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Stellenbosch Economic Working Papers: WP04/2022

www.ekon.sun.ac.za/wpapers/2022/wp042022

June 2022

KEYWORDS: gender inequality, STEM, mathematics performance, science performance, school dropout, repetition, attitudes, South Africa
JEL: C21, I20, I21, I24, J16

DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH
SOUTH AFRICA

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

Mind The Gap –
An Analysis of Gender Differences in Mathematics and Science Achievement in South Africa

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Rebekka Rühle[1]

Abstract:

This paper studies gender differences in mathematics and science achievement using the most recent Trends in International Mathematics and Science Study (TIMSS) data from 2019. Moreover, since grade repetition and dropouts are very common in South Africa and affect the magnitude of gender gaps, the first part of the analysis studies current gender differences in grade repetition and dropout. The descriptive analysis shows that South African boys are more likely to repeat a grade and to drop out of school compared to South African girls. Furthermore, girls outperform boys on average in mathematics and science, both in Grade 5 and 9, but the pro-girl gap is smaller in Grade 9. This suggests that the pro-girl advantage declines at higher grades. Another focus of the paper is to identify potential sources of the gender gaps besides the South African specific factors. This section finds that part of the pro-girl gap in Grades 5 and 9 can be attributed to the female advantage in school progression. Thus, without controlling for gender differences in over-age and dropouts by creating more comparable groups one would bias gender gaps in achievement. Furthermore, this paper shows that there are significant gender differences in attitudes towards mathematics and school in general and some are correlated with the gender differences in achievement. The multivariate analysis employing an ordinary least squares regression with interaction effects and school fixed effects shows that most considered interaction effects are not statistically significant in Grade 5, but several ones are significant in Grade 9. For example, ninth-grade girls are less affected by weekly bullying than their male peers, but value mathematics less. Although the results are an important step towards understanding the female advantage in mathematics and science, we need more studies that explain why girls are less likely to enrol in STEM degrees and why the pro-girl advantage in education does not result in a female advantage in the labour market. Moreover, the results show clearly that South African girls and boys face different challenges during their school careers, which both need equal attention.

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Many thanks to Professor Servaas van der Berg for offering me his guidance and knowledge throughout the process of this paper and beyond. Moreover, I want to thank all other lecturers in the (Stellenbosch) Economics Department that helped me along the way. Special thanks to Dr Heleen Hofmeyr for her helpful inputs.

1 Introduction

"My hope is that in the future, women stop referring to themselves as "the only woman" in their physics lab or only one of two in their computer science jobs." - U.S. Senator Kirsten Gillibrand

It is a well-documented fact, that boys and girls around the world still have different opportunities, rights, and life chances.[2] The three areas that received a lot of attention from researchers and policymakers are gender differences in education, labour market opportunities, and wages (Spaull and Makaluza, 2019). This paper focuses on gender inequality in education, specifically, on gender differences in mathematics and science performance since, historically, gender inequality in labour market and education outcomes was particularly large in the science, technology, engineering, and mathematics (STEM) fields.

Over the last few years, there have been several global efforts to increase and equalise the participation of girls in education. Consequently, most countries have achieved gender parity in access to primary and secondary schooling (Klasen, 2020). South Africa has no statistically significant gender gaps in access and attendance (Hall et al., 2018). Thus, the focus of researchers and politicians shifted towards gender gaps in achievement. In South Africa, girls outperformed boys in all past international literacy assessments and the gender gaps in mathematics became smaller or insignificant over the last years (Hofmeyr, 2020; Isdale et al., 2017; Spaull and Makaluza, 2019; Zuze et al., 2017). The above-mentioned studies all use data from 2016 or earlier. The most recent Trends in International Mathematics and Science Study data (TIMSS 2019) was published at the end of 2020 and has not been comprehensively analysed for gender differences in South Africa yet. Thus, this paper will analyse current gender differences in mathematics and science achievement and gender differences between population groups, location, school quintile, and provinces.

Moreover, several studies show that country grade averages are not accurate in countries with gender differences in repetition and dropout rates. South Africa is such a country as boys are more likely to repeat a grade and to drop out of school compared to girls (Van der Berg et al., 2019). Without accounting for this, calculated gender gaps in achievement would be biased. No literature has been found documenting both the effect of gender differences in repetition and dropout on student performance in South Africa. Hence this paper analyses whether girls outperform boys in numeracy because they learn more with the same amount of schooling, or because they proceed faster through school.

[2] See, for example, Klasen (2020) and World Bank (2011).

The pro-girl gaps continue in higher education. Van Broekhuizen and Spaull (2017) use a six-year panel data set for the period 2009 to 2014 and show that girls have an advantage in higher education. For example, 34% more girls than boys enrolled in university, and 66% more girls completed a bachelor's degree. Moreover, the authors find that girls are statistically more likely to graduate in certain fields compared to boys. Girls are more likely to graduate in 12 out of 19 fields, whereas boys are statistically more likely to graduate in five of the 19 fields, including engineering, mathematical sciences, and computer sciences (Van Broekhuizen and Spaull, 2017).

Although South African women are better educated than South African men, they remain underrepresented in the labour market (Spaull and Makaluza, 2019), particularly in higher skilled occupations. South Africa is not alone. All over the world women have lower labour force participation rates compared to men. The rates have increased substantially over the last years, both globally (Klasen, 2020) as well as in South Africa (Mosomi, 2019a). Nevertheless, South African women are still more likely to be unemployed, participating in unpaid work, and have a ten-percentage point lower labour force participation rate compared to South African men (Stats SA, 2021). Moreover, women are underrepresented in several occupations and especially in STEM fields and management and leadership positions, which tend to be better paid (Gradín, 2021; Shepherd, 2017). This might partially explain the persistent gender wage gap of around 16% in South Africa (Mosomi, 2019a, 2019b). The underlying question is why the female advantage in education does not lead to a female advantage in the labour market, and why are girls less likely to study a STEM degree initially if they perform as well or better than boys?

Given the underrepresentation of women in STEM fields, research is increasingly concerned with understanding the sources of gender gaps in mathematics achievement (Else-Quest et al., 2010). International evidence suggests that boys often report having more positive attitudes towards mathematics and science, despite having similar mathematics and science achievements (Meinck and Brese, 2019). The question is, are there gender differences in attitudes in South Africa and can those differences explain gender gaps in mathematics and science achievement, and hence, potentially provide evidence why fewer women pursue careers in STEM fields? Moreover, there are several other explanations for gender differences in learners' achievement. They range from biological (Fryer and Levitt, 2010) to social, and from cultural to school (Alexander, 2016; Buhl-Wiggers et al., 2021) and behavioural factors (Hofmeyr, 2020; Shepherd, 2017).

The majority of the South African studies focused on documenting gender gaps in achievement rather than on identifying potential sources of the gender gaps. There are a few studies such as Hofmeyr (2020), Shepherd (2017) and partially also Zuze and Beku (2019) that try to provide explanations. Yet, those studies either focus on one specific grade, some specific explanations such as attitudes or teacher gender, or report only some examples. Thus, it requires new research that considers multiple factors that can explain the observed gender differences in various grades. This is another focus of this paper.

An important result from this analysis is that South African girls outperformed boys in 2019 on average in mathematics and science, and in the majority of the considered subgroups, both in Grades 5 and 9, but the pro-girl gap is smaller in Grade 9. Moreover, part of the pro-girl gaps in Grades 5 and 9 can be attributed to the female advantage in school progression. Furthermore, this paper finds that there are significant gender differences in attitudes towards mathematics and school in general and some are correlated with the gender differences in achievement.

This paper proceeds as follows: section two provides a literature review; section three describes the data and methodology; section four provides an analysis of gender differences in repetition and dropout, as well as mathematics and science performance for Grades 5 and 9; section 5 considers gender differences in attitudes, followed by OLS results investigating gender differences in achievement with controls for repetition, dropout, attitudes, teacher gender and more; and section 6 concludes.

2 Literature Review

Before discussing gender issues in education, it is useful to distinguish some terminologies. *"Gender equality"* in education refers to equal rights, responsibilities, and treatment of students regardless of their gender. "*Gender equity*" implies policies and other practices that enhance the fair and equal treatment of girls and boys in education and "*gender parity"* means, for example, that equal numbers of boys and girls attend schools. Thus, gender equality can be seen as the ultimate goal, while gender parity and equity refers to attempts to achieve gender equality (Zuze and Beku, 2019).

The first section of the literature review provides an overview of the international and South African literature on gender differences in achievement, followed by an overview of some selected local and international studies on gender differences in repetition and dropout. The third section discusses potential reasons for gender differences in achievement.

2.1 Gender Differences in Achievement

Gender disparities in learning outcomes are still widespread (Benavot and UNESCO, 2015; World Bank, 2011). Many quantitative analyses on learning outcomes use data from cross-national assessments such as the Program for International Student Assessment (PISA), the Progress in

International Reading and Literacy Study (PIRLS), and the TIMSS study, because they are nationally representative and comparable across countries.

The international evidence on the relationship between educational achievement and gender is mixed, both across countries and within countries over time. In most developed countries girls currently do significantly better in reading whereas the evidence in mathematics and science is less clear. In all 79 countries that participated in PISA in 2018, 15-year-old girls outperformed their male peers in reading by 30 score points on average (OECD, 2019). A similar result was observed in PIRLS 2016. Of the 50 countries that participated in PIRLS, 48 had a pro-girl reading gap and two countries had no statistically significant gender gap (Mullis et al., 2017).[3]

In mathematics, boys outperformed girls on average across the participating PISA countries, but only by five score points. According to the PISA study, there is a pro-boy gap in 32 countries and a pro-girl gap in 14 countries (OECD, 2019). Interestingly, in TIMSS 2015, which has about the same participating countries as PISA, most countries had no significant gender differences and there were more countries where ninth-grade level girls outperformed boys than the other way round. Contrastingly, fourth-grade level boys had a higher average mathematics achievement than girls and boys significantly outperformed girls in more countries than vice versa (Mullis et al., 2017).

In contrast to mathematics and in the PISA 2015 assessment, on average, girls slightly outperformed boys in science in 2018. In 34 countries girls performed better in science than boys, while in six countries boys performed better than girls (OECD, 2019, 2016). In most participating TIMSS-countries there were no significant gender differences in science in Grades 4 and 8 (Martin et al., 2016). This suggests that the pro-boy gap in mathematics is no longer as clear as in the past and on average girls are doing equally well or better in science.

It should be noted that the above-mentioned figures are all country averages and that gender differences vary along the distribution. In most PISA-participating countries the variation in test scores is larger for boys in reading, mathematics, and science which means that more boys are both among the weakest performing and the best performing students (OECD, 2019).

