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# Trends in International Mathematics and Science Study Numeracy 2015

## An analysis of South African mathematics performance

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SA-TIED Working Paper #69 | July 2019

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**Abstract:** South Africa has consistently performed poorly on international mathematics tests, but there has been a lack of recent data on primary school mathematics achievement. South Africa's participation at Grade 5 level in the 2015 Trends in International Mathematics and Science Study Numeracy test provides the opportunity to gain insight into recent primary school mathematics achievement. This paper uses ordinary least squares regression to investigate the factors affecting Grade 5 mathematics performance in South Africa, and the reasons for the inequality in achievement in the South African schooling system are investigated using a three-stage Oaxaca-Blinder decomposition. It is found that the difference in achievement between wealthier and poorer schools (as measured by average learner socio-economic status) is not solely attributable to differences in factor endowments, but that significant differences exist in the returns to factors such as absenteeism, attitude towards mathematics, learner age, and the presence of a school library.

**Keywords:** Education, mathematics, South Africa, TIMSS, Oaxaca-Blinder, primary school
**JEL classification:** C21, I21, I24, J71

**Acknowledgements:** The author acknowledges the guidance and input of Professor Servaas van der Berg (Stellenbosch University), who supervised the master's research assignment from which this paper was adapted.

# 1 Introduction

South Africa has consistently performed poorly on international standardized assessments such as the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS). However, since testing began, there have been signs of improvement in literacy at Grade 5 level (Howie et al. 2017), and significant improvements in mathematics at Grade 9 level (Reddy et al. 2016).

The cause of the improvement in Grade 9 mathematics performance has not been identified definitively, and a lack of recent data on mathematics performance in the lower grades makes it difficult to know whether the poor Grade 9 performance, and subsequent improvements, is driven by primary schooling and changes in this system, or if the improvements are caused by other factors.

South Africa's participation in the TIMSS Numeracy (TIMSS-N) study in 2015 therefore provides a welcome opportunity to gain insight into the current state of primary school mathematics achievement and education in South Africa, and provides a comparative benchmark for Grade 5 South African achievement in future TIMSS assessments. Additionally, this data will enable cohort analysis as the 2015 Grade 5 learners participate in the 2019 TIMSS at Grade 9 level.

The Human Sciences Research Council (Isdale et al. 2018) has done a preliminary analysis of the data, but TIMSS-N 2015 is a new data set, with plenty that has yet to be explored. This research aims to perform a more in-depth analysis than that which has already been undertaken. Ordinary least squares (OLS) regressions are used to identify which characteristics are associated with mathematics achievement in South African primary schools, in order to identify potential policy-relevant characteristics that could be targeted to improve achievement. Furthermore, a Oaxaca-Blinder decomposition is performed to examine the differences in endowments and returns between the richest 10 per cent of schools, as classified by average learner socio-economic status (SES), and the other 90 per cent of schools. This decomposition is motivated by the documented bimodality of learner achievement in South Africa (Spaull 2012b, 2015) and the large and significant effect sizes of school wealth found in the OLS regressions using the 2015 TIMSS-N data.

A number of characteristics are found to be significantly associated with mathematics achievement. Language of learning and teaching (LOLT), pre-primary attendance, learner absenteeism, attitude towards mathematics, bullying, teacher specialization, and use of electronics in the classroom are all characteristics that could be targeted by government or school policy interventions. It is also found that while significant endowment differences exist between the richest 10 per cent and the other 90 per cent of schools, there also exist differences in the returns to these endowments. In particular, it is found that overage and underage learners receive less of an achievement penalty in richer schools than in poorer schools, while learner absenteeism carries more of a penalty in richer schools. Teacher qualification is found to have a higher return in poorer schools. These findings suggest further investigation into these characteristics is warranted in order to determine potential policy applications regarding repetition, effective use of classroom time, and teacher appointments and training.

This paper is structured as follows. Section 2 provides an overview of the individual, school, classroom, and teacher characteristics that have been associated with learner achievement in both local and international literature. The data and methodology employed in the analysis are subsequently explained in section 3. Thereafter, the results of the OLS regressions and the threefold Oaxaca-Blinder decomposition results are reported and discussed in section 4. Section 5 concludes with an overview of the study's findings and suggestions of areas for future research.

## 2 Literature review

A large body of literature exists in the economics of education field examining the different factors that influence learner achievement. Broadly, these factors can be classified into three categories: individual characteristics, school characteristics, and teacher and classroom characteristics. From a policy perspective, the effects of school, teacher, and classroom characteristics are most useful in determining what reforms would improve achievement, while the effects of learner characteristics may be used to identify at-risk groups and design interventions to improve the achievement of these learners. In order to identify characteristics to include in the analysis, the literature review provides an overview of characteristics that have been found to have an effect on learner performance, both in South Africa and internationally. The expected direction of the different effects is also discussed, in order to facilitate comparison of the results of this study with previous findings in the literature.

### 2.1 Individual characteristics

*SES*

The Coleman report (Coleman et al. 1966) was the first to highlight the importance of a learner's family background, and in particular his or her SES, when it came to educational achievement and attainment. A controversial finding of this report was that in the United States, family background played a far more important role in a learner's academic achievement than school factors. This finding has been disputed: Heyneman and Loxley (1983) found that in developing countries, school factors matter more than family background, with one possible reason being that in low-income countries, pressure on learners to perform academically is not as strongly associated with parental SES as in richer countries. This contradiction of the Coleman report's findings is often referred to as the Heyneman-Loxley effect in economics of education literature. Evidence to support this effect has been found in Kenyan data from the Southern Africa Consortium for Monitoring Educational Quality (SACMEQ) (Hungi and Thuku 2010a) and in Ghanaian TIMSS Grade 8 data (Butakor et al. 2017), although in many developing countries there nonetheless exists a small positive association between learner SES and achievement (Hungi and Thuku 2010b).

In South Africa, learner SES, as measured by asset-wealth indices, has been found to play an important role in learner achievement in both mathematics and literacy (see Armstrong 2009; Howie et al. 2017; Spaull 2011, 2012a; Taylor and Yu 2009). A confounding factor is that it is difficult to separate SES from race, class, and language, as these factors are all strongly related (Taylor 2010). School SES is usually found to be more important than individual SES, but individual SES plays a role through interactions with schooling inputs which increase the advantage for high-SES learners (Spaull 2011; Taylor 2010), and it is has been found that an SES gradient exists in the richer part of the school system (Hungi and Thuku 2010b; Taylor and Yu 2009; van der Berg 2006).

*Gender*

A factor that often affects learner achievement is gender, although it appears to have contradictory effects depending on the country. Internationally, some studies find that girls outperform boys (Burusic et al. 2012), while others find the opposite (Jami et al. 2012).

In most countries that participated in the first SACMEQ mathematics and literacy tests, Grade 6 girls experienced an advantage over boys, although in these countries, female participation in schooling was often lower, which could indicate a selection effect (Saito 2011). In contrast, Hungi and Thuku (2010a) find that gender effects in Kenya are either non-significant or favour boys, especially in mathematics. Boys were also found to outperform girls in Ghana in the 2007 TIMSS Grade 8 (Butakor 2016), and an in-depth discussion of three African countries where boys outperformed girls in SACMEQ II is provided by Zuze and Lee (2008). In the few SACMEQ countries, such as Tanzania, where boys outperform girls, it has been suggested that this is a result of girls in these countries appearing to be involved in more household tasks such as cooking, cleaning, and fetching water (Saito 2011).

In South Africa, there is evidence to support a female advantage in both mathematics and literacy achievement. In the SACMEQ test series, the achievement differential between girls and boys remains fairly consistent over time, with girls outperforming boys. This gender inequality lessened between 2000 and 2007 for urban and high-SES learners, but widened over the same period for low-SES learners (Saito 2011). In the 2016 PIRLS, there existed a significant achievement gap in literacy between South African boys and girls, also in favour of girls (Howie et al. 2017).

*Age*

Another learner characteristic that is frequently associated with achievement is learner age and grade repetition, with learners that are older or younger than the expected age for their grade performing worse than their correctly aged peers and those who have not repeated grades, in both international and South African contexts (see Chhinh 2003; Hungi and Thuku 2010a, 2010b; Spaull 2012a).

*Language*

Language plays a large role in education, and fluency in and frequency of speaking the language of testing at home is consistently associated with higher achievement (see Hungi and Thuku 2010a, 2010b). In South Africa, there is a strong preference among both teachers and parents for English instruction, despite English not being the home language of the majority of the South African population (Essien 2018). This has been found to have negative effects on achievement; one example of this is the 2016 PIRLS, where the frequency with which the LOLT is spoken at home was positively associated with achievement in PIRLS, especially for English LOLT (Howie et al. 2017).

