Analysing matric data to identify 'promising' schools in mathematics performance

DEBRA LYNNE SHEPHERD
SERVAAS VAN DER BERG

Stellenbosch Economic Working Papers: WP16/2020

www.ekon.sun.ac.za/wpapers/2020/wp162020

August 2020

KEYWORDS: mathematics performance, schools with promise, matric (NSC) data, South Africa
JEL: I10, I21

ReSEP (Research on Socio-Economic Policy)
http://resep.sun.ac.za

DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH

SOUTH AFRICA

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

BER
BUREAU FOR ECONOMIC RESEARCH

A WORKING PAPER OF THE DEPARTMENT OF ECONOMICS AND THE
BUREAU FOR ECONOMIC RESEARCH AT THE UNIVERSITY OF STELLENBOSCH

www.ekon.sun.ac.za/wpapers

Analysing matric data to identify 'promising' schools in mathematics performance[1]

Debra Shepherd[2] and Servaas van der Berg[2]

Abstract

This paper applies rigorous data analysis to the NSC fulltime 2010 to 2018 data to identity 'promising' schools in Mathematics amongst the group of Quintile 1 to Quintile 3 (Q1-Q3) public sector secondary schools. Several indicators of performance are investigated, including consistency in performance, above-expectations performance (using education production function analysis) and wasted Mathematics 'potential' through allowing and/or encouraging good matric candidates to take Mathematical Literacy. We find that enrolment in Mathematics is highest amongst Q1 and Q2 schools. However, enrolment in Mathematics is negatively correlated with average school performance in Mathematics in Q1-Q3 schools. Although the overall proportions of matriculants from Q4 and Q5 schools passing mathematics has declined over time, the pass rates of Q1-Q3 schools in Mathematics increased by roughly 30% between 2010 and 2018. However, despite a rise in the numbers of students achieving better (50% and higher) passes in Mathematics, the vast majority of Q1-Q3 schools show consistently low or inconsistent average performance. Roughly 10% of Q1-Q3 schools perform consistently above expected, less than 6% meet the potential to substantially improve their Mathematics pass rates, and only 21 Q1-Q3 schools indicate the potential to outperform Q5 schools.

Keywords. mathematics performance, schools with promise, matric (NSC) data, South Africa

JEL codes. I10, 121

[1] This paper draws from the report to Tshikululu Social Investments that sought to investigate national matriculation data to support the development of a strategy for the '*Maths Challenge*' programme funded by the Epoch and Optima Trusts. The main purpose was to identify schools which hold promise for interventions that form part of the Maths Challenge. All school names and other identifying information have been removed for the purposes of this working paper. The authors wish to acknowledge the invaluable comments and feedback from Tshikululu Social Investments and the Enoch and Optima Trust, in particular Joyce Wanjogu and Margie Keeton.

[2] Research on Socio-Economic Policy (ReSEP), Department of Economics, Stellenbosch University. Email: debrashepherd@sun.ac.za.

1. Introduction

Following South Africa's increased participation in regional and international assessments (e.g. SACMEQ[3] and TIMSS[4]) from 1995 onwards, widespread empirical evidence has pointed towards not only poor performance in mathematics in South Africa, but also high levels of inequity in performance across schools and students. South Africa ranked second from last amongst 49 participating countries in the TIMSS Grade 4 mathematics assessment, despite Grade 5 students in South Africa being tested using a less difficult assessment. Furthermore, whilst 7% of children from all participating countries performed below the low international benchmark of 400 points,[5] this proportion was 61% in South Africa.

Similarly, the average performance of South African Grade 9 students in the TIMSS 2015 Grade 8 mathematics assessment ranked second from last, with two-thirds of students performing below the low international benchmark. In terms of inequitable performance, a more than 150 point (1.5 international standard deviation) difference in the average achievement of Grade 5 students from schools with a more economically affluent student body[6]—representing less than 10 percent of all schools—and the average achievement of all other schools was observed. For Grade 9 students, this gap is approximately 130 points. And whilst 60-80% of students in public fee-paying and independent schools performed above the low international benchmark, less than 20% of students in public no-fee school performed similarly (Reddy *et al*., 2016: 8).

However dire the situation might be for students from low-income households especially, it is, as argued by Wills (2017: 2): "useful to ask whether there are exceptions to the norm; schools serving the poor that produce at least adequate levels of learning." Answers to this questions are not only relevant to educational policy that might assist in breaking the cycle of poor mathematics achievement, but also allows for better targeting of public and private sector resources.

Indeed, identifying schools that achieve consistently high school-leaving exam (NSC) pass rates—in the region of 95 percent and higher—from whom principles of best practice can be drawn has formed part of the Department of Basic Education's (DBE) National Education and Development Unit (NEEDU) "Schools that Work" studies produced in 2007 and 2017. Whilst the 2007 study focused solely on NSC pass rates amongst schools serving poor students only (i.e. quintile 1 to quintile 3 schools), the 2017 sample was chosen to be representative of all provinces and school quintiles. This latter study confirmed inequalities between even "outlier" schools: whereas the average teacher to Grade 12 learner ratio was 1:40 in physical science in quintile 5 schools in 2016, it was 1:69 in quintile 1 schools (DBE, 2018).

This latter finding indicates that it is perhaps 'doing' rather than 'having' that matters for school performance (Jansen & Taylor, 2003; Van der Berg, 2008; Timæus, Simelane & Letsoalo, 2013). Research points to a multitude of classroom- and teacher-level constraints that contribute to the paucity of academic performance. These include wasted time-on-task and weak pedagogical and content knowledge amongst

3 Southern and Eastern African Consortium for Monitoring Educational Quality

4 Trends in Mathematics and Science Survey

5 In most of these international evaluations, the initial set-point or mid-point was set to 500 and the standard deviation to 100, so that a score of 400 implies a performance of one standard deviation below the international mean.

6 At least 25 percent of student body coming from affluent home backgrounds and less than 25 percent coming from poor home backgrounds.

teachers (see Van der Berg *et al*., 2016). Underlying "an environment in which teachers can teach and learners can learn" (Taylor *et al*., 2003: 61) is effective school management and organisation, as well as governance and accountability (Taylor *et al*., 1999; Graaff, 2016; Van der Berg & Hofmeyr, 2018).

The "Maths Challenge Programme" (MCP) offered by the Enoch and Optima Trusts focuses on providing interventions to secondary schools in South Africa that consistently produce quality *Mathematics* passes. At the time of writing this paper, 59 schools were receiving the MCP intervention, 42 (71%) and 9 (15%) of which were quintile 5 and quintile 4 schools, respectively. This paper describes a process of identifying socioeconomically (Quintile 1 to Quintile 3) poor secondary schools in South Africa that hold promise for interventions such as the MCP. Rather than adopting a single measure of performance (e.g. the performance of the top student or number of students achieving above a certain threshold), this paper argues that an appropriate measure of 'performance' needs to be determined through experimentation with various combinations of criteria or indicators. In this way, top performing Quintile 1 to Quintile 3 schools in Mathematics can be differentiated from similarly poor schools are at the cusp of being classified as such.

Similar to NEEDU's "Schools that Work" criteria of consistently high NSC pass rates, an important question to investigate are patterns over time in the number and/or proportion of well-performing matric candidates in Mathematics. A further criteria warranting investigation is whether or not a school performs above what is expected (using multivariate regression analysis) for a given level of resources, demographic composition and performance in, for instance, English First Additional Language (FAL). Such schools can, therefore, be regarded as over-performers in Mathematics, or under-performers in English FAL. As with overall performance, consistency in classification as an over-performing school over time can be explored.

We also consider the distribution of matric candidates between Mathematics and Mathematical Literacy, and to evaluate to what extent good Mathematical Literacy performance could be an indication of possible acceptable Mathematics performances; that is, whether schools are 'wasting' Mathematics potential by allowing or even encouraging good candidates to take the easier Mathematical Literacy option in matric. For this purposes, the study applied an approximate conversion scale between the two subjects based on a methodology of Simkins (2010).

The next section of this paper gives a brief overview of the performance of South African schools in Mathematics which. Although still generally weak, there are indications of progress. Section three describes the NSC student-level data employed, followed by an analysis of the examination data undertaken from the perspective of the search for a tool to identify promising schools for mathematics interventions in section four. Section five sets out the indicators/criteria used to identify promising schools, and how the use of these reduce the number of schools to be considered for intervention to 27. Predictive analysis (i.e. the expected 'impact' of the MCP in these schools) is made utilising comparisons with Quintile 1, Quintile 2 and Quintile 3 schools already showing exceptional performance, existing Maths Challenge Programme schools, and Quintile 5 schools.

2. Background: Existing research on mathematics performance in South Africa

Although access to education and gaps in public spending per child in education have improved greatly with significant resource shifts towards poorer schools, the quality of education remains relatively poor (Arends, Winnaar & Mosimege, 2017, p.1). The effects of the apartheid system are still prevalent, with inequalities in the provision of quality education largely following racial lines. As noted in the 2009 NEEDU Report:

> "*... the highly unequal character of schools persists despite comprehensive reforms since 1994 in pursuit of equal education for all. There are well-endowed schools in South Africa with impressive resources and facilities that produce superior academic results over the 12 years of schooling. There are desperately poor schools with little to show in terms of academic performance. In the past, the former category of schools tended to be white and the latter black. With the opening of school to all children, increasingly the privileged schools tend to enrol white and black middle class students while the latter schools tend to remain all black. The resilience of these inequalities underlines the long shadow of history on all our schools.*"

What is particularly concerning is the poor Mathematical performance of students that has emerged from a number of national (e.g. NSES[7] and ANA[8]), regional (SACMEQ) and international (e.g. TIMSS and PIRLS[9]) assessments of educational achievement that South Africa has participated in since 1995 (c.f. Howie & Hughes, 1998; Reddy, 2006; Fleisch, 2008; Reddy *et al*. 2016). The analysis of these data, some of which is discussed below, have enabled researchers and policy makers to assess Mathematics achievement of different groups of South African students over time. While recent improvements in (particularly) Mathematics outcomes have emerged, the general consensus remains that the vast majority of student performance is subpar to what is expected in terms of the curriculum and grade being tested.

2.1 Studies at local and national level

Systemic Evaluations (SEs) and Annual National Assessments (ANAs) — At the national level, the Systemic Evaluations that tested a random sample of over 50 000 Grade 3 students in 2001 and 2007 indicated an average score of 35 percent in numeracy in 2007, up 5 percentage points from 2001.[10] However, the performance of the vast majority of the 2007 Grade three cohort was well behind the grade appropriate level, with less than a fifth (16%) of students showing grade appropriate performance. Analysis of Kotzé and Spaull (2015) further indicated dramatic differences in the distribution of achievement across school socioeconomic context. Specifically, they show a concentration of performance around 20 percent amongst Grade 3 students attending Quintile 1 to Quintile 4 schools, whilst at least half of the students attending Quintile 5 schools performed above the grade appropriate level. Between 2011 and 2014, the largest attempt (outside of the census) at gathering data came in the form of the standardised ANA assessments that evaluated Grades 1 through 6 and Grade 9. However, serious concerns were raised as to

7 National School Effectiveness Survey

8 Annual National Assessments

9 Progress in International Reading and Literacy Study

10 Comparability of the Systemic Evaluations across time have, however, come under scrutiny (Spaull, 2013).

the comparability of the ANA tests across and between grades (Spaull, 2013). The credibility of achievement differences and gains emerging from the ANAs has undergone particular scrutiny.

The National School Effectiveness Study (NSES) — The NSES provides the only large scale—albeit not nationally representative as Gauteng did not participate—longitudinal dataset from which to draw conclusions on achievement gains in numeracy. Students were provided with an opportunity to write the same Systemic Evaluation test calibrated at the Grade 3 level[11] in 2007, 2008 and 2009. Of the 15 000 students originally tested in Grade 3 in 2007, approximately 8 400 were tracked into the subsequent two grades. Average Grade 4 performance on this test was only 35 percent, a mere 7 percentage points higher than the average 28 percent scored by the same students a year previously. Similar to the findings of the 2009 NEEDU report mentioned above, Taylor (2011, p.6) notes that:

> "*…the distribution for Grade Five pupils in historically black schools was still a considerably weaker distribution than that of Grade Three pupils in historically white schools… by the fifth grade the educational backlog experienced in historically black schools is already equivalent to well over two years' worth of learning.*"

Analysis by Kotzé and Spaull (2015) speaks directly to this: By Grade 5, approximately a quarter of students in Quintile 1 to Quintile 4 schools were performing at the grade-appropriate level, compared to more than half of Quintile 5 students. Tracking students' ability to answer a Grade 3 level item[12] correctly over the three-year period, more than 40 percent of Quintile 1 to 4 students could not answer this problem at the end of Grade 5. The researchers further indicate, through the use of learning trajectory methodology, that by Grade 3, students in Quintile 5 schools are already three years' worth of learning ahead of their peers in Quintile 1 to Quintile 3 schools. This gap in learning not only extends into future grades, but also becomes progressively wider (Kotzé & Spaull, 2015).

2.2 Studies at regional and international level

The Southern and East African Consortium for Monitoring Educational Quality (SACMEQ) — The SACMEQ study is a cross-national initiative consisting of (at most) 15 countries in Southern and Eastern Africa that aims, amongst other things, to test the numeracy and literacy skills of Grade 6 students. To date, four rounds of the SACMEQ study have taken place in 1995, 2000, 2007 and 2012; South Africa has participated in the latter three. Of the 14 and 15 countries that participated in the 2000 and 2007 rounds, respectively, South Africa performed in 9th and 8th position in Mathematics. In both instances, the average Mathematics performance of South African students was below the SACMEQ overall average. Of the Grade 6 students tested in 2007, 40 percent could be classified as functionally innumerate (Spaull, 2011); the majority of these students attended Quintile 1 to Quintile 3 schools. Further learning gaps were found by geographical location and socioeconomic status of the school; for instance, Spaull (2012) shows that the average 2007 SACMEQ Mathematics score of students attending the wealthiest 25 percent of schools was more than 1.5 standard deviations higher than the average score of students attending the poorest 75 percent of schools.

[11] Although questions ranged from Grade 1 to Grade 4 level.

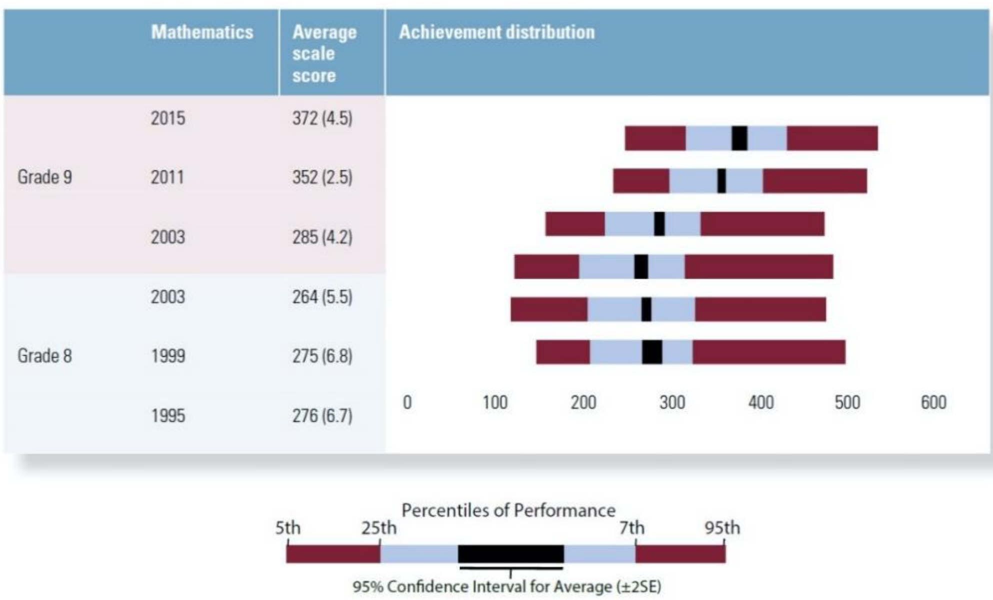
[12] Addition of whole numbers with at least three digits: "270 + 28 = _______".

The Trends in Mathematics and Science Survey — TIMSS is an international evaluation that assesses the performance in Mathematics and Physical Science in Grade 8. To date, South Africa has participated in five rounds of TIMSS, though Grade 9 South African students have been evaluated since 2003. Trends over time, as reflected in Figure 1, have been described as follows by Reddy (2018):

> *"We observe that the average national mathematics score remained the same, statistically, over the 1995, 1999 and 2003 cycles. In contrast, from 2003 to 2015 the average mathematics scores improved by 87 points. This change in the South African mathematics achievement scores means that the education system improved from a 'very low' (1995, 1999, 2003) to a 'low' (2011, 2015) national average."*

Figure 1 shows more progress between 2003 and 2011 than between 2011 and 2015. It also shows that progress was much greater at the lower end of the distribution, which implies an improvement in inequality in performance. Indeed, the proportion of Grade 9 students performing above the low international benchmark of 400 points increased from 24 percent in 2011 to 35 percent in 2015. TIMSS 2015 also represented the first time for Grade 5 learners in South Africa to be tested in Mathematics, and performed second weakest of all participating countries.

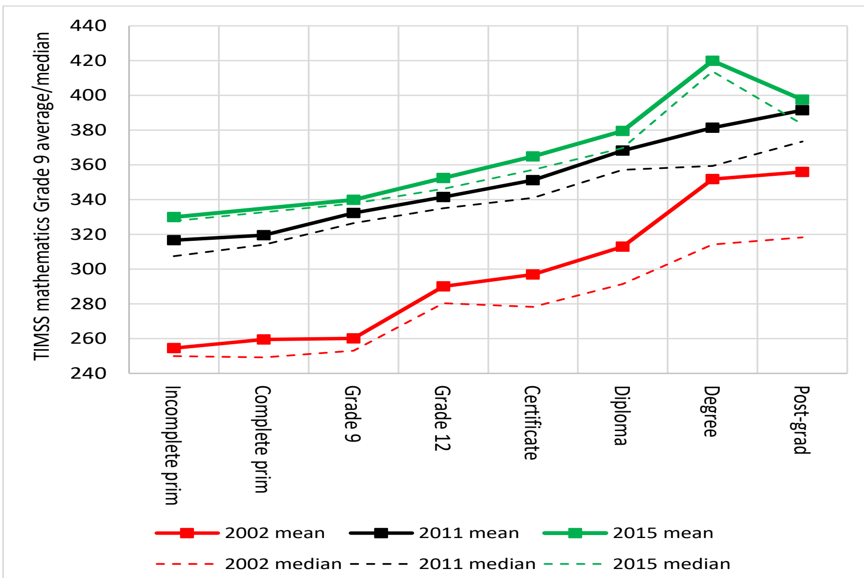
Figure 1: Trends in Mathematics performance in TIMSS, 1995 to 2015



Source: (Reddy V. , 2018, p. Fig.1)

Figure 2 further shows that Mathematics performance has been improving at all levels of parental education. In addition, average parental education is also improving over time (Van der Berg & Gustafsson, 2017, p.2), implying a shifting of the weight in this figure to the right, contributing further to enhanced performance.[13] Furthermore, since drop-out before Grade 9 has been reduced, the score improvement does not fully reflect all gains made (Van der Berg & Gustafsson, 2017, p. 6). However, in spite of this, inequality in test performance across socioeconomic, language and racial lines persists: Whilst 81 and 58 percent of South African students in independent and public fee-paying schools, respectively, scored above 400 points in the 2015 TIMSS Mathematics assessment, only 19 percent of students in public no-fee schools achieved at this level (Reddy *et al*. 2016, p.8).

Figure 2: TIMSS 2002 to 2015 performance by parent education



Source: Van der Berg & Gustafsson (2019)

2.3 Evidence on the determinants of poor performance in Mathematics in South Africa

Several reasons for the poor performance in Mathematics in South African schools have been identified, many of which relate to what occurs within the classroom. The role of teachers is of particular importance in creating a conducive environment for learning (Stols, 2013, p.1). Maree *et al.* (2006, p. 229) highlight that students acquire mainly rote knowledge of basic concepts, rather than engaging effectively with problem solving, and that teachers lack pedagogical skills.

As lamented by Makgato and Miji (2006, p.254), those who study Mathematics rarely pursue a career in teaching mathematics. Similar conclusions are put forward by Venkat and Spaull (2015, p. 122) who show that a large number of Mathematics teachers in South Africa lack a fundamental understanding of the

13 The lower average performance of learners whose parent/s have at least a postgraduate qualification in 2015 compared to 2011 could be as a result of measurement error or small sample bias; a significant proportion of Grade 9 learners do not report parent education, particularly boys attending Model C schools.

subject content. Furthermore, although subject content knowledge is a necessary factor for high quality teaching, it is not sufficient. For instance, Roberts and Venkat (2016, p.9) note that teachers require specialised knowledge for teaching mathematics and effective classroom management, whilst Carnoy, Chisholm and Chilisa (2012) and Carnoy and Chisholm (2008) show mathematical pedagogical knowledge to be positively related to teaching quality and student outcomes.

Arends, Winnaar and Mosimege (2017, p.1) found that weak teacher classroom practices related to, amongst others, clarity of presentation, lesson planning, and sensitivity towards differences in students' learning pace have an important bearing on learning outcomes. Stols (2013, p.1) classifies these factors as part of a larger, superordinate factor that contributes to poor performance in Mathematics, namely, inequality in the opportunities to learn (OTL). Using four variables to measure OTL for Grade 12 learners in Gauteng— time-on-task, curriculum coverage, curriculum coherence, and cognitive demand—Stols (2013) found that only two of the 18 schools studied were able to prepare more than 30 percent of their students for science-related careers.

A curriculum mapping exercise conducted by Shalem *et al.* (2013) with 50 intermediary and senior phase (Grades 3 to 9) Mathematics teachers teaching in Gauteng schools indicated that 44 percent and 76 percent of the expected Grade 3—6 and Grade 7—9 curriculum content, respectively, was reported as "not taught" by teachers .It has been recommended, therefore, that interventions aimed at improving mathematical performance should focus on more effective use of time, efficient teaching methods and the careful selection of learning activities (Stols, 2013, p.16).

Herholdt and Sapire (2014) argue that using results from standardised tests (e.g. average performance and pass rates) has limited benefit, and that more may be learnt if students' errors are analysed. This error analysis approach also involves a study of teachers' ability to fix these mistakes which, in line with the discussion above, requires good subject and pedagogical knowledge. In this way, teachers may adapt their teaching methods to address common errors (Herholdt & Sapire, 2014, p.57). They further recommend that the DBE should use the error pattern analysis to assess whether common errors are made by students across different language and cultural groups.

Visser, Juan and Feza (2015) and Juan and Visser (2017) argue that both school and home environments play a role in students' performance in Mathematics, with the latter generally, and socio-economic and parental education factors in particular, shown to have stronger relationships with achievement than the former. Graven (2014, p.1042) also identifies preschool education, homework frequency and the availability of textbooks as factors which impact learner mathematical performance. Spaull (2011, p.7) notes that the effect of socio-economic status is non-linear and only considerably positively associated with student performance at higher levels of SES. Closely related to socio-economic status is language of instruction and mother tongue of students, with many non-English home language students failing to master the language of instruction by Grade 9 (c.f. Howie, 2003; Kotzé & Spaull, 2015; Juan & Visser, 2017).

Initiatives to combat the problem of weak mathematical achievement have included the National Strategy for Mathematics, Science and Technology Education, the North West Department of Education's Mathematics, Science and Technology Unit, the Western Cape Education Department's Khanya Project and the Minister of Basic Education's Action Plan to ensure integrated interventions to improve education (Mapaire, 2016, p.2). Furthermore, there have been initiatives to reduce the average class size, to improve teacher training programmes and to increase expenditure on school infrastructure (Mapaire, 2016, p.2). Overall, these initiatives have done little to improve the mathematics performance in South African schools.

2.4 Existing analyses of the South African school-leaving (matriculation) examinations

Aside from the NEEDU reports and "Schools that Work" studies already referred to in earlier sections of this paper, descriptive analyses of the performance of Grade 12 (matric) students in Mathematics specifically have been conducted over the past decade. Several of these are now discussed.