In developing countries, there is somewhat more variation in the magnitude and direction of gender gaps, but in most countries, as in developed countries, girls do better at reading and gender differences in mathematics are mixed (Dercon and Singh, 2013; Saito, 2011). Dickerson et al. (2015) use the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) and the Program for the Analysis of Education Systems (PASEQ) data from 2007 for 19 Sub-Saharan African

[3] PISA, PIRLS and TIMSS test scores are all scaled to a mean of 500 and a standard deviation of 100.

countries. The authors find that boys significantly outperform girls in mathematics in ten countries and girls significantly outperform boys in three of the 19 countries. In a second step, the authors compare girls and boys with similar characteristics such as similar family background and schooling environment, then all countries have significant pro-boy gaps or no significant gender differences in mathematics. Moreover, the 2007 SACMEQ data shows that five out of 14 countries had a significant pro-girl reading gap and Malawi and Tanzania had a significant pro-boy reading gap (Saito, 2011). In Indonesia, girls outperform boys in primary schools both in literary and numeracy and the gap widens during secondary school (Suryadarma, 2015). More recent evidence from Buhl-Wiggers et al. (2021) shows that girls in Uganda, Kenya and Tanzania significantly outperform boys in literacy and numeracy. The authors use large-scale nationally representative household surveys which include learning outcomes of all children in the household and hence can control for unobserved household characteristics by using fixed effects. They show that the gender gaps are robust across all ages between six and 16. Moreover, they find that average gender differences vary across household factors and geographical locations (Buhl-Wiggers et al., 2021).

South Africa has participated in several regional and international assessments including SACMEQ, PRILS and TIMSS and hence several reliable sources on learners' achievement exist (Spaull and Makaluza, 2019; Zuze and Beku, 2019). In South Africa, girls outperformed boys in all past international literacy assessments and the gender gaps in mathematics have become smaller or insignificant over the last few years (Isdale et al., 2017; Spaull and Makaluza, 2019; Van Broekhuizen and Spaull, 2017; Zuze et al., 2017).

The reading gap in South Africa is so big that girls in Grade 4 who participated in the PIRLS Study were regarded one year ahead of the boys in Grade 4. This pro-girl gap is larger than in most other participating PIRLS countries and this gap occurred already in the first years of primary school (Mullis et al., 2017; Spaull and Makaluza, 2019).

The picture is less clear with regards to mathematics. Between 1995 and 1999 boys outperformed girls in mathematics, whereas after 1999 the difference declined. After 2005 girls outperformed boys, although not statistically significantly (Spaull and Makaluza, 2019). The more recent TIMSS studies (2011, 2015) also showed that South African girls performed better in mathematics and science, but the differences were not statistically significant at the Grade 9 level. Contrastingly, at the Grade 5 level, girls significantly outperformed boys by 16 test points in 2015 (Isdale et al., 2017).

Moreover, the studies by Van Broekhuizen and Spaull (2017) and Zuze and Beku (2019) show that gender gaps in South Africa differ across grades, socioeconomic status (SES), population group, location, and the schooling context, even though the direction remains mostly the same.

Zuze and Beku (2019) find that fifth-grade girls outperform fifth-grade boys in each school category. Contrastingly, in Grade 9, Zuze and Beku (2019) and Shepherd (2017) find that gender gaps differ by school quintile.[4] For example, Shepherd (2017) uses TIMSS 2011 data and shows that ninth-grade boys in Quintile 5 schools significantly outperform ninth-grade girls in mathematics and science by 33 test points, while there are no significant gender differences in Quintile 1 to 4 schools.

Although the gender differences in mathematics are small or insignificant in Grade 9, the picture changes in the National Senior Certificate, also known as Matric. In 2018 there is a pro-boy gap in mathematics, and boys have on average five percentage points higher test scores. Moreover, boys outperform girls in six out of 13 subjects including physical sciences, while girls outperform boys in subjects such as life orientation and English. However, Spaull and Makaluza (2019) show that the sample of females is not comparable to the sample of males due to sample selection. They show that boys are more likely to drop out and hence for every 100 girls who wrote Matric in 2018 there were only 80 boys. Consequently, they show that girls outperform boys in all subjects if one compares an equal number of boys and girls (Spaull and Makaluza, 2019).

In summary, in most countries as well as in South Africa girls do significantly better in reading whereas the evidence in mathematics and science is less clear.

2.2 Gender Differences in Repetition and Dropout

Although there are no substantial gender differences in initial school enrolment in South Africa, there are large and significant gender differences in repetition and dropout rates. South African boys are more likely to repeat a grade and to drop out of school compared to girls. This is not only the case in South Africa. Boys are more likely to repeat a grade in all considered regions, except in East Asia and the Pacific (UNESCO Institute for Statistics, 2012).

Repetition is often overlooked in the South African education system, although it is very common. Repetition is not only costly, but also indicates high levels of inefficiencies in the system (Van der Berg et al., 2021, 2019).[5] Due to high rates of repetition, a large proportion of South African learners are over-aged for their grade. The proportion of over-aged learners not only differs by gender but also by school quintile, whereby poorer schools have larger proportions of over-aged learners (Van der Berg et al., 2021). One-third of the learners are already over-aged by Grade 4 in 2018 and 2019. This

[4] School quintiles are a common way to clarify schools according to SES in South Africa. The Department of Basic Education (DBE) classifies schools into wealth quintiles using the poverty level of the community in which the schools are located as a proxy for the wealth of the students.

[5] Van der Berg et al. (2019) estimate that the cost of repetition is 20 billion Rand, which corresponds to 8% of the national budget assigned to basic education in 2018/2019.

number increases to over 55% in Grades 10, 11 and 12 (Van der Berg et al., 2021). Instead of catching up, repeating a grade is often associated with worse subsequent school performance (Hofmeyr, 2020).

Girls are more likely to be on track in terms of completed grade for age (Van der Berg et al., 2021, 2019; Zuze and Beku, 2019). The Community Survey (2016) data shows that already by Grade 1, male repetition rates were four percentage points higher compared to female repetition rates in 2016. This number increases to approximately six percentage points by Grade 4 (Van der Berg et al., 2019). The gap becomes smaller in Grades 9 and 10 because a larger share of boys drops out of school. Notably, by Grade 6 the dropout rates are already higher for boys compared to girls, but the gap increases substantially in higher secondary schooling (Branson et al., 2014; Spaull and Makaluza, 2019; Van der Berg et al., 2019). Since boys are more likely to repeat, there are more boys in each grade up to Grade 9. In Grade 9 there should be roughly equal numbers of girls and boys because there are more boys than girls that drop out of school. Thereafter, due to the higher male dropout rate, there are significantly more girls in schools in Grade 10 to 12 (Van der Berg et al., 2019).

Some studies showed that the reasons why girls and boys drop out of school are not always the same. Gustafsson (2011) suggests that one common reason why girls drop out of school is due to teenage pregnancy. Boys on the other hand often drop out due to financial reasons or because they are looking for jobs (Branson et al., 2014). Nevertheless, an often-cited reason for school dropout by both genders is academic difficulties (Gustafsson, 2011).

Gender differences in repetition and dropout is one source of sample selection bias. Without accounting for it, one might overestimate gender gaps in achievement. Sample selection with respect to repetition would not be a problem if one has performance data of 15-year-old learners that attend school and are enrolled in different grades, as is the case in the PISA assessments (Ferreira and Gignoux, 2014). Nevertheless, such data is not available for South Africa. Moreover, given that males are more likely to drop out, the remaining sample is more selective. For example, if boys that drop out are weaker students than the remaining boys and the sample of girls includes both types of students, then without accounting for it one would bias the estimates (Spaull and Makaluza, 2019; Zuze and Beku, 2019).

Crawfurd (2021) shows that without accounting for repetition and dropouts one would over-estimate the learning per year in Rwanda by over 60%. Moreover, Buhl-Wiggers et al. (2021) estimate that half of the observed pro-girl gender gap in Uganda, Kenya and Tanzania can be explained by the fact that girls proceed faster through primary schools. For South Africa, Hofmeyr (2020) uses an Oaxaca decomposition analysis and finds that part of the observed pro-girl achievement gap in Grade 4 and 5 in PILRS 2016 and TIMSS 2015 is the result of a selection effect, as boys are more likely to repeat a grade. Moreover, she finds that part of the pro-girl gaps remains if one compares only learners that are the appropriate age for that grade (Hofmeyr, 2020). As mentioned earlier, Spaull and Makaluza (2019) show that accounting for higher male dropout rates by creating enrolment-comparable cohorts changes the sign of the gender gap in mathematics and physical science from a pro-boy gap to a pro-girl achievement gap. This demonstrates how important it is to account for repetition and dropouts in countries with high repetition and dropout rates.

This reiterates the question: do South African girls outperform boys in literacy and numeracy because they learn more with the same amount of schooling or because they progress faster through school?

2.3 Potential Reasons for Gender Differences in Achievement

Besides repetition and dropping out, there are several other explanations for gender differences in learners' achievement. The explanations range from biological (Buhl-Wiggers et al., 2021; Fryer and Levitt, 2010) to social factors, and from cultural to school (Alexander, 2016; Buhl-Wiggers et al., 2021; Dickerson et al., 2015; Zuze and Beku, 2019) and behavioural factors (Hofmeyr, 2020; Shepherd, 2017; Zuze and Beku, 2019) and can be controversial (Zuze and Beku, 2019).

There are different theories on how biological differences may explain differences in academic achievement, particularly in mathematics and science. Some theories suggest that differences in spatial ability or brain structure might explain some differences in STEM achievement (Wilder and Powell, 1989). Others argue that girls perform better in school because they develop cognitive skills earlier (Gierl et al., 2003). Ceci et al. (2009) argue that the evidence is contradictory. Overall, the literature is undecided on how large the influence of biological differences is. Nevertheless, it is unlikely that biological factors explain the whole story (Buhl-Wiggers et al., 2021).

Several family factors, such as socioeconomic status (SES), are likely to influence gender differences in achievement (Buhl-Wiggers et al., 2021). If household resources are scarce, for example, due to an income shock, parents may have to decide in which child they will invest primarily. Some papers find that parents invest in their male children (Alcott and Rose, 2015; Björkman-Nyqvist, 2013). Studies from South Africa show that SES and gender interact in important ways (Shepherd, 2017; Spaull and Makaluza, 2019; Zuze et al., 2017). Wealthier families have access to a larger variety of schools. They tend to send their children to schools in higher quintiles that are better-equipped (van Dyk et al., 2019; Zuze and Beku, 2019). Moreover, Hofmeyr (2020) finds that the pro-girl achievement gap decreases with the school quintile.

Another dimension of socioeconomic status is parental education. Studies have shown that parental education and particularly maternal education is correlated with several educational outcomes

(Alexander, 2016; World Bank, 2011). Educated mothers or parents tend to have a higher preference for educated girls compared to uneducated mothers and hence invest relatively more in the education of their female children. Furthermore, having an educated mother might raise the aspirations of girls (Buhl-Wiggers et al., 2021).

Moreover, school location might explain gender differences in achievement. In rural areas, cultural practices tend to be more traditional than in urban areas and hence might be more restrictive for the education of girls (Zuze and Beku, 2019). One reason might be that girls in rural areas are responsible for time-consuming activities such as collecting water and firewood, and looking after younger siblings (Aikman and Unterhalter, 2007). Zuze and Beku (2019) find the opposite for South Africa. They find that girls in rural areas significantly outperform boys in mathematics and science and that this pro-girl achievement gap is larger than in urban areas.