*Other*

Aspirations and attitude towards school have been investigated as possible factors influencing achievement. Higher educational aspirations, as well as higher self-confidence, were associated with higher achievement in TIMSS 2007 and TIMSS 2011 for Grade 8 Ghanaian learners (Butakor 2016; Butakor et al. 2017), while higher self-efficacy strengthened the relationship between achievement and school SES among Australian 15-year-olds (McConney and Perry 2010). Interest in mathematics has also been associated with higher performance in Cambodian primary schools (Chhinh 2003). In South Africa, no clear relationship between learners' enjoyment of reading and literacy achievement is evident in PIRLS, although parental enjoyment of reading is positively associated with learner achievement (Howie et al. 2017).

Parental education is also found to affect learner achievement, with more educated parents being associated with higher learner achievement (Hungi and Thuku 2010a), while early childhood development activities, such as attendance at preschool, are associated with higher literacy achievement among South African Grade 5 learners in PIRLS (Howie et al. 2017).

## 2.2 School characteristics

*School wealth*

As mentioned in the learner SES literature, school SES and its relationship with learner SES is often found to be significant in international literature. In Belgium, five-year-old learners were tracked for seven years, and it was found that high-SES schools resulted in more positive achievement growth than mixed- or low-SES schools (Belfi et al. 2016). In Namibia, school SES determined how relevant teacher effects were: in low-SES schools, the most effective teachers were in school environments with higher average years of teacher training, were highly competent in their subject, and set homework daily. In contrast, in high-SES schools, classroom practices were the more important determinants of effective teachers (Duthilleul and Allen 2005). In South Africa, school wealth is highly associated with achievement, as previously mentioned. The bimodality of learner achievement according to school wealth in the South African education system is well documented and evident across all grade levels (Spaull 2012b, 2015), with an achievement gap far higher than that found in other countries, such as the SACMEQ II participants (van der Berg 2006).

*School resources*

In Kenya, an increase in school resources such as stationery and workbooks has been associated with an increase in academic achievement, even after learner SES is controlled for (Hungi and Thuku 2010a). The South African data does not always replicate this: in PIRLS 2016, achievement was not affected by resource shortages (Howie et al. 2017), but in SACMEQ III, the availability of reading textbooks was an important factor associated with learner achievement (Spaull 2012a). School resources in the form of libraries are also shown to be positively associated with literacy achievement before other school and learner characteristics are controlled for (Howie et al. 2017).

*Absenteeism and bullying*

In Hungi and Thuku (2010a), hierarchical linear modelling is used to analyse Grade 6 Kenyan learners' achievement in SACMEQ II. Lower average school and class absenteeism were both associated with higher achievement. In contrast, in India, class attendance was not significant at an aggregate level for early-grade primary school achievement, but the relationship varied between classrooms, pointing to the role of the teacher in learner achievement. From this, it is hypothesized that improving student attendance may be ineffective unless teacher quality is improved (Jami et al. 2012). Absenteeism has also been shown to be detrimental in Cambodian primary schools (Chhinh 2003).

Behavioural problems have been found to be negatively associated with achievement in Kenya (Hungi and Thuku 2010a). In recent studies, behavioural problems in the form of bullying and school discipline have also been associated with South African literacy achievement (Howie et al. 2017) and mathematics achievement (Cahu and Fall n.d.).

## 2.3 Teacher and classroom characteristics

*Teacher gender and experience*

Teacher gender has been investigated as a factor influencing learner achievement. In Croatia, there are no gender interaction effects found between teachers' and learners' gender for learners aged 10 and 14 years, but it has been found that female teachers are better at predicting student achievement on standardized assessments (Burusic et al. 2012). United States high-school teachers' gender has been found not to significantly affect achievement once teacher behaviour and attitude are taken into account (Sansone 2017). In India, at Grade 4 and 6 levels, female teachers are associated with higher literacy but not higher mathematics achievement. A possible explanation for this is the different views on classroom management and practices that male and female teachers have (Chudgar and Sankar 2008). A similar explanation is given by Lam et al. (2010) as to why Hong Kong Grade 4 learners, regardless of learner gender, achieve better results in PIRLS if they have female teachers.

In South Africa, teacher experience has been explored, but often with inconclusive effects: Armstrong (2009) uses hierarchical linear modelling with 2003 TIMSS Grade 8 South African data to find that only teacher experience of 26–30 years positively influences learner achievement in mathematics, while Howie et al. (2017) find no clear association between teacher experience and South African literacy achievement in PIRLS.

*Teacher qualifications and knowledge*

Teacher qualifications, as well as the area of study (specifically, specialization in mathematics), are frequently found to be associated with learner achievement, in both South African (Armstrong 2009) and international studies (Butakor 2016). Teacher subject knowledge is not associated with large achievement effects in South Africa (Spaull 2012a), although higher teacher confidence and ability to answer learners' questions was found to be associated with higher mathematics achievement for Grade 9 South African learners in TIMSS 2011, as was the ability of teachers to provide more challenging problems to more capable learners (Arends et al. 2017). In Kenya, on the other hand, teacher knowledge did have a positive effect on Grade 4 learner achievement, as did teacher effort and ability to challenge learners (Wamalwa and Burns 2018).

*Classroom practices of testing, homework assignment, and use of technology*

Hungi and Thuku (2010a) found that in Kenya, higher frequency of mathematics testing was positively associated with academic achievement at the classroom level. Studies in other countries have confirmed this association unless testing is done too frequently, in which case it may negatively affect achievement (Arends et al. 2017; Polly et al. 2018).

The more frequent assignment of homework has been associated with increased academic achievement (Butakor et al. 2017; Howie et al. 2017; Hungi and Thuku 2010a; Spaull 2012a), but in Kenya the revision and assignment of homework is negatively associated with achievement (Wamalwa and Burns 2018). The use of technology such as computers and calculators in the classroom has also been investigated: it is negatively associated with mathematics performance in Ghana (Butakor 2016).

## 3 Data and methodology

### 3.1 Data

All analysis in this study is performed on the 2015 TIMSS-N data for Grade 5 South African learners. TIMSS is administered at Grade 8 and Grade 4 levels, although some countries such as South Africa participate with higher grades to ensure better curriculum overlap. To obtain more meaningful data for countries which found the Grade 4 test too difficult for their learners, an easier assessment for Grade 4 was developed for the 2015 testing cycle; this less difficult assessment is known as TIMSS-N (IEA 2016). As a first-time participant at Grade 5 level, it was deemed best for South Africa to participate in TIMSS-N in 2015, based on the performance of South Africa's Grade 9 learners in previous cycles of TIMSS (Isdale et al. 2018). TIMSS-N, which collects achievement data for mathematics along with a number of school, parent, and learner contextual data, allows a thorough analysis of learner performance.

The South African sample consists of a nationally representative and randomly selected sample of 10,932 learners from 297 schools. Throughout the analysis, appropriate design weights are used in order to maintain nationally representative results. Wherever possible, and unless otherwise stated, non-responses to questions are kept in the sample as a separate category, to preserve the sample size in the regression analyses. This is motivated by the non-randomness of non-response, as evidenced by significant coefficients on the missing categories in the regression analyses. A detailed analysis of non-response is beyond the scope of this paper; therefore, non-response is included only as a control, and the related coefficients are not discussed in the text.

The outcome variable in this analysis is mathematics achievement, which is taken to be the first plausible value of mathematics achievement as provided by TIMSS-N. This score is a Rasch achievement value that is standardized by TIMSS to have an international mean of 500 and a standard deviation of 100. South Africa's mean performance of 375.7 places the country below the low international benchmark of 400–75 set by TIMSS to indicate that learners possess 'some basic mathematical knowledge' (Mullis et al. 2016).

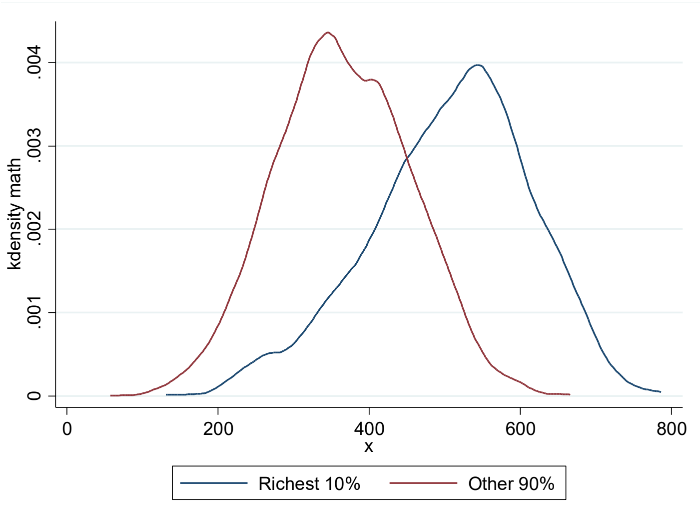
*Socio-economic status and the 90/10 split by school wealth*

In order to obtain an indicator of learner SES, an asset index was created using multiple correspondence analysis. This index was then standardized to have a mean of zero and a standard deviation of one, in order to aid with interpretation of the coefficient in the regression analysis. Non-response to 'yes/no' questions regarding the presence of assets was treated in the same way as a negative response, while non-response to asset questions (such as the number of books present at home, in a categorical response) was dealt with by imputation of the modal response to that question in that learner's school, owing to the homogenous nature of learner characteristics within South African schools.

