathematics and Science Study mathematics scores by school subsystem and identification.

Variable	Subsystem P		Subsystem M	
	Mean score	*n*	Mean score	*n*
Not identified in matric	220	5042	398	463
Identified in matric	247	1767	434	610

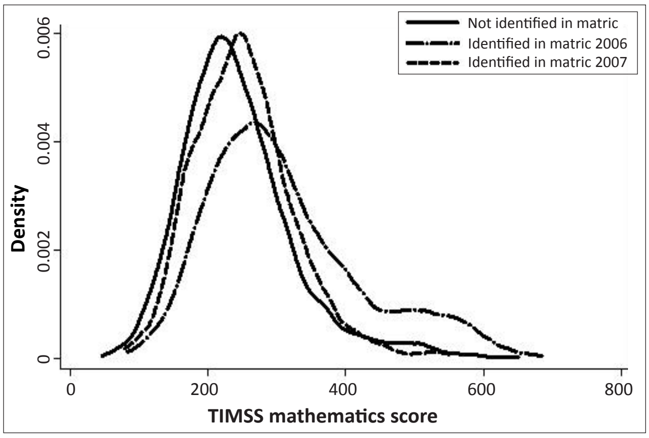

FIGURE 1: Kernel density of the Trends in International Mathematics and Science Study (TIMSS) mathematics scores by identification and matric year.

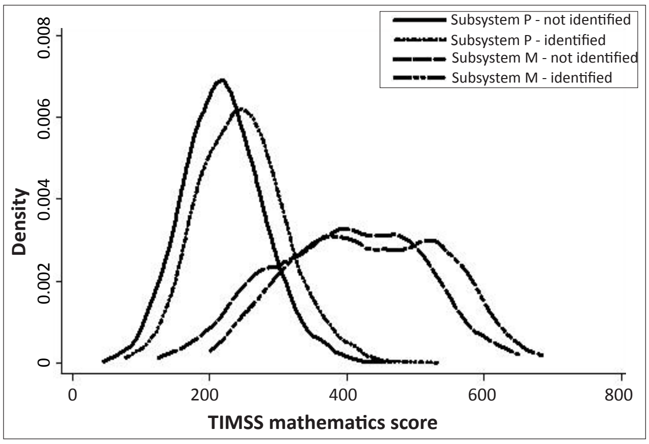

FIGURE 2: Kernel density of the Trends in International Mathematics and Science Study (TIMSS) mathematics scores by school subsystem and identification.

The analysis was extended to examine the patterns of TIMSS score for those who ‘passed matric’ and those who ‘did not pass’, in Subsystem P and Subsystem M schools (Figure 3). There was a high degree of overlap of the TIMSS scores between those who ‘passed matric’ and those who ‘did not pass matric’ in Subsystem P schools. The mean TIMSS scores were extremely low (226) for those who did not pass matric and 261 for those who passed matric. There was thus a small difference of 35 points between the two groups. In the Subsystem M schools, there was a higher degree of differentiation. The mean TIMSS score was 324 for those who did not pass matric and 444 for those who did pass (Table 3). There was thus a sizeable difference of 120 points between the two groups.

To further explore the relationship between TIMSS mathematics scores and those who passed matric, the TIMSS scores of those who passed matric were disaggregated into deciles, and the extent to which students from Subsystem P and Subsystem M schools converted their TIMSS scores to matric passes was examined (Figure 4).

As expected, students in the higher deciles (deciles 8 to 10) of TIMSS scores had higher pass rates than those in the lower deciles. Students in the higher performance deciles from both subsystems converted to matric passes at an almost similar rate. The pass rates of students in the same TIMSS decile (deciles 5 to 7) were different for students from Subsystem P and Subsystem M schools, with students from Subsystem M schools converting to matric passes at a higher rate. Thus students starting with the same mathematics capability in Grade 8, measured by TIMSS score, converted to passing matric at a different rate in Subsystem P and Subsystem M schools. A further point of significance is that two out of every ten students who fell into the lowest four TIMSS mathematics deciles did pass matric.