Furthermore, school factors such as differences in bullying, sense of belonging, class behaviour and teacher gender are likely to influence gender differences in achievement (Hofmeyr, 2020; Mullis et al., 2020; Zuze and Beku, 2019). Several studies in South Africa and other countries have shown that boys are more likely to be bullied, whereas girls are more likely to experience sexual violence at school (Burton and Leoschut, 2013; Popp et al., 2014; Zuze and Beku, 2019). Results from TIMSS 2019 show that being bullied frequently and regularly engaging in disorderly behaviour is associated with lower mathematics and science achievement across several countries (Mullis et al., 2020). Moreover, a study shows that boys in the UK benefit more from instructional clarity and respond more negatively than girls to poor teaching due to disruptive behaviour (Machin and McNally, 2005). Other studies have suggested that girls have a higher sense of school belonging, which in turn might partially explain the pro-girl achievement gap (Hofmeyr, 2020; Hughes et al., 2015).

Another important factor might be that teachers treat girls and boys differently, for example by having different academic expectations (Buhl-Wiggers et al., 2021; Jones and Dindia, 2004). Some scholars find that girls perform better at school if they have a female teacher, while there is no effect on boys (Lee et al., 2019; Muralidharan and Sheth, 2016) or, instead, a positive effect on boys (Hwang and Fitzpatrick, 2021). Other studies, in turn, find that boys perform better if they have a same-sex teacher (Dee, 2007). Contrastingly, Shepherd (2017) finds that having a female teacher with a mathematics background is negatively associated with girls' performance in wealthier schools in South Africa, but not in poorer schools. This suggests that the relationship between teacher gender and student gender is highly context specific.

Moreover, research has shown that gender differences in mathematics and science attitudes are correlated with gender gaps in achievement (Zuze et al., 2017). Results from TIMSS 2019 show that learners with positive attitudes such as 'liking mathematics' and 'valuing mathematics' have higher average test scores (Mullis et al., 2020). Despite similar mathematics and science achievements, international evidence suggests that boys often report having more positive mathematics and science attitudes (Meinck and Brese, 2019). They typically report having higher intrinsic motivation, greater mathematics and science enjoyment, higher levels of confidence in both subjects and a higher likelihood to pursue a STEM-related career. In contrast, girls often report having lower self-efficacy and self-concept, valuing mathematics and science less and having higher levels of mathematics and science anxiety (Else-Quest et al., 2010; OECD, 2015, 2013).[6]

Evidence from South Africa shows, on the one hand, that fifth-grade students do not report large gender differences in the level of confidence in 2015. On the other hand, a larger proportion of ninth-grade boys report being confident in mathematics compared to girls (Zuze and Beku, 2019). This may suggest that girls become less confident over time (Zuze and Beku, 2019). Some studies have shown that competency beliefs fall over the school career and differ by gender (Jacobs et al., 2002). Moreover, Shepherd (2017) finds for Grade 9 that there are no gender differences in the level of reported confidence in Quintile 1 to 4 schools. Contrastingly, girls attending Quintile 5 schools have lower levels of confidence compared to their male counterparts and have significantly lower levels of mathematics and science achievement.

Finally, it should be noted that it is usually an interplay of the different factors that influence the achievement and hence it is practically impossible to disentangle the influence of each factor (Alexander, 2016; Cobb-Clark and Moschion, 2017). Nevertheless, for methodological reasons it makes sense to distinguish between categories (Hofmeyr, 2020).

There are few studies including the paper by Hofmeyr (2020), Shepherd (2017) and partially the paper by Zuze and Beku (2019) that try to provide explanations for the observed gender differences in South Africa. However, those studies either focus on one specific grade, some specific explanations such as attitudes or teacher gender, or report only some examples. Thus, it requires new research considering multiple factors that can explain the observed gender differences in various grades.

3 Data and Method

This paper uses in large parts the most recent TIMSS data from 2019. For the learner flow section, the most recent General Household Survey data is used (GHS 2019). TIMSS is conducted by the

[6] See OECD (2013) and Zuze and Beku (2019) for the definitions and differences between intrinsic motivation, self-efficacy (self-confidence) and self-concept.

International Association of the Evaluation of Educational Achievement (IEA) and was administered by the Human Sciences Research Council (HSRC) in South Africa (HSRC, 2019). Since the official TIMSS data does not include provincial information and school quintiles, the IEA TIMSS data were merged with TIMSS (2019) data provided by the HSRC which includes both provinces and school quintiles.[7]

TIMSS is an international standardized large-scale assessment conducted approximately every four years and was conducted most recently in 2019. Thousands of students all over the world write the same test in which they are tested on their mathematics and science knowledge, and their problem-solving skills (Mullis et al., 2020). TIMSS was initially developed to compare educational achievements across high-income countries, but today some low- and middle-income countries also participate (Hofmeyr, 2020).

Countries that suspect that the tests are too difficult have the option to administer the assessment to Grades 5 and 9 students instead of Grades 4 and 8 students and can write the less difficult mathematics assessment called 'TIMSS Numeracy' (Hofmeyr, 2020; Isdale et al., 2017). Fifty five countries participated in the Grade 4 assessment, and 39 countries participated in the Grade 8 assessment (Mullis et al., 2020). South Africa chose to conduct the assessment with learners from Grades 5 and 9 and opted for the Numeracy version in mathematics in Grade 5 (Reddy et al., 2020a, 2020b).

TIMSS data is particularly suitable for this analysis because it contains several contextual questions. For example, students, their teachers and principals were asked questions about their socio-economic background, the school environment, and their classroom and school experience (Mullis et al., 2020).

TIMSS employs a two-stage stratified cluster sampling design, to achieve that the data is nationally representative (Isdale et al., 2017; Martin et al., 2020). Moreover, TIMSS uses an item response theory scaling method to create five plausible values for each student (Martin et al., 2020; Reddy et al., 2020b). For simplicity, and similarly to Shepherd (2017), only the first plausible value is used in this study. The test scores are scaled to a mean of 500 and a standard deviation of 100. The 500 represents approximately the average of a typical learner across all participating countries in the first round of TIMSS in 1995, with a standard deviation of 100, where 40 points is often considered roughly equivalent to one year of learning.[8]

[7] It is noteworthy that these quintiles are the quintiles that the Department of Basic Education uses to classify schools according to SES, but they may not be fully accurate.

[8] See Martin et al. (2020) and Isdale et al. (2017) for more information on the scale. The actual standard deviation of South Africa in Grade 5 is 98 in mathematics and 129 in science and in Grade 9 77 in mathematics and 102 in science.

In the latest TIMSS assessment in 2019, 20,829 Grade 9 students from 519 South African schools and 11,891 Grade 5 students from 297 schools participated (Reddy et al., 2020a, 2020b). More precisely, one class per school participated and the test was administered in English or Afrikaans.

In addition, this paper uses the most recent GHS (2019) data for the section on repetition and dropouts. GHS collects data on health, education, housing and living standards. Moreover, it is one of few household surveys in South Africa that includes questions on repetition (Van der Berg et al., 2019), and includes age, gender and the current grade of learners (Stats SA, 2019). GHS also employs a two-stage stratified sampling design and is nationally representative. For this analysis, the individual level data set is used. The 2019 data set contains 68,986 individuals.

The following section of this paper provides a descriptive analysis of gender differences in mathematics and science performance for Grades 5 and 9, as well as current gender differences in repetition and dropout. Moreover, this section analysis gender differences for various subgroups and combines the first two subsections by analysing gender differences in achievement after creating more comparable groups by accounting for gender differences in repetition and dropout. This is followed by a multivariate analysis employing an ordinary least squares (OLS) regression with school fixed effects to study whether the gender differences in achievement remain even after controlling for school quintile, region, repetition, and dropout simultaneously and other factors that may explain gender differences.

The following OLS model (Model 1) is estimated:

$$Mathematics\ test\ score_{is} = \beta_0 + \beta_1 * female_{is} + \beta_2 * Q_{is} + \beta_2 * assetidx\_std_{is} + \beta_4 * province_{is} + \beta_5 * Rarely\_speak\_testlanguage\_home_{is} + \beta_5 * urban_{is} + \beta_6 * parent\_matric_{is} + \beta_7 * overage\_all_{is} + \beta_7 * class\_size_{is} + \beta_7 * gender\_balance_{is} + \vartheta_s + \varepsilon_i$$

where the dependent variable is the mathematics test score for student i in school s. $Female$ is the main explanatory variable and takes a value of 1 if a learner is female. Q is a categorical variable that indicates the official school quintile of the school to which student i goes (it takes a value between 1 and 6, whereby the value 6 indicates 'independent schools'). The $assetidx\_std$ is a standardized measure for the student wealth (SES) (with a mean of zero and SD of 1), province is a categorical variable between 1 and 9 and indicates the province. $Rarely\_speak\_testlanguage\_home$ is a dummy variable that is assigned a value of 1 if student i does not speak the test language frequently at home. $Urban$ is a dummy variable indicating whether a learner lives in an urban area and $parent\_matric$ is a dummy variable indicating whether parents have matric or a higher educational level. This is followed by the variable $overage\_all$ which is a categorical variable that takes a value between 0 and 3, whereby a value of 0 is assigned if the learner has the correct age, a 1 is assigned if the learner is one year over-age and so on. $Class\_size$ is a continuous variable and indicates the number of learners in the class of student i and $gender\_balance$ is a dummy variable and takes the value of 1 if the girl is among the weakest performing girls. ϑ_s represents classroom fixed effects.

Model 1 is extended in Model 2 to 4 by various attitude indices, teacher gender, and interactions terms to study whether these factors are correlated with gender differences in achievement. The models will be discussed in more detail in the multivariate analysis section.

4 Gender Differences in Educational Achievement and Learners Flows

The first part of the descriptive analysis studies current gender differences in grade repetition and dropout. This is followed by a detailed analysis of gender differences in achievement in section 4.2. This section mainly asks the following research question: are South African girls currently outperforming South African boys in mathematics and science, and if so, do girls outperform boys because they learn more with the same amount of schooling or because they progress faster through school?