Since departmental classification of schools according to wealth is not provided in the TIMSS-N data set, the average learner SES is taken to be indicative of school SES, and this is then used to classify schools into wealth quintiles. Quintile 1 therefore contains the poorest 20 per cent of schools, while quintile 5 is split further into 5a and 5b, whereby quintile 5b contains the richest 10 per cent of schools, and 5a the remainder of the schools in quintile 5. This further division of quintiles is to account for non-linearity in performance within the fifth quintile. For the Oaxaca-Blinder decomposition, the sample is separated into the richest 10 per cent of schools (quintile 5b) and the remainder of schools. This split is chosen based on the clear differences in the distribution of mathematics achievement in these two groups, which can be seen in Figure 1, with the richest

10 per cent of schools' achievement distribution lying clearly to the right of the poorer schools' achievement distribution.

Figure 1: Kernel density of mathematics achievement according to school wealth



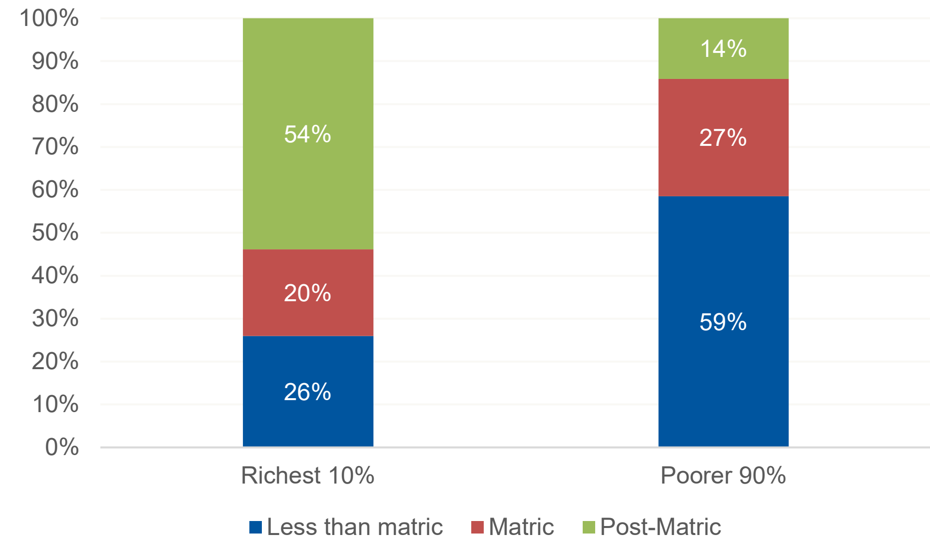

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

The remainder of this section will present the variables used in the study, along with illustrations of how these variables differ according to school wealth.

*Parental education*

In the simple OLS regression models, parental education is included separately for each parent, and is classified according to the highest level completed. In order to simplify the Oaxaca-Blinder decomposition's model specification, maternal and paternal education are combined, and the new parental education variable takes on the higher value out of maternal and paternal education. Figure 2 shows that a higher percentage of parents in the richest schools have attained higher levels of education than parents in the poorer schools.

Figure 2: Highest level of parental education according to school wealth




Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

*Language*

To incorporate language into the model, a dummy variable is included to indicate if the LOLT is spoken at least sometimes at home. Only four per cent of learners in the richest 10 per cent of schools never speak the LOLT at home, compared with 13 per cent of learners in the poorer schools. A separate language variable indicates if the LOLT was spoken at home before the learner began attending school. Eighty-eight per cent of learners in the poorer 90 per cent of schools did not speak the LOLT at home prior to entering school, compared with 60 per cent of the learners in the richest schools.

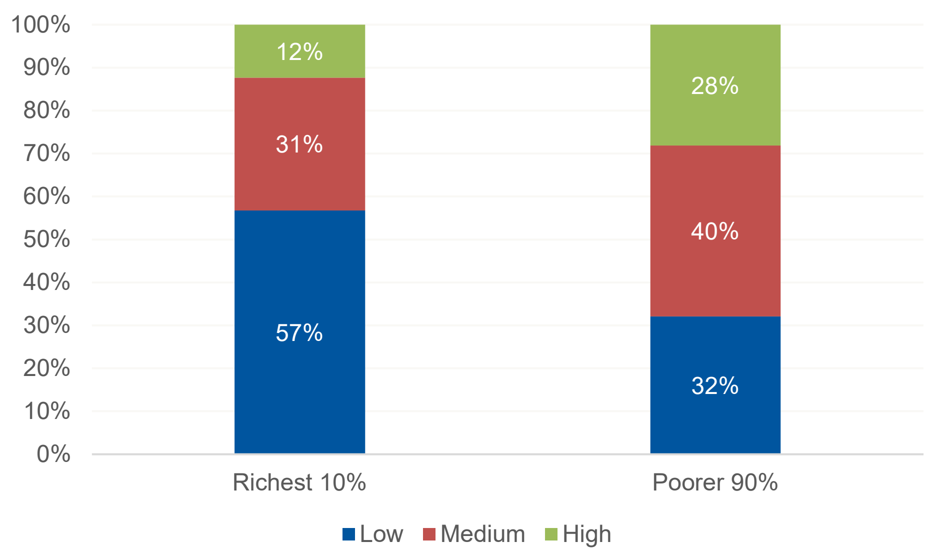
*Absenteeism and aspirations*

Based on the findings of the literature review, learner absenteeism and a proxy for student aspirations were both included in the model. The wealthiest schools experienced less absenteeism, with 84 per cent of learners reporting being absent once a month or less frequently, compared with 59 per cent of learners in the poorer 90 per cent of schools. Although student aspiration data is not available, parents' expectations regarding how far their child will go in education were available, and these were used to create a dummy variable to indicate if parents expected their child to obtain a bachelor's degree or higher. Seventy-four per cent of parents in wealthier schools expected their children to obtain a bachelor's degree or higher, compared with 60 per cent of parents in the poorer 90 per cent of schools.

*Bullying and attitude towards mathematics*

In the TIMSS learner questionnaire, learners had to indicate how frequently they were the victim of various types of bullying, and to what extent they agreed with various statements about their enjoyment of mathematics. Based on the responses to these questions, a dummy variable was created to indicate if the learner had a positive attitude towards mathematics ('liking maths'), and a similar index was created to indicate the extent of bullying experienced in the school environment. Similar percentages of learners liked mathematics in the richest 10 per cent of schools compared with the poorer schools, while bullying was more prevalent in poorer schools, as illustrated in Figure 3.

Figure 3: Level of bullying according to school wealth




Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

*Learner age, gender, and pre-primary attendance*

As in Isdale et al. (2018), learners aged 10.5–11.5 years at the time of testing are deemed to be appropriately aged for Grade 5. Table 1 illustrates the age appropriateness of learners, from which it is clear that wealthier schools have more students of the appropriate age for their grade: 61 per cent of learners in the richest 10 per cent of schools are the correct age for their grade, compared with 46 per cent of learners in poorer schools. Other learner characteristics included in the statistical analysis include dummy variables for learner gender and attendance of pre-primary education. Learner gender proportions are similar regardless of school wealth, while learners in the richest 10 per cent of schools are more likely to have attended pre-primary education (70 per cent compared with 48 per cent).

Table 1: Learner age according to school wealth

| | Richest 10% | Poorer 90% |
|---|---|---|
| Correct | 61% | 46% |
| Underage | 4% | 10% |
| Overage | 35% | 45% |

Source: author's calculations using TIMSS-N 2015 South African Grade 5 data.

*School location*

School location was classified in one of the following three categories: urban, small town or village, and remote rural. When one is interpreting results for school location, it is important to note that among the richest 10 per cent of schools, only two schools were located in remote rural locations (accounting for 36 learners), and nine schools were located in small towns or villages (accounting for 280 learners). The locations of schools were more evenly distributed in the poorer 90 per cent of schools.