TIMSS scores and matric selection and performance

We analysed the extent to which TIMSS mathematics scores were associated with the choice of mathematics as a matric subject and the performance in matric mathematics. Firstly, we plotted the kernel density of TIMSS mathematics scores for students identified in the matric data set, according to whether they took mathematics in matric or not (Figure 5); secondly, we plotted a graph of average matric mathematics marks by TIMSS decile positions in order to examine their correlation (Table 4).

The kernel density plots of TIMSS scores of students from Subsystem P and Subsystem M schools who either took or did not take matric mathematics as a subject reflect different patterns of choice. In Subsystem P schools, there was little difference in the prior TIMSS mathematics performance between students who did and students who did not choose mathematics as a matric subject. In contrast, students in Subsystem M schools who took mathematics at matric generally had higher TIMSS mathematics scores in Grade 8 than those who did not continue with mathematics.

As noted in Table 1, matric mathematics performance and TIMSS mathematics performance were low. The relationship between the average matric mathematics mark and TIMSS mathematics scores is illustrated by a plot of these two sets of scores by the TIMSS deciles into which the student scores fall (Figure 6). Although low, the average matric mathematics mark increased in higher TIMSS deciles, and there was a strong correlation between Grade 8 TIMSS and Grade 12 matriculation mathematics performance. Thus the TIMSS Grade 8 mathematics mark strongly correlated with the mathematics performance in Grade 12.

Key findings

We examined the correlation between Grade 8 mathematics performance and the mathematics pathways in high

TABLE 3: Mean Trends in International Mathematics and Science Study mathematics score by school subsystem and matric passing.

Variable	Subsystem P		Subsystem M	
	Mean score	*n*	Mean score	*n*
Did not pass matric	226	529	324	29
Passed matric	261	1066	444	550
Not identified in matric	220	5042	398	463

Should be read in conjunction with Figure 3.

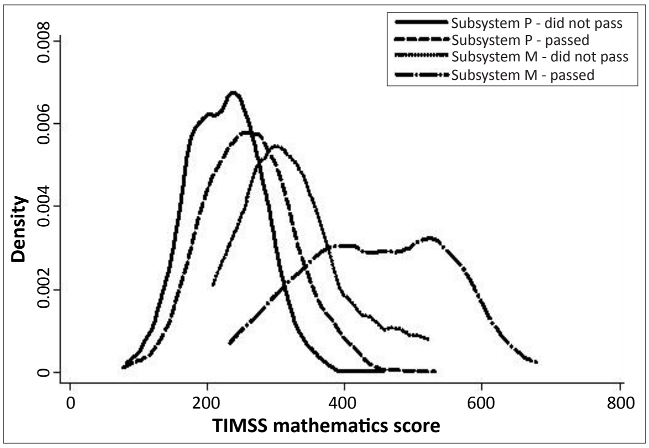

FIGURE 3: Kernel density of the Trends in International Mathematics and Science Study (TIMSS) mathematics scores by school subsystem and matric passing.

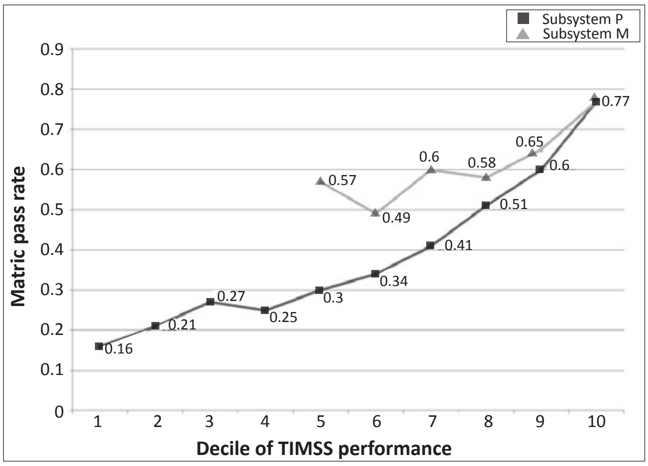

FIGURE 4: Conversion of the Trends in International Mathematics and Science Study (TIMSS) mathematics achievement to matric pass rates by school subsystem and decile of TIMSS scores.

schools and performance in Grade 12 examinations. Grade 8 mathematics scores are a good indicator of analytical capabilities, and one would expect that those with higher mathematics scores would have progressed to Grade 12 and achieved success in the Grade 12 examinations. The expectation would also be that their subject choices in the senior secondary level would have included mathematics at the higher-grade levels, and that those with better TIMSS mathematics performance would have achieved higher matric mathematics scores.