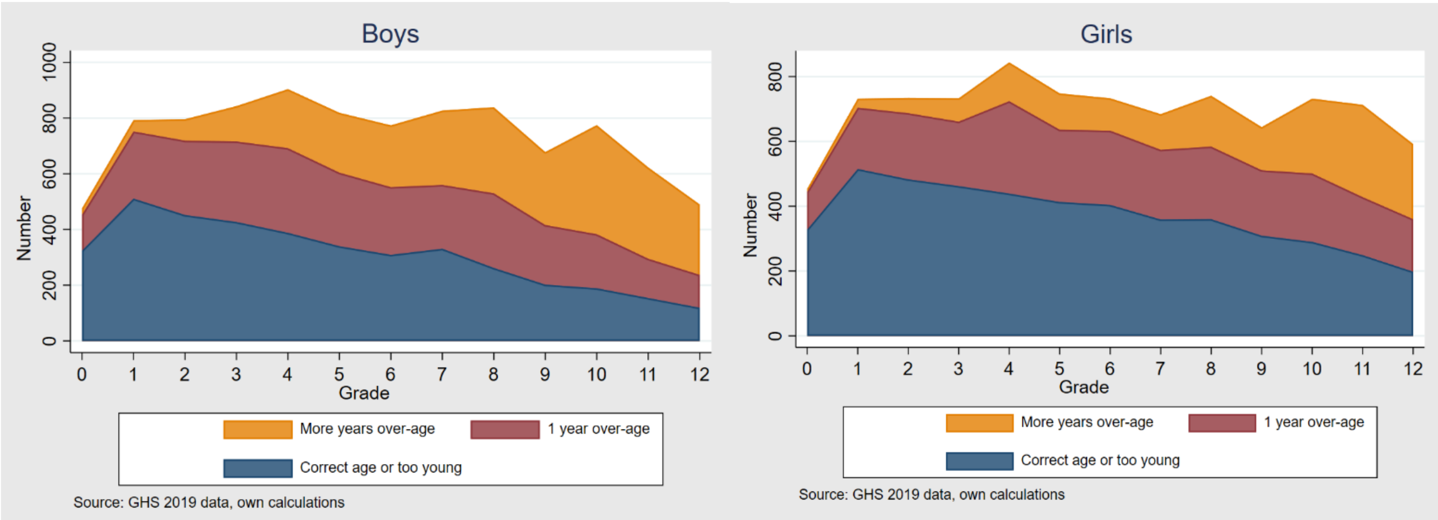
4.1 Recent Gender Differences in Grade Repetition and Dropout

The available figures for South Africa that take gender differences in repetition and dropout into account are from 2016 and hence are potentially somewhat outdated. Moreover, to determine whether the observed patterns of over-age in the TIMSS 2019 data are realistic, this section uses household survey data, more precisely GHS data from the same year. Unfortunately, neither GHS nor TIMSS data include direct measures of whether a learner repeated a grade or dropped out of school. Instead, the student's age, more specifically if learners are one or more years over-age, is used as a proxy for repetition.

Figure 1, which follows, illustrates the learner flows by gender and show the number of the correct age, one year over-age and two and more year's over-age learners in each grade. Most South African learners start schooling (Grade 1) in the year they turn seven (Van der Berg et al., 2021). Figure 2 confirms that this is the case. In Grade 1, 95% of the boys and 96% of the girls are the correct age for Grade 1. These figures are almost identical to the figure in Grade R (pre-school), which suggests that 5% of the boys and 3% of the girls were not ready for school and hence are over-age without having repeated a grade. Contrastingly, learners that did not start late and are over-age in the subsequent years have most likely repeated a grade. This confirms that over-age is a suitable proxy for earlier grade repetition.

Figure 1 shows three interesting trends which are all in line with the papers by Van der Berg et al. (2021, 2019). Firstly, girls and boys have somewhat different patterns in repetition.

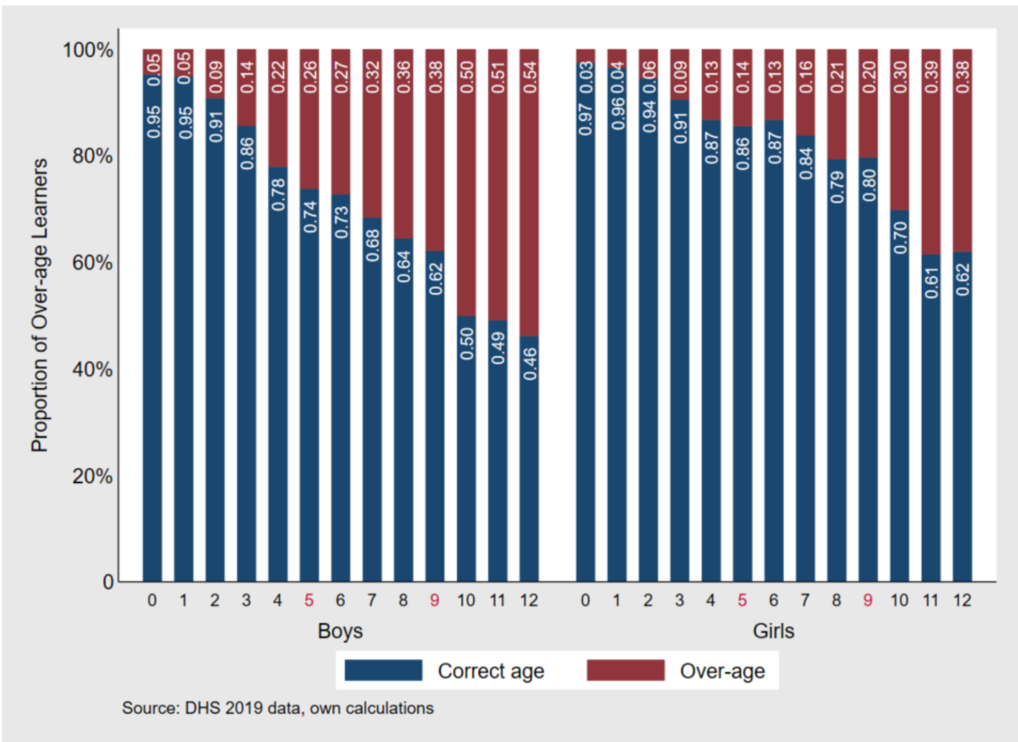
Figure 1: Number of Over-age Boys and Girls in Each Grade



Secondly, repetition is particularly high for boys and girls in Grades 4, 8, and 10. This is indicated by the so-called enrolment bulges in these grades. Thirdly, boys are more likely to be two or more years over-age and to drop out of school compared to girls. The differences in dropout are visible between Grade 10 to 12, where the number of boys attending school reduces sharply.

Figure 2 shows the proportion of over-age girls and boys by grade. More specifically, this figure illustrates the cumulative effect of repetition throughout the schooling system.

Figure 2: Proportion of Over-age Learners by Grade

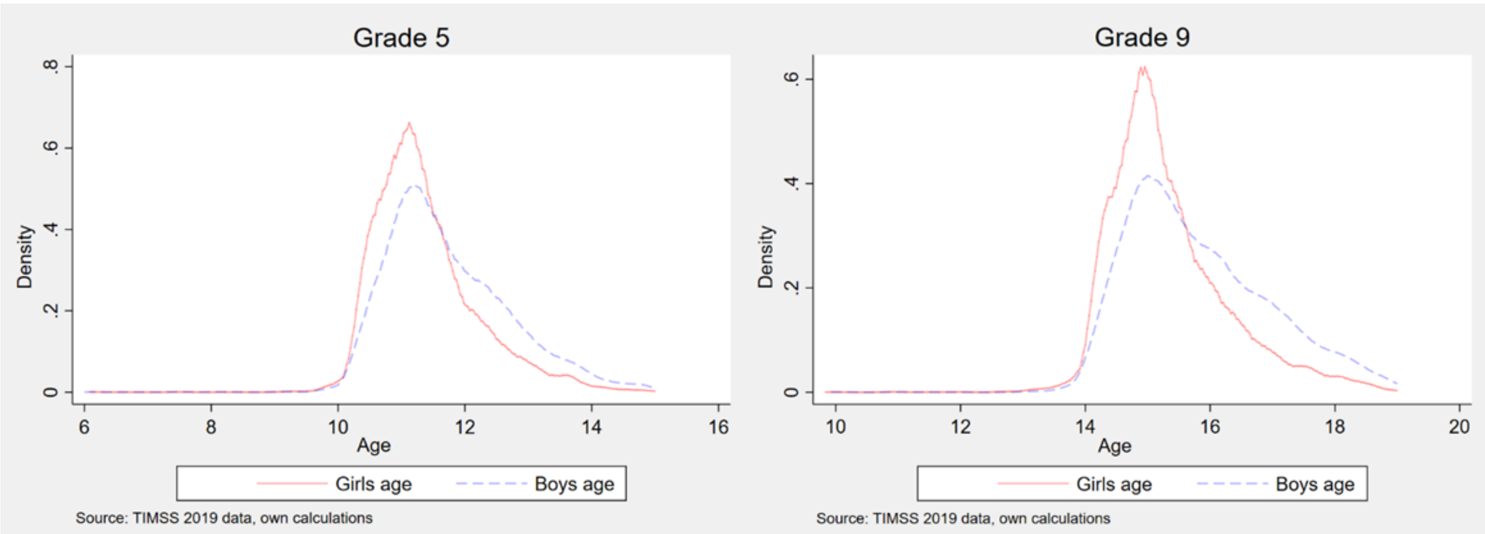


This figure shows that the proportion of over-age learners is similar among boys and girls in Grades R and 1 and starts to diverge in Grade 2. This gap becomes larger over time. The GHS data shows that one quarter of the fifth-grade boys are already over-age and thus one year or more behind by Grade 5, compared to 14% of the fifth-grade girls. The numbers increase to 38% in Grade 9 for the boys and 20% for the girls. The numbers for Grade 5 are relatively similar to the numbers reported in the study by Van der Berg et al. (2019), whereas in Grade 9 the numbers of over-age boys and girls are approximately 10 percentage points lower for boys and girls in the more recent GHS data. It is unclear whether the differences are due to a decline in repetition over time or due to underlying differences in the GHS and community survey data.

The TIMSS 2019 data shows that the average age of girls is 11.4 years in Grade 5 and 15.3 years in Grade 9 and the average age of boys is 11.7 years in Grade 5 and 15.8 years in Grade 9. Learners that start schooling at the right age and do not repeat a grade should be between 10 and 11.5 years in Grade 5 and between 14 and 15.5 in Grade 9. Thus, girls are on average slightly younger than boys.

The following density plots in Figure 3 show the whole age distribution of boys and girls in Grades 5 and 9. The density plots shows that boys' age is more skewed to the right in both grades. This shows that more boys are over-aged than girls and that is the reason why girls are on average younger.

Figure 3: Kernel Density of Student Age by Gender and Grade



Figures 4 and 5 show the proportion of correct age and over-age girls and boys in each grade. Figure 4 shows that 66% of the fifth-grade boys are the correct age for Grade 5, compared to 81% of the fifth-grade girls. These percentages of over-aged learners are around 6-8 percentage points higher for both girls and boys compared to the GHS data.