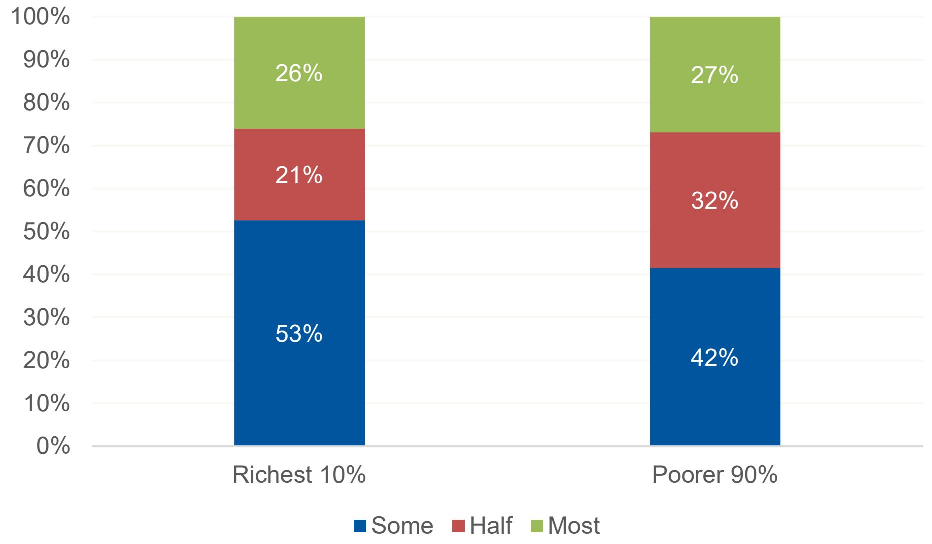
*Frequency of testing and homework*

Mathematics testing was less frequent in the richest 10 per cent of schools, as illustrated in Figure 4. Homework frequency was classified as the number of times homework was assigned per week on average, and it is evident from Figure 5 that homework was assigned more frequently in the richest 10 per cent of schools.

*Libraries and use of technology*

A dummy variable was created to indicate if computers or tablets were used daily for classwork at school. Interestingly, only seven per cent of learners in the richest 10 per cent of schools used a computer or tablet daily at school, compared with 23 per cent in the poorer 90 per cent of schools. A library was present in 85 per cent of schools in the richest 10 per cent, compared with 35 per cent of the poorer 90 per cent of schools.

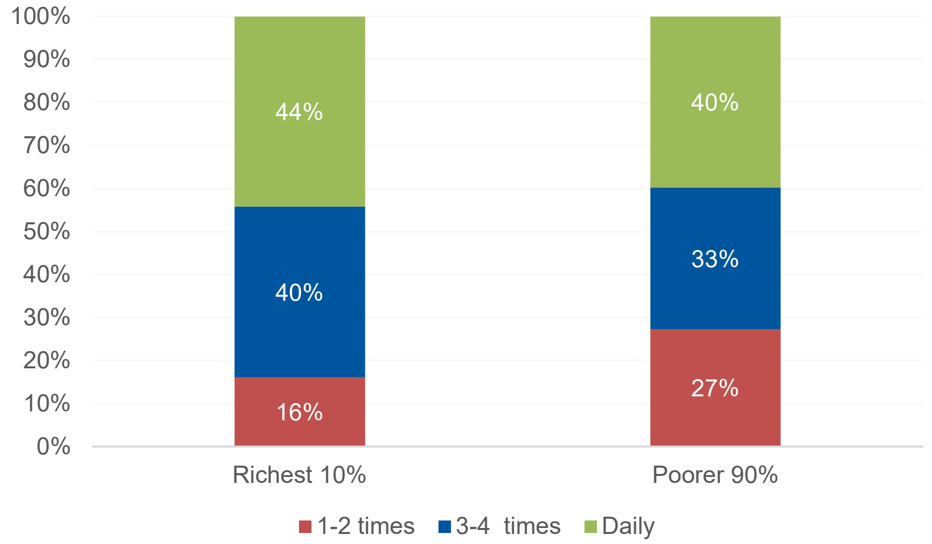
Figure 4: Frequency of testing according to school wealth




Notes: Some = testing in some lessons; half = testing in half of lessons; most = testing in most lessons.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

Figure 5: Frequency of homework per week according to school wealth




Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

*Teacher characteristics*

Teacher qualification distinguishes between teachers who possess a degree or higher and those who possess a diploma or lower qualification. Additionally, teachers' specialization is included in the model through a dummy variable indicating if their area of degree specialization was mathematics. In the richest 10 per cent of schools, more teachers possess a degree (60 per cent compared with 42 per cent), and similarly, more teachers specialized in mathematics (54 per cent compared with 47 per cent).

### 3.2 Methodology

For the data analysis, a similar methodology to Isdale et al. (2018) is followed, whereby a standard education production function approach is employed to identify the factors influencing mathematics achievement at Grade 5 level in South Africa. The OLS regressions take the form:

$$\boldsymbol{y} = \alpha + \beta'\boldsymbol{x} + \varepsilon \qquad [1]$$

In equation 1, $\boldsymbol{y}$ represents mathematics achievement; $\boldsymbol{x}$ is a vector of individual, school, teacher, and classroom characteristics; $\beta$ is a vector of coefficients; $\alpha$ is a constant; and $\varepsilon$ is an error term, assumed to have a zero mean. Interaction effects are introduced to the model through interactions between the two language variables.

In order to analyse the difference in performance between the richest 10 per cent of schools and the remaining 90 per cent, Oaxaca-Blinder decomposition is used. Traditionally, Oaxaca-Blinder decomposition has been used in labour economics to identify discrimination; however, the method has also been used in educational studies to study achievement gaps between groups. These groups have been immigrants and non-immigrants (see Cattaneo and Wolter 2012; Entorf and Tatsi 2009; Song 2011), racial groups (Duncan and Sandy 2013; Song et al. 2014), rural-urban groups (Lounkaew 2013; Ramos et al. 2012; Sandy and Duncan 2010), countries (Gigena et al. 2011; McEwan and Marshall 2004; Sakellariou 2008; Zhang and Lee 2011), SES groups (Polidano et al. 2013), or testing in different time periods (Cahu and Fall n.d.; Da Maia 2012). The mathematics underlying the Oaxaca-Blinder decomposition method appears in full in Jann (2008).

In this case, Oaxaca-Blinder can decompose the difference in mathematics performance between the richest 10 per cent of schools and the other 90 per cent based upon linear regressions. Equation 2 is a modified version of equation 1, with the subscript $\boldsymbol{i}$ denoting the group to which learners belong.

$$y_i = \alpha_i + \beta_i \boldsymbol{x}_i \qquad [2]$$

A manipulation of equation 2 yields the following equation for the difference in achievement between quintile groups, where $i$=90 represents the poorest 90 per cent of schools and $i$=10 represents the richest 10 per cent of schools:

$$Y_{90} - Y_{10} = (\alpha_{90} - \alpha_{10}) + (\beta_{90} - \beta_{10})X_{10} + \beta_{90}(X_{90} - X_{10}) \qquad [3]$$

In equation 3, $\beta_{90}(X_{90} - X_{10})$ is the difference in achievement that can be explained by differences in characteristics or endowments; the residual term, $(\alpha_{90} - \alpha_{10}) + (\beta_{90} - \beta_{10})X_{10}$, cannot be explained by differences in endowments, but could potentially be explained by changes in the 'effectiveness' of the inputs into the education production function (Jann 2008).

## 4 Results

Table 2 provides key results from various model specifications. All models in Table 3 include the appropriate probability weights, and cluster standard errors at school level to account for the TIMSS sampling design. Complete results from the models are provided in Table A1 in the Appendix.