The findings of the study indicate, firstly, that educational achievement in South Africa, measured by TIMSS mathematics scores, is extremely low. The participation, performance and progression rates in Subsystem M and Subsystem P are significantly different, with Subsystem M students performing at a higher level than those in Subsystem P.

TABLE 4: Mean Trends in International Mathematics and Science Study mathematics scores by mathematics selection in Grade 12 and school subsystem.

Variable	Subsystem P		Subsystem M	
	Mean score	*n*	Mean score	*n*
Maths not selected	233	596	365	205
Maths selected	256	1095	467	392

Should be read in conjunction with Figure 5.

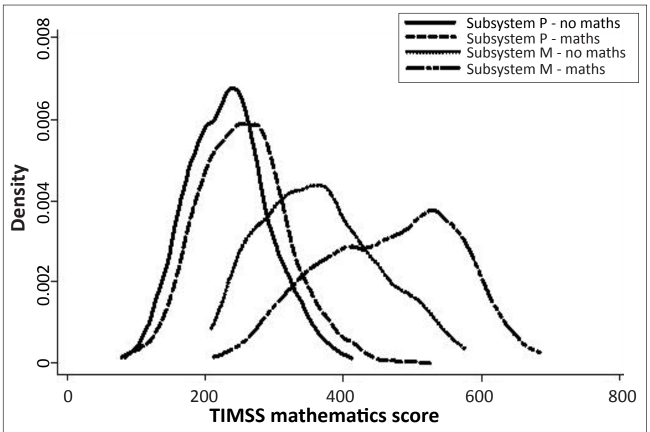

FIGURE 5: Kernel density of the Trends in International Mathematics and Science Study (TIMSS) mathematics scores by school subsystem and mathematics selection in Grade 12.

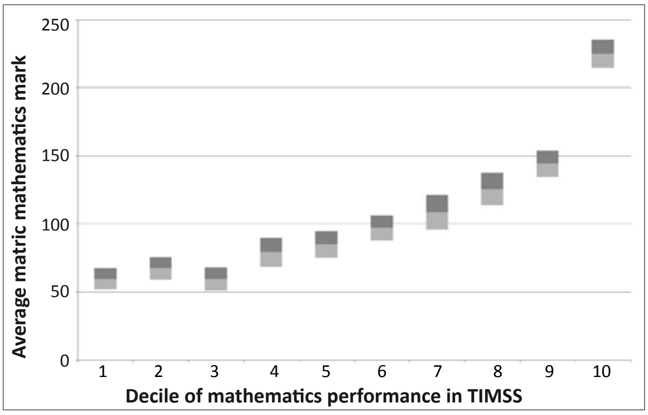

FIGURE 6: Average matric mathematics mark by performance in the Trends in International Mathematics and Science Study (TIMSS), showing 95% confidence intervals.

Secondly, we found that students starting with similar TIMSS Grade 8 mathematical scores may have quite different educational outcomes 4 years later. Grade 8 mathematics scores appear not to predict who will or will not reach matric, although this result may at least partly be attributable to our not being able to successfully identify all those who actually reached matric. However, Grade 8 mathematics scores are a good indicator of who can *pass* matric in Subsystem M schools. For Subsystem P schools, although the higher TIMSS scores can predict who has a higher probability of passing matric examinations, this relationship is not as strong. Students who come to secondary school with high Grade 8 mathematics scores, whether from Subsystems M or P, are able to convert to passing matric. For those in the middle bands of performance, the rate of conversion is different in the two subsystems, with Subsystem M achieving higher rates of conversion than Subsystem P schools. A surprising finding was that, in Subsystem P schools, one in five students (20%) whose TIMSS score was in the lowest four deciles was nevertheless able to convert that low demonstrated capability into passing matric.

Thirdly, for Subsystem M schools, TIMSS Grade 8 scores are a good sorter for the choice of matric mathematics as a subject, but, for the majority in Subsystem P schools, the subject choice of mathematics has little to do with earlier mathematics performance in TIMSS. Many students with weak TIMSS scores have high aspirations for participation and performance in mathematics, and, even with low scores, register for higher-grade rather than for standard-grade mathematics.