Figure 4: Proportion of Over-age Learners in Grade 5

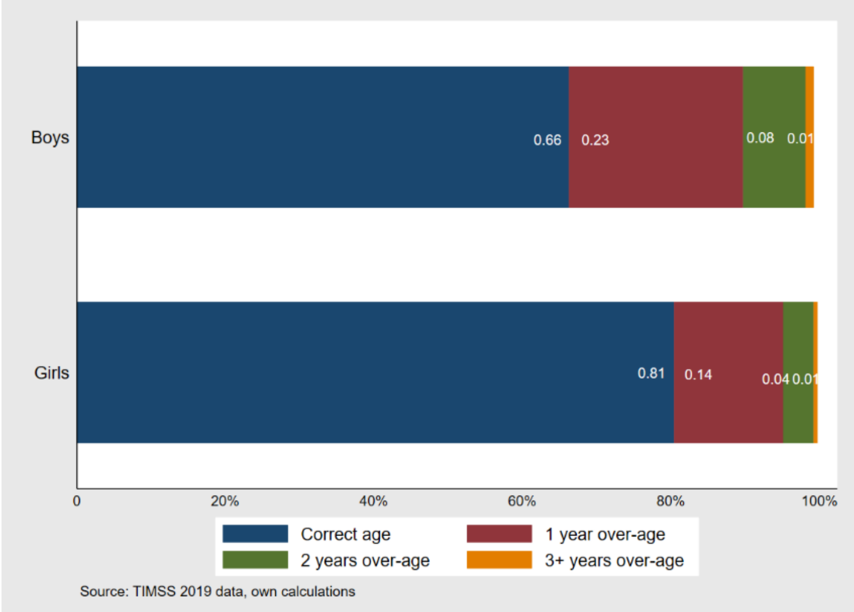
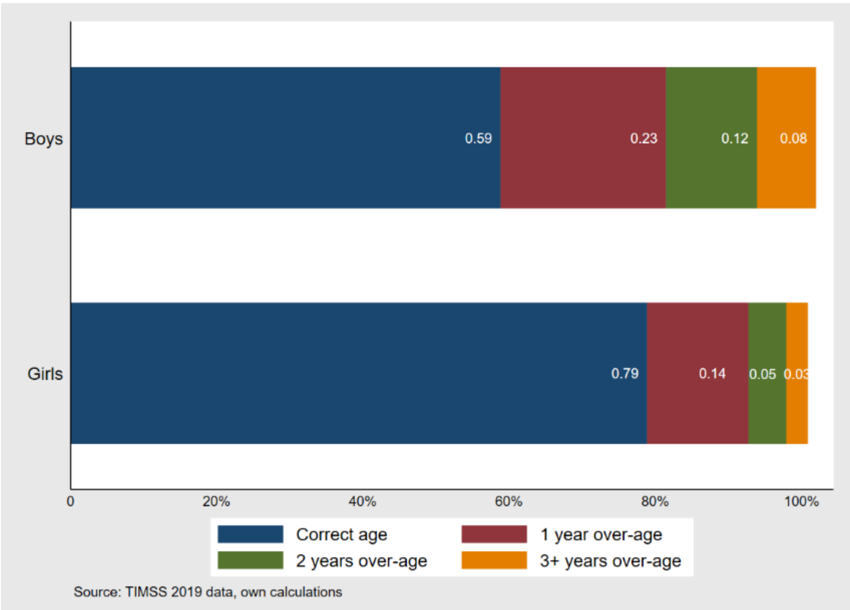


Figure 5: Proportion of Over-age Learners in Grade 9



According to the TIMSS 2019 data, the number of over-age learners in Grade 9 is not that much higher compared to the numbers in Grade 5 and there are fewer over-age ninth-grade girls compared to ninth-grade boys. Figure 5 shows that 59% of the ninth-grade boys are the correct age, compared to 79% of the ninth-grade girls. In contrast to the Grade 5 findings, the Grade 9 findings are in line with the GHS findings. Nevertheless, this finding is surprising since GHS data and the existing literature would suggest that most repetition happens in higher grades. TIMSS data from 2015 indicates that the Grade 5 figures are very similar in 2015 and 2019, whereby 65% of the boys and 79% of the girls are the correct age for Grade 5 in 2015. This suggests that the TIMSS data for Grade

5 slightly overestimates the proportions of over-age learners, which might reduce the average performance.[9]

Furthermore, there are large differences in the proportions of over-age learners by school quintile and provinces. Girls are less likely to be over-age than boys in all groups, both in Grades 5 and 9. Figures 6 and 7 indicate that boys are more likely to be over-age than girls in each school quintile, and the proportions of over-age learners become smaller in higher school quintiles.[10]

Figure 6: Proportions of Over-age Learners in Grade 5 by School Quintile

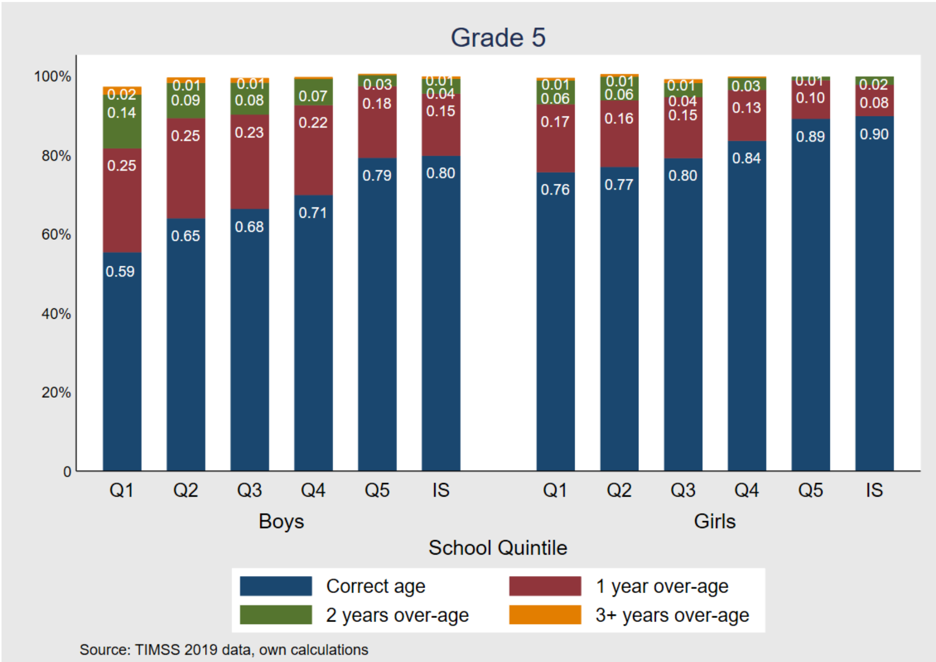
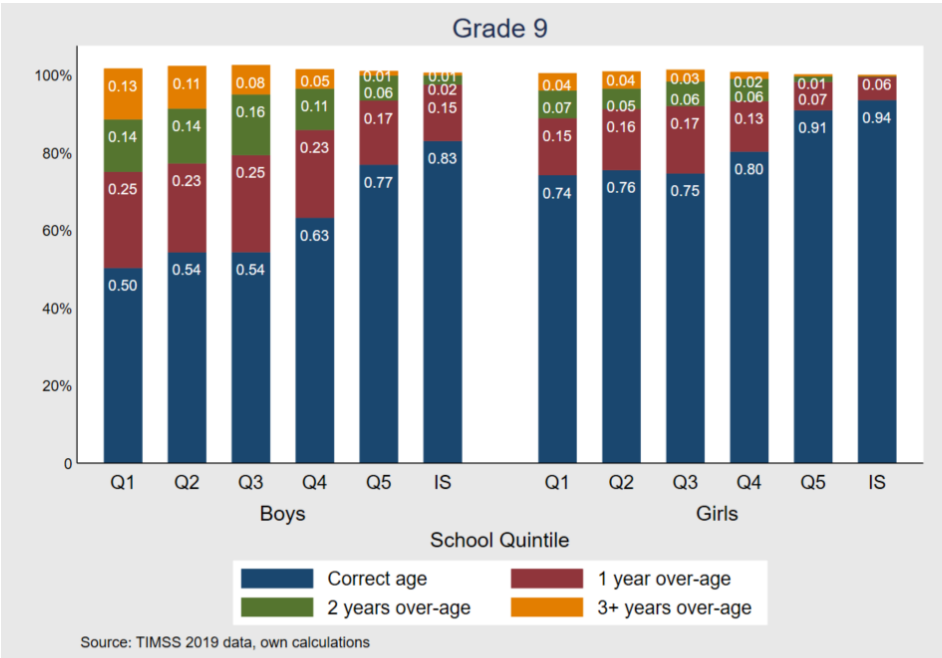


Figure 7: Proportions of Over-age Learners in Grade 9 by School Quintile



9 Moreover, it should be noted that the figures for Grades 5 and 9 are not directly comparable because it is a different cohort of learners. However, as the 2015 and 2019 figures are similar for Grade 5, this comparison seems plausible.

10 IS stands for 'independent schools'.

Moreover, the data shows that Gauteng and the Western Cape have lower rates of over-aged boys and girls compared to the other provinces.

Regarding dropouts, the GHS data shows that a larger proportion of school-age boys are no longer attending an educational institution. 18.4% of boys aged 16 and below reported being out of school, compared to 15.9% of the 16-year-old girls. GHS data does not include information about the timing of the repetition and dropout. Hence, whilst useful for description, GHS data is not suitable to determine what the proportion of girls and boys should be at the beginning of each grade.

The TIMSS 2019 data shows that in Grade 5, 49.7% of the sample are girls and 50.3% are boys. Contrastingly, in Grade 9, 52.01% of the learners are female compared to 47.99% males. According to GHS 2019 data, there are equal numbers of 15-year-old boys and girls in South Africa. Moreover, since there are no statistically significant gender differences in initial enrolment (Hall et al., 2018), there would be an equal number of girls and boys in Grade 9 without gender differences in repetition and dropout. Thus, given that boys are more likely to drop out before Grade 9, the remaining sample is more selective and must be adjusted.

4.2 Gender Differences in Primary and Secondary School Mathematics and Science Achievement

The most recent TIMSS data (2019) was published at the end of 2020 and has not been comprehensively analysed for gender differences in South Africa yet. This will be done in the following subsections.

4.2.1 Gender Differences in The Most Recent TIMSS Sample: South Africa Compared to Other Countries

Regardless of the gender differences, Figures 8 to 10 show that the performance of South African students is one of the lowest among TIMSS countries, and also, lower than the performance of the other participating African countries. This has already been observed in the past (Zuze et al., 2017). In 2019, in Grade 5 (Grade 4 for most other countries), South African girls and boys have the third lowest test score in mathematics and science with only Pakistan and the Philippines exhibiting lower mean test scores.