Table 2: Key results from model specifications

| | Model | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Outcome variable | | Mathematics | |
| Learner SES | 20.371*** | 9.097*** | 8.605*** |
| | (1.993) | (1.481) | (1.402) |
| Female | 6.846*** | 6.155*** | 6.193*** |
| | (2.408) | (2.146) | (2.120) |
| Underage | -17.543*** | -9.370*** | -10.468*** |
| | (3.429) | (3.593) | (3.388) |
| Overage | -31.498*** | -28.578*** | -28.131*** |
| | (2.275) | (2.478) | (2.450) |
| Mother matric | 12.251*** | 10.171*** | 10.408*** |
| | (2.643) | (2.405) | (2.190) |
| Mother post-matric | 46.244*** | 32.542*** | 31.445*** |
| | (4.004) | (3.933) | (3.834) |
| Father matric | 8.257*** | 6.529** | 6.598** |
| | (2.598) | (2.639) | (2.587) |
| Father post-matric | 30.341*** | 16.133*** | 15.145*** |
| | (4.149) | (3.951) | (3.856) |
| LOLT prior-school | 35.544** | 16.428 | 19.844 |
| | (14.387) | (14.445) | (14.191) |
| Speak LOLT at home | 33.941*** | 26.894*** | 27.315*** |
| | (4.254) | (4.299) | (3.867) |
| LOLTxLOLT | 28.510** | 18.926 | 17.322 |
| | (14.152) | (14.579) | (14.420) |
| No pre-primary | -10.451*** | -7.394*** | -6.488*** |
| | (2.795) | (2.571) | (2.187) |
| Absent | -26.220*** | -22.957*** | -21.814*** |
| | (2.829) | (2.639) | (2.510) |
| Expectations | 8.645*** | 9.367*** | 8.390*** |
| | (2.439) | (2.399) | (2.509) |
| Likes maths | 26.363*** | 26.028*** | 25.138*** |
| | (3.031) | (2.645) | (2.579) |
| Bullied - medium | -22.439*** | -19.014*** | -17.904*** |
| | (2.876) | (2.508) | (2.460) |
| Bullied - high | -49.893*** | -43.082*** | -36.585*** |
| | (3.813) | (3.398) | (3.194) |
| Small town | | -17.992** | -19.602*** |
| | | (7.005) | (6.790) |
| Remote rural | | -39.886*** | -38.956*** |
| | | (7.709) | (7.140) |
| Q2 | | -3.609 | -5.955 |
| | | (8.716) | (7.891) |
| Q3 | | -0.244 | -5.053 |
| | | (8.938) | (9.038) |
| Q4 | | 16.516* | 11.163 |
| | | (9.869) | (9.512) |
| Q5a | | 31.376** | 24.697** |
| | | (12.227) | (11.875) |
| Q5b | | 67.824*** | 62.596*** |

| | | | |
|---|---|---|---|
| | | (13.674) | (13.962) |
| No library | | 0.423 | 1.276 |
| | | (6.147) | (6.381) |
| Class size | | -0.527** | -0.496** |
| | | (0.244) | (0.234) |
| Maths degree | | | 11.586** |
| | | | (5.382) |
| Test - half | | | 2.301 |
| | | | (6.341) |
| Test - most | | | -2.543 |
| | | | (6.984) |
| Daily computer | | | -18.380*** |
| | | | (3.758) |
| Homework - 3-4 times | | | 14.459** |
| | | | (6.831) |
| Homework - daily | | | 7.287 |
| | | | (6.175) |
| Male teacher | | | 0.809 |
| | | | (6.009) |
| Teacher degree | | | 7.562 |
| | | | (5.580) |
| Constant | 345.268*** | 380.059*** | 368.791*** |
| | (6.997) | (14.804) | (16.192) |
| Observations | 10,932 | 10,205 | 10,205 |
| R-squared | 0.442 | 0.520 | 0.538 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

Model 1 is an OLS regression including only learner characteristics as explanatory variables. Individual learner SES has a relatively large association[1] with performance, with one standard deviation increase in individual wealth resulting in just over one fifth of a standard deviation increase in performance. Girls outperform boys, although the effect size of 0.07 standard deviations is comparatively small. In contrast, being overage or underage is strongly negatively associated with achievement. Parental education is an important factor, with maternal education appearing to have more of an effect than paternal education. Learners with parents that have completed matric outperform those whose parents have not completed matric, while the achievement advantage is even greater for those whose parents have completed some form of post-matric qualification. Having parents that have both completed some form of post-matric qualification is associated with nearly 0.8 standard deviations increase in performance, compared with having parents who have not completed matric.

Having spoken the LOLT at home prior to entering school, as well as some speaking of the LOLT at home, are both associated with higher achievement, each with associations of a similar magnitude to that of parental education. The interaction term of these two factors indicates that

[1] The use of the term 'association' throughout the results section is intentional, in order to avoid presenting the results as causal and precise. Of interest in this study is the direction and relative size of the coefficients, in order to identify possible important factors that may impact on achievement. Further studies will need to be conducted focusing on a specific variable, or group of variables, in order for more causal results to be obtained.

learners who entered school having spoken the LOLT at home, and who still speak the LOLT at least sometimes at home, gain an even greater advantage over peers who did not do one of these. However, this interaction effect is only significant at a five per cent level.

Pre-primary education is associated with higher performance, as is lower absenteeism, with the association between absenteeism and achievement being 0.26 standard deviations, nearly three times as large as the association between pre-primary education and achievement. The degree of bullying that a child experiences at school has a strong (up to 0.49 standard deviations) negative association with achievement, whereas parental expectations have only a small positive association with achievement when parents expect their child to obtain a bachelor's degree or higher educational qualification. Finally, learner attitude towards mathematics is also positively associated with higher achievement, with a relatively high (0.26 standard deviations) association.

Model 2 includes both school and learner characteristics. Once school characteristics are included in the model, the coefficient on learner SES decreases greatly, supporting the hypothesis from Heyneman and Loxley (1983) that in developing countries school factors matter more than home and individual factors. All learner characteristics maintain the same direction of association, but the coefficient sizes on some learner characteristics decrease substantially once school factors are included in the model, once again supporting the Heyneman-Loxley effect. These coefficient changes include the penalty for underage learners, the advantage from having a mother or father with a post-matric qualification or higher, the advantage from having spoken the LOLT prior to entering school (this factor is no longer significant at a 10 per cent level, nor is its interaction with the frequency of speaking the LOLT at home), and the penalty from absenteeism. All other learner characteristics have similar coefficients to model 1.

In model 2, the following results are obtained regarding school characteristics. Schools located in urban areas outperform those located in small towns or remote rural areas. Quintile 2 and 3 schools' achievement does not differ significantly from quintile 1 schools, but moving from quintile 4 to quintile 5b (the richest 10 per cent of schools) results in greater achievement and greater statistical significance regarding achievement differences from quintile 1. The presence of a library has no significant or large association with achievement, while class size has only an economically insignificant effect as a result of its small estimated impact. Additionally, class size is only a significant predictor at a five per cent level.

Model 3 adds classroom and teacher characteristics to model 2. The addition of these characteristics does not result in large changes to the size or significance of any of the learner characteristics included in model 2, with the exception of bullying, where learners who experience high amounts of bullying are affected less once classroom factors are included in the model. In terms of school characteristics, quintile 4 schools no longer differ significantly from quintile 1 schools, and quintile 5a schools experience less of an advantage than in model 2. When we examine the effects of classroom and teacher characteristics, it is found that while teacher qualification, in terms of having a degree versus a diploma, is not associated with achievement, the type of teaching qualification appears to have an effect, as specialization in mathematics is associated with higher achievement at a five per cent significance level. While not significant, and small in effect sizes, there is also a very slight indication that some testing may improve achievement, but too frequent testing may become detrimental to achievement. Interestingly, the daily use of computers or electronics in class is negatively associated with achievement. Homework appears to have a non-linear association with performance, with the only benefit arising from homework three or four times per week—more or less frequently than this is not associated with higher achievement. Teacher gender has no association with performance, nor do any interaction effects exist with student gender, although these results are not reported.

Table 3 provides the model specification that is used in the Oaxaca-Blinder decomposition. Complete results from the models are provided in Table A2 in the Appendix. A preliminary look at the OLS regressions for the richest 10 per cent of schools (model 4) compared with the rest of the schooling system reveals a number of differences. These will be mentioned superficially in this section, while a detailed analysis of the differences will be provided in the Oaxaca-Blinder decomposition.

Table 3: Model specification used in Oaxaca-Blinder decomposition

| | Model | |
|---|---|---|
| | (4) | (5) |
| Outcome variable | Mathematics | |
| | Richest 10% | Poorest 90% |
| Learner SES | 17.900*** | 8.929*** |
| | (4.415) | (1.474) |
| Female | 3.719 | 7.566*** |
| | (4.459) | (2.222) |
| Parent matric | -3.403 | 13.931*** |
| | (7.391) | (2.748) |
| Parent post-matric | 23.706*** | 37.524*** |
| | (8.712) | (3.739) |
| LOLT prior-school | 35.986*** | 40.196*** |
| | (9.073) | (7.051) |
| Likes maths | 5.047 | 31.304*** |
| | (5.804) | (2.651) |
| Maths degree | 5.677 | 7.955 |
| | (13.076) | (5.931) |
| Underage | -19.436** | -9.414*** |
| | (9.143) | (3.428) |
| Overage | -16.234** | -28.779*** |
| | (6.057) | (2.543) |
| Freq. LOLT | 18.781 | 29.176*** |
| | (12.643) | (3.822) |
| Pre-primary | 13.260** | 5.879** |
| | (6.293) | (2.345) |
| Absent | -40.830*** | -20.733*** |
| | (6.119) | (2.573) |
| Expectations | 1.540 | 9.545*** |
| | (8.639) | (2.635) |
| Small town | -55.129** | -19.366*** |
| | (24.208) | (6.990) |
| Remote rural | -2.694 | -39.572*** |
| | (46.503) | (6.786) |
| Bullied - medium | -12.557** | -17.141*** |
| | (5.685) | (2.673) |
| Bullied - high | -35.827*** | -37.186*** |
| | (8.431) | (3.486) |
| Library | 72.335*** | 0.985 |
| | (21.299) | (6.441) |
| Test - half | -42.096** | 11.443* |
| | (19.590) | (6.738) |
| Test - most | -45.389** | 5.249 |
| | (18.162) | (7.094) |

| | | |
|---|---|---|
| Daily computer | -21.226*** | -18.603*** |
| | (6.828) | (3.986) |
| Homework - 3-4 | 20.326 | 13.824* |
| | (15.203) | (7.686) |
| Homework - daily | 30.941 | 6.279 |
| | (22.495) | (6.798) |
| Teacher degree | -21.376 | 8.046 |
| | (14.275) | (5.842) |
| Constant | 405.134*** | 333.963*** |
| | (24.893) | (10.862) |
| Observations | 1,086 | 9,002 |
| R-squared | 0.490 | 0.387 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