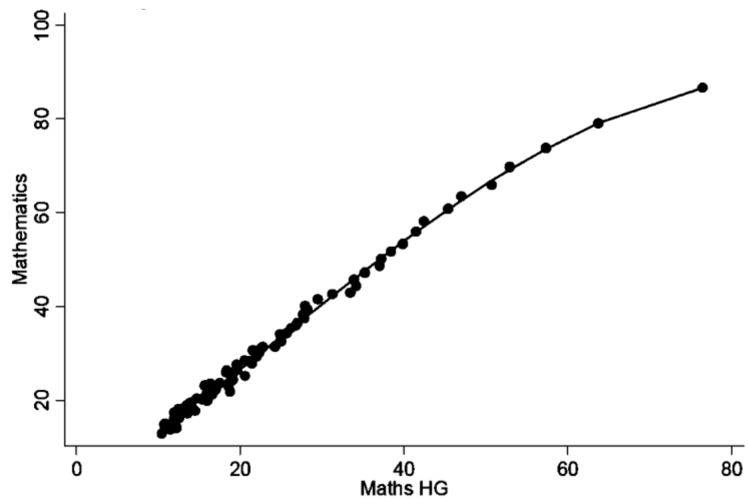
A novel analysis of Reddy *et al*. (2012) of students' pathways and Mathematics performance through secondary school (Grade 8 to Grade 12) used a panel-like data set that tracked 2 734 Grade 8 students who participated in TIMSS 2002 into the 2006 and 2007 matriculation examinations. Of this group, 60 percent were observed to participate in Mathematics in Grade 12, 10 percent of whom participated at the higher-grade (HG) level. At this point it is worth noting that, under the old school-leaving Senior Certificate (SC) that was last written in 2007, Mathematics was not a compulsory subject. Furthermore, matriculants under the SC could opt to do Mathematics on either a higher (HG) or a standard grade (SG) level.

Overall, Reddy *et al*. (2012) found the Mathematics performance amongst tracked students to be low: the average SG and HG Mathematics scores were 25 percent and 43 percent, respectively. What was most surprising, however, was that the TIMSS Grade 8 Mathematics scores did not appear to be a strong determinant of continuation into matric or selection into Mathematics as a subject, particularly within the poorer subsystem of schools. This finding is similar to that of Lam, Ardington and Leibbrandt (2011) who find grade progression in Quintile 1 to Quintile 3 schools to be poorly linked to ability and learning.

In 2010, Charles Simkins set out to evaluate Mathematics, Science and English performance of Grade 12 candidates in the 2008 NSC examination in order to compare the difficulty levels of the new Mathematics and Mathematical Literacy curricula with the former HG and SG Mathematics, as the new examinations could not be evaluated against past outcomes. His methodology essentially comprised ranking students by percentiles on their aggregate mark excluding the Mathematics mark, and then calculating, for each percentile of the performance distribution of candidates in all subjects excluding Mathematics, a HG Mathematics mark (2007) or a Mathematics mark (2008). These marks were then plotted on a graph. For instance, the seventh percentile from the top achieved a Mathematics mark of just over 60% in 2008, whilst the same percentile of the distribution of matric marks in subjects other than Mathematics had achieved a mark of 45% in HG Maths in 2007. From this he drew a correspondence line, one that fitted the HG Mathematics marks for each percentile of the non-Mathematics performance to the Mathematics (2008) mark of the non-Mathematics performance. This correspondence curve is shown in Figure 3 below and again presented in tabular form in the Appendix (Table A1).

The assumption in this methodology is of course that both performance in Mathematics HG in 2007 and Mathematics in 2008 are highly correlated with performance in other subjects. Deriving similar correspondence between Mathematics and Mathematical Literacy for 2008, Simkins estimated that about 220 000 students passed, or could have passed mathematics at the 30 percent (passing) level, i.e. 39 percent of all candidates. "*Nationally, therefore, it would not be appropriate for more than about 40% of National Senior Certificate candidates to attempt mathematics. The rest should enter for mathematical literacy*." This topic is returned to later.

Figure 3: Mathematics 2008 against Mathematics Higher Grade 2007: Simkins' 'correspondence curve'



Source: Simkins (2010)

Using the conversion factors derived from his correspondence analysis and then ranking schools according to their Mathematics performance, Simkins found that for schools where some form of Mathematics was offered in both years, 12 percent performed in the top quintile in both years and 6 percent in the bottom quintile in both years. The correlation between the percentiles in which schools fell was 0.55, but if the top and the bottom quintiles were excluded, this correlation fell to 0.18. He concludes that *"ranking of schools by mathematics performance can really only divide them into good, a nearly random middle and bad.*" In the final conclusion he states it even more strongly:

> *"The most alarming result found is the high degree of instability among the majority of secondary schools between 2007 and 2008 in respect of performance in mathematics and science. The top schools tended to stay at the top, and the truly awful schools tended to stay at the bottom, but almost anything could happen for all the schools between."*

Concern with the standard of Mathematics in Grade 9 and the consequent large flow of learners switching to Mathematical Literacy rather than Mathematics after completing this grade led the Advisory Committee for Mathematics (ACM) to recommend a National Examination for Gr9 Mathematics, as "…*the pool of learners leaving grade 12 with Mathematics is diminishing and this impacts on the number of learners available to study important fields such as Science and Engineering at South African universities."* (Govender, 2014)

A concern with cross-time analyses such as those discussed above is that the difficulty of particular matric examinations papers results may vary, thereby limiting the accuracy of comparisons over time. There is some value, therefore, in using relative performance. To compare over time, Van der Berg and Gustafsson (2017; 2019) and Gustafsson (2016) used a threshold derived from the performance level of the 80th percentile of all white matriculation candidates to calibrate the performance of other students. This should approximate a constant or even rising performance threshold. The number of matriculants reaching this can then be considered an indication of the (relative) quality of performance. In 2002 there were 18 601 students who obtained a mark in mathematics of at least 65 percent;[14] by 2016 this had risen to 25 054. The number of black African students attaining this high level mathematics threshold that would allow entry into, for instance, engineering at university rose by 65 percent between 2002 and 2016. In 2018, 11 737 black African students achieved highly in Mathematics. Table **1** and Table 2 show, this expansion occurred across a growing number of schools, particularly schools largely serving poorer segments of the population. Gains (in absolute terms) were especially large over the period 2009 to 2016 following the 2008 curriculum change, with the fastest improvements occurring in lower quintiles and in Mpumalanga and Limpopo. Quintile 1 recorded a 160% increase in the number of high-level Maths achievers between 2002 and 2016, and Quintile 2 and 3 around 90 percent.[15] It is encouraging that the percentage of schools achieving at least some high-level mathematics passes increased for all quintiles, with 41 percent of schools even in the poorest quintile now producing such performers. Gustafsson (2016) found substantial equity gains in Mathematics performance. Whilst in 2002 just under half of all high-level mathematics performers in the public examination system were not white, by 2016 this proportion had increased to over two-thirds. However, he found little progress in gender-based inequalities in Mathematics performance: In both 2002 and 2016 a female Grade 12 student was only two-thirds as likely of being a high-level mathematics performer than a male.

Table 1: High achievers in Mathematics, by school category (2002—2016)

	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Indep-endent**
Number of high achievers in mathematics						
2002	465	687	1 403	1 476	10 107	948
2009	782	957	2 115	2 043	10 325	1 207
2016	1 209	1 294	2 670	2 292	8 978	1 100
% increase 2002-2016	*160%*	*88%*	*90%*	*55%*	*-11%*	*16%*
% increase 2002-2009	*68%*	*39%*	*51%*	*38%*	*2%*	*27%*
% increase 2009-2016	*55%*	*35%*	*26%*	*12%*	*-13%*	*-9%*
% of schools with at least one high-level mathematics achiever						
2002	23%	28%	41%	56%	84%	51%
2009	34%	39%	52%	63%	86%	76%
2016	41%	48%	56%	67%	85%	73%

Notes: Only students attending schools that could be categorized by Quintile or independent school and that could be tracked over the period concerned are covered in Table 1, which explains the differences between these totals and those mentioned in the text above. Source: Van der Berg & Gustafsson (2019)

14 A 'high-level achiever' is one who performs above the bottom of the range of the top 20 percent white Grade 12 learners. Roughly, this cut-off is equivalent to a 65 percent or higher in Mathematics, and would permit a learner entry into a mathematically oriented university programme.

15 The decline in Quintile 5 can probably be ascribed mainly to the reduction in white student numbers due to demographic change and to shifts to independent schools, although independent schools did not show particularly large improvement.

Table 2: High achievers in Mathematics, by school category (2014—2018)

	Q1	Q2	Q3	Q4	Q5	Indep-endent	MCP schools
Number of high achievers in mathematics							
2014	1 881	2 213	2 863	2 965	10 904	2 205	2 245
2018	2 172	2 288	2 669	2 479	9 129	1 819	2 023
% increase 2014-2018	*15%*	*3%*	*-7%*	*-16%*	*-16%*	*-18%*	*-10%*
% of schools with at least one high-level mathematics achiever							
2014	37%	42%	52%	68%	83%	56%	100%
2018	39%	43%	51%	70%	85%	54%	100%

Notes: Only students attending schools that could be categorized by Quintile or independent school and that could be tracked over the period concerned are covered in Table 2. The total numbers of schools and students in Table 2 is larger than shown in Table 1. Therefore, the only information that can be compared across the two tables are the trends (growth rates), and not the raw numbers. Source: own calculations using NSC 2010-2018 data.

Unfortunately, there has been a general decline in the production of high mathematics performance over the most recent years, particularly amongst Quintile 4, Quintile 5 and independent schools. The number of black African students achieving a mark of at least 65 percent fell by 16 percent between 2016 and 2018; however, numbers of high achievers still grew within Quintile 1 schools between 2014 and 2018, albeit at a lower rate than observed previously. However, it needs to be remembered that enrolment in mathematics in Quintile 4 and Quintile 5 schools is 9.1 percent and 4.4 percent lower than it was in 2014, respectively (enrolment numbers in Quintile 1 to Quintile 3 schools grew over this period). Therefore, the relative decline in the proportion of high achievers in Mathematics is lower than what is suggested by Table 1 and Table 2.

Van der Berg and Gustafsson (2017, p. 14) put forward a number of factors that could have stimulated improvement between 2002 and 2016. The first relates to support in the household: In 2003 only 41 percent of students in schools enjoyed the presence of at least one household member with at least a Grade 12 qualification. By 2015, this figure had risen to 56 percent. They also refer to **three changes in schooling** that the DBE's *Action Plan to 2019* mention as contributing to quality improvements:

1. Firstly, **better access amongst learners to textbooks**. TIMSS data show that in 2002 only 30 percent of Grade 9 teachers reported using a textbook as their main classroom resource for teaching mathematics, a figure that increased to 70 percent in 2011.
2. Secondly, more standardised testing, in particular **the introduction of the Annual National Assessments (ANA) programme**.
3. Thirdly, **more suitable curriculum documents** and training associated with this.

3. Data description

Before moving into the empirical analysis of this paper, it is important to first clarify that the data analysed in this report comes from the provincial fulltime National Senior Certificate (NSC) student-level records for the years 2010-2012 and 2014-2018.[16] The total numbers of Grade 12 students enrolled in either one of Mathematics or Mathematical Literacy are shown by year and province in Table 3 below. Comparisons to the *total* enrolment numbers from the DBE 2018 Technical Report are shown for 2014 to 2018. It is evident that incomplete data was provided for several provinces in 2012 and we therefore chose to exclude this year for analysis purposes. The total enrolment numbers provided in the DBE reports only slightly exceed the enrolment numbers in Mathematics and Mathematical Literacy computed from the fulltime NSC data. This is because a very small number of matriculants (<0.01%) are not enrolled for either of these subjects.

Table 3: Numbers of Grade 12 students enrolled in Mathematics and Mathematical Literacy, by province

Province	**2010**	**2011**	**2012**	**2014**	**2015**	**2016**	**2017**	**2018**
Eastern Cape	68 463	68 813	69 456	69 303 (69 306)	89 684 (89 740)	92 754 (92 755)	83 026 (82 257)	80 273 (81 842)
Free State	28 228	26 394	3 180	26 756 (26 756)	35 209 (35 209)	28 901 (28 901)	27 723 (27 723)	28 034 (29 209)
Gauteng	94 385	87 328	12 971	101 210 (101 212)	112 061 (112 064)	112 160 (112 164)	108 517 (108 552)	104 568 (107 166)
KwaZulu Natal	133 161	128 527	24 412	147 346 (147 355)	169 757 (169 769)	168 983 (169 023)	153 123 (153 125)	149 557 (151 166)
Limpopo	95 896	74 674	78 215	73 543 (73 543)	102 616 (102 618)	110 640 (110 639)	100 036 (100 041)	95 819 (96 840)
Mpumalanga	54 651	49 607	49 100	45 900 (45 900)	55 943 (55 945)	60 790 (60 794)	59 498 (59 500)	57 086 (57 867)
Northern Cape	10 416	10 485	9 241	8 950 (8 950)	12 172 (12 173)	11 821 (11 821)	10 519 (10 519)	11 825 (12 157)
North West	29 608	25 930	27 581	26 382 (26 382)	33 844 (33 845)	35 403 (35 403)	35 729 (35 733)	33 460 (34 718)
Western Cape	47 062	41 219	7 378	48 811 (48 835)	56 532 (56 562)	53 117 (53 152)	51 704 (51 735)	52 870 (53 768)
All	561 870	512 977	281 534	548 201 (548 239)	667 818 (667 925)	674 569 (674 652)	629 875 (629 155)	613 492 (624 733)

Notes: Numbers in parentheses are taken from the NSC 2018 Technical Report (presented on 3 January 2019). Source: own calculations using NSC 2010-2018 data.

It is also important to note up front that the number of Grade 12 students recorded as enrolled in Mathematics and Mathematical Literacy in the fulltime NSC data are not necessarily equivalent to the number of students with a recorded final mark at the end of the matric examinations. It is concerning to see that the difference in the number of students enrolled for these subjects and the number receiving a final

16 At the time of writing the report, complete data for 2013 was unavailable.

performance mark is increasing over time (from 9 000 in 2014 to 85 000 in 2018). Table 4 compares the numbers of students between 2014 and 2018 with a final mark recorded from the fulltime student level NSC data and the DBE 2018 Technical and Subject Reports. For various reasons,[17] the numbers across these two data sources differ, although they correspond very closely. In particular, the numbers of students performing at different levels (30%, 40% and 80%) match almost exactly.

Table 4: Comparison of NSC student-level data and DBE Reports (2014—2018)

		Enrolment		**Final mark recorded**		**Proportion passing (>30%)**		**Proportion >40%**		**Proportion >80%**	
		Math	Math Lit	Math	Math Lit	Math	Math Lit	Math	Math Lit	Math	Math Lit
2014	DBE report	229 888	318 994	225 458	312 054	53.5	84.1	35.1	59.5	-	-
	NSC data	229 886	318 315	226 341	312 690	52.4	83.3	35.1	59.4	3.2	2.4
	Discrepancy	*-2*	*-679*	*+883*	*+136*	*-1.1*	*-0.8*	*0*	*-0.1*	-	-
2015	DBE report	269 253	398 632	263 903	388 845	49.1	71.4	31.9	44.3	-	-
	NSC data	269 219	398 599	263 862	388 808	48.0	70.3	31.0	44.2	3.0	1.6
	Discrepancy	*-34*	*-33*	*-41*	*-37*	*-1.1*	*-1.1*	*0*	*-0.1*	-	-
2016	DBE report	285 406	389 163	265 810	361 865	51.1	71.3	33.5	46.4	-	-
	NSC data	285 406	389 163	265 880	362 022	50.2	70.1	33.5	46.3	3.0	1.2
	Discrepancy	*0*	*0*	*+70*	*+157*	*-0.9*	*-1.2*	*0*	*-0.1*	-	-
2017	DBE report	276 084	353 019	245 103	313 030	51.9	73.9	35.1	45.0	2.7	0.6
	NSC data	276 488	353 387	245 424	313 676	51.0	72.5	35.1	45.0	2.7	0.6
	Discrepancy	*+404*	*+368*	*+321*	*+646*	*-0.9*	*-1.4*	*0*	*0*	*0*	*0*
2018	DBE report	270 516	342 976	233 858	294 204	58.0	72.5	37.1	45.4	2.5	1.3
	NSC data	270 467	342 976	233 839	294 205	57.2	71.1	37.1	45.4	2.5	1.3
	Discrepancy	*-49*	*0*	*-19*	*+1*	*-0.8*	*-1.4*	*0*	*0*	*0*	*0*

Source: own calculations using NSC 2014-2018 data and DBE 2018 NSC Examinations Technical Report and Subject Report.

As the primary interest of this paper is in identifying promising Quintile 1 to Quintile 3 schools for the Maths Challenge Programme, a consistent indicator of school poverty quintile across time is required. However, information on this variable is not always complete or up to date within the EMIS[18] data, particularly in earlier years. In order to make data suitably comparable over time, the most recent (2018) quintile of a school is used; this, however, relies on the ability to match EMIS numbers over time. Unfortunately, not all schools in the 2010 and 2011 datasets could be matched to data from later years: quintile data was missing from the 2011 data altogether, and in both the 2010 and 2011 data there were a substantial number of schools with missing EMIS numbers (see table 5). As examination centre numbers are not consistent over time, this identifier could not be used for matching. Therefore, the number of matriculants with missing school quintile data remains high at 107 586 and 92 734 in 2010 and 2011,

17 For example, remarking of examination scripts and students re-sitting the matriculation examinations the following year.

18 Education Management Information System

respectively. These numbers drop to below 25 000 from 2014 onwards, the majority of which is accounted for by independent/private schools who are not assigned to school poverty quintiles.

Table 5: Number of schools represented in the 2018 NSC fulltime student data, 2010-2018

	2010	2011	2014	2015	2016	2017	2018
EMIS not missing	5 716	5 775	6 668	6 765	6 810	6 740	6 782
Centres with EMIS missing	826	816	49	2	15	71	89
Quintile missing/NA	826	-	623	635	619	555	551
Independent	290	-	493	524	535	518	523

Source: own calculations using NSC 2010-2018 data.

4. Enrolment and performance in Grade 12 mathematics subjects

4.1 Enrolment in Mathematics and Mathematical Literacy, 2010 - 2018

Tables 6 and 7 below describe the trends in mathematics enrolment over the period of interest and by school quintile. The first two columns of Table 6 show the racial and gender[19] distribution of Grade 12 students by school poverty quintile in 2018. Quintile 1, 2 and 3 schools are predominantly attended by black African students, with fewer than 5% from any of the other race groups. In Q4 and Q5 schools, 75% and 44% respectively are black African. The remaining part of the 2018 cohort in Q5 schools comprised of 28% white students, 19% coloured students and 8% Indian/Asian students.

Close to half (48.1%) of all Grade 12 students in Q1 schools in 2018 enrolled for Mathematics, compared to 44% in Q2 and Q5 schools, 40% in Q3 schools, and 37% in Q4 schools. Figure 4 indicates a quite high propensity of black students to enrol in Mathematics rather than Mathematical Literacy. Students are quite evenly distributed across the school quintiles by gender, with approximately 55% of all Gr12 students being girls. Girls are slightly overrepresented amongst those enrolled for Mathematics; in 2018, 56.6% of matriculants enrolled in Mathematics were female. This is largely driven by enrolment trends in Q1 to Q4 schools, where the representation of girls is approximately 2-3 percentage points higher than their representation in the Grade 12 population (again, see Figure 4).

Table 7 illustrates that the proportion of matriculants enrolled in Mathematics decreased by 5 percentage points between 2010 and 2018, with the sharp decline to 2014 being partly reversed since (enrolment in Mathematics was 13.4% lower in 2014 than in 2010). Conversely, enrolment in Mathematical Literacy has risen. The largest declines in Mathematics enrolment over the period 2010 to 2018 was observed for Q3 and Q4 schools.[20] Despite higher average enrolment in Mathematics in lower quintiles, expected performance in Mathematics and Mathematical Literacy increases from lower to higher quintiles.

19 No information regarding the gender and race group of matriculants was available in the dataset used for 2010.

20 Note that the school quintile and sector of a large number of schools could not be determined in the 2010 data, even when merging with 2018 data.

The final columns of Table 6 further reflect this, with the average proportion of matriculants achieving different thresholds of performance in Mathematics increasing with school quintile. On average, 25% of matriculants students enrolled for Mathematics in a Q1-Q3 school obtained a final mark of 40% or higher in 2018, compared to 60% of students in Q5 schools. Once a relatively high performance threshold of 60% is chosen, the gap between the school quintiles is substantially widened: Only about 6% of Gr12 students enrolled for Mathematics in Q1-Q3 schools obtain a final mark of 60% or higher, compared to almost a quarter in Q5 schools. With regards to mathematical literacy, the differences between Q1-Q3 and Q5 are even larger at all thresholds of performance. For example, the average proportion of students in Q5 schools meeting a performance threshold of 60% being about nine-fold that of Q1-Q3 schools.

As can be seen from Figure 5, there is a tendency for the average Mathematics performance in Q1–3 schools to decrease as the proportion of the matric class enrolled in mathematics increases. In the case of Mathematical Literacy, no such relationship is observed. The block insert in the left-hand side figure indicates those schools that (1) achieved an average mark of 50% or more in mathematics, and (2) had at least 60% of Gr12 learners enrolled in mathematics.

Figure 6 indicates Q1-Q3 schools' average scores in Mathematics compared to their average English FAL scores. The orange line provides a linear prediction of average school Maths performance given a particular level of average school performance on the English FAL examination; for example, a Q1-Q3 school that obtained an average English FAL performance of 60% is expected to have obtained an average mathematics performance of 40%. All schools represented by points lying above the orange line performed "above expectations" in Mathematics (for a given level of English FAL performance), and vice versa for schools below the line. Similar scatterplots are shown for the relationship between Mathematical Literacy and English FAL (Figure 7), Mathematics and Physical Science (Figure 8), as well as Physical Science and English FAL (Figure 9).

The correlations between school performance in Mathematics and Mathematical Literacy on the one hand, and school performance in Physical Sciences, English FAL and Home Language on the other are shown in Table 8 below. None of the associations are even moderately strong. Furthermore, the weakest correlations are observed between performance in STEM and language subjects. This is quite different from associations observed for Q5 schools, where the correlation between, for example, Physical Sciences and Home Language is 0.67.

4.2 Performance in Mathematics and Mathematical Literacy, 2010 - 2018

From Figure10a below, it can be observed that over the period 2010 to 2018, the Mathematics pass rate rose from 47.0% to 57.1%, whilst the Mathematical Literacy pass rate fell from 83.7% to 71.1%. However, approximately the same overall proportion of matriculants passed either one of the two Mathematics module (roughly two-thirds), with the majority of passes accounted for by Mathematical Literacy. In 2018, only a quarter of all matriculants passed Mathematics, whilst a further 40% passed Mathematical Literacy. This implies that roughly a third of matriculants failed to pass any mathematics subject.