Figure 8: Average TIMSS Achievement by Gender and Country, Grade 4/5

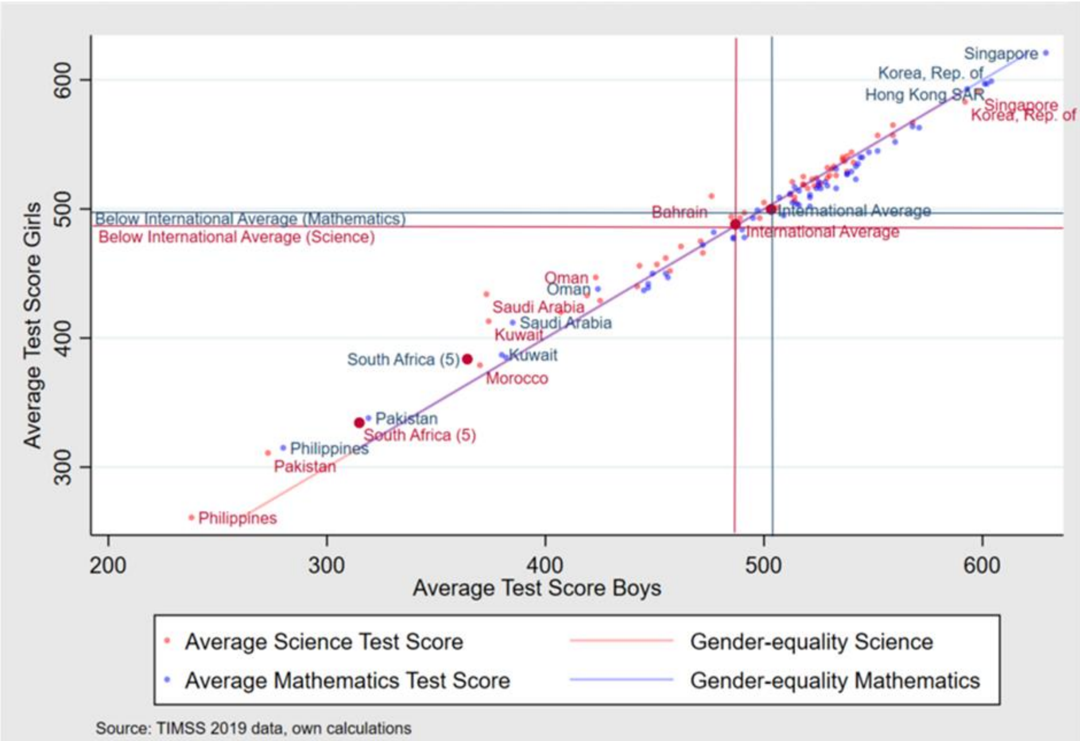


Figure 9: Average Mathematics Achievement by Gender and Country, Grade 8/9

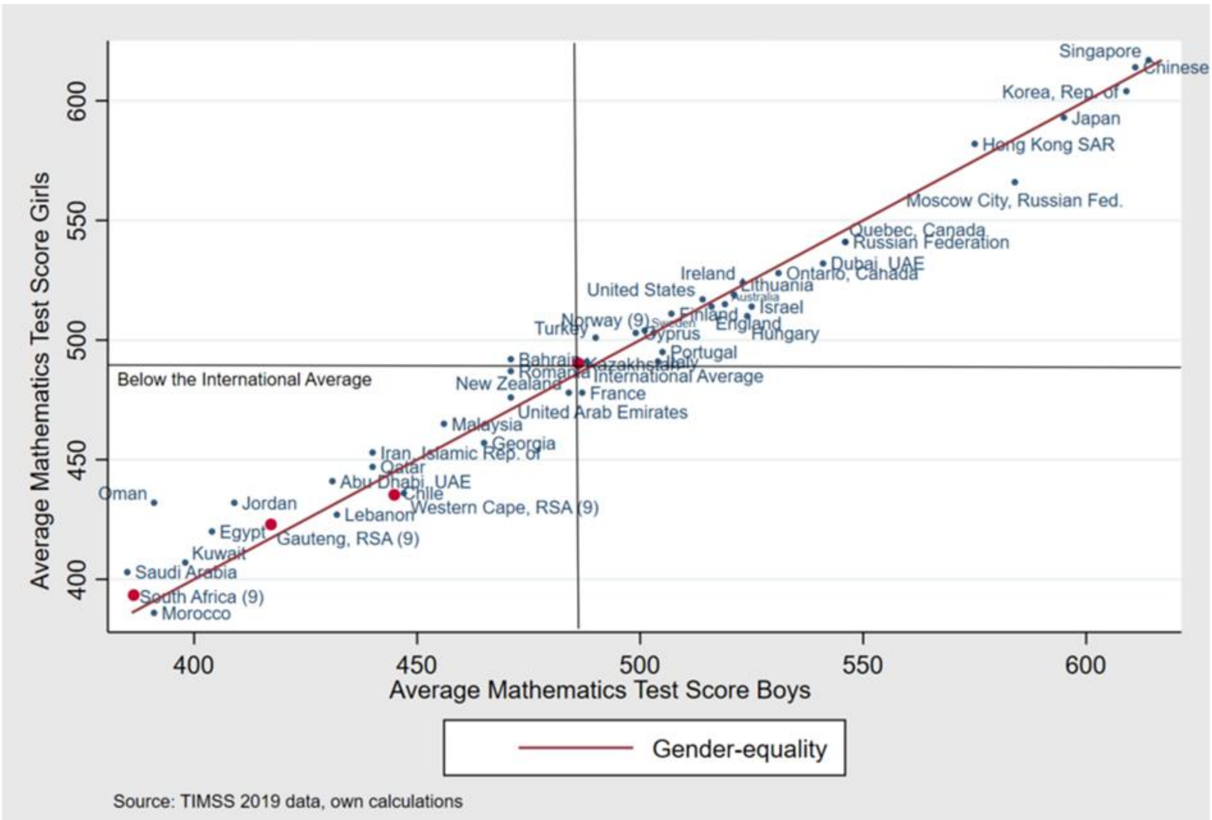
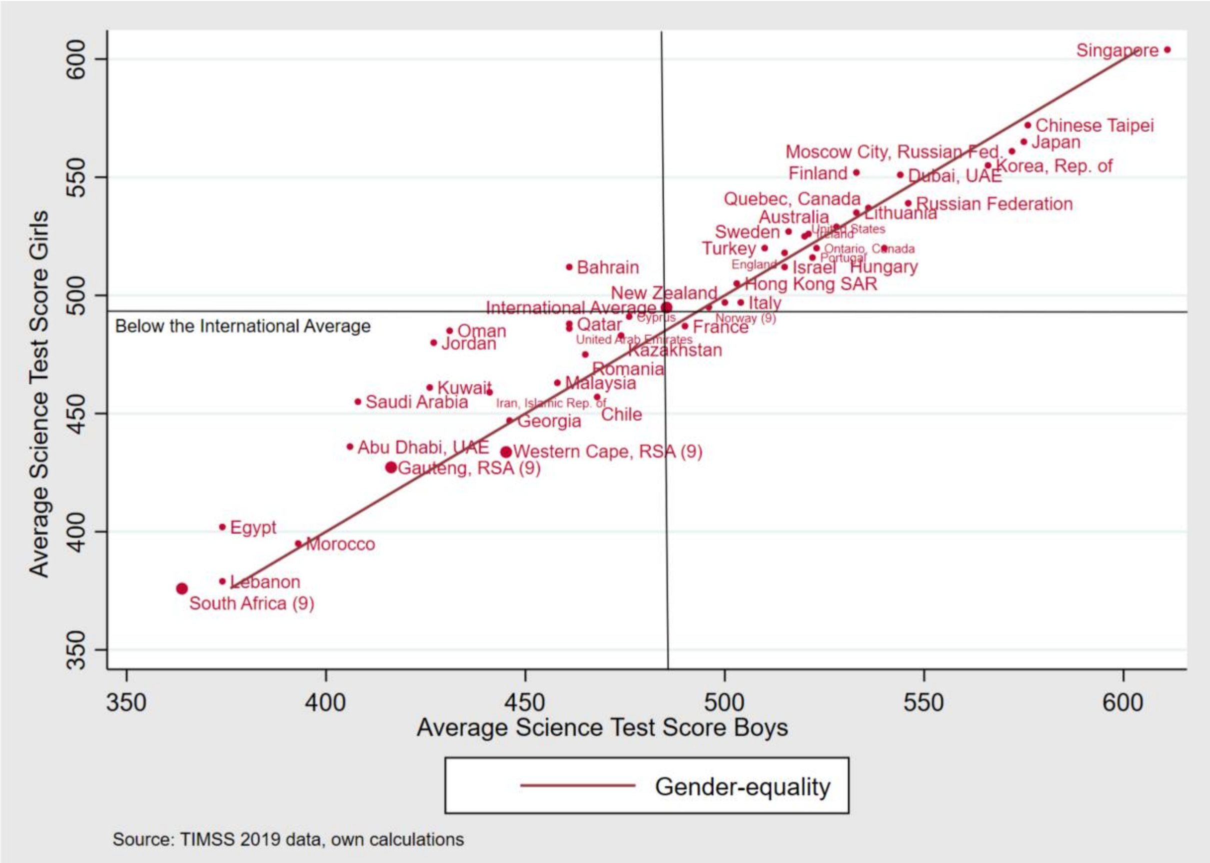


Figure 10: Average Science Achievement by Gender and Country, Grade 8/9



In Grade 9 (internationally Grade 8), South African girls and boys have the lowest science achievement score of all participating countries, and in mathematics the second lowest score. The exact test scores of South African learners will be discussed in the next section. Moreover, the figures show that South Africa has a pro-girl mathematics and science achievement gap in Grades 5 and 9.[11]

On average across all participating countries, girls outperformed boys in 2019 in mathematics and science in Grade 8/9 and in science in Grade 4/5, but the gender differences were small, with around three to ten points between girls and boys. Contrastingly, in mathematics in Grade 4/5 there is a small pro-boy gap of four test points on average across all participating countries. In addition, the data shows that around half of the participating countries have no statistically significant gender difference in mathematics and science achievement at Grades 4 and 8. Of the remaining countries in science, there are more countries where girls significantly outperform boys in Grades 4 and 8, whereas in mathematics there are more countries where boys significantly outperform girls at the Grade 4 level. At the Grade 8 level there is one more country with a pro-girl mathematics achievement gap as compared to a pro-boy gap (Mullis et al., 2020).

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[11] All countries that lie above the 45°- line have a pro-girl achievement gap.

Furthermore, Figure 8 shows that South Africa has one of the largest pro-girl gaps in Grade 4/5 in the sample, with approximately 22 test points in mathematics and science. The magnitude of this pro-girl advantage was the third largest in mathematics and seventh largest in science out of the 58 participating countries in TIMSS 2019.

In Grade 9, the magnitude of the pro-girl South African advantage was the 12th largest in mathematics and 13th largest in science, of the 39 participating countries.

Two of the eight South African provinces have been oversampled in TIMSS 2019. Usually, 30 schools participate in TIMSS in each South African province, but in 2019 150 schools participated at the Grade 9 level in the Western Cape and Gauteng. The figures for Grade 9 show two trends. First, as in the past, the Western Cape and Gauteng have a higher mean test score than South Africa on average, and secondly, while Gauteng has a significant pro-girl gap in mathematics and science, the Western Cape has a significant pro-boy gap in both subjects in Grade 9.

4.2.2 Gender Differences in Mathematics and Science Performance

This section reports descriptive statistics about gender differences in mathematics and science achievement for Grades 5 and 9 before adjusting for repetition and dropouts. As mentioned in the last section, the latest TIMSS data shows that on average, South African girls perform better than South African boys in mathematics and science, both in Grades 5 and 9. In contrast to 2015, all four South African pro-girl gaps are statistically significant. Table 1 shows that the pro-girl achievement gap amounts to 22 test points in both subjects in Grade 5, is statistically significant and larger than in 2015.

Table 1: Mean Achievement by Gender and Grade

	Mathematics					Science				
	Girls Mean Testscore	**Girls** SE	**Boys** Mean Testscore	**Boys** SE	**Gender-gap** Diff.	**Girls** Mean Testscore	**Girls** SE	**Boys** Mean Testscore	**Boys** SE	**Gender-gap** Diff.
Average Grade 5 - 2015*	384.00	3.80	368.00	4.40	16 ***					
Average Grade 5 - 2019	385.05	4.48	362.95	4.52	22 ***	336.91	6.12	315.29	6.09	22 ***
Average Grade 9 - 2015*	376.00	5.30	369.00	4.60	7	362.00	6.70	353.00	5.50	9
Average Grade 9 - 2019	393.72	2.83	387.03	2.92	7 ***	375.25	3.89	362.19	4.19	13 ***

Note: Own Calculations. *Source: Mullis et al.(2017) and Isdale et al. (2017). red font = below low benchmark (400). Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,613 - 11,857 in Grade 5 and between 20,535 - 20,786 in Grade 9.