Individual characteristics appear to have a larger association with achievement in the poorest schools, with gender, overage classification, parental education, language variables, parental aspirations, and attitude towards mathematics all having stronger and more significant associations with achievement than in the richest 10 per cent of schools. The only exceptions to this are individual learner SES, absenteeism, being underage, and having attended pre-primary schooling, all of which have larger coefficients in the richest schools. In terms of school and classroom characteristics, poorer schools have higher returns to urban location and frequency of testing, but have more negative returns to bullying. The richest schools have far higher returns to libraries, and slightly lower negative returns to daily use of technology.

The explanatory power of these two models is fairly good (0.49 in the richest schools, and 0.386 in poorer schools), and these model specifications are therefore used in the Oaxaca-Blinder decomposition.

Table 4 provides the results of the Oaxaca-Blinder decomposition for the specification used in models 4 and 5 in Table 3. Between the richest 10 per cent of schools and the other 90 per cent, the difference in mean mathematics achievement is 150.547, with the richer schools achieving the higher mean of 509.22. Of this difference in means, 117.957 (78.4%) is accounted for by endowments or explained factors, while 66.974 (44.5%) is attributed to differences in the returns to productive characteristics or unexplained factors, and -34.384 (-22.8%) can be attributed to the joint or interaction effect of the endowment and coefficient effects. However, the interaction effect is not significant at a 10 per cent level, indicating that the difference in means is rather attributable to the endowment and coefficient effects acting separately and not simultaneously. For each explanatory variable, the size of the endowment and coefficient effects is reported in Table 4, while the interaction effects are available in full in Table A3 in the Appendix. The overall effects represent the sum of the individual effects of each variable. For example, the overall coefficient effect of 66.974 is equal to the sum of the coefficients values in column 3 of Table 4.

Table 4: Oaxaca-Blinder decomposition results

| Variables | Overall | Endowments | Coefficients |
|---|---|---|---|
| Poorest 90% | 358.673*** | | |
| | (4.211) | | |
| Richest 10% | 509.220*** | | |
| | (11.834) | | |
| Difference | -150.547*** | | |
| | (12.561) | | |
| Endowments | -117.957*** | | |
| | (23.905) | | |
| Coefficients | -66.974*** | | |
| | (10.515) | | |
| Interaction | 34.384 | | |
| | (22.873) | | |
| Learner SES | | -25.226*** | -11.050* |
| | | (6.320) | (5.667) |
| Female | | 0.111 | 1.753 |
| | | (0.188) | (2.229) |
| Parent matric | | -0.307 | 3.268** |
| | | (0.655) | (1.503) |
| Parent post-matric | | -9.652*** | 7.467 |
| | | (3.588) | (5.044) |
| LOLT prior-school | | -10.856*** | 1.724 |
| | | (3.622) | (4.639) |
| Likes maths | | 0.079 | 20.650*** |
| | | (0.158) | (4.956) |
| Maths degree | | 0.134 | 1.049 |
| | | (0.668) | (6.481) |
| Underage | | -1.211** | 0.450 |
| | | (0.613) | (0.441) |
| Overage | | -1.948** | -3.981* |
| | | (0.875) | (2.071) |
| Freq. LOLT | | -2.159 | 10.054 |
| | | (1.437) | (12.485) |
| Pre-primary | | -2.582** | -4.936 |
| | | (1.292) | (4.401) |
| Absent | | -9.329*** | 3.384*** |
| | | (1.715) | (1.178) |
| Expectations | | -0.137 | 5.685 |
| | | (0.751) | (6.274) |
| Small town | | -1.687 | 6.732 |
| | | (4.079) | (5.210) |
| Remote rural | | -1.107 | -0.374 |
| | | (18.645) | (0.552) |
| Bullied - medium | | -1.159* | -1.367 |
| | | (0.601) | (1.838) |
| Bullied - high | | -6.196*** | -0.162 |
| | | (1.682) | (1.064) |
| Library | | -38.652*** | -64.042*** |
| | | (12.104) | (19.910) |
| Test - half | | -6.282 | 7.964* |
| | | (4.124) | (4.452) |

| | | | |
|---|---|---|---|
| Test - most | | 0.679 | 14.969** |
| | | (4.473) | (7.309) |
| Daily computer | | -3.792*** | 0.177 |
| | | (1.266) | (0.524) |
| Homework - 3-4 times | | -2.096 | -2.589 |
| | | (2.556) | (6.676) |
| Homework - daily | | -1.283 | -11.196 |
| | | (3.377) | (10.703) |
| Teacher degree | | 4.667 | 18.986* |
| | | (3.703) | (10.101) |
| Constant | | | -71.171*** |
| | | | (26.591) |
| Observations | 10,088 | 10,088 | 10,088 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

The negative value on endowments indicates that, on average, learners in the richest schools have better factor endowments than those in the poorer schools. The breakdown of the endowment differences is provided in Table 4, and the significant differences (at a 10 per cent level) will be discussed below. Unsurprisingly, given that school SES is constructed using average learner SES, learners in the richest schools have higher individual SES, which accounts for just over 20 per cent of the overall endowment effect. These learners are also better endowed, with at least one parent possessing some sort of post-matric qualification, and more learners in the richest schools spoke the LOLT at home prior to entering school. Fewer learners in the richest schools are the incorrect age for their grade, although this is a relatively small contribution to the overall endowment effect, and only significant at a five per cent level. Also small and significant at a five per cent level, more learners in the richest schools attended pre-primary education before beginning formal education. Nearly eight per cent of the overall endowment effect can be attributed to lower absenteeism in the richest schools, while a further six per cent collectively can be attributed to fewer learners being subjected to high or medium levels of bullying. More rich schools have libraries available, and this accounts for nearly 33 per cent of the overall endowment effect. Fewer of the richest schools use computers or electronics in class on a daily basis. All other endowment effects are relatively small in size, and insignificant at a 10 per cent level, indicating that there are no significant endowment differences in those characteristics or factors between the richest 10 per cent of schools and the other 90 per cent.

The reported total coefficient effect of -66.974 can be interpreted as follows: if the coefficients from the production function for the poorest 90 per cent of schools were to be applied to the endowments of the learners in the richest 10 per cent of schools, learners in the richest schools would achieve, on average, 66.974 points (or 0.66974 standard deviations) lower than their current scores. This suggests that the poorest schools are less efficient at converting inputs (in terms of individual, school, teacher, and classroom characteristics) into educational outcomes, namely achievement in mathematics. Similarly to the decomposition of the overall endowment effect, it is possible to examine the contribution of individual coefficient effects to the overall coefficient effect.

Over 15 per cent of the overall coefficient effect can be attributed to a difference in the coefficient on learner SES, significant at a 10 per cent level. The negative coefficient indicates that high-SES learners in the richest schools in South Africa benefit more than high-SES learners in poorer schools, which is consistent with the findings of Taylor and Yu (2009), van der Berg (2006), and Hungi and Thuku (2010b), discussed in section 2.

While no significant coefficient effect exists for parental education post-matric, the returns to having at least one parent with a completed matric are higher in the poorer 90 per cent of schools. The coefficient effect from a student liking mathematics is double the coefficient effect of learner SES, with the opposite sign. This indicates that there is a higher return to liking mathematics in the poorest 90 per cent of schools than in the richest schools. Additionally, being overage in the poorest 90 per cent of schools has a greater negative effect than in the richest schools. This might potentially be explained by the effectiveness of grade repetition in the two different schooling systems, or it may be indicative of better remedial assistance being offered to repeaters in the richest schools.