Table 6: Distribution of enrolment and final performance in Mathematics and Mathematical Literacy by school quintile, 2018

	% black African students	% female students	% enrolled in subject	% of enrolled students in subject that are black	% of enrolled students in subject that are female	Averages per school: Average % of students per school enrolled for subject	Average final mark	Average % achieving above 40%	Average % achieving above 50%	Average % achieving above 60%
Mathematics										
Quintile 1 *Number*	99.3	55.2	48.1 *67 431*	99.8	56.9	52.0 (27.7)	30.9 (9.15)	24.7 (18.4)	12.3 (12.1)	5.8 (7.2)
Quintile 2 *Number*	98.5	54.5	44.0 *62 071*	99.6	57.1	46.8 (25.8)	31.6 (9.12)	25.0 (17.9)	12.5 (11.5)	6.1 (7.1)
Quintile 3 *Number*	94.3	54.6	40.4 *59 248*	98.4	57.4	42.2 (24.0)	32.0 (9.08)	26.0 (18.0)	13.6 (11.8)	6.8 (7.4)
Quintile 4 *Number*	74.9	55.6	37.3 *28 501*	85.7	57.3	37.0 (22.6)	36.7 (10.2)	37.5 (23.0)	21.4 (17.3)	11.5 (11.5)
Quintile 5 *Number*	44.4	54.7	43.7 *42 337*	42.6	54.3	42.0 (18.6)	46.2 (11.1)	59.9 (24.7)	39.8 (23.2)	23.9 (18.3)
All schools *Number*	85.8	54.9	43.3 *270 516* [a]	88.2	56.7	46.0 (25.4)	34.7 (11.2)	32.9 (29.8)	18.7 (18.3)	10.0 (12.6)
Mathematical Literacy										
Quintile 1			50.9 *71 345*	98.7	53.9	60.6 (20.87)	34.7 (6.4)	26.6 (16.3)	11.5 (10.2)	4.3 (5.4)
Quintile 2			54.5 *76 971*	97.5	52.9	61.8 (19.7)	35.2 (6.3)	27.6 (16.3)	12.0 (10.1)	4.5 (5.4)
Quintile 3			57.7 *84 697*	91.4	53.3	64.0 (19.5)	36.1 (6.2)	29.9 (16.4)	13.9 (10.8)	5.4 (5.9)
Quintile 4			59.5 *45 485*	67.9	56.0	66.8 (19.6)	41.2 (8.0)	45.9 (22.6)	25.4 (19.7)	12.1 (13.7)
Quintile 5			53.6 *51 926*	46.1	56.9	57.5 (18.9)	54.1 (10.4)	78.0 (21.9)	59.2 (26.7)	38.4 (25.6)
All schools			54.9 *342 976* [a]	84.0	54.3	61.9 (20.2)	39.7 (10.4)	39.9 (26.7)	23.0 (24.1)	12.1 (18.3)

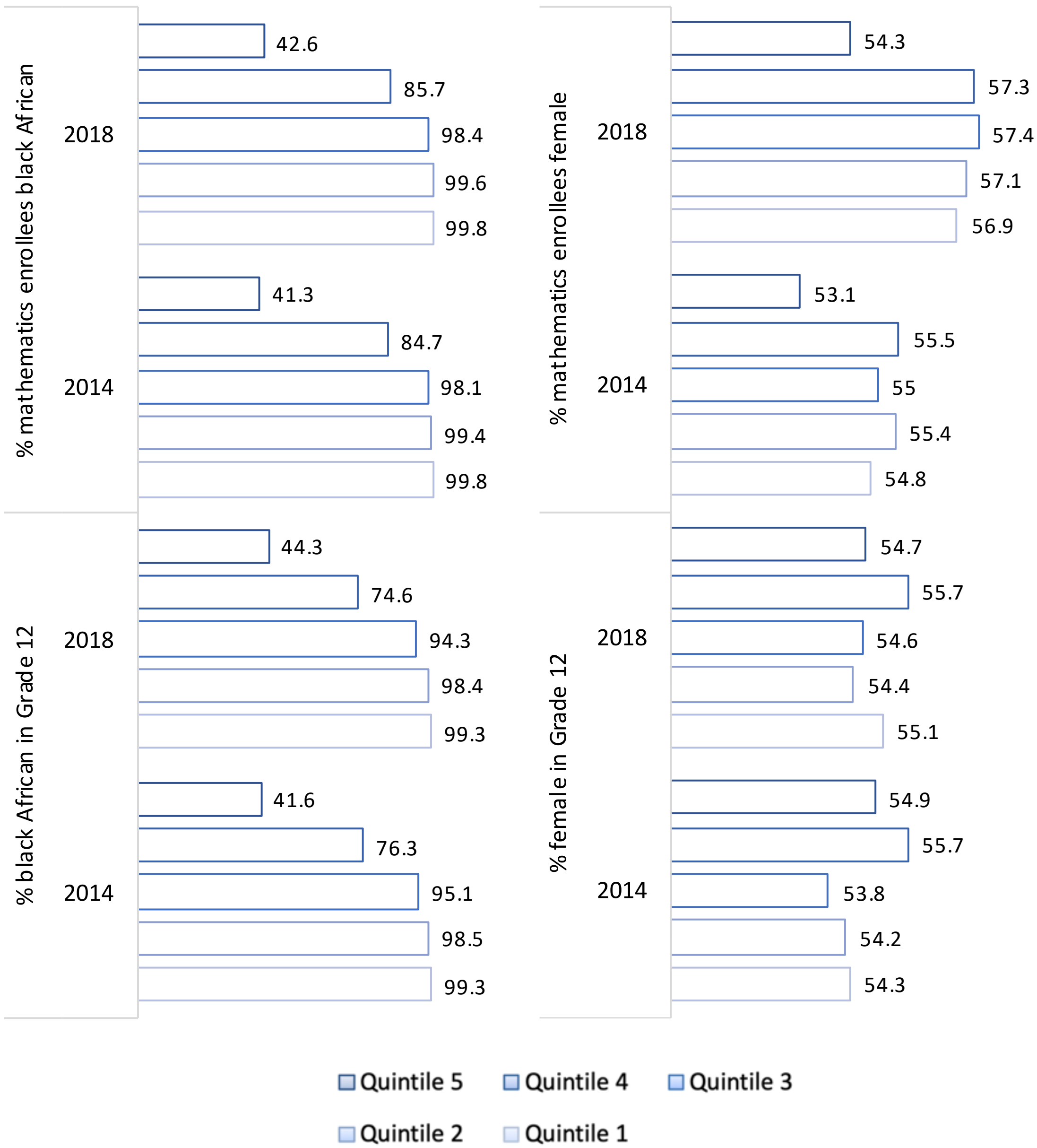
Note: Standard deviations shown in parentheses. Source: own calculations using 2010, 2014 and 2018 NSC fulltime data. [a] The school quintile of 10 933 Gr12 students enrolled for mathematics and 12 555 Gr12 students enrolled for mathematical literacy could not be determined from the data.

Table 7: Grade 12 enrolment in Mathematics and Mathematical Literacy between 2010 and 2018

	2010			2014			2018		
	Number enrolled	**% of group**	**% of Gr12s**	**Number enrolled**	**% of group**	**% of Gr12s**	**Number enrolled**	**% of group**	**% of Gr12s**
				Mathematics					
Demographic									
Female	..	..	..	125 866	42.1	23.0	153 280	44.8	24.5
Male	..	..	..	104 019	41.7	19.0	117 236	41.6	18.8
Black African	..	..	..	194 043	42.6	35.4	238 291	44.5	38.1
Coloured	..	..	..	9 904	24.4	1.8	9 722	21.5	1.6
Indian/Asian	..	..	..	7 960	55.3	1.5	6 737	59.1	1.1
White	..	..	..	17 835	47.8	3.3	15 625	47.7	2.5
School Quintile									
Quintile 1	56 682	49.6	10.1	48 162	43.9	8.8	67 431	48.1	10.8
Quintile 2	58 945	50.5	10.5	48 594	41.5	8.9	62 071	44.0	9.9
Quintile 3	56 261	49.8	10.0	50 468	39.6	9.2	59 248	40.4	9.5
Quintile 4	23 471	47.4	4.2	28 337	39.6	5.2	28 501	37.3	4.6
Quintile 5	27 820	45.8	5.0	43 519	44.7	7.9	42 337	43.7	6.8
Quintile unknown	48 992	45.5	8.7	10 428	43.6	1.9	10 928	46.8	1.7
School sector									
Public	222 695	49.1	39.6	217 572	41.8	39.7	258 832	43.1	41.4
Independent	9 476	55.6	1.7	11 686	45.8	2.1	11 430	48.2	1.8
Sector unknown	39 730	43.9	7.1	628	34.6	0.1	254	44.3	0.0
Total	272 172	48.4	48.4	229 886	41.9	41.9	270 516	43.3	43.3
				Mathematical Literacy					
Demographic									
Female	..	..	..	173 159	57.9	31.6	186 079	54.3	29.8
Male	..	..	..	145 156	58.3	26.5	156 897	55.6	25.1
Black African	..	..	..	261 519	57.4	47.7	288 152	53.9	46.1
Coloured	..	..	..	30 746	75.6	5.6	34 461	76.3	5.5
Indian/Asian	..	..	..	6 437	44.7	1.2	4 557	40.0	0.7
White	..	..	..	19 496	52.2	3.6	15 683	47.9	2.5
School Quintile									
Quintile 1	54 835	50.4	10.3	61 630	56.1	11.2	71 345	50.9	11.4
Quintile 2	59 378	49.5	10.3	68 609	58.5	12.5	76 971	54.5	12.3
Quintile 3	61 243	50.2	10.1	77 126	60.5	14.1	84 697	57.7	13.6
Quintile 4	33 284	52.7	4.6	43 256	60.4	7.9	45 485	59.5	7.3
Quintile 5	44 288	54.2	5.9	53 764	55.3	9.8	51 926	53.6	8.3
Quintile unknown	58 572	54.4	10.4	13 930	56.2	2.5	12 552	53.2	1.9
School sector									
Public	231 049	50.9	41.1	303 294	58.2	55.3	330 377	55.0	52.9
Independent	7 794	44.4	1.4	13 833	54.2	2.5	12 279	51.8	2.0
Sector unknown	50 855	56.1	9.1	1 188	65.4	0.2	320	55.8	0.1
Total	289 698	51.6	51.6	318 315	58.1	58.1	342 976	54.9	54.9

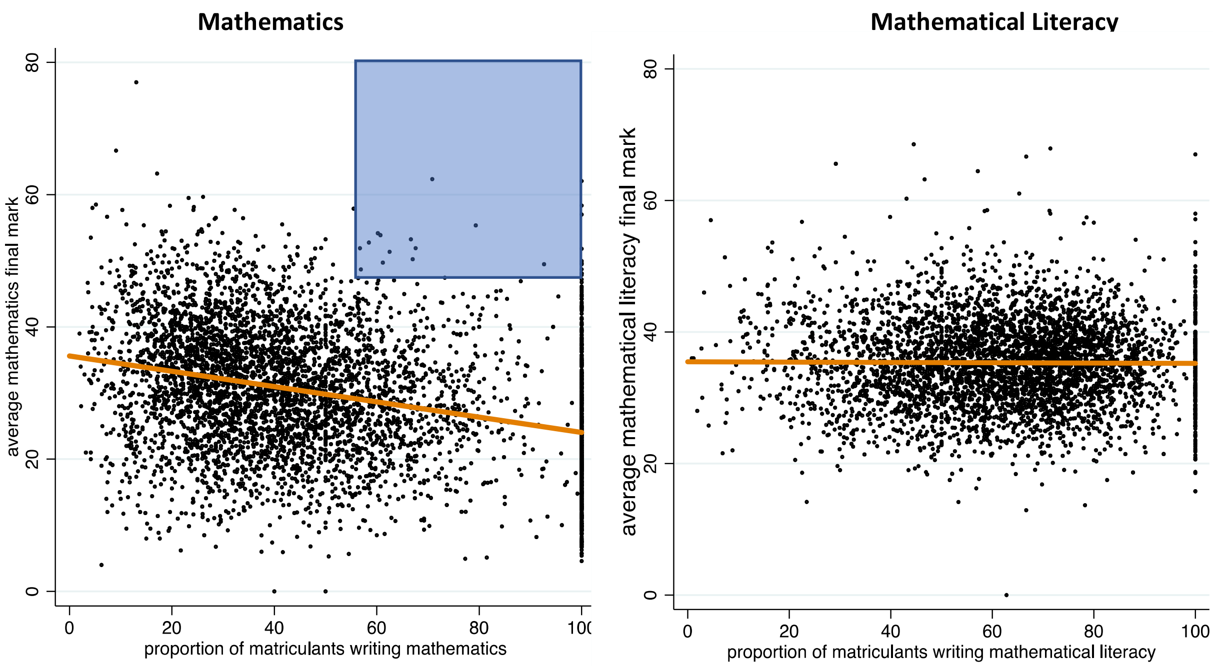
Notes: 2018 data is used to infer school quintile in cases of missing information in 2014 and 2010. Source: own calculations using 2010, 2014 and 2018 NSC fulltime data.

Figure 4: Black African and female enrolment in Mathematics, by school quintile



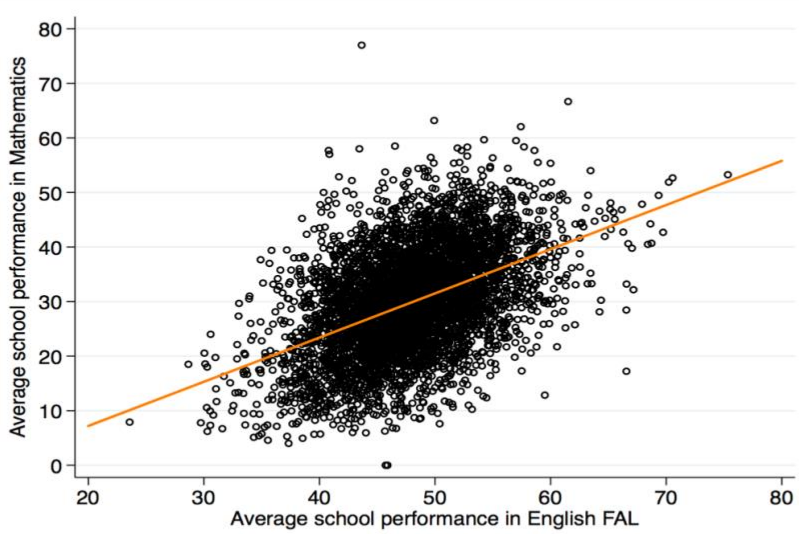
Notes: 2018 data is used to infer school quintile in cases of missing information in 2014. Source: own calculations using 2010, 2014 and 2018 NSC fulltime data.

Figure 5: Proportion of matriculants writing each subject versus school average final mark for Quintile 1-3 schools, 2018



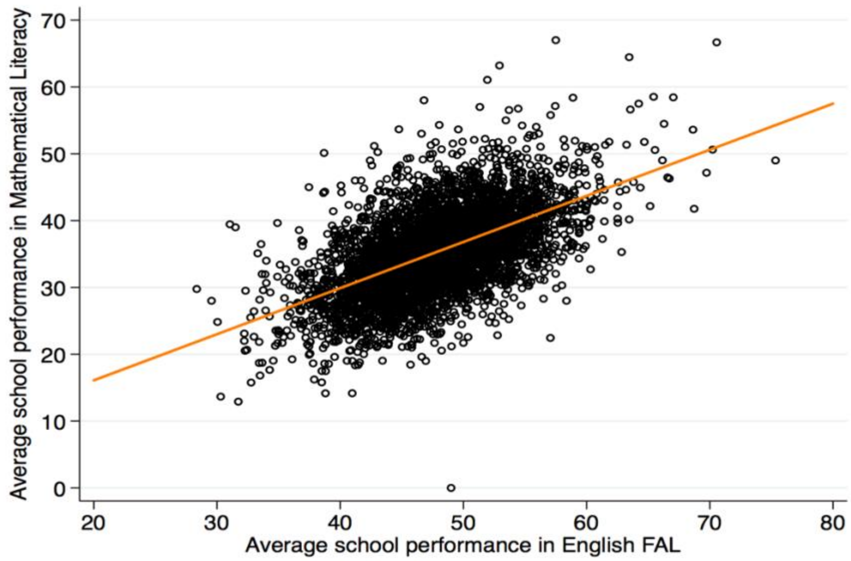
Notes: Each dot represents a school. The orange line is the line of best fit. The block insert indicates those schools that achieved an average mark of 50% or more in mathematics and had at least 60% of Gr12 learners enrolled in mathematics. Source: own calculations using NSC fulltime 2018 data.

Figure 6: Mathematics performance versus English FAL performance (Q1-Q3)



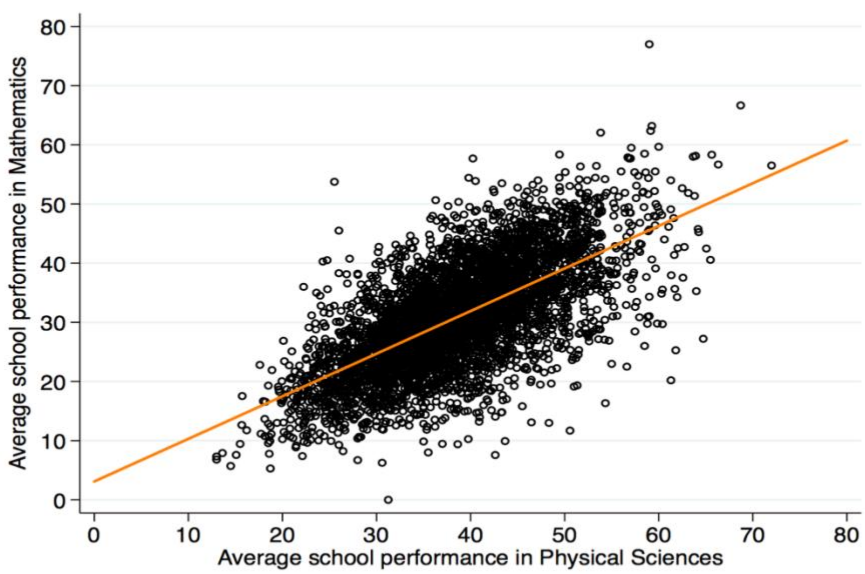
Notes: Each dot represents a school. The orange line is the line of best fit. Source: own calculations using NSC fulltime 2018 data.

Figure 7: Mathematical Literacy performance versus English FAL performance (Q1-Q3)



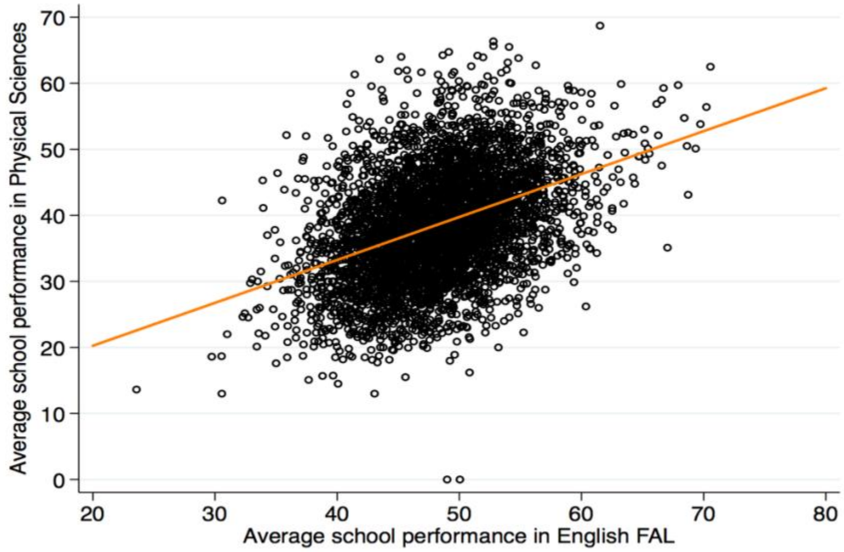
Notes: Each dot represents a school. The orange line is the line of best fit. Source: own calculations using NSC fulltime 2018 data.

Figure 8: Mathematics performance versus Physical Science performance (Q1-Q3)



Notes: Each dot represents a school. The orange line is the line of best fit. Source: own calculations using NSC fulltime 2018 data.

Figure 9: Mathematics performance versus Physical Science performance (Q1-Q3)



Notes: Each dot represents a school. The orange line is the line of best fit. Source: own calculations using NSC fulltime 2018 data.

Table 8: Correlations between school average performance in selected subjects (Q1 – Q3 schools only)

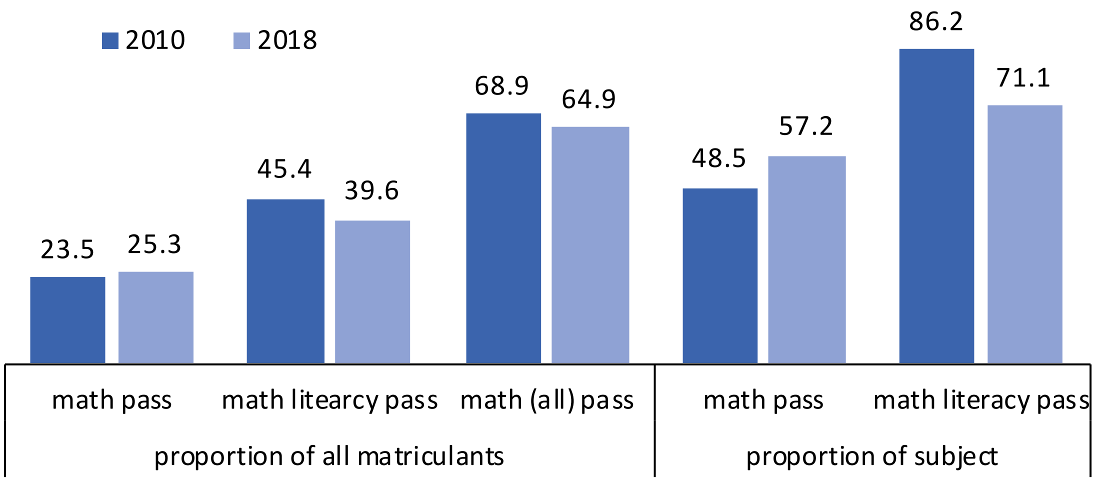
	Mathematics	**Maths Literacy**	**Physical Sciences**	**English FAL**	**Home Language**
Mathematics	1.00				
Maths Literacy	0.52	1.00			
Physical Sciences	0.66	0.43	1.00		
English FAL	0.33	0.36	0.27	1.00	
Home Language	0.14	0.24	0.21	0.36	1.00

Source: own calculations using NSC fulltime 2018 data.

Figure 10b shows similar data by school quintile. From this figure we can see a sharp incline in mathematics pass rates from Q1-Q3 to Q4, but especially from Q4 to Q5. It is most encouraging to see that the pass rates of Q1-Q3 schools in Mathematics increased by approximately a third between 2010 and 2018, whilst pass rates remained fairly the same in Q4 and Q5 schools. Conversely, the pass rates in Mathematical Literacy fell across all school quintiles over time, most notably in quintiles 1 to 4.[21]

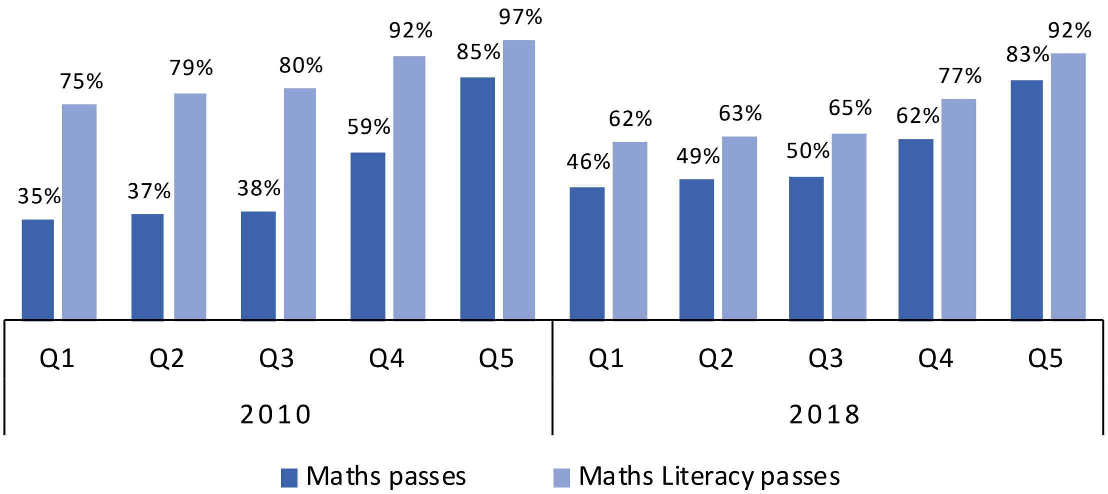
21 A summary of the number of students achieving at different levels by mathematics subject and school quintile over time (2010 to 2018) are provided in Tables A.2 and A.3 of the Appendix.

Figure 10a: Proportion of Grade 12 learners passing mathematics, 2010 and 2018



Source: own calculations using NSC fulltime 2010 and 2018 data.