Interestingly, the pro-girl advantage in Grade 9 has declined in comparison to the pro-girl advantage in Grade 5 in 2019.[12] Nevertheless, in contrast to the 2015 data, the pro-girl gap is still statistically significant. In 2019, Table 1 shows that girls outperform boys on average by approximately seven test points in mathematics and 13 test points in science in Grade 9. It could be that the girl's mathematics and science performance improved significantly between 2015 and 2019 which would be in line with the finding that the pro-girl gap in Grade 9 is significant in the latest TIMSS data. Alternatively, or additionally, it could be that young adults have decreasing levels of confidence in mathematics during lower secondary school. The decline in confidence might be associated with lower mathematics and science achievement and might be more pronounced among girls than among boys. This would be in line with the findings by Jacobs et al., (2002).

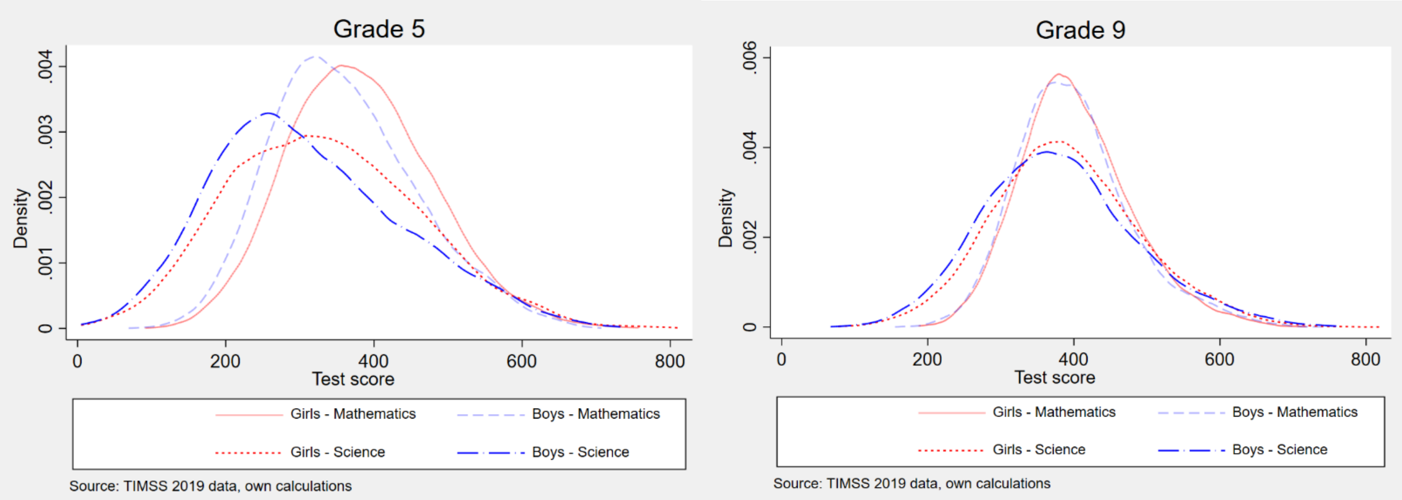
Furthermore, Table 1 shows that fifth-grade and ninth-grade learners are on average below the low international benchmark of 400, a score which represents basic mathematics and science knowledge.

So far, the analysis has focused on the average performance by gender. It could be that boys do better than girls at other parts of the distribution, for instance at the advanced benchmark. TIMSS categorises the mathematics and science abilities by four benchmarks. The low benchmark is 400 test points, and the intermediated benchmark, where students can show and apply the basic mathematics and science knowledge is at 475 test points. This is followed by the high benchmark at 550 points. At this level students have more understanding of the subjects and can apply their knowledge. Lastly, the advanced benchmark is achieved from a value of 625. Students that reach this score have more understanding of complex mathematics and science problems (Mullis et al., 2020; Reddy et al., 2020a).

Figure 11 shows the distribution of test scores in TIMSS by gender for Grades 5 and 9. The figure for Grade 5 shows a pro-girl achievement gap in mathematics and science and shows that the spread of science test scores is larger. More precisely, the test score distributions of girls lie to the right and larger numbers of boys and girls have lower test scores in science compared to mathematics. Moreover, the figure for Grade 5 shows that boys science test scores are skewed to the left and hence boys are over-represented in the lowest performing category in science. Furthermore, the figures suggest that few, but roughly equal numbers of female and male observations, lie in the higher performing test score range.

[12] It is noteworthy that these comparisons are always relative comparisons, and the figures for Grades 5 and 9 (and 2015 and 2019) are not directly comparable because it is a different cohort of learners. However, as the 2015 and 2019 figures are similar for Grade 5, this comparison seems plausible.

Figure 11: Kernel Density of Learners Achievement by Gender and Grade



In contrast, the density plots for Grade 9 girls and boys are nearly identical. There is only a small pro-girl gap in science visible. Similar to Grade 5, the spread of the science values is larger both for girls and boys and roughly equal numbers of female and male observations lie in the higher performing test score range.

As indicated by the kernel density plots and Table 1, the TIMSS data shows that the majority of Grade 5 and Grade 9 learners do not reach the low international benchmark of 400. A similar result was already found by Zuze and Beku (2019) using TIMSS 2015 data. In 2019, 58% of the fifth-grade girls and 67% of the fifth-grade boys have a test score below the low international benchmark of 400 in mathematics, and 69% of the fifth-grade girls and 75% of the fifth-grade boys scored below the international benchmark in science. Moreover, less than 2% of the boys and girls reach the advanced benchmark of 625 in mathematics and science in Grade 5.

The percentages for Grade 9 are fairly similar to the percentages for Grade 5, but the pro-girl gaps are smaller in Grade 9. In Grade 9, 57% of the girls and 61% of the boys have a mathematics test score below 400 and 62% of the girls and 67% of the boys have a science test score below 400. Only 0.5% of the girls and boys have a test score above 625 in mathematics and only 1% of the boys and girls have a test score above 625 in science.

In summary, TIMSS 2019 data suggest that more South African male students are in the lowest performance category compared to their female counterparts, but equal numbers of boys and girls are among the best performers. This result contrasts with the literature, such as OECD (2019) and Spaull and Makaluza (2019), which finds that boys are typically over-represented in the lowest and highest performance categories. Nevertheless, since very few students have test scores above the advanced benchmark, gender comparisons in this category are questionable from a sample size perspective (Spaull and Makaluza, 2019).

4.2.3 Gender Differences in Mathematics and Science Performance for Various Subgroups

South Africa is a big and diverse country with persisting inequalities, thus studying only overall gender differences is not very informative.[13] Instead, this analysis also looks at gender differences between population groups, location, school quintile (school SES), and provinces. Tables 2 and 3 report the gender differences in the average mathematics and science test scores for the different subgroups for Grades 5 and 9 respectively.

Home language

Overall, 81% of South Africans are classified as African/Black (Stats SA, 2021). Moreover, approximately 94% of the Black population speak one of the nine indigenous South African languages such as Sepedi, IsiZulu or IsiXhosa as their home languages (Stats SA, 2012).[14] [15] Although the TIMSS questionnaire does not ask students about their population group, there is a question that asks how often students speak the test language at home. Since the test was administered in either English or Afrikaans, every learner who answered that he or she speaks the test language only “sometimes” or “never” was coded as ‘rarely speak test language at home’ and everyone that answered speaking the test language “always or almost always” was coded as ‘mostly speak test language at home’. Consequently, the dummy variable ‘rarely speaking the test language at home’ can be a proxy for being Black. This is only a weak proxy because other population groups such as Indian people might not speak English or Afrikaans regularly at home, and some Black people speak English or Afrikaans as their first language.

According to this measure, 65% of the fifth-grade learners and 72% of the ninth-grade learners in the sample rarely speak the test language at home and hence are potentially Black. Tables 2 and 3 show that learners that rarely speak the test language have significantly lower average test scores compared to learners that mostly speak the test language at home in both grades. Moreover, Table 2 shows that fifth-grade girls have significantly higher test scores in both subgroups.

[13] See, for example, Spaull (2019) and Díaz Pabón et al. (2021).
[14] See Mohohlwane (2019) for more information on the relationship between home language, instructional language and inequality in the education system.
[15]The term "Black" is intentionally capitalized here and does not refer necessarily to the real skin color or a biological characteristic and instead to differences in privileges. The anti-racism movement uses these terms/style to counter racism in language (Ogette, 2018).

Table 2: Average Mathematics and Science Achievement for Grade 5 by Gender and Subgroup

Grade 5	**Mathematics**					**Science**				
	Girls	**Girls**	**Boys**	**Boys**	**Gender-gap**	**Girls**	**Girls**	**Boys**	**Boys**	**Gender-gap**
Subgroup	Mean Testscore	SE	Mean Testscore	SE	Diff.	Mean Testscore	SE	Mean Testscore	SE	Diff.
Average	**385.05**	**4.48**	**362.95**	**4.52**	**22 *****	**336.91**	**6.12**	**315.29**	**6.09**	**22 *****
Mostly Speak Test Language at Home	422.06	7.70	393.67	7.89	28 ***	396.06	10.01	366.35	10.29	30 ***
Rarely Speak Test Language at Home	368.31	3.33	349.99	3.45	18 ***	309.13	4.53	292.60	4.61	17 ***
Rural	355.26	4.09	332.69	4.07	23 ***	294.88	5.55	272.40	5.36	22 ***
Urban	428.97	7.43	414.09	8.25	15 ***	399.55	9.90	387.64	11.30	12 **
Quintile 1 School	342.77	5.11	319.18	5.34	24 ***	277.03	7.00	253.40	7.09	24 ***
Quintile 2 School	349.06	5.71	326.54	5.55	23 ***	282.21	8.56	262.10	6.93	20 ***
Quintile 3 School	364.55	7.16	344.43	6.22	20 ***	312.24	9.51	290.21	8.05	22 ***
Quintile 4 School	402.50	8.41	377.18	7.96	25 ***	368.65	11.24	340.25	12.33	28 ***
Quintile 5 School	494.58	10.42	480.56	10.41	14	486.52	14.14	480.02	13.42	7
Independent Schools	472.05	17.46	458.72	16.97	13	453.46	21.63	443.80	22.74	10
Fee-paying	456.28	8.61	438.90	9.56	17 **	437.07	11.31	422.96	13.24	14
No-Fee	352.91	3.79	331.06	3.56	22 ***	291.73	5.28	270.08	4.64	22 ***
Eastern Cape	375.13	17.23	335.55	11.17	40 **	320.38	22.75	276.11	15.60	44 *
Free State	390.39	11.90	386.74	14.99	4	332.54	16.75	334.82	21.05	-2
Gauteng	417.16	10.11	405.03	12.22	12 *	385.63	14.11	375.08	16.89	11
KwaZulu-Natal	370.93	8.75	349.43	9.72	21 ***	313.46	12.87	296.75	13.87	17 *
Limpopo	345.92	11.15	318.74	8.27	27 ***	289.96	13.59	260.89	10.80	29 ***
Mpumalanga	353.73	10.87	332.40	11.88	21 **	292.95	15.49	277.99	15.78	15
North West	365.53	8.60	345.84	8.52	20 ***	312.34	13.23	288.19	11.91	24 ***
Northern Cape	380.01	9.36	364.67	12.68	15 **	338.47	12.56	326.54	16.38	12 *
Western Cape	450.63	11.22	430.96	11.95	20 **	428.24	14.08	403.72	15.93	25 **

Note: Own Calculations. red font = below low benchmark (400). Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. light blue font = pro-male gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,613 - 11,857.