The positive coefficient effect for absenteeism indicates that absenteeism is more detrimental to achievement in the richest schools, which may suggest that more work is covered in the richest schools in a day, resulting in a larger achievement penalty for learners in these schools who are absent frequently. There is also a far higher return to having a library in the richest schools, and this effect size makes up over 95 per cent of the overall coefficient effect, although it must be kept in mind that the opposite sign directions of the coefficient effects mean that not only five per cent of the total coefficient effect is attributable to higher returns to other factors—the sum of all the different effect sizes adds up to 100 per cent of the overall effect. This greater return to a library in the richest schools could indicate that the richest schools make better use of the libraries: it is possible that these libraries are better staffed or resourced, or that learners are better encouraged to make use of libraries in these schools.

Returns from testing in approximately half of mathematics lessons and from testing in most or every lesson differ significantly between schools at a 10 per cent and five per cent level respectively, and contribute a collective negative 34 per cent to the total coefficient effect. Frequency of testing is therefore more beneficial in the poorest 90 per cent of schools, especially as the frequency of testing increases. This could mean that in the richest schools, learners benefit more from instructional time than from testing, potentially as a result of higher-quality teaching. On the other hand, if the instructional quality is poor in the poorer schools, the negative effect from losing instructional time while writing tests may be offset by the positive learning resulting from the testing. For teacher qualification, the coefficient effect is large (negative 28 per cent of total coefficient effect), positive, and significant at a 10 per cent level. This indicates that the returns to a teacher having a degree, compared with a diploma or less, in the poorest 90 per cent of schools are higher than in the richest schools. Finally, the constant term represents the intercept of each model's regression, and can be interpreted as the advantage learners in the richest 10 per cent of schools have over learners in the other 90 per cent of schools unrelated to the different endowments and returns to the factors included in this Oaxaca-Blinder decomposition (Da Maia 2012). This is a very large effect, with a size of over 71 points—more than 100% of the overall coefficient effect. This might potentially relate to school or teacher quality factors which are not included in the model, or to differences in characteristics such as the abilities of learners in the different parts of the school system.

## 5 Conclusion

This research aimed to investigate the mathematics performance of Grade 5 South African learners using TIMSS-N 2015 data in order to determine what learner, school, teacher, and classroom characteristics influence achievement, and to gain insight into a more recent South African schooling system than other data sets measure. The results obtained through OLS regression on the entire sample did not yield any surprises, but they did confirm results found in previous studies. Oaxaca-Blinder decomposition was subsequently used to break down the achievement differential between the richest 10 per cent and the other 90 per cent of schools. The most notable finding from this was that the difference was not explained by differences in endowments only: a significant portion of the difference resulted from different returns to the learner, school, classroom, and teacher inputs.

As the results section cautions, the findings of this study cannot be interpreted as causal with direct policy applications. Rather, these findings can be used to identify factors that warrant further investigation, to provide better insight into areas that can be targeted by policy. School language policies could benefit from a closer look at language effects, while the effects of teacher qualification and specialization may provide guidance on optimal teacher training methods. Learner absenteeism appeared as a significant factor in both the OLS regressions and the Oaxaca-Blinder decomposition, and further investigation is required to identify both the reasons for absenteeism and the reasons for the difference in (negative) returns to absenteeism according to school wealth. Similarly, the effects of age appropriateness on performance should be examined further, as it is not immediately clear why over- or underaged learners receive a greater penalty in poorer schools than in richer schools. Policies can then be designed to reduce learner absenteeism and to lessen the negative return to absenteeism, as well as to lessen the negative achievement effects associated with being of an inappropriate age.

Other significant factors that can be influenced by policy or interventions include pre-primary school attendance, school safety (or bullying), learner attitude towards mathematics, and the use of technology in the classroom. In particular, this last factor warrants attention, since the use of technology in classrooms is expensive and relatively new, and it should be used with caution if further studies find a negative association with learner achievement.

As already mentioned, a major limitation of this and similar studies is that it is not always clear what is driving the associations between various factors and achievement, and it is therefore difficult to implement policy reform based on these results. Moving forward, it is the author's belief that results such as these should be used to identify possible areas for intervention, and projects such as the Early Grade Reading Study (Department of Basic Education 2019) and Funda Wande (2019) should be conducted and evaluated with a focus on mathematics achievement, in order to identify effective policy interventions. Future TIMSS studies can provide insight into how national achievement changes over time, but unless interventions are made, it is likely that South Africa will experience little to no improvement, and no reduction in the inequality of educational outcomes.

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## Appendix

Table A1: Complete results from model specifications

| | Model | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Outcome variable | | Mathematics | |
| Learner SES | 20.371*** | 9.097*** | 8.605*** |
| | (1.993) | (1.481) | (1.402) |
| Female | 6.846*** | 6.155*** | 6.193*** |
| | (2.408) | (2.146) | (2.120) |
| Underage | -17.543*** | -9.370*** | -10.468*** |
| | (3.429) | (3.593) | (3.388) |
| Overage | -31.498*** | -28.578*** | -28.131*** |
| | (2.275) | (2.478) | (2.450) |
| Mother matric | 12.251*** | 10.171*** | 10.408*** |
| | (2.643) | (2.405) | (2.190) |
| Mother post-matric | 46.244*** | 32.542*** | 31.445*** |
| | (4.004) | (3.933) | (3.834) |
| Father matric | 8.257*** | 6.529** | 6.598** |
| | (2.598) | (2.639) | (2.587) |
| Father post-matric | 30.341*** | 16.133*** | 15.145*** |
| | (4.149) | (3.951) | (3.856) |
| LOLT prior-school | 35.544** | 16.428 | 19.844 |
| | (14.387) | (14.445) | (14.191) |
| Speak LOLT at home | 33.941*** | 26.894*** | 27.315*** |
| | (4.254) | (4.299) | (3.867) |
| Speak LOLT at home (mis) | -40.258** | -40.909** | -38.415** |
| | (16.718) | (16.555) | (16.535) |
| LOLTxLOLT | 28.510** | 18.926 | 17.322 |
| | (14.152) | (14.579) | (14.420) |
| LOLTxLOLT (mis) | -18.265 | 12.899 | -13.056 |
| | (23.620) | (24.022) | (25.001) |
| No pre-primary | -10.451*** | -7.394*** | -6.488*** |
| | (2.795) | (2.571) | (2.187) |
| Pre-primary (mis) | -8.918** | -7.681** | -5.383 |
| | (3.866) | (3.504) | (3.314) |
| Absent | -26.220*** | -22.957*** | -21.814*** |
| | (2.829) | (2.639) | (2.510) |
| Absent (mis) | -51.679*** | -42.177*** | -37.026*** |
| | (6.569) | (6.760) | (6.150) |
| Absent (omitted) | 93.241*** | 92.427*** | 74.076** |
| | (34.604) | (30.333) | (28.628) |
| Expectations | 8.645*** | 9.367*** | 8.390*** |
| | (2.439) | (2.399) | (2.509) |
| Expectations (mis) | 16.373*** | 8.389** | 9.784** |
| | (6.063) | (4.248) | (4.062) |
| Likes maths | 26.363*** | 26.028*** | 25.138*** |
| | (3.031) | (2.645) | (2.579) |
| Small town | | -17.992** | -19.602*** |
| | | (7.005) | (6.790) |
| Remote rural | | -39.886*** | -38.956*** |

| | | | |
|---|---|---|---|
| | | (7.709) | (7.140) |
| Bullied - medium | -22.439*** | -19.014*** | -17.904*** |
| | (2.876) | (2.508) | (2.460) |
| Bullied - high | -49.893*** | -43.082*** | -36.585*** |
| | (3.813) | (3.398) | (3.194) |
| Bullied (mis) | -71.268*** | -75.061*** | -65.480*** |
| | (13.791) | (14.005) | (13.498) |
| Q2 | | -3.609 | -5.955 |
| | | (8.716) | (7.891) |
| Q3 | | -0.244 | -5.053 |
| | | (8.938) | (9.038) |
| Q4 | | 16.516* | 11.163 |
| | | (9.869) | (9.512) |
| Q5a | | 31.376** | 24.697** |
| | | (12.227) | (11.875) |
| Q5b | | 67.824*** | 62.596*** |
| | | (13.674) | (13.962) |
| No library | | 0.423 | 1.276 |
| | | (6.147) | (6.381) |
| Library (mis) | | 22.754 | 17.870 |
| | | (20.268) | (21.319) |
| Class size | | -0.527** | -0.496** |
| | | (0.244) | (0.234) |
| Maths degree | | | 11.586** |
| | | | (5.382) |
| Test - half | | | 2.301 |
| | | | (6.341) |
| Test - most | | | -2.543 |
| | | | (6.984) |
| Test (mis) | | | 23.955* |
| | | | (12.405) |
| Daily computer | | | -18.380*** |
| | | | (3.758) |
| Computer (mis) | | | -24.430*** |
| | | | (4.619) |
| Homework - 3-4 times | | | 14.459** |
| | | | (6.831) |
| Homework - daily | | | 7.287 |
| | | | (6.175) |
| Homework (mis) | | | -54.006*** |
| | | | (18.935) |
| Male teacher | | | 0.809 |
| | | | (6.009) |
| Teacher gender (mis) | | | 12.416 |
| | | | (15.673) |
| Teacher degree | | | 7.562 |
| | | | (5.580) |
| Degree (mis) | | | -34.348** |
| | | | (14.364) |
| Constant | 345.268*** | 380.059*** | 368.791*** |
| | (6.997) | (14.804) | (16.192) |

| | | | |
|---|---|---|---|
| Observations | 10,932 | 10,205 | 10,205 |
| R-squared | 0.442 | 0.520 | 0.538 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