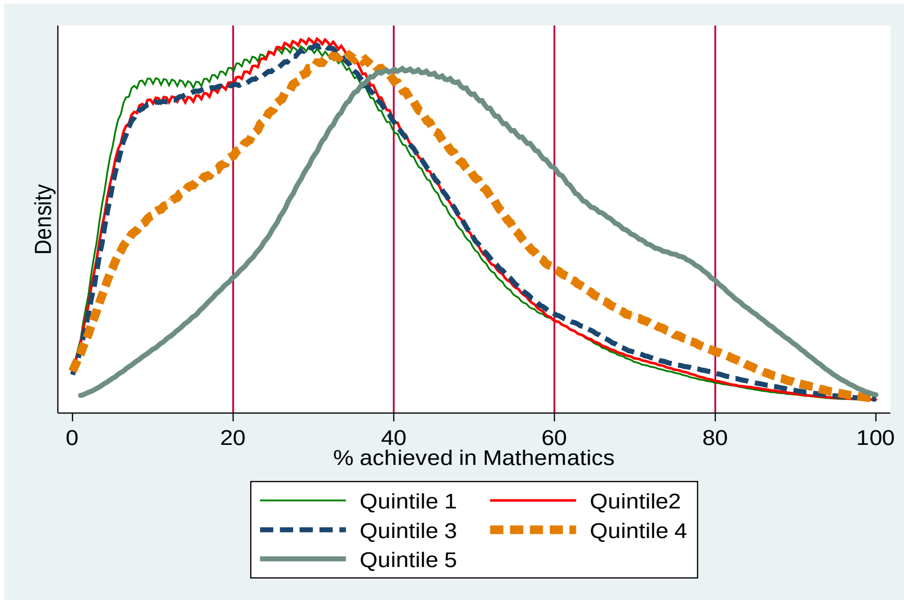
Figure 10b: Proportion of Grade 12 learners passing mathematics, 2010 and 2018, by school quintile



Source: own calculations using NSC fulltime 2010 and 2018 data.

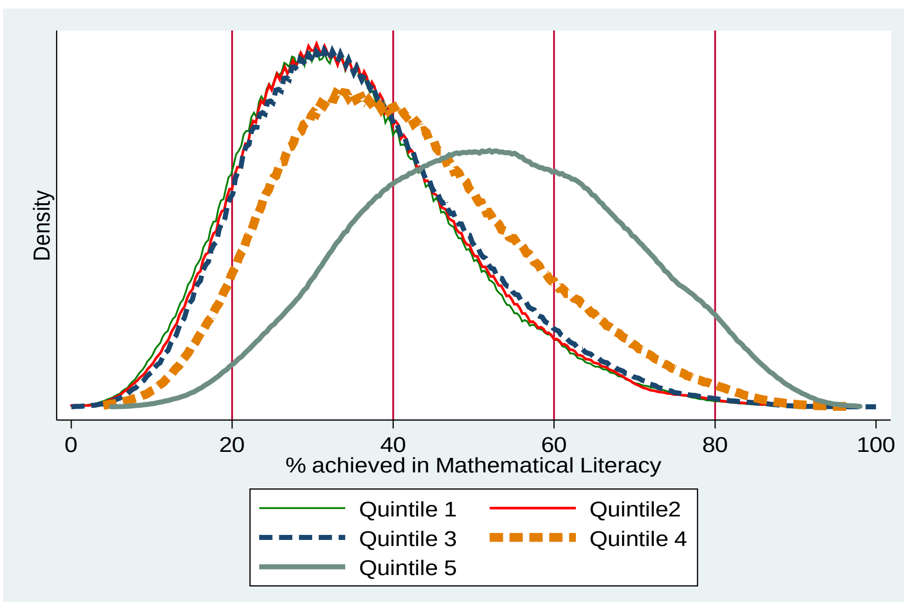
The distribution of Mathematics (Figure 11) and Mathematical Literacy (Figure 12) performance by school quintile shows great differences between the bottom three quintiles, which are almost indistinguishable, and Quintile 4 and especially Quintile 5. But even for Quintile 5, the mode (peak) lies more to the left for Mathematics than for Mathematical Literacy, indicating that those who have elected to do this subject, even in the most affluent schools, still do struggle in performing well. Even in Quintile 5, a large proportion of students do not manage to obtain a pass in Mathematics.

Figure 11: Distribution of Mathematics marks by school quintile, 2018



Source: own calculations using 2018 NSC fulltime data.

Figure 12: Distribution of Mathematical Literacy marks by school quintile, 2018



Source: own calculations using 2018 NSC fulltime data.

Despite the option of taking Mathematical Literacy that is considerably less challenging, a large proportion (43%) of students who choose to do Mathematics still end up failing the subject. In fact, approximately 100 000 fail Mathematics at the 30% level, while only about 85 000 fail Mathematical Literacy. Around 80 000 of those who fail Mathematics are in the bottom three quintiles of schools. Pass rates for the two subjects by quintile are shown in Table 3: The choice between these subjects is clearly an important one that requires attention, and this will again be returned to later in this report.

Table 3: Pass rates by quintile in Mathematics and Mathematical Literacy, 2018

School quintile	*Mathematical Literacy*	*Mathematics*
1	62.2%	46.6%
2	63.5%	48.8%
3	65.1%	50.0%
4	76.6%	62.5%
5	92.1%	83.4%
unknown	83.0%	70.8%
All	**71.1%**	**57.2%**

Source: own calculations using 2018 NSC fulltime data.

Disaggregating by school poverty quintile (Figures 13 and 14),[22] it can be observed that whilst enrolment in Mathematics has remained fairly constant in Q5 schools, Q1-Q3 schools experienced a decline in average enrolment until 2015, following which average enrolment has been increasing. Q4 schools had a similar decline in average enrolment until 2015, with the proportion remaining more or less around 37-38% since. Over time, Q1 schools consistently have the highest average enrolment in Mathematics, whilst Q4 have the lowest average enrolment. As is expected, opposite trends in average enrolment in Mathematical Literacy are observed.

4.3 Investigating the relationship between enrolment and performance

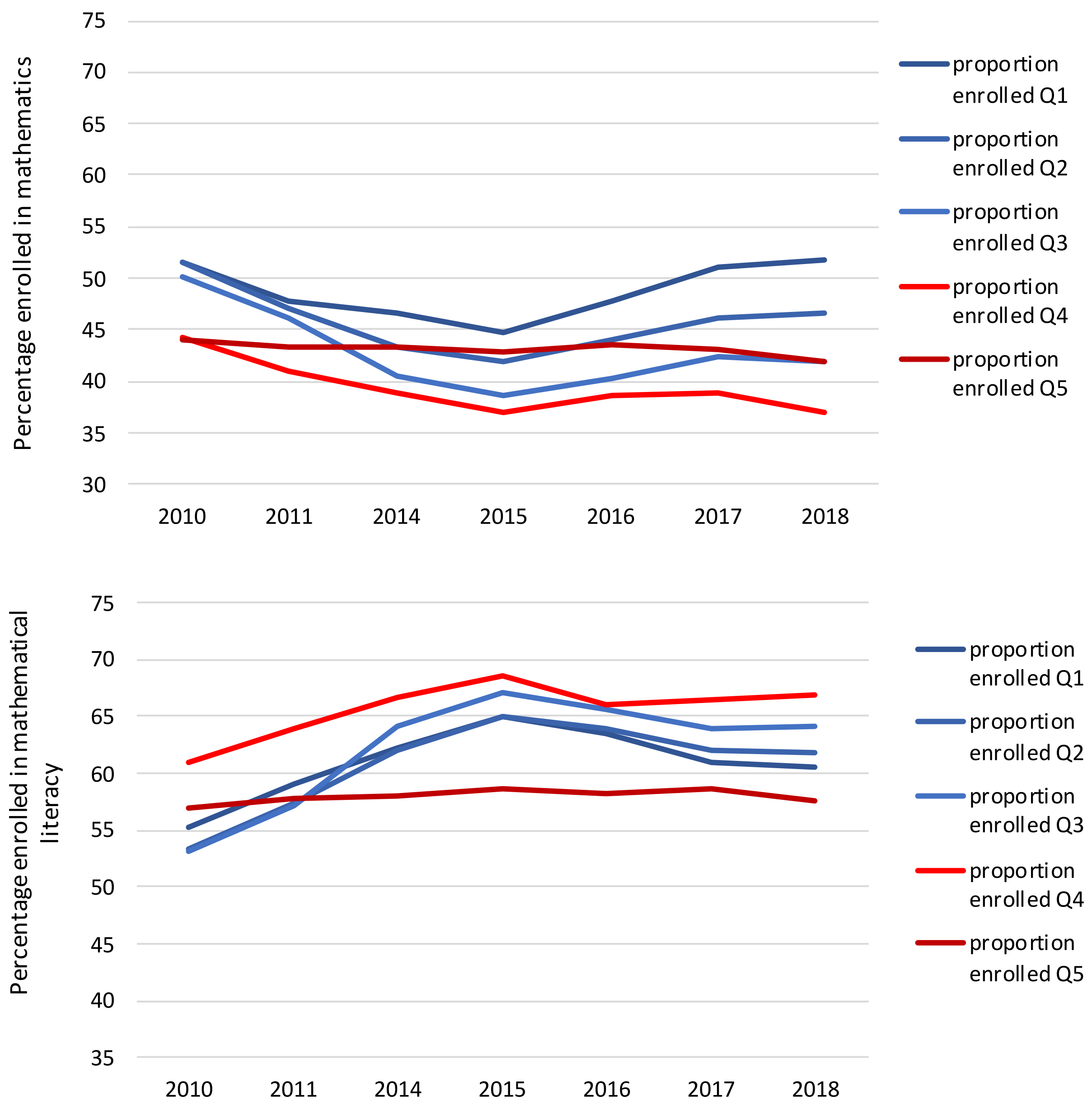
As already seen in Figure 5, the average Mathematics pass rates (i.e. the proportion of students enrolled in Mathematics in a school achieving a final percentage of 30% or more for this subject) appears to have a negative relationship with Mathematics enrolment. This is tested using the following linear regression model:

$$Y_{st} = \alpha_s + \gamma_t + \sum_{k=1}^{5} \beta_k X_{skt} + \varepsilon_{st}$$

where Y is the proportion of matriculants in school s passing Mathematics in year t, and X is the proportion of matriculants in school s categorised into school Quintile k (1, 2, 3, 4, 5) enrolled in Mathematics in year t. α_s and γ_t are school and year fixed effects, respectively, and ε_{st} is a random error.

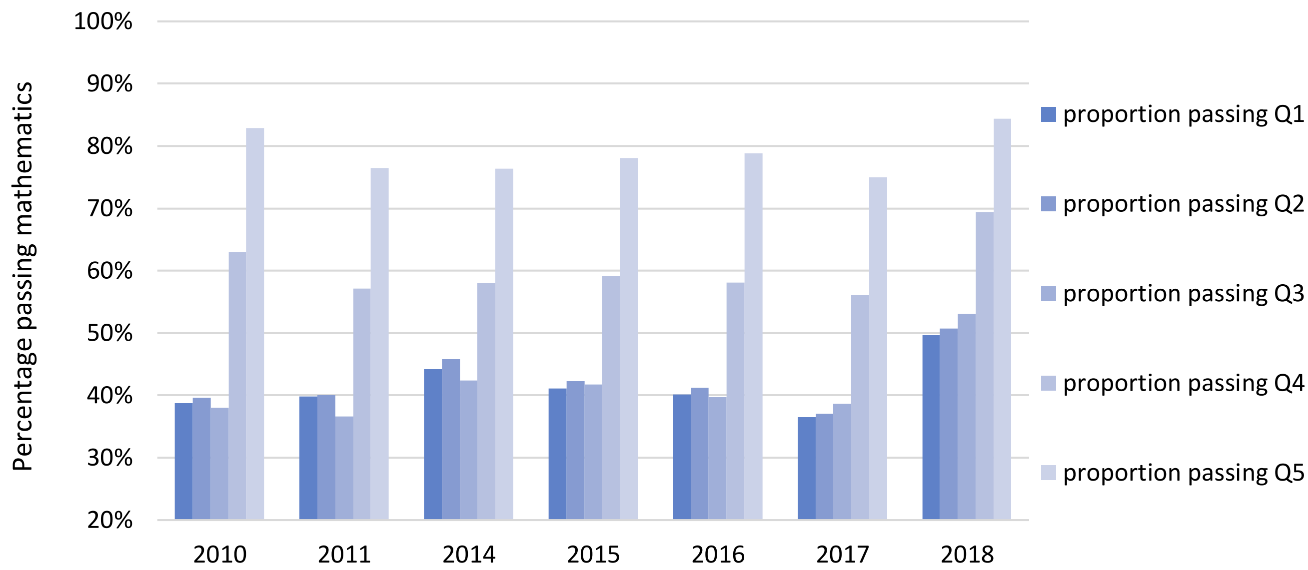
22 Quintile classification information was not available for all schools in 2010. The school Quintile information for 2018 was therefore used to backward classify schools with missing Quintile data in earlier years.

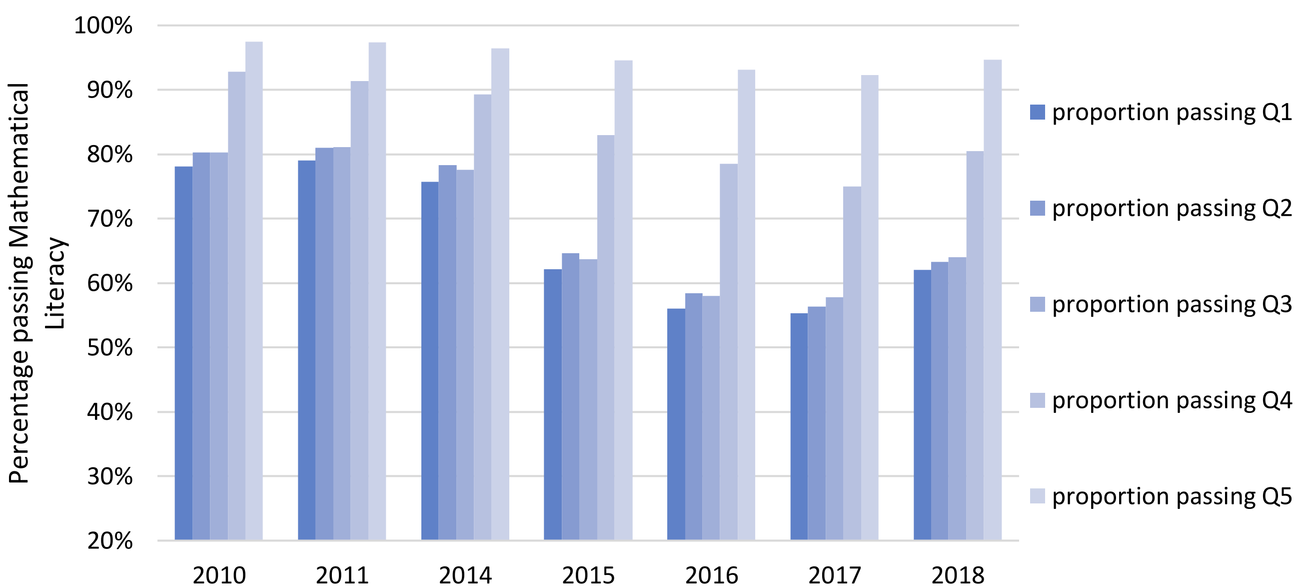
Figure 13: Enrolment in Mathematics and Mathematical Literacy over time, by school quintile



Source: own calculations using 2010 - 2018 NSC fulltime data.

Figure 14: Pass rates in Mathematics and Mathematical Literacy over time, by school quintile





Source: own calculations using 2010 - 2018 NSC fulltime data.

The estimates indicate a significant negative relationship between these two factors for all school quintiles; specifically, for every 10-percentage point increase in the share of enrolment in Mathematics, the pass rate is expected to decrease by 3.9 to 4.3 percentage points in the case of Q1-Q3 schools, 5.5 percentage points for Q4 schools, and 4.4 percentage points for Q5 schools. The only exception to this trend is 2018, where the average Mathematics pass rates of all school Quintiles increased by 10 percentage points, irrespective of the direction of change in enrolment. For Mathematical Literacy, no such relationship is observed.

The top panel of Table A.4 of the Appendix shows that the average proportions of matriculants obtaining a Mathematics pass within schools increased between 2010 and 2018. This was particularly the case for the final achievement bracket of 30-50%, as well as amongst Q1-Q3 schools more generally (see Figure 14). Surprisingly, the average proportion of matriculants in Q5 schools obtaining a final mark in Mathematics of 50% or higher declined steadily over the period. Therefore, the overall pass rate in Q5 schools was sustained by an increase in the proportions of students obtaining final marks between 30% and 50%.

Nonetheless, the proportions of Grade 12 learners in Q5 schools passing Mathematics with a 50% or higher is four-fold that of Q1-Q3 schools, and double that of Q4 schools. Mathematical Literacy passes, however, have fallen across all school Quintiles, with proportions of learners achieving less than 30% in Mathematical Literacy increasing approximately two-fold in Q1-Q3 schools, and three-fold amongst Q4 and Q5 schools. Similar to Mathematics, the proportions of Grade 12 learners passing Mathematical Literacy with 50% or higher is three-fold that of Q1-Q3 schools.

The second last column of Table 6 showed that, amongst Q5 schools, the average proportion of Gr12 students enrolled in mathematics that achieved 50% or higher was 39.8%. The schools represented in Figure 15 are all Q1 schools that meet this condition (note the starting value on the y-axis). However, the heterogeneity of this group of schools in terms of performance is evident. Most of these schools have Mathematics enrolment that is below the average of Q1 schools more generally (48%). There is a clear set of outlying schools that, besides meeting the condition of at least 40% of students passing mathematics with 50% or more, have a high mathematics enrolment (above 60%) as well as a matric pass rate that is above the Q1 average of 57%; these are circled in Figure 15.

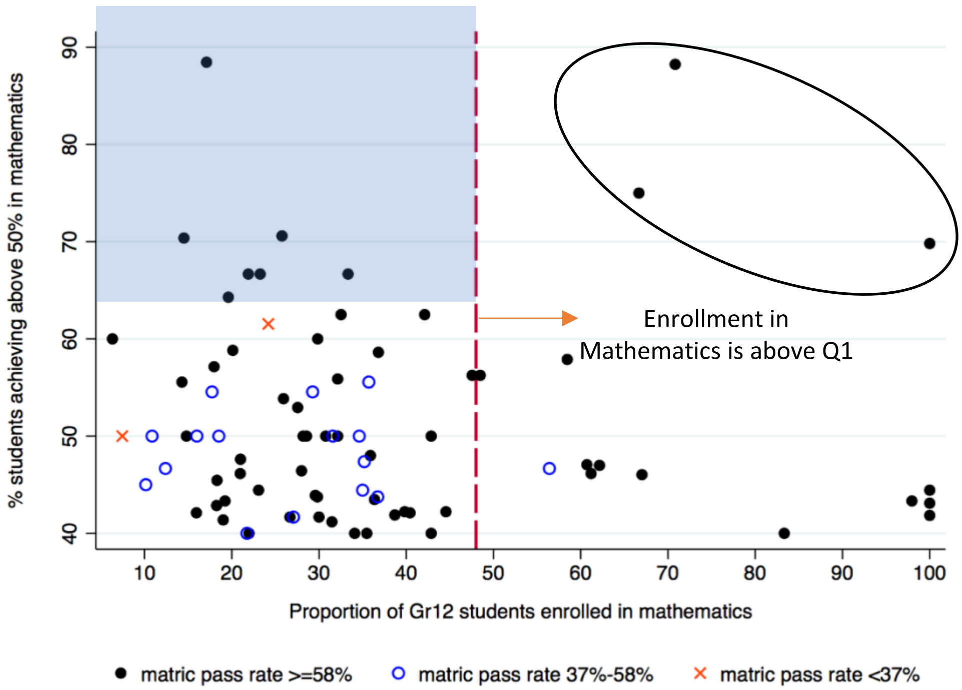
There is also another group of schools in which least 60% of students achieved 40% or more in mathematics, the matric pass rate is above the Q1 average, but enrolment in mathematics in these schools is lower than the Q1 average of 52%; these are indicated by the shaded area in Figure 15. The findings of Figure 15 provide further evidence of a negative relationship between enrolment in Mathematics and school performance in Mathematics in Q1 schools. Figure 16 and Figure 17 are similarly drawn for Q2 and Q3 schools, and Figure 18 for the existing Maths Challenge Programme (MCP) schools. Comparisons of these figures indicate that the majority of MCP schools have close to universal matric pass rates and substantially higher average enrolments in Mathematics (71%). Furthermore, there does not appear to be the same trade-off between enrolment and performance amongst MCP schools.

5. Identifying schools with 'promise'

5.1 Consistency in performance

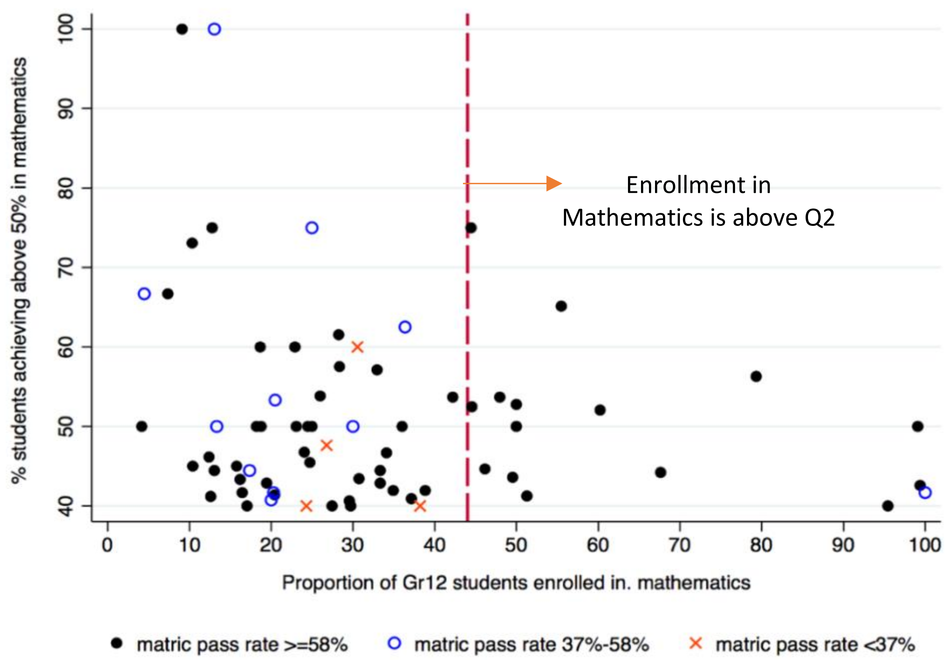
Most teachers attest that not every matric year is the same: Some matric years are good, whilst others are not. Therefore assessing a school based on a single year's NSC results may not always reflect the school's ability to perform. A regression of school average performance in Mathematics in earlier years on current (2018) Mathematics' performance indicates that the strongest determinant of current Mathematics performance amongst Q1-Q3 schools is the most recent year's (2017) performance: for each 10 percentage point increase in average 2017 performance, average 2018 performance increases by 3.9 percentage points.

Figure 15: Relationship between Maths passes above 50% and Maths enrolment in Q1 schools, 2018



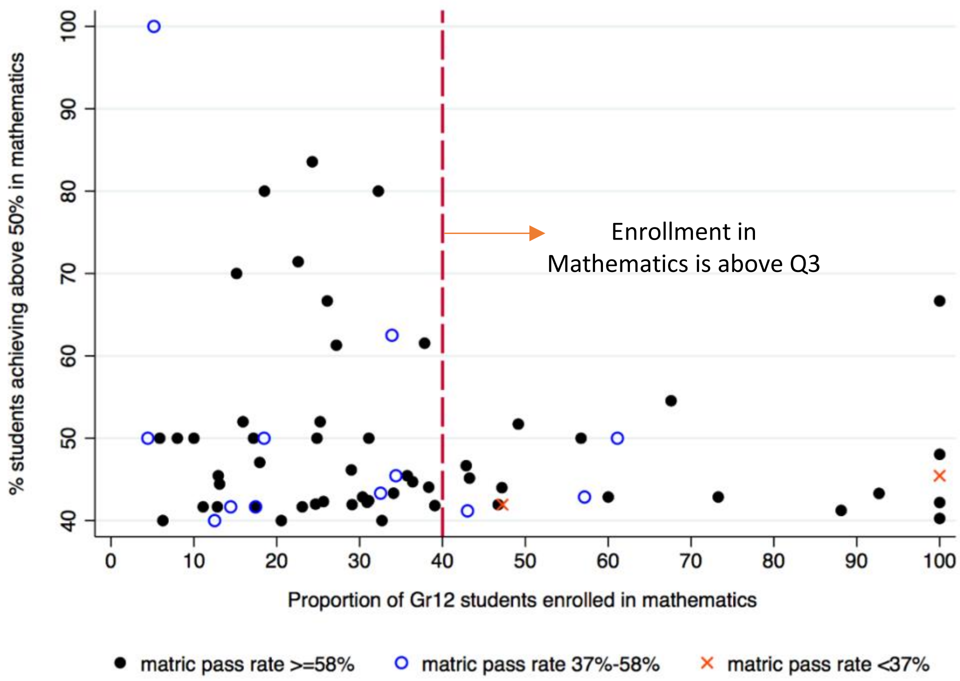
Notes: each dot represents a school. Source: own calculations using 2018 NSC fulltime data.