Lastly, there is a high correlation between the mean Grade 8 mathematics score and the matric mathematics scores, with this correlation being higher in Subsystem M schools than in Subsystem P schools. Students with higher Grade 8 mathematics performance scores tend to achieve success in matric mathematics. However, it would seem that for students who have low mathematics scores in Grade 8, schooling cannot provide the necessary inputs to overcome their low mathematics scores achieved in earlier grades and cannot improve their mathematical competencies.

Conclusion: Talking back to theory and policy

In our unequal, low performing educational system, Grade 8 mathematics performance predicts Grade 12 mathematics performance for all students. Across the two subsystems, Grade 8 performance does not predict equally strongly who will or will not reach matric. The two subsystems also behave differently with respect to mathematics subject selection and passing the matriculation examination. In Subsystem P, selection of mathematics for further study is not influenced by earlier mathematics performance, whilst in Subsystem M students with higher TIMSS scores select mathematics to study further. For students from schools historically serving middle-class households, Grade 8 mathematics performance is strongly correlated to passing matric; however, Grade 8 mathematics performance is poorly correlated with passing matric in students from lower-resourced schools situated in poorer areas and serving poorer students.

The strong relationship between Grade 8 and Grade 12 mathematics scores corroborates findings in the literature that earlier mathematics performance and strong foundational knowledge form the base for subsequent learning. Analytical skills in mathematics need to be built up from the early years. Mathematical knowledge is hierarchical in nature, and strong prior knowledge is therefore critical for conceptual development. The acquisition of these capabilities is shaped in the early years by the nature and quality of interactions in the home and community, and by the quality of inputs from the school.

In Subsystem P, the progression from Grade 8 to Grade 12 does not fit the expected pattern, that is, that those with high Grade 8 mathematics scores will reach and pass matric and those with lower mathematics scores may not do so. Students starting with similar mathematics scores at the Grade 8 level may have different educational outcomes 4 years later. The reason why students with low TIMSS mathematics scores from poorer schools pass at matric level may be that TIMSS mathematics scores are not an adequate indicator of requirements for passing matric, or that students with weaker mathematics background are nonetheless successful in passing matric because of better performance in other subjects. Educational investments made post Grade 8 may enable students to improve their performance in subjects besides mathematics, and to pass matric despite failing mathematics.

The pathways of students post Grade 8 in Subsystem P schools, that is, whether or not they select mathematics as a subject, shows that there is little relationship between demonstrated ability and choice of subjects. Students do not seem to be using information about their prowess in mathematics to make appropriate subject choices, perhaps because they do not receive enough accurate feedback at school about their mathematics performance.

The policy implication from these findings is that raising the mathematics scores at Grade 12 requires raising the scores at Grade 8. Extrapolating from this, and linking to the literature on cognitive development, we need to raise the mathematics and numeracy scores in the earlier years of schooling. High levels of attention paid to the early years of learning (reception year and foundation phase) for children from environments of lower household and parental resources would contribute to breaking the cycle of poor academic performance. Without this, both the background and school will continue to let the children down and the reproduction of inequality will continue. Students must know and understand earlier concepts; only when they do understand these early concepts, will they progress. We have shown that by the time students reach the secondary level, it is too late to significantly improve matric mathematics performance.

Ideally, the study would have used data of cognitive scores from the early years and tracked the cohort to later years, but as the only available cohort cognitive performance data is for Grades 8 and 12, only the relationship between Grades 8 and 12 could be examined. How cognitive development is shaped, in mathematics and in other subjects, can be assisted by panel studies research, by collecting data from the earlier years of schooling, and by paying greater attention to obtaining cognitive data. These issues should therefore be on the education research agenda for future studies.

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Competing interests

We declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this article.

Authors' contributions

V.R. was the principal author and conceptualised the study with S.v.d.B. S.v.d.B. provided econometric input and contributed to the writing of the manuscript. D.J.v.R. was involved in data construction, analysis and econometric input. S.T. provided data support, econometric input and assistance with analysis.

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