Table A2: Complete results from Oaxaca-Blinder model specifications

| | Model | |
|---|---|---|
| | (4) | (5) |
| Outcome variable | Mathematics | |
| | Richest 10% | Poorest 90% |
| Learner SES | 17.900*** | 8.929*** |
| | (4.415) | (1.474) |
| Female | 3.719 | 7.566*** |
| | (4.459) | (2.222) |
| Parent matric | -3.403 | 13.931*** |
| | (7.391) | (2.748) |
| Parent post-matric | 23.706*** | 37.524*** |
| | (8.712) | (3.739) |
| LOLT prior-school | 35.986*** | 40.196*** |
| | (9.073) | (7.051) |
| Likes maths | 5.047 | 31.304*** |
| | (5.804) | (2.651) |
| Maths degree | 5.677 | 7.955 |
| | (13.076) | (5.931) |
| Underage | -19.436** | -9.414*** |
| | (9.143) | (3.428) |
| Overage | -16.234** | -28.779*** |
| | (6.057) | (2.543) |
| Freq. LOLT | 18.781 | 29.176*** |
| | (12.643) | (3.822) |
| Freq. LOLT (mis) | - | |
| Pre-primary | 13.260** | 5.879** |
| | (6.293) | (2.345) |
| Pre-primary (mis) | 0.837 | 0.665 |
| | (9.698) | (3.388) |
| Absent | -40.830*** | -20.733*** |
| | (6.119) | (2.573) |
| Absent (mis) | 8.213 | -41.895*** |
| | (21.161) | (6.285) |
| Expectations | 1.540 | 9.545*** |
| | (8.639) | (2.635) |
| Expectations (mis) | 18.832 | 1.654 |
| | (13.142) | (5.221) |
| Small town | -55.129** | -19.366*** |
| | (24.208) | (6.990) |
| Remote rural | -2.694 | -39.572*** |
| | (46.503) | (6.786) |
| Bullied - medium | -12.557** | -17.141*** |
| | (5.685) | (2.673) |
| Bullied - high | -35.827*** | -37.186*** |
| | (8.431) | (3.486) |

| | | |
|---|---|---|
| Bullied (mis) | 94.810*** | -61.822*** |
| | (18.552) | (13.628) |
| Library | 72.335*** | 0.985 |
| | (21.299) | (6.441) |
| Test - half | -42.096** | 11.443* |
| | (19.590) | (6.738) |
| Test - most | -45.389** | 5.249 |
| | (18.162) | (7.094) |
| Daily computer | -21.226*** | -18.603*** |
| | (6.828) | (3.986) |
| Computer (mis) | -12.253 | -24.799*** |
| | (16.489) | (4.838) |
| Homework - 3-4 times | 20.326 | 13.824* |
| | (15.203) | (7.686) |
| Homework - daily | 30.941 | 6.279 |
| | (22.495) | (6.798) |
| Teacher degree | -21.376 | 8.046 |
| | (14.275) | (5.842) |
| Teacher degree (mis) | -97.616*** | -39.469** |
| | (17.829) | (15.445) |
| Constant | 405.134*** | 333.963*** |
| | (24.893) | (10.862) |
| Observations | 1,086 | 9,002 |
| R-squared | 0.490 | 0.387 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author's calculations based on TIMSS-N 2015 South African Grade 5 data.

Table A3: Complete results from Oaxaca-Blinder decomposition

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variables | Overall | Endowments | Coefficients | Interaction |
| Poorest 90% | 358.673*** | | | |
| | (4.211) | | | |
| Richest 10% | 509.220*** | | | |
| | (11.834) | | | |
| Difference | -150.547*** | | | |
| | (12.561) | | | |
| Endowments | -117.957*** | | | |
| | (23.905) | | | |
| Coefficients | -66.974*** | | | |
| | (10.515) | | | |
| Interaction | 34.384 | | | |
| | (22.873) | | | |
| Learner SES | | -25.226*** | -11.050* | 12.642* |
| | | (6.320) | (5.667) | (6.474) |
| Female | | 0.111 | 1.753 | 0.115 |
| | | (0.188) | (2.229) | (0.203) |
| Parent matric | | -0.307 | 3.268** | 1.564* |
| | | (0.655) | (1.503) | (0.809) |
| Parent post-matric | | -9.652*** | 7.467 | -5.625 |
| | | (3.588) | (5.044) | (3.819) |
| LOLT prior-school | | -10.856*** | 1.724 | -1.270 |
| | | (3.622) | (4.639) | (3.423) |
| Likes maths | | 0.079 | 20.650*** | 0.413 |
| | | (0.158) | (4.956) | (0.686) |
| Maths degree | | 0.134 | 1.049 | 0.054 |
| | | (0.668) | (6.481) | (0.409) |

| | | | | |
|---|---|---|---|---|
| Underage | | -1.211** | 0.450 | 0.624 |
| | | (0.613) | (0.441) | (0.610) |
| Overage | | -1.948** | -3.981* | -1.505* |
| | | (0.875) | (2.071) | (0.867) |
| Freq. LOLT | | -2.159 | 10.054 | -1.195 |
| | | (1.437) | (12.485) | (1.489) |
| Freq. LOLT (mis) | | 0.000 | 0.000 | -0.067 |
| | | (0.000) | (0.000) | (0.041) |
| Pre-primary | | -2.582** | -4.936 | 1.437 |
| | | (1.292) | (4.401) | (1.308) |
| Pre-primary (mis) | | 0.040 | -0.026 | -0.008 |
| | | (0.456) | (1.545) | (0.483) |
| Absent | | -9.329*** | 3.384*** | 4.592*** |
| | | (1.715) | (1.178) | (1.570) |
| Absent (mis) | | 0.128 | -0.118 | -0.781** |
| | | (0.322) | (0.080) | (0.355) |
| Expectations | | -0.137 | 5.685 | -0.712 |
| | | (0.751) | (6.274) | (0.830) |
| Expectations (mis) | | -0.798 | -2.590 | 0.728 |
| | | (0.857) | (2.166) | (0.843) |
| Small town | | -1.687 | 6.732 | 1.095 |
| | | (4.079) | (5.210) | (2.711) |
| Remote rural | | -1.107 | -0.374 | -15.159 |
| | | (18.645) | (0.552) | (18.912) |
| Bullied - medium | | -1.159* | -1.367 | -0.423 |
| | | (0.601) | (1.838) | (0.579) |
| Bullied - high | | -6.196*** | -0.162 | -0.235 |
| | | (1.682) | (1.064) | (1.545) |
| Bullied (mis) | | 0.596*** | -0.050 | -0.985*** |
| | | (0.185) | (0.051) | (0.280) |
| Library | | -38.652*** | -64.042*** | 38.126*** |
| | | (12.104) | (19.910) | (12.557) |
| Test - half | | -6.282 | 7.964* | 7.989* |
| | | (4.124) | (4.452) | (4.848) |
| Test - most | | 0.679 | 14.969** | -0.758 |
| | | (4.473) | (7.309) | (4.989) |
| Daily computer | | -3.792*** | 0.177 | 0.469 |
| | | (1.266) | (0.524) | (1.387) |
| Computer (mis) | | -0.481 | -0.439 | -0.493 |
| | | (0.649) | (0.601) | (0.677) |
| Homework - 3-4 times | | -2.096 | -2.589 | 0.671 |
| | | (2.556) | (6.676) | (1.842) |
| Homework - daily | | -1.283 | -11.196 | 1.023 |
| | | (3.377) | (10.703) | (2.761) |
| Teacher degree | | 4.667 | 18.986* | -6.424 |
| | | (3.703) | (10.101) | (4.397) |
| Teacher degree (mis) | | 2.548 | 2.805 | -1.518 |
| | | (4.724) | (2.949) | (2.866) |
| Constant | | | -71.171*** | |
| | | | (26.591) | |
| Observations | 10,088 | 10,088 | 10,088 | 10,088 |

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: author’s calculations based on TIMSS-N 2015 South African Grade 5 data.