Figure 16: Relationship between Maths passes above 50% and Maths enrolment in Q2 schools, 2018



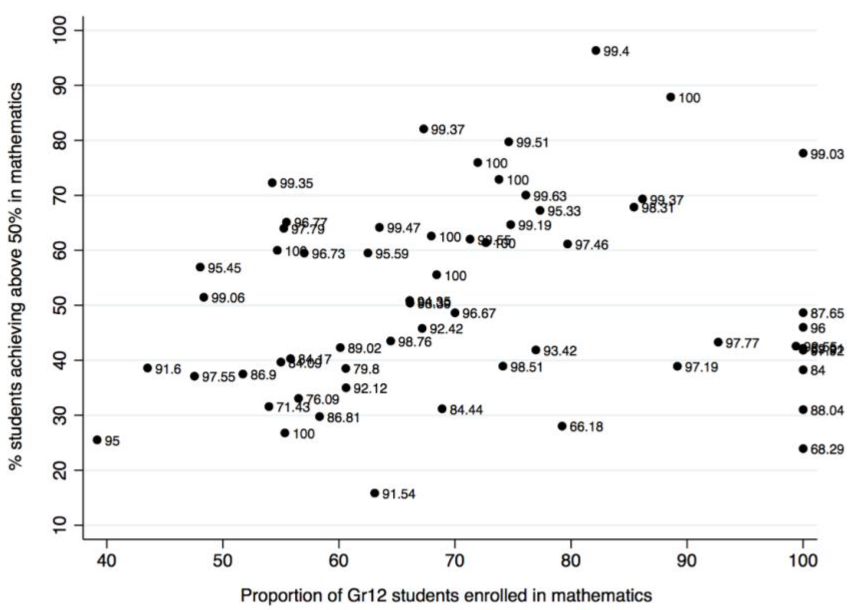
Notes: each dot represents a school. Source: own calculations using 2018 NSC fulltime data.

Figure 17: Relationship between Maths passes above 50% and Maths enrolment in Q3 schools, 2018



Notes: each dot represents a school. Source: own calculations using 2018 NSC fulltime data.

Figure 18: Relationship between Maths passes above 50% and Maths enrolment in Maths Challenge Programme schools, 2018



Notes: each dot represents a school. Source: own calculations using 2018 NSC fulltime data.

Earlier years (2014, 2015 and 2016) have a significantly smaller association with 2018 performance. In fact, less than 20% of the variation in Q1-Q3 school performance in Mathematics in 2018 can be explained by school Mathematics performance 3 or 4 years previously (see Table 4 below). This is compared to Q5 schools where 50% of the variation in 2018 performance in Mathematics can be explained by performance 3 to 4 years previously, respectively, indicating substantially more stability in Mathematics' performance over time. The same pattern is observed for Mathematical Literacy, although in this case the relationship between current and past performance is even weaker in the case of Q1-Q3 schools.

Figure 19 confirms that there is substantial variation amongst Q1-Q3 schools in particular. On average, the interquartile range (IQR)[23] of the rank positions of Q1-Q3 schools between 2010 and 2018 is around 23 percentage points. This could imply movements across three to four deciles of performance ranking. An IQR of 15 percentage points represents a movement in ranking over time that spans, at most, two deciles. Only 22% of Q1 and Q2 schools illustrate this kind of consistency in performance, compared to 76% of Q5 schools. In Q5 schools the average movement is only across one to two deciles. Maths Challenge Programme (MCP) schools show even more consistency in performance over time than the average Q5 school, moving within 8-percentage points (less than one decile), and only a quarter of schools showing movement of at least one performance ranking decile or more.

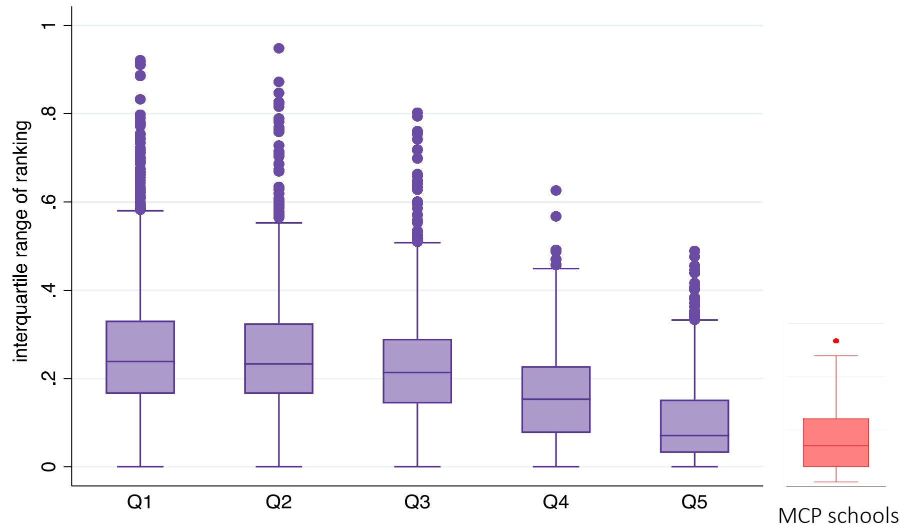
Table 4: Regression analysis of Mathematics and Mathematical Literacy performance in 2018 based on performance in earlier years

	Q1-Q3 schools						**Q5 schools**					
	Dependent variable: School average performance in Mathematics											
2017 Maths %	0.64				0.39	0.36	0.84				0.39	0.37
2016 Maths %		0.51			0.12	0.14		0.70			0.14	0.25
2015 Maths %			0.44		0.09	0.15			0.69		0.12	0.12
2014 Maths %				0.39	0.08	0.13				0.62	0.18	0.11
Additional controls	No	No	No	No	No	Yes	No	No	No	No	No	Yes
R^2	**0.41**	**0.26**	**0.19**	**0.15**	**0.43**	**0.73**	**0.74**	**0.58**	**0.56**	**0.50**	**0.78**	**0.85**
	Dependent variable: School average performance in Mathematical Literacy											
2017 Maths %	0.32				0.17	0.15	0.68				0.18	0.09
2016 Maths %		0.21			0.06	0.06		0.52			0.17	0.22
2015 Maths %			0.19		0.03	0.04			0.55		0.24	0.21
2014 Maths %				0.21	0.06	0.05				0.57	0.15	0.06
Additional controls	No	No	No	No	No	Yes	No	No	No	No	No	Yes
R^2	0.18	0.07	0.06	0.07	0.19	0.27	0.62	0.42	0.47	0.51	0.71	0.74

Notes: Additional controls include demographic composition of the school, Dinaledi status, school sector and district fixed effects.

23 The size of the gap between the performance of the 25th and the 75th percentile of schools.

Figure 19: Boxplot of the interquartile range of pass rate rankings between 2010 and 2018, by quintile and compared to MCP schools



Focusing on the three most recent years of data (2016, 2017 and 2018) and allowing for a movement of only one performance (pass rate) decile, 19% of Q1-Q3 schools displayed this kind of performance consistency (compared to two-thirds of Q5 schools). However, 60% of these schools performed consistently within the bottom three deciles of school performance, whilst only 15% of Q1-Q3 schools performed consistently within the top three deciles of mathematics pass rates (Table 11). Clearly, consistent performance does not always imply a suitable level of performance.

Table 11: Transition tables of performance (mathematics passes) rankings for Q1-Q3 schools between 2016 and 2018, with ranking IQRs of less than 10 percentage points

		Decile rank 2018									
		1	2	3	4	5	6	7	8	9	10
Decile rank 2016	1	28.7	4.6								
	2	5.5	8.8	3.4							
	3		2.7	5.6	0.8						
	4			1.4	2.4	1.4					
	5				1.1	2.7	1.8				
	6					1.3	3.7	1.3			
	7						1.1	2.8	2.3		
	8							2.0	4.6	1.2	
	9								1.4	4.2	0.5
	10									1.0	1.8

Source: own calculations using 2018 NSC fulltime data.

Taking instead an IQR of 10-20 percentage points—that is, a movement limited to only one to three performance deciles—just more than half of all Q1-Q3 schools meeting these criteria moved between the 4th and 8th deciles of school performance (Table 12). Furthermore, the majority of the Q1-Q3 schools that were observed to move within this range of performance ranking are observed to have a pass rate in mathematics of at least 40% (Table 13). This is visually depicted in Figure 20, where a pass rate of less than 40% is found to strongly correspond with either a very low (stable, but poor performance) or very high (unstable performance) rank interquartile range.

Table 12: Transition tables of performance (mathematics passes) rankings for Q1-Q3 schools between 2016 and 2018, with ranking IQRs of 10-20 percentage points

		Decile rank 2018									
		1	2	3	4	5	6	7	8	9	10
Decile rank 2016	1	2.2	3.8	2.4							
	2	3.7	3.5	4.6	1.7						
	3	2.6	5.4	2.6	3.1	1.3					
	4		2.4	4.0	2.9	2.8	1.2				
	5			1.5	4.3	2.0	2.7	1.3			
	6				1.3	3.2	1.8	2.6	1.2		
	7					1.5	3.6	2.1	2.7	1.5	
	8						1.8	3.6	2.4	1.3	0.2
	9							1.8	2.4	0.8	1.3
	10								0.4	0.7	0.1

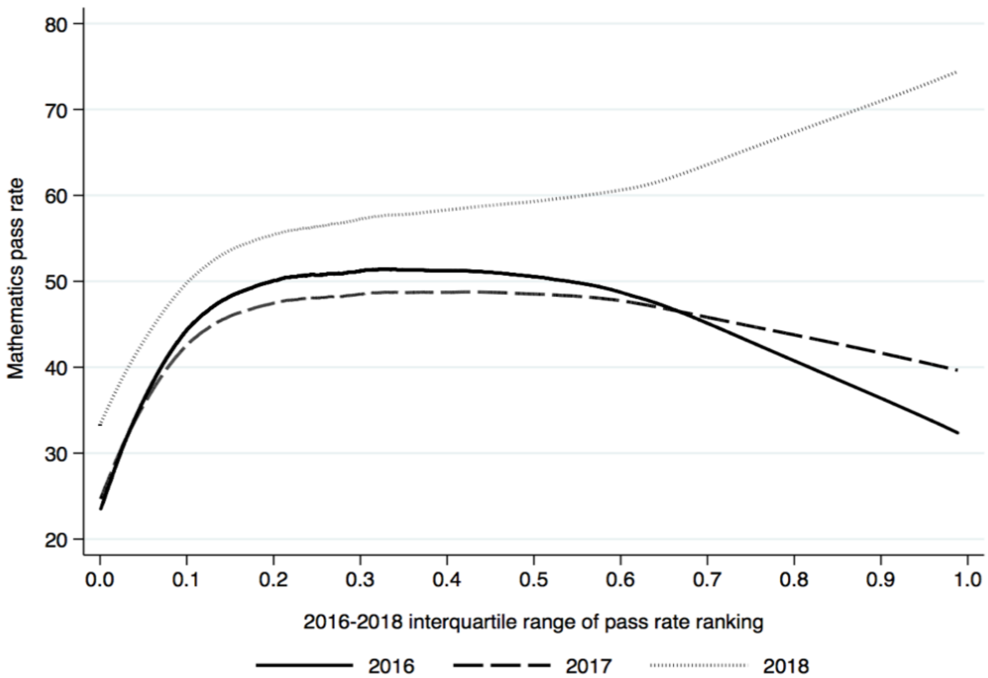
Source: own calculations using 2018 NSC fulltime data.

Table 13: Transition of average mathematics passes between 2016 and 2018 for Q1-Q3 schools with ranking IQRs of 10-20 percentage points

		Decile rank 2018									
		1	2	3	4	5	6	7	8	9	10
Decile rank 2016	1	11→ 17	10→ 35	14→ 43							
	2	26→ 16	26→ 34	24→ 45	26→ 51						
	3	33→ 20	36→ 34	36→ 45	36→ 52	37→ 58					
	4		43→ 37	44→ 44	44→ 53	44→ 59	50→ 65				
	5			52→ 46	53→ 52	53→ 59	53→ 66	54→ 72			
	6				59→ 54	61→ 59	61→ 66	60→ 73	62→ 78		
	7					68→ 61	70→ 66	70→ 73	70→ 81	71→ 86	
	8						76→ 68	79→ 73	79→ 80	78→ 88	79→ 97
	9							86→ 74	87→ 80	88→ 88	87→ 98
	10								95→ 81	98→ 88	100→ 100

Source: own calculations using 2018 NSC fulltime data.

Figure 20: Lowess regression of school ranking interquartile range on Mathematics pass rate



Source: own calculations using 2018 NSC fulltime data.

5.2 Performance "above expectations"

Another means of assessing the mathematical performance of school is to determine whether or not observed performance is greater than the "expected" (or predicted) school performance (or performance of learners in the school), considering factors believed to be related to Mathematics performance, such as performance on other NSC examinations (e.g. Home Language and English First Additional Language) and the socioeconomic conditions of the school (e.g. school quintile and Dinaledi status). Regression (education production function) analysis that controls for these factors as well as district level fixed effects was performed for the 2018 learner performance in Mathematics and Mathematical Literacy, as well as 2018 school average performance in Mathematics and Mathematical Literacy.

As indicated in Table 14 below, 55.4% and 61.1% of schools are attaining average performances in Mathematics and Mathematical Literacy, respectively, that exceeds expectations. There is some variation across school quintile: Approximately 51% to 54% of Q1-Q3 schools are performing above expectations in Mathematics, compared to just more than 60% of Q4 and Q5 schools. However, when it comes to Mathematical Literacy, at least two-thirds of Q1 schools perform above expectations. However, many of these "above-expected" performances lie very close to actual performance. Observing schools that performed at least half a standard deviation above expected, the proportions of schools performing above expectation in Mathematics and Mathematical Literacy drops by roughly 40% and 50%, respectively. Observing only those schools that performed at least one standard deviation above expectation, the overall proportions drop to 13.5% and 18.2%. It is unsurprising that the biggest drop is observed for Q5 schools.

Table 14: Number of schools performing above expectations based on regression analysis of average school performance (marks) in Mathematics and Mathematical Literacy in 2018, by school quintile

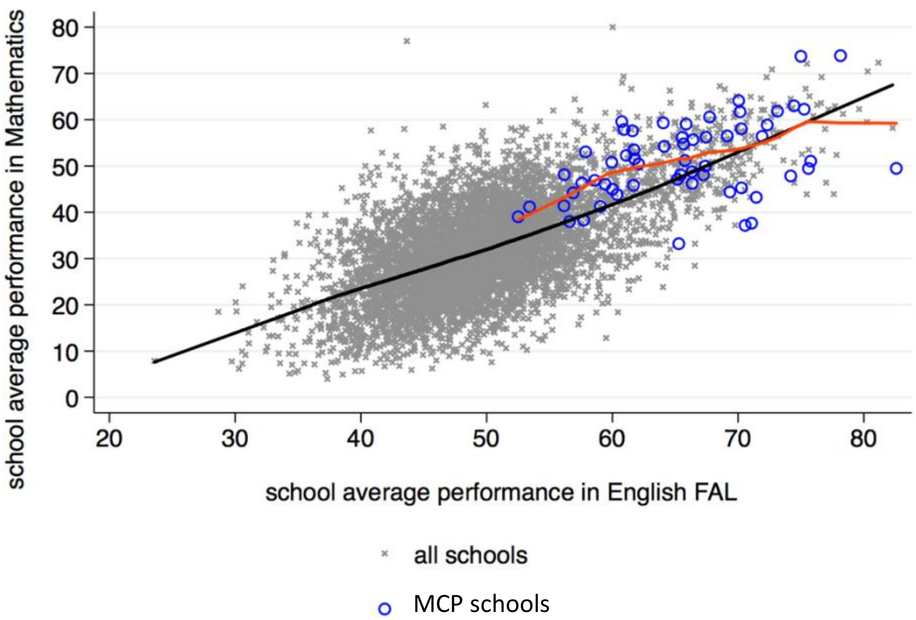
	Q1	Q2	Q3	Q4	Q5	All
Mathematics:						
Schools with average Maths % above expected	924 (54.0%)	826 (50.7%)	695 (51.6%)	354 (61.2%)	448 (63.7%)	3 570 (55.4%)
Schools with average Maths % more than ½ s.d. above expected	561 (32.8%)	460 (28.2%)	406 (30.1%)	226 (39.1%)	231 (32.9%)	2 125 (33.0%)
Schools with average Maths % more than 1 s.d. above expected	224 (13.1%)	181 (11.1%)	157 (11.7%)	116 (20.0%)	50 (7.1%)	870 (13.5%)
Mathematical Literacy:						
Schools with average Maths Literacy % above expected	1 002 (67.1%)	867 (57.9%)	744 (58.1%)	318 (55.8%)	432 (62.2%)	3 682 (61.1%)
Schools with average Maths Literacy % more than ½ s.d. above expected	447 (29.9%)	379 (25.3%)	288 (22.5%)	183 (32.1%)	211 (30.4%)	1 740 (28.9%)
Schools with average Maths Literacy % more than 1 s.d. above expected	356 (23.8%)	248 (16.6%)	172 (13.4%)	116 (20.4%)	75 (10.8%)	1 096 (18.2%)

Notes: s.d. = standard deviation. One standard deviation in Mathematics is approximately 12 percentage points, and one standard deviation in Mathematical Literacy 14 percentage points. Source: own calculations using 2018 NSC fulltime data.

As can be seen in Figure 21 below, there is a positive relationship between the average performance of a school in English FAL and Mathematics and, even stronger, between English FAL and Mathematical Literacy (Figure 22). Proportionally, fewer MCP schools perform below expected in Mathematics and Mathematical Literacy for a given average school performance in Home Language.[24] Therefore, controlling for English First Additional Language (FAL) in the above analysis implies that "above expected" performance in Mathematics is determined for a given level of performance in English FAL. This could be related to the relative quality of teaching in English FAL compared to the quality of teaching in Mathematics and Mathematical Literacy. Otherwise stated, a school is more likely to be classified as performing above expectations in Mathematics if average performance in English FAL is low, and less likely to be classified as performing above expectations in Mathematics if average performance in English FAL is high. This is confirmed by Figure 23.

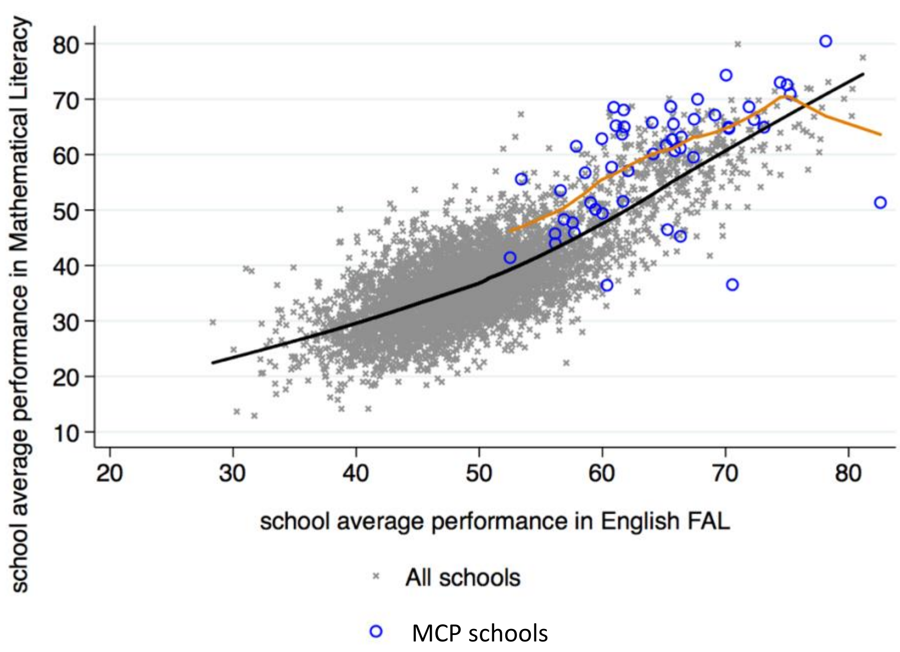
[24] The comparison to Home Language is made for EOT school as the majority of matriculants in these schools do not take English as an Additional Language

Figure 21: School performance in English FAL (Home Language) compared to school performance in Mathematics (for MCP schools), 2018



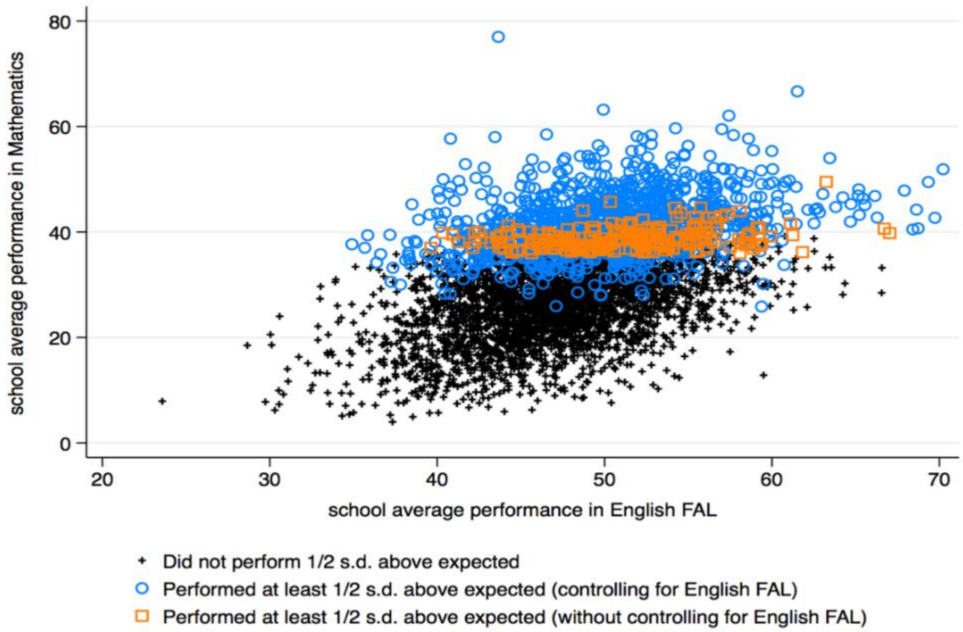
Source: own calculations using 2018 NSC fulltime data.

Figure 22: School performance in English FAL compared to school performance in Mathematics Literacy, 2018



Source: own calculations using 2018 NSC fulltime data.

Figure 23: School performance in English FAL compared to school performance in Mathematics (Q1-Q3 schools only)



Source: own calculations using 2018 NSC fulltime data.

Repeating the production function analysis of Table 14 and excluding school performance in English FAL, there are a significant number of schools (approximately 300) that, given relatively weaker English FAL performance, would have been excluded from the group considered performing above expectations (see Table 15). Taking into account distance from the regression line, the number of Q1-Q3 schools performing 1 standard deviation above expected increases from 562 to 854 schools; the numbers of schools performing 1 standard deviation above expected in Mathematical Literacy remains roughly the same. Regarding existing MCP schools, at least 51 of the 59 schools performed above expected in Mathematics and Mathematical Literacy. Accounting for distance from the regression line, 43 (73%) and 22 (37%) of the 59 schools performed ½ and 1 standard deviation above expected, respectively.

The final rows of Table 15 indicate that whilst just fewer than 40% of Q1-Q3 schools performed above average in both mathematics subjects in 2018, only 428 (8.7%) performed at least ½ a standard deviation above expected in both subjects, and only 105 (2.1%) schools performed at least 1 standard deviation above expected in both subjects. The hurdle of showing above-expected performance in both subjects, therefore, appears to be a high one. Overall, approximately 30% of MCP schools performed above expectations in both Mathematics and Mathematical Literacy.

Average school performance in Mathematics is moderately correlated to average school performance in Mathematical Literacy (r = 0.52). Given this relationship, and in order to simplify the analysis, a "composite" average mathematics score for each school was calculated by applying the Mathematics score that "corresponds" to a given performance in Mathematical Literacy, as provided by Simkins (2010).[25] Table 16 illustrates the results from repeating the analysis of Table 15 for each of the years between 2014 and 2018 using this "composite" score.

Table 15: Comparison of number of schools performing above expectations with and without controlling for English FAL in 2018

	Q1	Q2	Q3	Q4	Q5	All
Schools performing above expectations in Mathematics						
School average Maths % > expected (without Eng FAL)	924	870	712	317	391	3 524
School average Maths % > expected (with OR without Eng FAL)	1 009	945	772	379	469	3 920
School average Maths % > ½ s.d. above expected (with OR without Eng FAL)	621	548	479	256	277	2 439
School average Maths % > 1 s.d. above expected (with OR without Eng FAL)	332	283	239	148	136	1 318
MCP school average Maths % > ½ s.d. above expected (with or without Eng FAL/HL)	2	2	3	5	27	39
MCP school average Maths % > 1 s.d. above expected (with or without Eng FAL/HL)	2	2	3	1	14	22
Schools performing above expectations in Mathematical Literacy						
School average Maths Literacy % > expected (without Eng FAL)	1 012	934	766	303	379	3 683
School average Maths Literacy % > expected (with OR without Eng FAL)	1 099	1 005	841	347	438	4 057
School average Maths Literacy % > ½ s.d. above expected (with OR without Eng FAL)	526	445	333	188	251	1 959
School average Maths Literacy % > 1 s.d. above expected (with OR without Eng FAL)	344	240	167	107	81	1 073
MCP school average Maths Literacy % > ½ s.d. above expected (with or without Eng FAL/HL)	2	2	3	6	30	43
MCP school average Maths Literacy % > 1 s.d. above expected (with or without Eng FAL/HL)	2	2	2	5	11	22
Schools performing above expectations in both Mathematics and Mathematical Literacy						
School average Maths Literacy and Maths % > expected (with OR without Eng FAL)	669	651	571	278	374	2 803
School average Maths Literacy and Maths % > ½ s.d. above expected (with OR without Eng FAL)	190	182	156	131	179	985
School average Maths Literacy and Maths % > 1 s.d. above expected (with OR without Eng FAL/HL)	37	35	33	58	55	302
MCP school average Maths Literacy and Maths % > ½ s.d. above expected (with OR without Eng FAL/HL)	2	2	2	3	25	34
MCP school average Maths Literacy and Maths % > 1 s.d. above expected (with OR without Eng FAL/HL)	2	2	2	1	10	17

Source: own calculations using 2018 NSC fulltime data.

25 See Table A.1 of the Appendix.

The first row of Table 16 indicates that roughly 18% of schools never performed above expected in the five-years 2014-2018, given their socioeconomic context and/or performance in language. Overall, approximately one-fifth of all Q1-Q3 schools performed above expectations for all five years, and a further 16% Q1-Q3 schools performed above expectations in all but one of the five years. When the benchmark is increased to performance that is ½ a standard deviation above expected—estimated at 7 percentage points—the proportion of Q1-Q3 schools that met this condition for all five years is halved (10.7%). In total, 1 701 (34.5%) Q1-Q3 schools achieved average performance that was ½ standard deviation above expected at least three times during the period 2014 to 2018.

Table 16: Number of schools by frequency of performing above expectations, 2014 to 2018

	Q1	Q2	Q3	Q4	Q5	All
Schools that never performed above expectations	363	331	291	70	81	1 230
Number of schools performing above expectations…						
… once	267	252	206	76	63	946
… twice	234	245	178	82	72	880
… 3 times	239	242	206	89	76	912
… 4 times	315	250	216	108	140	1 115
… 5 times	391	386	312	187	282	1 717
Number of schools performing ½ s.d. above expectations…						
… once	336	327	241	129	109	1 215
… twice	242	262	229	104	100	991
… 3 times	209	201	185	92	86	833
… 4 times	227	200	150	89	87	809
… 5 times	198	182	149	79	155	873

Source: own calculations using 2014 - 2018 NSC fulltime data.

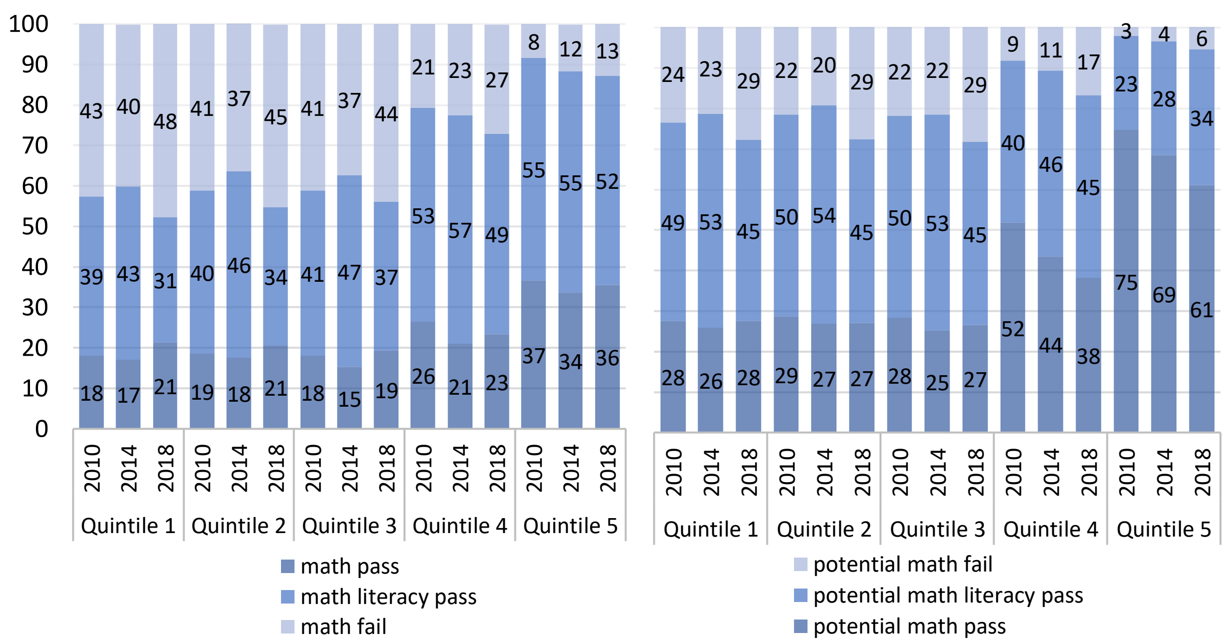
5.3 'Potential' performance in Mathematics and Mathematical Literacy

In order to determine the potential performance in Mathematics and Mathematical Literacy in relation to actual learner performance, the correspondences derived by Simkins (2010) are again used. As concluded by Simkins (2010), the most serious waste of potential in 2008 was the 35 495 matriculants who wrote Mathematical Literacy but could have passed Mathematics with a mark of at least 50% instead (see the first column of Table A.5 of the Appendix). This would have taken the total number of matriculants passing Mathematics to 93 576. Furthermore, 83 458 matriculants who wrote Mathematics and failed with a final mark of 13-29% had the potential to pass Mathematical Literacy with a score of at least 30% (although 9 809 of these learners did not have the option of taking Mathematical Literacy as a subject in the schools they attended). This analysis indicated that a third of matriculants enrolled in Mathematical Literacy in 2008 had the potential to pass Mathematics. Similarly, 51% of matriculants who failed Mathematics in 2008 showed the potential to pass Mathematical Literacy. Overall, the proportion of matriculants failing Mathematics in 2008 may have been halved.

The results for 2010 are very similar to those obtained by Simkins for 2008 (see column 2 of Table A.5 of the Appendix): just less than 30% of matriculants enrolled in Mathematical Literacy showed the potential to pass Mathematics, and almost 70% of the students failing Mathematics showed the potential to pass Mathematical Literacy. However, by 2018 these proportions had declined substantially: 20% of matriculants writing Mathematical Literacy showed potential to pass Mathematics, whilst 47% of matriculants failing Mathematics showed the potential to pass Mathematical Literacy. This is likely related to the fact that whilst the proportions of matriculants enrolled in Mathematics rather than Mathematical Literacy fell over the period 2010 to 2018, aggregate performance in Mathematical Literacy fell, whilst performance in Mathematics rose. Nevertheless, a potential reduction in the mathematics failure rate of about a third may have been realised, had learners chosen differently which of these two subjects to select.

Figure 24 indicates that whilst the expected proportion of students within a school obtaining a pass in Mathematics has remained fairly constant over time, the expected proportions of matriculants obtaining a pass in Mathematical Literacy has fallen across all school quintiles, and the expected proportions of matriculants failing to pass either Mathematics or Mathematical Literacy has risen across all school quintiles. When taking the 'potential' to pass into account, similar patterns emerge. However, it can be noted that the proportion of matriculants achieving a pass in Mathematics and a pass in Mathematical Literacy increased by 8-11 percentage points in Q1-Q3 schools. Conversely, Q4 and Q5 schools demonstrated a substantially larger capacity to generate twice as many Mathematics passes, at the cost of more Mathematical Literacy passes, than they are currently doing. Furthermore, the expected proportion of students failing either Mathematics or Mathematical Literacy shows the potential to fall by more than a third.

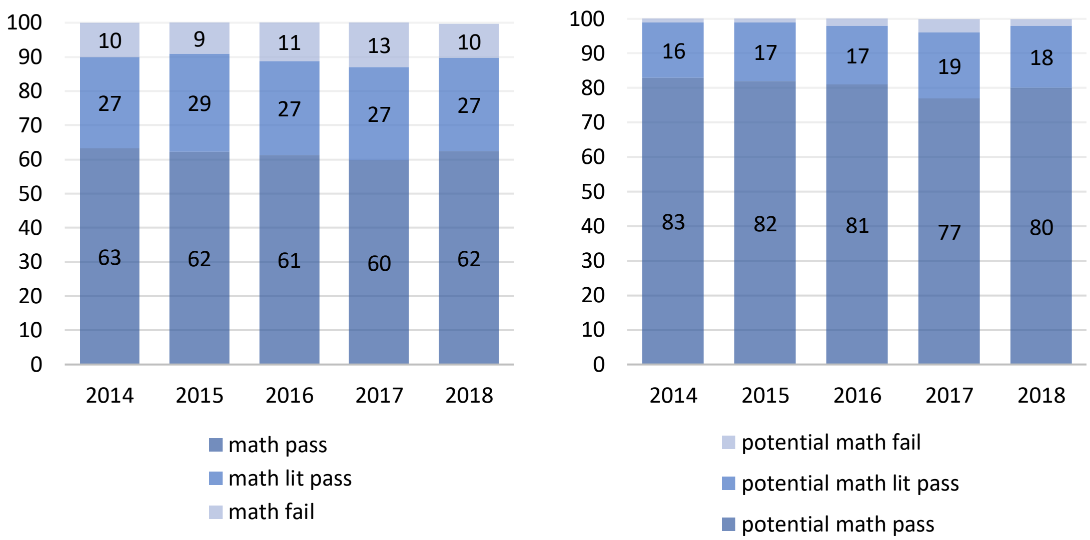
Figure 24: Actual vs potential pass rates over time, by school quintile



Notes: the definitions of a "potential" Mathematics and Mathematical Literacy pass are found in Table A.5 of the Appendix. Source: own calculations using 2018 NSC fulltime data.

Figure 25 similarly indicates the actual and potential mathematics pass and fails rates for the Maths Challenge Programme (MCP) schools. It is immediately clear that these schools outperform (in terms of passes achieved) even the average Q5 school. Just more than 60% of matriculants attending these schools exit Grade 12 with a pass in Mathematics, almost twice the ratio of Q5 school matriculants. The proportion of matriculants failing to achieve a pass in either Mathematics or Mathematical Literacy is similar to that of Q5 schools. However, MCP schools show the potential to reduce their fail rates to less than 2%. Furthermore, unlike Q4 and Q5 schools, the MCP schools have displayed consistency in their actual and potential mathematics pass rates over time.

Figure 25: Actual vs potential pass rates over time amongst MCP schools



Notes: the definitions of a "potential" Mathematics and Mathematical Literacy pass can be found in Table A.5 of the Appendix. Source: own calculations using 2018 NSC fulltime data.

Using the information from Table A.6 of the Appendix, several benchmarks for schools in terms of currently meeting the pass rates suggested by the potential pass rates, as well as showing the potential to meet the pass rates, can be established:

i. First, a school is considered as currently **meeting their potential** if:

- their pass rates are currently higher than the average potential pass rate identified for their quintile group/Q5 schools/all schools; and
- the school's fail rate is currently lower than the average potential fail rate identified for their quintile group/Q5 schools/all schools.

ii. Secondly, a school is considered as **showing potential** if:

- their potential pass rate is at least 1.5 times their actual pass rate; and
- their potential fail rate is half their actual fail rate.

Meeting the Q5 schools' benchmark is viewed as meeting and showing the highest level of potential for Q1-Q3 schools. The assessment of potential is performed only for Mathematics, as the higher the potential Mathematics pass rate, the lower the potential Mathematical Literacy pass rate is likely to be. Combining this with a lower potential Mathematics fail rate, therefore, allows for scenarios in which schools show both a higher potential Mathematics pass rate and higher Mathematical Literacy pass rate.

From Table 17 below it can be seen that just more than one-fifth of all schools in 2018 have Mathematics pass rates that exceed the average potential of schools within their school poverty quintile group; this proportion declines as we move up school quintile group. All but 2 of the 59 MCP schools produced more than 33.9% of matriculants with mathematics passes in 2018. MCP schools also showed the greatest proportion of schools (88%) performing below the potential fail rates of all schools. Overall, 50 of the 59, or 85%, of MCP schools are meeting potential in terms of producing both high mathematics passes and low mathematics fail rates; this is compared to only 13% of the total school sample.

Table 17: Number of schools meeting the criteria and showing potential in pass rates in 2018

Meet potential	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**MCP**	**All**
pass rate ≥ group's average potential pass rate	501 (27.7%)	457 (26.8%)	349 (24.8%)	107 (17.5%)	86 (12.0%)	N/A	1 460 (21.5%)
pass rate ≥ overall average potential pass rate (33.9%)	310 (17.1%)	256 (15.0%)	207 (14.7%)	136 (22.2%)	345 (48.3%)	57 (96.6%)	1 460 (21.5%)
pass rate ≥ Q5 average potential pass rate (61%)	57 (3.2%)	49 (2.9%)	32 (2.3%)	30 (4.9%)	86 (12.0%)	30 (50.8%)	329 (4.8%)
fail rate < group's average potential fail rate	425 (23.5%)	426 (25.0%)	393 (27.9%)	196 (32.0%)	308 (43.1%)	N/A	2 119 (31.2%)
fail rate < overall average potential fail rate (24.2%)	307 (17.0%)	325 (19.1%)	260 (18.5%)	287 (46.9%)	585 (81.9%)	52 (88.1%)	2 119 (31.2%)
fail rate < Q5 average potential fail rate (5.9%)	50 (2.8%)	38 (2.2%)	25 (1.8%)	89 (14.5%)	308 (43.1%)	28 (47.5%)	676 (9.9%)
pass rate ≥ group's average potential pass rate AND fail rate < group's average potential fail rate	198 (10.9%)	195 (11.4%)	176 (12.5%)	59 (9.6%)	62 (8.7%)	N/A	883 (13.0%)
pass rate ≥ overall average potential pass rate AND fail rate < overall average potential fail rate	106 (5.9%)	99 (5.8%)	78 (5.5%)	94 (15.4%)	325 (45.5%)	50 (84.7%)	883 (13.0%)
pass rate ≥ Q5 average potential pass rate AND fail rate < Q5 average potential fail rate	12 (0.7%)	6 (0.4%)	3 (0.2%)	5 (0.8%)	62 (8.7%)	19 (32.2%)	133 (2.0%)
Show potential	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**MCP**	**All**
potential pass rate is at least 1.5 times actual pass rate	482 (26.6%)	500 (29.3%)	529 (37.5%)	356 (58.2%)	505 (70.7%)	11 (18.6%)	2 708 (39.8%)
potential fail rate is at least 0.5 times actual fail rate	583 (32.2%)	498 (29.2%)	345 (24.5%)	240 (39.2%)	540 (75.6%)	55 (93.2%)	2 577 (37.9%)

Source: own calculations using 2018 NSC fulltime data.

In terms of showing potential in mathematics, it is unsurprising that Q5 schools show the most potential given the higher proportion of matriculants enrolled in Mathematical Literacy, as well as higher performance in Mathematical Literacy. It is also unsurprising that MCP schools show the least potential: as was already discussed above, they are currently meeting their potential; that is, there is very little wastage of potential in MCP schools.

6. Towards a tool for selecting schools that show 'promise'

The analysis outlined in Section 5 of this paper provides several performance indicators that can be employed in a step-wise fashion, as will be illustrated below, to provide a quantitative tool whereby Q1-Q3 schools that show the potential to perform in mathematics can be identified. A descriptive summary of the schools meeting each of the indicators that will be discussed below are found in Table 18.

Indicator 1*: Above-expected performance* — Based on the findings above, a school is defined as performing above-expectation in mathematics if the observed combined Mathematics score (computed using the correspondences between Mathematics and Mathematical Literacy) is at least ½ a standard deviation (7 percentage points) above the predicted (or expected) performance of the school given (a) their socioeconomic circumstances and/or (b) their performance in English FAL. **In 2018, a total of 1 673 Q1-Q3 schools performed at least ½ a standard deviation above expected.**

Indicator 2*: Stability in above-expected performance over time* **—** Above expected performance in mathematics in 2018 does not represent consistency in performance. A further criterion must then be added, that schools should have performed at least ½ a standard deviation above expectations for 2018, and also at least twice in the previous four years. **This reduces the number of Q1-Q3 schools meeting the conditions of Indicator 1 and Indicator 2 to 1 265.**

Indicator 3*: At least 40% of Gr12s passing mathematics and mathematical literacy at 50%* **—** The findings of section 5.1 indicated that Q1-Q3 schools that achieve at least a 40% pass rate in mathematics (both subjects combined, i.e. 40% of matriculants pass either the one or the other) are significantly more likely to outrank the lowest three deciles of school performance (measured by pass rates), as well as show relative consistency in their performance ranking over time. **The number of Q1-Q3 schools meeting the conditions of Indicator 1, 2 and 3 is 1 120**.[26]

Indicator 4*: shows the potential for lower failure and higher pass rates in mathematics* — Based on the findings of Section 5.5, schools that show evidence of potential improvement in their Mathematics performance could satisfy at least one of two benchmarks:

1. A potential fail rate in Mathematics that is half their current fail rate in Mathematics.
2. A potential pass rate in Mathematics that is 1.5 times higher than their current pass rate in Mathematics.

Satisfying both of these benchmarks would imply that the school has the potential to improve both its Mathematics and Mathematical Literacy pass rates, which could only occur if the school's potential Mathematical Literacy pass rate is lower than the observed Mathematical Literacy pass rate. This would

26 If we use a stricter benchmark of at least 40% of Gr12 learners passing Mathematics and Mathematical Literacy with a mark of at least 50%, the number of schools falls dramatically to 13. The majority of these schools are included amongst the group of schools that contribute the most of Q1-Q3 mathematics results over 60% and are highlighted in table A.7 of the appendix.

imply that schools show the potential to improve their pass rate specifically through a migration to Mathematics. Therefore, applying only benchmark (1) represents the schools that, already having satisfied indicator 1 through 3, experienced an increase in the overall mathematics pass rate through improving the pass rate in either of the two mathematics subjects. **Of the 1 120 schools identified after applying the conditions of Indicator 3, only 361 were found to show the potential to achieve a mathematics fail rate that is half their current mathematics fail rate**. Applying the stricter benchmark of having a potential Mathematics pass rate that is 1.5 higher than the observed Mathematics pass rate, **the number of schools falls to 275**.[27]

Applying both (1) and (2), **the number of schools meeting all indicators is 53**. This group of schools is almost equally spread across the three quintiles, have smaller than average matric classes, and are better performing, at least by the standards of average mathematics performance and NSC pass rates. On closer inspection of these schools, it is clear that several schools on the list are, due to the nature of the indicators and the very low performance base from which some of these schools are coming from, lower performing than the rest, either in terms of mathematics performance and/or mathematics pass rates. Half of the 'promising' schools (highlighted in Table A.7) have average performance in mathematics that is below the 'promising' school average of 37.7%; that is, their maths mark rank is outside the top 30%. These schools appear on the list of 'promising' schools by virtue of their being able to produce better mathematical literacy performance. The remaining schools (not highlighted in Table A.7) form the group of 'promising' schools that show the most "promise" for interventions such as the Maths Challenge.

These 'promising' schools can be compared to several groups of schools, allowing us to "predict" what an intervention such as the Maths Challenge Programme might achieve in different contexts:

Category 1: All schools already forming part of the Maths Challenge Programme

Category 2: Q1-Q3 schools that form part of the Maths Challenge Programme

Category 3: Q1-Q3 schools that have consistently high pass rates in mathematics

Category 4: Q1-Q3 schools that contribute the most to mathematics passes of 60% or higher[28]

Category 5: Q1-Q3 schools more generally

Category 6: Q4 schools more generally

Category 7: Q5 schools more generally

Table 19 lists performance statistics for all of these categories relative to the 53 'promising' schools and the 27 top-performing 'promising' schools. A quick overview of the statistics indicates that the top performing 'promising' schools, although still a bit smaller in size (in terms of Gr12 learners registered), lie somewhere between a typical Q4 (category 6) and a typical Q5 (category 7) school in terms of performance indicators.[29] Specifically, in terms of average mathematics performance and NSC pass rates,

27 It is interesting to note that the group of schools selected by applying condition (1) mentioned above have, on average, a larger matric class size, are more likely to be Q2/Q3, and more likely to be located in urban-dense provinces.

28 Cumulatively, 5% of students from Q1-Q3 achieving at this level in any given year (2014 to 2018) came from these schools.

29 The average number of Grade 12 students in a Q4 and Q5 school in 2018 was 125 and 136, respectively.

these 27 schools lie closer to the average Q5 school, but lie closer to the average Q4 school when it comes to proportions of students achieving at higher levels of mathematics performance that would allow access to, for example, science and commerce degrees at university.

Table 18: Schools that satisfy the different criteria for selection as promising for mathematics interventions

	Indicator 1	Indicator 2	Indicator 3	Indicator 4			Top performing
				Fail rate	Pass rate	Both	
Total number	**1 680**	**1 265**	**1 120**	**361**	**275**	**53**	**27**
Eastern Cape	202	128	101	44	14	3	0
Free State	98	82	81	32	36	11	9
Gauteng	198	177	176	32	93	13	7
KwaZulu Natal	389	263	226	60	22	6	2
Limpopo	400	300	263	105	35	9	3
Mpumalanga	255	226	187	76	30	6	4
North-West	71	43	42	8	20	3	2
Northern Cape	13	9	9	0	3	0	0
Western Cape	47	37	35	4	22	0	0
Quintile 1	614	466	394	134	82	16	8
Quintile 2	566	425	385	124	88	18	9
Quintile 3	493	374	341	103	105	19	10
Average Gr12 class size	128	141	140	127	142	110	109
Average mark in…							
…Mathematics	35.7%	36.2%	37.8%	36.7%	40.2%	37.6%	43.1%
…Maths Lit	37.1%	37.5%	38.4%	41.7%	42.3%	47.4%	49.3%
…English FAL	49.3%	49.9%	50.4%	52.6%	50.5%	53.7%	56.3%
…Physical Sciences	42.5%	42.9%	43.8%	43.1%	45.4%	45.4%	47.7%
NSC pass rate (%)	63.6	66.4	68.8	70.3	73.8	80.2	83.3
Bachelor pass rate (%)	25.2	27.2	28.9	31.1	32.2	38.2	43.2

Source: own calculations using the NSC fulltime 2015 to 2018 data.

MCP schools perform at a much higher level across all indicators. The one defining characteristic of 'promising' Q1-Q3 schools relative to categories 1, 2 and 4 schools is that they have a substantially lower enrolment in mathematics, and they do not produce a high density of mathematics performance above 50%. However, their performances are in the region of Q4 (category 6) schools, and the top performing 'promising' schools especially show mathematics performance and pass rates similar to that of existing MCP Q1-Q3 (category 2) schools.

Category 4 schools are substantially larger (average Gr12 class size of 241 students) than either the list of 'promising' schools or the list of existing MCP schools. This is to be expected, as larger schools are, by virtue of their size, more likely to produce greater *numbers* of students performing at all levels of mathematics performance. Utilising an indicator such as 'number of students achieving 60% or higher in mathematics' can be misleading, as schools meeting this criterion in one year can display substantial performance variation over time. Amongst this group of schools there are:

- those schools that currently perform at the level of existing MCP schools;
- schools that are close to performing at the level of existing MCP schools;
- and schools that show relative inconsistency in performance over time

Category 3 schools show performance (in terms of average results and pass rates) that is somewhere between category 1 and category 4 schools. However, one thing that is very different about these schools is that they are substantially smaller on average (half of these schools have 50 Gr12 learners or less), as well as have a lower proportion of Gr12 learners enrolled in Mathematics. Therefore, this group of schools might not be a suitable comparator group for the 'promising' schools.

It is difficult to predict the outcome should the top performing 'promising' schools increase their mathematics enrolment to be similar to that of existing MCP Q1-Q3 schools. We use the performance of two Q3 schools already in MCP who are (1) smaller in size and (2) have lower than the MCP average enrolment in Mathematics as an **upper-bound prediction of the MCP** in promising schools and, given the current mathematics enrolment of the “promising” schools of roughly 38%, we expect the **lower-bound prediction of the MCP** to be that of the **typical Q5 school**. This provides the following ranges of expected performance:

- **Increase** in **mathematics average** from **43.1%** to **45.5% – 51.3%** (increase of 5.5% - 19%)
- **Increase** in **NSC pass rate** from **83.3%** to **87.2% – 96.3%** (increase of 4.7% - 15.6%)
- **Increase** in **bachelor pass rate** from **43.2%** to **52.9% – 58.3%** (increase of 22.5% - 35%)
- **Increase** in **mathematics passes of 50% plus** from **25.7%** to **40.3% – 42.6%** (increase of 56.8% - 65.8%)
- **Increase** in **mathematics passes of 60% plus** from **15%** to **25%** (increase of 66.7%)

6. Conclusion

The analysis presented in this paper set out to identify 'promising' secondary schools for interventions such as the Maths Challenge Programme (MCP) amongst no-fee (Q1 to Q3) public schools. An important question to investigate was patterns in Mathematics performance over time. Therefore, the fulltime NSC data for the period 2010 to 2018 was used. Furthermore, an appropriate measure of performance itself had to be determined through experimentation with various combinations of criteria and/or indicators. These included: consistency in performance over time; performance above expectations (for a given socioeconomic context and English First Additional Language performance); and 'wasted' potential through allowing or encouraging good candidates to take the easier Mathematical Literacy option in matric. In the case of the latter, an approximate conversion scale between Mathematics and Mathematical Literacy based on a methodology of Simkins (2010) was applied.

Approximately a third (1 673) of Q1-Q3 schools are predicted to have performed at least half a standard deviation above what is expected for a school of a similar socioeconomic characteristics and performance in other key examinations. Of this group of schools, 75% (1 265) display consistency in this above-expectations performance. A further indicator of performance consistency is found in a school’s mathematics pass rate: Q1-Q3 schools with mathematics pass rates exceeding 40% are significantly less likely to fall within the lowest 30% of the school mathematics pass rate distribution, as well as show relative consistency in their performance ranking. Overall, just more than 20 percent (1 120) of Q1-Q3 schools meet all the above conditions that relate to performance that is above-expectations and consistent.

Table 5: 'heat' comparison of school groups

Category		**Math average**	**Math Lit average**	**NSC pass (%)**	**Bach pass (%)**	**# writing maths in 2018**	**# writing maths literacy in 2018**	**% wrote maths 2018**	**# passing maths at 30%**	**maths pass at 30% (%)**	**# passing maths at 50%**	**2018 NSC maths pass at 50% (%)**	**# passing maths at 60%**	**2018 NSC maths pass at 60% (%)**
	'Promising' schools	37.6	47.4	80.3	38.3	40.6	66.8	38.6%	23.8	58.5%	8.6	20.0%	4.8	11.3%
	Top performing 'promising' schools	43.1	49.3	83.3	43.2	39.6	67.8	38.0%	29.0	73.6%	11.7	25.7%	6.5	15.0%
1	MCP schools	50.9	59.3	93.1	67.9	133.5	61.8	71.3%	114.4	85.5%	67.4	50.2%	43.7	32.5%
2	Q1-Q3 MCP schools	43.5	42.7	85.7	47.2	162.4	52.4	81.8%	128.8	78.5%	62.9	37.7%	36.6	22.3%
3	Q1-Q3 schools with consistently high pass rates in mathematics	50.6	51.9	93.4	53.2	33.8	49.6	33.7%	32.7	98.0%	14.8	41.2%	11.2	27.9%
4	Q1-Q3 school contributing most to # of Gr12s achieving maths passes of 60% and higher	44.1	43.0	81.3	45.0	158.7	104.9	67.3%	103.0	70.8%	47.5	34.5%	28.8	21.4%
5	All Q1-Q3 schools	30.1	35.3	56.1	20.0	40.2	54.5	47.2%	16.8	42.7%	6.3	14.7%	4.0	8.8%
6	All Q4 schools	37.3	42.6	72.3	32.6	49.3	79.8	36.9%	27.9	60.4%	11.9	24.6%	7.4	14.9%
7	All Q5 schools	45.5	53.5	87.2	52.9	60.2	74.8	41.9%	49.7	78.8%	28.4	40.3%	19.0	25.2%
	'Promising schools' larger than 100 learners	38.0	47.3	80.6	39.2	57.7	98.4	37.5%	34.4	58.9%	13.7	22.9%	7.3	12.3%

Notes: red = low performance; green = high performance

The key indicator in this analysis is that which is related to 'wasted' potential related to subject choice. Specifically, we identified a school as 'showing potential' if their 'potential' fail rate in Mathematics (calculating using Simkins (2010) correspondences) is half their current fail rate *and* their 'potential' pass rate in Mathematics is 50% (1.5 times) higher than their current pass rate. Satisfaction of both of these benchmarks implies that the school has the potential to improve its pass rates in both mathematics subjects through a migration to Mathematics and not Mathematical Literacy. Although roughly a third of Q1-Q3 schools are able to improve their pass rates through a migration to Mathematical Literacy, only 1.1% (53) of schools meet *both* of these benchmarks as well as display performance consistency. Future analysis could focus on the effect of subject transitions that show potential to increase school pass rates on the quality of the pass for the student. That is, is the choice to take Mathematical Literacy taken to improve one's opportunities for access to post-secondary education, albeit it limited to qualifications that do not require Mathematics.

It is both surprising and unsurprising to find such a small number of Q1-Q3 'promising' schools in mathematics. It is surprising given evidence of system-wide improvements (Reddy *et al*., 2016), which was further evidenced in the analysis of this paper that showed substantial increases in the numbers of students achieving Mathematics passes of 50% and higher. However, it is unsurprising for precisely this reason: amongst the 100 Q1-Q3 schools producing the highest numbers of students achieving 60% or higher in Mathematics, these students represent on average less than 20% of their Grade 12 class enrolled in Mathematics. It is uncertain, then, as to whether or not the high performance of these students is related to the functionality of the schools they attend.

The findings of this paper suggest, similar to Wills (2017), that although there is a relative scarcity of best-practice within the Q1-Q3 school system, there is “the possibility that a continuum of effectiveness exists” (p.32). The indicators identified and explored by this paper provide further metrics that could be used by system actors to identify school performance variation, as well as expand our understanding of school quality effects outside of privileged schools.

Bibliography

Arends, F., Winnaar, L., & Mosimege, M. (2017). Teacher classroom practices and Mathematics performance in South African schools: A reflection on TIMSS 2011. *South African Journal of Education*, 37(3),

Carnoy, M., & Chisholm, L. (2008). Towards understanding student academic performance in South Africa: a pilot study of grade 6 mathematics lessons in Gauteng province.

Carnoy, M., Chisholm, L & Chilisa, B. (2012). *The low achievement trap: comparing schooling in Botswana and South Africa*. Cape Town: HSRC Press.

Centre for Development and Enterprise (CDE). 2013. Mathematics outcomes in South African schools: What are the facts? What should be done? (2013). Mathematics outcomes in South African schools: What are the facts? What should be done? *CDE Insight*.

Centre for Development and Enterprise. (2001a). *Mathematics and physical science results in the Senior Certificate examinations of 1998 and 2000.* Johannesburg: CDE.

Centre for Development and Enterprise. (2001b). *School and community determinants of mathematics and physical science results in the Senior Certificate examinations of 1998 and 2000.* Johannesburg: CDE.

Centre for Development and Enterprise. (2010). *The maths and science performance of South Africa's public schools: Some lessons from the past decade.* Johannesburg: CDE.

Christie, P., Butler, D., & Potterton, M. (2007). *Ministerial Committee on Schools that Work.* Report to the Minisiter of Education.

Crouch, L., & Mabogoane, T. (1998). When the residuals matter more than the coefficients: An educational perspective. *Studies in Economics and Econometrics*, *22*(2), 1-14.

Crouch, L., & Mabogoane, T. (2001). No magic bullets, just tracer bullets: The role of learning resources, social advantage, and education management in improving the performance of South African schools. *Social Dynamics, 27*(1), 60-78.

DBE. (2007). *Ministerial Committee Report: Schools That Work*. Pretoria: Department of Basic Education.

DBE. (2011). *Annual Natonal Assessments 2011: A guideline for the interpretation and use of ANA results.* Pretoria: Department of Basic Education.

DBE. (Report on the Quantiative Analysis of the ANA 2011 Results). (2012). Pretoria: Department of Basic Education.

DBE. (2018). *NEEDU Schools That Work II: Full report*. Pretoria: Department of Basic Education.

DBE. (2019). NSC Examinations 2018: Technical Report. Pretoria: Department of Basic Education.

DBE. (2019). NSC Examinations 2018: School Subjects Report. Pretoria: Department of Basic Education.

Fleisch, B. (2008). *Primary education in crisis: Why South African schoolchildren underachieve in reading and mathematics*. Juta and Company Ltd.

Govender, V. (2014). *Some issues surrounding learner performance in the grade 9 ANA for Mathematics in South Africa: Is there a case for introducing a National Examination for Grade 9 Mathematics?*

Pretoria: Advisory Committee for Mathematics (ACM). Retrieved July 13, 2017, from http://www.samf.ac.za/ana-mathematics-grade-9

Gustafsson, M. (2005). *The relationships between schooling inputs and outputs in South Africa: Methodologies and policy recommendations based on the 2000 SACMEQ dataset.* Retrieved from http://www.sacmeq.org.org/links.htm

Gustafsson, M. (2016). *Understanding trends in high-level achievement in Grade 12 mathematics and physical science.* Pretoria: Department of Nasic Education. Retrieved June 2017, from http://resep.sun.ac.za/wp-content/uploads/2016/06/Correcting-racial-imbalances-2016-01-25.pdf

Herholdt, R., & Sapire, I. (2014). An error analysis in the early grades mathematics-A learning opportunity?. *South African Journal of Childhood Education, 4(1),* 43-60.

Hoadley, U. (2007). *Managing Curriculum and Instruction in Secondary Schools.* Conference paper presented at the "Teacher Development and Institutional Change in an Evolving Education Context" May 2007, Human Sciences Research Council.

Hoadley, U., & Ward, C. (2009). *Managing to Learn: Instructional Leadership in South African Secondary Schools. Teacher Education in South Africa Series.* HSRC Press.

Howie, S., & Hughes, C. A. (1998). *Mathematics and Science Literacy of Final-Year School Students in South Africa*. A Report on the Performance of South African Students in the Third International Mathematics and Science Study (TIMSS).

Howie, S. J. (2003). Language and other background factors affecting secondary pupils' performance in Mathematics in South Africa. *African Journal of Research in Mathematics, Science and Technology Education*, *7(1)*, 1-20.

Jansen, J. & Taylor, N. (2003). *Educational Change in South Africa 1994-2003: Case Studies in Large-Scale Education Reform*. World Bank Country Studies: Education Reform and Management Publication Series, vol. II, No. 1. October.

Juan, A., & Visser, M. (2017). Home and school environmental determinants of science achievement of South African students. *South African Journal of Education, 37(1).*

Kanjee, A., & Prinsloo, C. (2005). *Improving Learning in South African Schools: The Quality Learning Project (QLP). Summative Evaluation (2000 to 2004).* Cape Town: HSRC Press.

Lam, D., Ardington, C., & Leibbrandt, M. (2011). Schooling as a lottery: Racial differences in school advancement in urban South Africa. *Journal of development economics, 95(2)*, 121-136.

Makgato, M. & Mji, A. (2006). Factors associated wiht high school learners' poor performance: a spotlight on mathematics and physical science. South African Journal of Education, 26(2).

Mapaire, L. (2016). Learners' performance in Mathematics: A case study of public high schools, South Africa. *European Journal of STEM Education, 1(3)*, 1-10.

Maree, K., Aldous, C. H., A., S. A., & Van der Linde, M. (2006). Predictors of learner performance in mathematics and science according to a large-scale study in Mpumalanga. *South African Journal of Education, 26(2),* 229-252.

Reddy, V. (2006). *Mathematics and science achievement at South African schools in TIMSS 2003*. HSRC Press.

Reddy, V. (2018). *TIMSS in South Africa: Making global research locally meaningful.* Pretoria: Human Sciences Research Council. Retrieved August 23, 2019, from http://www.hsrc.ac.za/en/review/hsrc-review-april-june-2018/timss-in-sa

Reddy, V., Van Der Berg, S., Janse van Rensburg, D., & Taylor, S. (2012). Educational outcomes: Pathways and performance in South African high schools. *South African Journal of Science, 108(3-4)*, 88-95.

Reddy, V. V., Winnaar, L., Arends, F. J., Prinsloo, C., & Isdale, K. (2016). *TIMSS 2015: Highlights of mathematics and science achievement of grade 9 South African learners.* Pretoria: Human SCiences Research Council. Retrieved August 23, 2019, from http://www.hsrc.ac.za/en/research-outputs/view/8456

Roberts, N., & Venkat, H. (2016). Learning from disruptive classroom behaviour in a Grade 2 mathematics lesson. *South African Journal of Childhood Education, 6(1)*, 1-10.

Shalem, Y., Sapire, I., & Huntley, B. (2013). Mapping onto the mathematics curriculum-an opportunity for teachers to learn. *Pythagoras*, 34(1), 1-10.

Simkins, C. (2010). *Interpreting the mathematics, science and English performance of candidates in the November 2008 National Senior Certificate examination.* Johannesburg: CDE.

Simkins, C. (2013). *Performance in the South African educational system: What do we know?* Johannesburg: CDE.

Simkins, C., & Paterson, A. (2015). *Learner Performance in South Africa: Social and economic determinants of success in language and mathematics.* Pretoria: HSRC.

Spaull, N. (2011). *A preliminary analysis of SACMEQ III South Africa*. Stellenbosch Economic Working Papers No.11/2011, Stellenbosch University.

Spaull, N. (2012). *Equity and efficiency in South African primary schools: a preliminary analysis of SACMEQ III South Africa*. Masters thesis, Stellenbosch University.

Spaull, N. (2013). *South Africa's education crisis: The quality of education in South Africa 1994-2011*. Johannesburg: Centre for Development and Enterprise, 1-65.

Spaull, N., & Kotze, J. (2015). Starting behind and staying behind in South Africa: The case of insurmountable learning deficits in mathematics. I*nternational Journal of Educational Development*, 41, 13-24.

Stols, G. (2013). An investigation into the opportunity to learn that is available to Grade 12 mathematics learners. South African Journal of Education, 33(1).

Taylor, N. *et al*. (1999). Systemic and Institutional Culture of Teaching and Learning. In Taylor, N. ed. *Getting Learning Right: Report to the President's Education Initiative Research Project*. The Joint Education Trust.

Taylor, N., Muller, J., & Vinjevold, P. (2003). *Getting Schools Working.* Cape Town: Pearson Education.

Taylor, S. (2011). *Uncovering indicators of effective school management in South Africa using the National School Effectiveness Study*. Stellenbosch Economic Working Papers No.10/2011, Stellenbosch University.

Timæus, I.M., Simelane, S. & Letsoalo, T. (2013). Poverty, race, and children's progress at school in South Africa. *The Journal of Development Studies, 49(2)*, 270-284.

Van der Berg, S. (2008). How effective are poor schools? Poverty and educational outcomes in South Africa. *Studies in Educational Effectiveness, 34(3)*, 145-154.

Van der Berg, S., Spaull, N., Wills, G., Gustafsson, M., & Kotzé, J. (2016). *Identifying binding constraints in education*. Available at SSRN 2906945.

Van der Berg, S., & Gustafsson, M. (2017). *Quality of basic education. A report to working group 1 of the High Level Panel on the assessment of key legislation.* Stellenbosch: Resep, Stellenbosch University.

Van der Berg, S. & Hofmeyr, H. (2018). *An incomplete transition: Overcoming the legacy of exclusion in South Africa*. Background note to the World Bank Group's Republic of South African Systematic Country Diagnostic.

Van der Berg, S., & Gustafsson, M. (2019). Educational outcomes in Post-apartheid South Africa: Signs of progress despite great inbequality. In N. Spaull, & J. Jansen, *South African Schooling: The Enigma of Inequality. A study of the present situation and fuiture possibilities.* Springer.

Venkat, H., & Spaull, N. (2015). What do we know about primary teachers' mathematical content knowledge in South Africa? An analysis of SACMEQ 2007. *International Journal of Educational Development, 41*, 121-130.

Visser, M., Juan, A., & Feza, N. (2015). Home and school resources as predictors of mathematics performance in South Africa. *South African Journal of Education, 35(1).*

Wills, G. (2017). *What do you mean by 'good'? The search for exceptional primary schools in South Africa's no-fee school system*. Stellenbosch Economic Working Papers No.16/2017, Stellenbosch University.

Appendix

Table A.1: Correspondences between Mathematics and Mathematical Literacy marks, 2008

Mathematics	Mathematical Literacy
13	30
19	40
26	50
30	54
36	60
40	64
47	70
50	72
54	75
60	78
62	80
66	82
70	84
80	86

Source: Simkins (2010)

Table A.2: Grade 12 Mathematics performance between 2010 and 2018

	80%+	70-80%	60-70%	50-60%	40-50%	30-40%	<30% (fail)	Total
All matriculants enrolled in Mathematics								
2010	9 745	8 233	12 762	19 842	31 637	45 919	144 034	264 089
2011	5 875	7 564	11 447	17 186	26 198	37 612	117 698	223 580
2014	7 217	9 278	13 819	20 183	28 885	39 166	107 793	226 341
2015	7 792	9 661	14 359	21 778	30 683	42 306	137 283	263 862
2016	8 070	10 198	15 260	23 071	32 518	44 375	132 388	265 880
2017	6 734	9 939	15 398	22 346	31 750	39 084	120 173	245 424
2018	5 828	8 598	13 726	22 551	36 136	46 932	100 072	233 839
Matriculants in Quintile 1-3 schools enrolled in Mathematics								
2010	1 457	2 068	4 192	8 345	17 030	29 292	103 075	165 459
2011	970	1 783	3 711	7 099	13 754	23 199	86 183	136 699
2014	1 803	2 964	5 324	9 347	16 226	25 608	83 141	144 413
2015	2 154	3 322	5 835	10 581	17 362	27 870	111 099	178 223
2016	2 165	3 570	6 468	11 585	19 193	30 226	107 365	180 572
2017	2 049	3 806	6 954	11 580	18 976	26 344	95 598	165 307
2018	1 666	3 124	6 012	11 270	21 479	31 829	80 434	155 814
Matriculants in Quintile 4 schools enrolled in Mathematics								
2010	990	1 008	1 454	2 289	3 472	4 575	9 227	23 015
2011	548	844	1 216	1 775	2 667	3 618	8 789	19 457
2014	890	1 221	1 861	2 735	3 858	4 973	12 523	28 061
2015	942	1 211	1 833	2 682	4 049	5 406	13 984	30 107
2016	944	1 325	1 978	3 071	4 230	5 503	13 686	30 737
2017	813	1 227	1 947	2 768	3 869	4 542	12 447	27 613
2018	687	1 065	1 701	2 800	4 387	5 405	9 611	25 656
Matriculants in Quintile 5 schools enrolled in Mathematics								
2010	4 165	2 796	3 657	4 317	4 586	4 013	4 187	27 721
2011	2 478	2 542	3 139	3 714	4 034	3 789	4 577	24 273
2014	3 883	4 372	5 602	6 761	7 253	6 846	8 629	43 346
2015	4 003	4 325	5 597	7 093	7 548	7 199	8 715	44 480
2016	4 355	4 554	5 770	6 988	7 418	6 869	8 008	43 962
2017	3 439	4 558	5 491	6 648	7 182	6 526	8 847	42 391
2018	3 020	3 784	5 065	7 053	8 338	7 606	6 943	41 809

Note: Due to missing data for school quintile in 2010 and 2011 in particular, as well as the misclassification/reclassification of schools, the school quintile information from 2018 is used. Data for 2012 and 2013 was incomplete (less than 300 000 matriculants recorded in the data acquired) and are therefore excluded from the analysis. Differences in totals are accounted for by schools with missing quintile data. Source: own calculations using NSC fulltime 2010 to 2018 data.

Table A.3: Grade 12 Mathematical Literacy performance between 2010 and 2018

	80%+	70-80%	60-70%	50-60%	40-50%	30-40%	<30% (fail)	Total
All matriculants enrolled in Mathematical Literacy								
2010	9 931	18 993	33 355	51 746	67 900	60 358	38 945	281 228
2011	7 577	18 268	33 053	52 970	67 078	58 061	38 192	275 199
2014	7 390	16 848	31 362	51 606	78 433	74 738	52 313	312 690
2015	6 130	14 542	27 541	47 002	76 697	101 347	115 549	388 808
2016	4 365	13 314	27 603	47 474	74 957	86 198	108 111	362 022
2017	1 884	8 643	22 179	41 335	67 011	86 365	86 259	313 676
2018	3 957	10 677	22 355	37 534	58 929	75 777	84 976	294 205
Matriculants in Quintile 1-3 schools enrolled in Mathematical Literacy								
2010	869	3 721	12 162	27 518	44 818	44 946	31 852	165 886
2011	796	3 608	11 695	27 911	43 764	42 329	30 176	160 279
2014	859	3 637	11 894	28 815	55 137	58 793	44 239	203 374
2015	701	3 013	9 611	24 685	52 068	78 873	99 423	268 374
2016	449	2 666	9 819	25 129	50 486	67 386	93 700	249 635
2017	246	1 659	7 018	19 533	42 715	64 783	71 776	207 730
2018	708	2 615	8 179	18 571	36 677	55 148	69 451	191 349
Matriculants in Quintile 4 schools enrolled in Mathematical Literacy								
2010	895	2 228	4 090	5 740	6 497	4 517	1 648	25 615
2011	741	2 012	3 947	5 814	6 285	4 335	2 050	25 184
2014	865	2 563	5 402	8 790	11 396	9 010	4 636	42 662
2015	685	2 137	4 655	8 070	11 601	12 760	10 210	50 118
2016	423	1 795	4 513	7 914	11 531	10 877	9 266	46 319
2017	180	1 073	3 381	6 701	10 393	11 677	8 933	42 339
2018	414	1 410	3 350	6 018	9 376	10 716	9 564	40 848
Matriculants in Quintile 5 schools enrolled in Mathematical Literacy								
2010	4 390	6 352	7 223	6 641	4 816	2 473	794	32 689
2011	3 241	5 748	6 794	5 920	3 940	2 011	671	28 325
2014	5 039	9 282	11 958	11 336	9 074	4 843	1 758	53 290
2015	4 141	8 110	11 264	11 638	10 349	7 312	3 905	56 719
2016	3 136	7 789	11 267	11 742	10 145	5 839	3 117	53 035
2017	1 322	5 180	10 180	12 685	11 334	7 640	3 519	51 860
2018	2 480	5 771	9 172	10 775	10 448	7 694	3 971	50 311

Note: Due to missing data for school quintile in 2010 and 2011 in particular, as well as the misclassification/reclassification of schools, the school quintile information from 2018 is used. Data for 2012 and 2013 was incomplete (less than 300 000 matriculants recorded in the data acquired) and are therefore excluded from the analysis. Differences in totals are accounted for by schools with missing quintile data. Source: own calculations using NSC fulltime 2010 to 2018 data.

Table A.4: Proportion of all Grade 12 learners reaching Maths benchmarks, by school quintile

	2008	2010						2018					
		All	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Maths passes above 60%		21787	2004	2656	3057	3452	10618	28152	3567	3399	3836	3453	11869
	58 081	10.5%	3.8%	5.0%	5.9%	15.5%	38.1%	9.8%	5.3%	5.2%	5.9%	10.6%	28.4%
Maths passes of 50-60%	19.6%	14951	2490	2953	2902	2289	4317	22551	3881	3736	3653	2800	7053
		7.2%	4.7%	5.5%	5.6%	10.3%	15.5%	7.8%	5.7%	5.7%	5.6%	8.6%	16.9%
Maths passes 30-50%	73558	62968	15246	15987	15089	8047	8599	83064	18658	17814	16836	9792	15945
	24.9%	30.3%	28.9%	29.9%	29.2%	36.2%	30.9%	28.9%	27.5%	27.3%	25.9%	30.1%	38.1%
Maths passes	**44.5%**	**47.9%**	**37.4%**	**40.3%**	**40.7%**	**62.0%**	**84.5%**	**46.6%**	**38.5%**	**38.2%**	**37.4%**	**49.3%**	**83.4%**
Maths Literacy passes of 72%+a	35495	15247	962	1068	1343	2562	9312	11752	789	745	982	1422	6814
	13.4%	6.8%	1.7%	1.9%	2.4%	10.0%	28.5%	4.0%	1.3%	1.2%	1.4%	3.5%	13.5%
Maths Literacy passes of 54-72%b	52637	48377	8392	9200	10056	7938	12791	45518	5345	5787	7231	7005	16978
	19.8%	21.6%	15.2%	16.6%	18.3%	31.0%	39.1%	15.5%	9.1%	9.2%	10.4%	17.1%	33.7%
Maths Literacy passes of 30-54%	122389	126272	33734	35198	34081	13467	9792	151959	30454	33327	37238	22857	22548
	46.1%	56.3%	61.0%	63.4%	61.9%	52.6%	30.0%	51.7%	51.8%	53.1%	53.4%	56.0%	44.8%
Maths Literacy passes	**79.2%**	**84.7%**	**77.9%**	**81.9%**	**82.7%**	**93.6%**	**97.6%**	**71.1%**	**62.2%**	**63.5%**	**65.1%**	**76.6%**	**92.1%**
Maths fail 13-30%c in schools where Maths Literacy available	73649	66674	18475	20087	19450	5237	3425	58319	15884	14919	14113	5580	5691
	24.9%	32.0%	35.0%	37.5%	37.6%	23.6%	12.3%	20.3%	23.4%	22.8%	21.7%	17.2%	13.6%
Maths fail of 13-30%c in schools with no Maths Literacy	9809	7394	2311	1779	1656	1549	99	10279	3575	2575	2227	1342	303
	3.7%	3.6%	4.4%	3.3%	3.2%	7.0%	0.4%	3.6%	5.3%	3.9%	3.4%	4.1%	0.7%
Maths fail <13%	80583	42421	13616	13267	12434	2441	665	31474	10421	8687	8013	2689	949
	27.3%	20.4%	25.8%	24.8%	24.1%	11.0%	2.4%	11.0%	15.4%	13.3%	12.3%	8.3%	2.3%
Maths fails	**55.5%**	**52.1%**	**62.6%**	**59.7%**	**59.3%**	**38.0%**	**15.5%**	**53.4%**	**61.5%**	**61.8%**	**62.6%**	**50.7%**	**16.6%**
Maths Literacy fails	55276	34294	12244	10074	9534	1648	794	84976	22233	22897	24321	9564	3971
	20.8%	**15.3%**	**22.1%**	**18.1%**	**17.3%**	**6.4%**	**2.4%**	**28.9%**	**37.8%**	**36.5%**	**34.9%**	**23.4%**	**7.9%**

Notes: Own calculations using NSC examination and EMIS data 2010 – 2018. [a] had potential to get 50%+ for mathematics; [b] had potential to get 30% for mathematics; [c] had potential to pass mathematical literacy.

Table A.5: Proportion of all Grade 12 learners reaching Maths benchmarks, by school quintile

		2010						2018					
	2008	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Mathematics passes above 60%	58 081 (10.3%)	21 787 4.0%	2 004 1.8%	2 656 2.4%	3 057 2.8%	3 452 7.1%	10 618 17.6%	28 152 5.3%	3 567 3.1%	3 399 3.0%	3 836 3.2%	3 453 5.2%	11 869 12.9%
Mathematics passes of 50-60%		14 951 2.3%	2 490 2.6%	2 953 2.6%	2 902 4.7%	2 289 7.1%	4 317 4.3%	22 551 3.4%	3 881 3.3%	3 736 3.1%	3 653 4.2%	2 800 7.7%	7 053 2.3%
Mathematics passes 30-50%	73 558 (13.1%)	62 968 11.5%	15 246 13.9%	15 987 14.2%	15 089 13.8%	8 047 16.5%	8 599 14.2%	83 064 15.7%	18 658 16.3%	17 814 15.6%	16 836 14.2%	9 792 14.7%	15 945 17.3%
Mathematics passes	**26.4%**	**18.3%**	**18.0%**	**19.2%**	**19.2%**	**28.4%**	**39.0%**	**25.3%**	**22.7%**	**21.9%**	**20.5%**	**24.1%**	**37.8%**
Mathematical Literacy passes of 72%+[a]	35 495 (6.3%)	15 247 2.8%	962 0.9%	1 068 1.0%	1 343 1.2%	2 562 5.3%	9 312 15.4%	11 752 2.2%	789 0.7%	745 0.7%	982 0.8%	1 422 2.1%	6 814 7.4%
Mathematical Literacy passes of 54-72%[b]	52 637 (9.4%)	48 377 8.9%	8 392 7.7%	9 200 8.2%	10 056 9.2%	7 938 16.3%	12 791 21.2%	45 518 8.6%	5 345 4.7%	5 787 5.1%	7 231 6.1%	7 005 10.5%	16 978 18.4%
Potential Mathematics passes	**39.1%**	**30.0%**	**26.6%**	**28.4%**	**29.6%**	**49.9%**	**75.5%**	**36.2%**	**28.1%**	**27.6%**	**27.5%**	**36.8%**	**63.7%**
Mathematical Literacy passes of 30-54%	122 389 (21.8%)	126 272 23.2%	33 734 30.8%	35 198 31.4%	34 081 31.1%	13 467 27.7%	9792 16.2%	151 959 28.8%	30 454 26.5%	33 327 29.3%	37 238 31.4%	22 857 34.4%	22 548 24.5%
Mathematical Literacy passes	**37.5%**	**34.8%**	**39.4%**	**40.5%**	**41.5%**	**49.3%**	**52.8%**	**39.6%**	**31.9%**	**35.0%**	**38.4%**	**47.0%**	**50.3%**
Mathematics fail 13-30%[c] in schools with Mathematical Literacy	73 649 (13.1%)	66 674 12.2%	18 475 16.9%	20 087 17.9%	19 450 17.7%	5 237 10.8%	3 425 5.7%	58 319 11.0%	15 884 13.8%	14 919 13.1%	14 113 11.9%	5 580 8.4%	5 691 6.2%
Mathematics fail of 13-30%[c] in schools with no Mathematical Literacy	9 809 (1.7%)	7 394 1.4%	2 311 2.1%	1 779 1.6%	1 656 1.5%	1 549 3.2%	99 0.2%	10 279 1.9%	3 575 3.1%	2 575 2.3%	2 227 1.9%	1 342 2.0%	303 0.3%
Potential Mathematical Literacy passes	**36.7%**	**36.7%**	**49.8%**	**50.8%**	**50.4%**	**41.6%**	**22.0%**	**41.8%**	**43.5%**	**44.6%**	**45.2%**	**44.8%**	**31.0%**
Mathematics fail <13%	80 583 (14.4%)	42 421 7.8%	13 616 12.4%	13 267 11.8%	12 434 11.3%	2 441 5.0%	663 1.1%	31 474 6.0%	10 421 9.1%	8 687 7.6%	8 013 6.8%	2 689 4.0%	949 1.0%
Mathematical Literacy <30%	55 276 (9.8%)	34 294 6.3%	12 244 11.2%	10 074 9.0%	9 534 8.7%	1 648 3.4%	794 1.3%	84 976 16.1%	22 233 19.4%	22 897 20.1%	24 321 20.5%	9 564 14.4%	3 971 4.3%
Mathematical fails	**39.0%**	**27.7%**	**42.6%**	**40.3%**	**39.3%**	**22.4%**	**8.2%**	**35.0%**	**45.4%**	**43.1%**	**41.1%**	**28.8%**	**11.8%**
Potential Mathematics fails	**24.2%**	**14.1%**	**23.6%**	**20.8%**	**20.0%**	**8.4%**	**2.4%**	**22.1%**	**28.4%**	**27.7%**	**27.3%**	**18.4%**	**5.3%**
TOTAL	**561 447 (100%)**	**545 317 (100%)**	**109 474 (100%)**	**112 269 (100%)**	**109 602 (100%)**	**48 630 (100%)**	**60 410 (100%)**	**528 044 (100%)**	**114 807 (100%)**	**113 886 (100%)**	**118 470 (100%)**	**66 504 (100%)**	**92 121 (100%)**

Notes: Own calculations using NSC examination and EMIS data 2010 – 2018. [a] could have got 50%+ for mathematics; [b] could have got 30% for mathematics; [c] could have passed mathematical literacy

Table A.6: Average proportion of Grade 12 learners within a school reaching Maths benchmarks, by school quintile

	2010						2014						2018					
	All	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Mathematics passes above 60%	7.2	3.8	3.9	4.1	8.6	17.5	7.0	4.5	4.5	4.3	6.6	14.2	6.8	4.9	4.3	4.4	6.5	12.9
Mathematics passes of 50-60%	4.7	3.9	4.0	3.7	5.4	7.4	4.9	4.4	4.1	3.6	4.7	7.2	5.5	5.0	4.6	4.3	5.2	7.9
Mathematics passes 30-50%	15.1	15.5	15.0	14.1	16.0	14.4	13.5	14.2	13.8	11.3	13.0	14.4	16.9	17.6	16.8	15.1	15.5	17.5
Maths passes	**21.3**	**18.1**	**18.6**	**18.0**	**26.4**	**36.7**	**19.7**	**17.1**	**17.6**	**15.2**	**21.0**	**33.7**	**23.1**	**21.4**	**20.6**	**19.3**	**23.4**	**35.5**
Maths Lit passes of 72%+[a]	7.0	3.0	3.0	2.8	9.0	16.3	6.6	3.0	2.7	2.5	6.7	13.2	4.9	2.7	2.3	2.2	4.3	8.1
Maths Lit passes of 54-72%[b]	12.7	10.1	10.2	10.2	19.8	22.6	12.9	9.2	9.6	9.5	18.3	22.7	10.3	6.8	6.9	7.2	13.3	19.1
Potential Maths passes	**35.7**	**27.5**	**28.6**	**28.4**	**51.8**	**74.7**	**34.3**	**25.8**	**26.8**	**25.2**	**43.5**	**68.5**	**33.9**	**27.5**	**27.0**	**26.5**	**38.2**	**61.0**
Mathematical Literacy passes of 30-54%	31.0	33.6	33.1	32.4	30.1	17.9	36.9	39.6	40.2	40.0	36.3	20.9	32.5	31.8	32.9	33.5	37.5	27.6
Maths Lit passes	**42.5**	**39.3**	**40.2**	**40.8**	**52.8**	**54.9**	**47.7**	**42.8**	**46.0**	**47.4**	**56.5**	**54.6**	**38.1**	**30.9**	**34.1**	**36.8**	**49.4**	**51.7**
Mathematics fail 13-30%[c] in schools with Mathematical Literacy	17.1	18.2	18.9	18.7	12.6	7.2	14.8	16.7	16.4	15.2	12.0	8.6	13.8	16.2	15.3	13.9	10.5	7.7
Maths fail of 13-30%[c] in schools with no Mathematical Literacy	34.4	34.5	36.2	37.1	30.9	25.0	38.5	40.5	41.2	38.8	31.2	32.0	35.3	37.7	35.7	36.1	28.2	22.4
Potential Maths Lit passes	**45.7**	**49.0**	**49.9**	**49.8**	**40.0**	**23.3**	**49.0**	**52.9**	**54.1**	**53.3**	**45.8**	**28.1**	**43.5**	**44.8**	**45.4**	**45.2**	**45.1**	**33.6**
Mathematics fail <13%	14.6	16.7	15.4	14.4	8.2	3.6	11.5	15.1	11.8	11.3	7.0	3.6	13.3	17.1	14.1	12.0	7.3	3.4
Mathematical Literacy <30%	11.6	14.0	11.7	11.3	6.7	3.9	14.2	16.3	14.8	15.6	9.1	4.7	21.2	23.4	23.4	23.7	16.7	8.0
Maths fails	**36.2**	**42.6**	**41.2**	**41.2**	**20.8**	**8.4**	**32.6**	**40.0**	**36.5**	**37.4**	**22.5**	**11.6**	**38.7**	**47.7**	**45.1**	**43.9**	**27.1**	**12.8**
Potential Maths fails	**19.5**	**24.2**	**22.2**	**22.1**	**8.7**	**2.9**	**18.0**	**22.7**	**20.1**	**22.2**	**10.9**	**4.0**	**24.2**	**29.4**	**28.7**	**29.3**	**17.0**	**5.9**
S.D. of Maths scores	**14.2**	**13.4**	**13.8**	**14.1**	**15.7**	**16.5**	**14.4**	**13.2**	**13.8**	**14.6**	**16.1**	**16.5**	**14.0**	**13.4**	**13.7**	**14.2**	**15.0**	**15.1**
S.D. of Maths Lit scores	**12.9**	**12.8**	**12.7**	**13.1**	**12.9**	**12.6**	**12.2**	**11.6**	**11.7**	**12.3**	**13.2**	**12.9**	**12.1**	**11.6**	**11.8**	**12.2**	**12.7**	**12.6**

Notes: Own calculations using NSC examination and EMIS data 2010 – 2018. SD = standard deviation. [a] could have got 50%+ for mathematics; [b] could have got 30% for mathematics; [c] could have passed mathematical literacy.

Table A.7: Performance statistics of Q1-Q3 schools meeting all indicators

School	Province	Quintile	Math average	MathLit average	Eng FAL average	# 60%+ in Math or 72%+ in MathLit	NSC pass (%)	Bachelor pass (%)	Pass rank in 2018	Math mark rank 2018
1	Eastern Cape	3	35	46	49	13	75	34	8	6
2	Eastern Cape	3	31	46	51	7	62	26	8	5
3	Eastern Cape	3	27	51	43	5	57	30	6	4
4	Free State	3	41	51	53	13	90	36	9	8
5	Free State	3	47	54	50	20	67	29	10	9
6	Free State	2	31	46	48	2	71	29	8	5
7	Free State	2	35	41		9	64	19	7	6
8	Free State	2	32	47	49	1	56	33	8	5
9	Free State	3	39	48	49	6	85	26	9	8
10	Free State	1	38	45	55	4	95	42	9	7
11	Free State	1	52	56	57	17	100	68	10	10
12	Free State	1	39	46	49	1	99	43	9	8
13	Free State	3	40	55	53	14	80	56	9	8
14	Free State	2	40	53	56	3	90	57	9	8
15	Free State	3	39	54	48	8	92	30	9	8
16	KwaZulu-Natal	3	28	46	51	4	50	23	6	4
17	KwaZulu-Natal	2	45	51	66	17	77	47	9	9
18	KwaZulu-Natal	2	41	46	67	15	90	60	7	8
19	KwaZulu-Natal	1	28	46	61	8	95	56	6	4
20	KwaZulu-Natal	3	58	61	52	76	81	74	10	10
21	KwaZulu-Natal	1	36	42	53	6	92	48	7	7
22	North-West	1	42	52	65	14	96	49	9	8
23	North-West	3	46	59	65	5	95	67	9	9
24	North-West	1	36	52	62	6	96	56	8	7
25	Gauteng	3	45	47	57	18	91	39	9	9
26	Gauteng	3	34	42	58	6	81	39	7	6
27	Gauteng	3	46	45	53	11	73	34	9	9
28	Gauteng	2	48	54	55	7	89	44	10	9
29	Gauteng	3	35	50	53	3	72	28	7	6
30	Gauteng	1	41	52	55	5	77	33	9	8
31	Gauteng	3	36	43	54	6	84	39	7	7
32	Gauteng	2	29	38	57	7	85	46	5	4
33	Gauteng	2	41	47	55	23	71	33	9	8
34	Gauteng	3	44	48	58	17	88	47	9	9
35	Gauteng	2	32	42	50	12	75	25	7	5

School	Province	Quintile	Math average	MathLit average	Eng FAL average	# 60%+ in Math or 72%+ in MathLit	NSC pass (%)	Bachelor pass (%)	Pass rank in 2018	Math mark rank 2018
36	Gauteng	1	38	44	57	12	88	30	8	7
37	Gauteng	1	35	43	52	9	62	20	8	6
38	Gauteng	1	28	44	50	4	94	43	7	4
39	Mpumalanga	2	42	48	54	1	100	77	9	8
40	Mpumalanga	1	33	42	48	2	90	34	6	6
41	Mpumalanga	2	41	47	53	11	83	38	9	8
42	Mpumalanga	1	39	47	51	4	97	38	9	8
43	Mpumalanga	1	32	42	54	5	98	54	6	5
44	Mpumalanga	2	39	43	54	5	100	58	8	8
45	Limpopo	2	41	48	51	1	75	18	10	8
46	Limpopo	3	35	46	53	3	74	18	8	6
47	Limpopo	2	31	44	55	2	66	23	5	5
48	Limpopo	1	38	46	55	2	51	15	8	7
49	Limpopo	2	27	50	47	3	81	24	7	4
50	Limpopo	3	28	43	47	4	53	18	6	4
51	Limpopo	2	42	48	58	4	67	37	9	8
52	Limpopo	2	35	41	48	6	61	16	6	6
53	Limpopo	1	28	44	48	1	72	19	7	4

Notes: shaded rows represent schools with both or one of the performance rankings (pass and average mark) lying outside of top 30% (deciles 8 – 10).

Table A.8: Performance statistics of the Maths Challenge Programme schools

School	Province	Quintile	Math average	Math Lit average	NSC pass (%)	Bach pass (%)	% wrote maths 2018	maths pass at 30% (%)	maths pass at 50% (%)	maths pass at 60% (%)
1	Eastern Cape	5	52.3	65.2	99.1	79.8	48.4	94%	51%	31%
2	Kwa-Zulu Natal	5	50.4	57.1	94.4	58.8	66.1	91%	50%	28%
3	North West	4	46.2	45.3	86.9	42.8	51.7	83%	36%	21%
4	Western Cape	5	51.2	65.5	98.4	82.3	66.1	92%	50%	29%
5	Western Cape	3	49.5	N/A	89.9	52.3	100	91%	42%	29%
6	Kwa-Zulu Natal	5	62.3	70.9	100	94.5	73.8	98%	73%	52%
7	Limpopo	1	47.8	N/A	97.9	52.9	100	91%	42%	22%
8	Kwa-Zulu Natal	5	38.3	45.9	95	65	39.2	66%	26%	13%
9	Kwa-Zulu Natal	4	44.2	48.3	91.6	55.7	43.5	74%	39%	25%
10	Free State	5	64.1	74.3	99.4	96.9	67.3	98%	81%	57%
11	Limpopo	3	43.8	36.4	76.1	36.1	56.5	74%	32%	22%
12	Kwa-Zulu Natal	5	50.8	62.9	92.4	66.7	67.2	83%	45%	33%
13	Gauteng	5	51.6	65	100	84.2	68.4	92%	56%	26%
14	Eastern Cape	1	43.2	N/A	84	51	100	73%	38%	20%
15	Mpumalanga	2	48.1	N/A	92.6	44.1	99.4	84%	39%	19%
16	Gauteng	5	57.6	63.7	97.8	73.5	55.3	94%	64%	47%
17	Kwa-Zulu Natal	5	45.8	51.6	93.4	52	77	72%	42%	29%
18	Northern Cape	5	58	64.9	100	88.3	54.7	97%	60%	50%
19	Kwa-Zulu Natal	5	54.8	62.3	97.5	76.1	79.7	91%	61%	38%
20	Limpopo	3	37.2	36.5	66.2	26.6	79.2	49%	23%	13%
21	Western Cape	5	54.3	60.1	95.5	73.4	48.1	91%	55%	34%
22	Mpumalanga	4	41.2	55.6	100	68.9	55.3	75%	26%	11%
23	Kwa-Zulu Natal	5	56.2	68.7	99.2	89.8	74.8	95%	65%	39%
24	Limpopo	4	51	N/A	87.7	57.8	100	83%	44%	27%
25	Limpopo	4	37.6	N/A	68.3	28.5	100	54%	23%	15%
26	Kwa-Zulu Natal	5	39	41.4	71.4	34.5	54	62%	31%	19%

School	Province	Quintile	Math average	Math Lit average	NSC pass (%)	Bach pass (%)	% wrote maths 2018	maths pass at 30% (%)	maths pass at 50% (%)	maths pass at 60% (%)
27	Kwa-Zulu Natal	5	46	50.1	92.1	49.7	60.6	88%	35%	18%
28	Western Cape	5	50	59.5	96.7	72.9	70	92%	48%	28%
29	Kwa-Zulu Natal	5	56.4	68.6	100	92.8	72.7	97%	61%	43%
30	Gauteng	5	59.6	57.7	95.3	70.7	77.3	93%	66%	46%
31	Gauteng	5	61.8	64.9	100	98.1	72	99%	76%	58%
32	Limpopo	4	44.4	N/A	88	51.1	100	78%	29%	18%
33	Kwa-Zulu Natal	5	56.5	67.1	99.6	96.9	71.3	97%	62%	37%
34	Western Cape	5	55.7	63.2	99.5	85.7	63.5	98%	64%	38%
35	Kwa-Zulu Natal	5	38	53.5	84.4	51.9	68.9	65%	31%	15%
36	Kwa-Zulu Natal	5	48.8	61.2	98.8	78.5	64.5	86%	43%	24%
37	Gauteng	5	59.3	65.8	98.3	80.3	85.4	96%	68%	49%
38	Gauteng	5	60.6	70	99.6	93.4	76.1	97%	70%	51%
39	Kwa-Zulu Natal	5	59.1	60.7	99.4	88.9	54.3	95%	72%	48%
40	Western Cape	5	73.7	72.6	100	94.6	88.6	100%	88%	78%
41	Limpopo	4	39	N/A	73.5	34.5	87	59%	26%	14%
42	Kwa-Zulu Natal	5	46.3	47.8	89	52.6	60.1	85%	42%	23%
43	Eastern Cape	2	57.9	68.5	96.8	72.3	55.5	100%	65%	41%
44	North West	4	41.3	51.3	86.8	41.7	58.3	74%	30%	15%
45	Western Cape	5	47.1	61.7	98.5	84.1	74.1	84%	39%	24%
46	Kwa-Zulu Natal	5	41.4	45.7	79.8	35.5	60.6	64%	38%	23%
47	Gauteng	5	53	61.5	95.6	56.6	62.5	95%	59%	33%
48	Kwa-Zulu Natal	5	48.1	44	84.1	48.6	55	83%	40%	29%
49	Eastern Cape	5	53.5	68	96.7	74.8	57	95%	59%	34%
50	Western Cape	5	45.3	64.7	97.2	81.5	89.2	80%	39%	20%
51	Limpopo	3	49.5	51.3	97.8	62.4	9.7	86%	43%	30%
52	North West	3	33.2	46.5	91.5	61.5	63.1	59%	16%	6%
53	Gauteng	5	61.7	N/A	99	82.5	100	99%	78%	54%

School	Province	Quintile	Math average	Math Lit average	NSC pass (%)	Bach pass (%)	% wrote maths 2018	maths pass at 30% (%)	maths pass at 50% (%)	maths pass at 60% (%)
54	Eastern Cape	4	48.1	N/A	96	65	100	84%	46%	31%
55	Western Cape	5	73.8	80.5	99.4	98.2	82.1	99%	96%	83%
56	Kwa-Zulu Natal	5	63	73	99.5	96.6	74.6	100%	80%	59%
57	Gauteng	5	46.9	56.7	97.6	67.7	47.6	87%	37%	21%
58	Kwa-Zulu Natal	5	45	49.4	84.2	45	55.8	78%	40%	23%
59	Western Cape	5	58.9	66.3	99.4	90.6	86.2	98%	69%	46%
Average			**50.8**	**59.0**	**93.0**	**67.6**	**70.0**	**85.3%**	**50.0%**	**32.4%**