Table 3: Average Mathematics and Science Achievement for Grade 9 by Gender and Subgroup

Grade 9	**Mathematics**					**Science**				
	Girls	**Girls**	**Boys**	**Boys**	**Gender-gap**	**Girls**	**Girls**	**Boys**	**Boys**	**Gender-gap**
Subgroup	Mean Testscore	SE	Mean Testscore	SE	Diff.	Mean Testscore	SE	Mean Testscore	SE	Diff.
Average	**393.72**	**2.83**	**387.03**	**2.92**	**7 *****	**375.25**	**3.89**	**362.19**	**4.19**	**13 *****
Mostly Speak Test Language at Home	432.66	4.25	429.30	4.84	3	436.35	5.29	426.28	6.66	10 **
Rarely Speak Test Language at Home	378.01	2.53	372.70	2.40	5 ***	350.53	3.40	340.31	3.40	10 ***
Rural	373.09	3.02	365.35	2.65	8 ***	343.53	3.96	329.84	3.74	14 ***
Urban	424.14	4.33	423.98	5.00	0	422.01	5.58	416.83	6.91	5
Quintile 1 School	361.91	4.29	353.41	4.11	9 **	325.01	4.29	311.28	6.04	14 ***
Quintile 2 School	371.25	5.16	364.66	4.39	7 **	341.02	5.16	328.68	5.97	12 ***
Quintile 3 School	373.63	3.27	368.55	2.92	5 ***	349.66	3.27	337.60	4.08	12 ***
Quintile 4 School	408.66	6.29	406.91	7.46	2	400.96	6.29	393.60	10.02	7
Quintile 5 School	464.18	6.98	464.79	7.71	-1	477.18	6.98	472.77	10.66	4
Independent Schools	480.42	9.41	471.33	13.07	9	496.22	9.41	484.44	15.86	12
Fee-paying	441.11	4.50	439.05	5.00	2	445.07	5.81	437.89	7.48	7
No-Fee	369.39	2.46	362.84	2.24	7 ***	339.62	3.17	327.01	3.20	13 ***
Eastern Cape	370.23	7.64	365.27	9.69	5	340.72	9.01	325.55	13.07	15 *
Free State	401.33	11.29	393.01	7.58	8	384.47	14.69	374.04	10.50	10
Gauteng	424.08	4.45	417.61	4.43	6 **	426.18	5.68	414.48	5.79	12 ***
KwaZulu-Natal	381.34	7.90	376.24	7.42	5	355.99	10.89	346.39	10.68	10
Limpopo	369.83	6.09	360.89	4.94	9 **	337.30	8.43	322.70	7.03	15 **
Mpumalanga	384.05	5.80	370.34	6.81	14 **	359.82	8.74	336.77	9.61	23 ***
North West	383.11	7.03	382.52	6.62	1	360.14	9.82	354.25	9.80	6
Northern Cape	378.76	3.47	379.73	5.18	-1	357.69	5.16	355.30	7.33	2
Western Cape	437.46	6.04	448.12	6.72	-11 **	433.01	7.63	444.22	8.37	-11 *

Note: Own Calculations. red font = below low benchmark (400). Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. light blue font = pro-male gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 20,535 - 20,786.

In Grade 9, girls also statistically outperform boys across both subgroups and in both subjects, except in mathematics in the subgroup that mostly speaks English or Afrikaans at home.

School Location

Furthermore, Tables 2 and 3 show that learners in urban areas have significantly higher average test scores, above the low benchmark of 400 in all groups except for the science score in Grade 5.[16]

Girls outperform boys in urban and rural areas in both subjects and both grades, but not all gaps are statistically significant. In Grade 5, girls significantly outperform boys in mathematics and science in urban and rural areas. Interestingly, the pro-girl gap is almost twice as large in rural areas compared to urban areas. Zuze and Beku (2019) also found that the pro-girl achievement gap was larger in rural than in urban locations in 2015. This result contrasts with the findings in Grade 9 that girls significantly outperform boys in mathematics and science in rural areas but not in urban areas.

School Quintile/ Fee-status

South African schools differ substantially by available resources and infrastructure, and school quintiles are one way to consider these differences. The Department of Basic Education (DBE) classifies schools into wealth quintiles using the poverty level of the community in which the schools are located as a proxy for the wealth of the students. Students from socio-economically disadvantaged families go to Quintile 1 to 3 schools, where students do not have to pay fees. Quintile 4 and 5 schools receive smaller shares of state funding and therefore charge fees (van Dyk et al., 2019; Wills, 2016). More affluent families, therefore, send their children to wealthier Quintile 4 or 5 schools. Thus, school quintile, SES and gender might interact in meaningful ways. Moreover, 98% of the learners in no-fee schools are either Black or Coloured (Spaull, 2019).[17] Hence, school quintiles and ethnicity are also highly correlated. The school quintile variable and school status variable (fee status) in my data set was provided by the HSRC. 'School quintile' is a categorical variable between one and six that indicates the official DBE school quintile of the school.

Tables 2 and 3 show that Quintile 1 to 3 schools (no-fee schools) have similar mathematics and science achievements. Contrastingly, learners in Quintile 4 and 5 schools (fee-paying schools) and independent schools have significantly higher mathematics and science test scores with a differences of up to 150 test points. Simultaneously, the pro-girl gaps tend to become smaller as the quintile increases. This is in line with the findings in the paper by Hofmeyr (2020). At the Grade 5 levels, girls outperform boys on average in mathematics and science in each school category, but not all pro-

[16] More precisely, urban schools include schools that are in urban and suburban areas and in medium cities.

[17] This paper follows the current South African government's and South African researcher's usage of the racial category "Coloured". It is noteworthy that the term "Coloured" is not acceptable outside of South Africa.

girl gaps are statistically significant. The biggest statistically significant fifth-grade gender gap is the 25-test point difference in mathematics and the 28-test point difference in science in Quintile 4 schools.

At the Grade 9 level, girls achieve significantly higher mathematics and science test scores compared to boys in Quintile 1 to 3 schools (no-fee schools), while the gender differences in fee-paying schools and independent schools are not statistically significant. The largest pro-girl gap in Grade 9 based on school type is the 14-test point difference in science and the 9-test point difference in mathematics in Quintile 1 schools. This result contrasts with the findings by Shepherd (2017).[18] Although she finds a decrease in the pro-girl achievement gap with increasing school quintiles, she finds no significant gender gap in Quintile 1 to 4 schools, but a significant pro-boy gap in mathematics in Quintile 5 schools.

Provinces

Previous studies have shown that there are large differences in the financial resources available and the test score between the nine South African provinces (Isdale et al., 2017; Zuze et al., 2017). Despite this, no other studies have yet analysed gender gaps in provinces using TIMSS data.[19]

The TIMSS 2019 data shows that learners in the Western Cape and Gauteng have one of the highest averages where both girls and boys have an average test score above 400 in mathematics in Grades 5 and 9 and in science in Grade 9. Students in Limpopo have the lowest average mathematics and science test scores of all provinces in Grades 5 and 9, which are on average far below 400 and the national averages.

In most provinces, girls perform better than boys. At the Grade 5 level, the pro-girl gaps in mathematics are statistically significant in all provinces. The only exception is Free State. In science, fewer pro-girl gaps are statistically significant in Grade 5. Girls significantly outperform boys in the Eastern Cape, KwaZulu-Natal, Limpopo, North West, in the Northern Cape and the Western Cape.

At the Grade 9 level, the gender gaps are smaller than in Grade 5 and less are statistically significant. The pro-girl gaps in mathematics and science are only statistically significant in Gauteng, Limpopo, and Mpumalanga. Interestingly, in the Western Cape ninth-grade boys statistically outperform girls by approximately 11 test points in mathematics and science. This suggests that the pro-girl advantage

[18] It should be noted that Hofmeyr (2020) and Shepherd (2017) did not use the official school quintiles, because the data was not available back then. Instead, they both constructed the school quintiles based on socio-economic status (SES) of students and schools (asset index) using home possessions variables.
[19] This might be due to the fact, that the linking files with the provincial data were not available until recently.

in Grade 5 in the Western Cape declines over the years and becomes a pro-boy advantage in higher grades.

It is not clear why the Western Cape has a pro-boy gap in Grade 9. One explanation could be, that the Western Cape has better functioning schools, for example, a third of the schools in the Western Cape are Quintile 5 schools. Moreover, it is one of the provinces where most learners speak the test language at home. Thus, all the subgroups where pro-girl gaps are smaller or not statistically significant are overrepresented in the Western Cape. The following sections will study other factors that might explain the observed gender differences in achievement.

To sum up, Tables 2 and 3 show that girls significantly outperform boys in the majority of the considered subgroups. Overall, the pro-girl gaps are larger in Grade 5 compared to Grade 9 and the trends are relatively similar across both subjects.

4.2.4 Gender Differences in Mathematics and Science Performance After Considering Gender Differences in Repetition and Dropouts

The previous analysis has shown that on average girls outperform boys in mathematics and science and boys are more likely to repeat a grade and to drop out of school compared to girls. The question that remains is, does the girls' advantage in school progression explain a sizable part of the gender gap in achievement? If gender differences in repetition and dropout are correlated with the pro-girl mathematics and science achievement gaps, then we would expect to see a change in the gender gap after accounting for repetition and dropout. This section will analyse this correlation by reporting descriptive statistics about gender differences in mathematics and science achievement after accounting for gender differences in repetition both in Grades 5 and 9 and additionally gender differences in dropout rates in Grade 9. Both factors are considered to create more comparable groups.

The previous analysis has shown that students' (over-)age is a suitable proxy for repetition. Thus, in both grades gender differences in mathematics and science achievement are analysed for four groups to account for gender differences in repetition: learners that are the correct age for the grade, that are one-year-, two years- and three or more years over-age.

The South African literature suggests that dropout rates are already higher for boys than girls by Grade 6 (Branson et al., 2014). While this type of truncation is negligible in Grade 5 it is more of a problem in Grade 9. Thus, the Grade 9 sample must additionally be adjusted for higher male dropouts, otherwise one would compare a more selected group of boys with a more mixed group of girls.

There are different ways to account for truncated samples, but all require assumptions and often do not solve the sample selection problem completely. Following Spaull and Makaluza (2019), this paper uses a simple method to create a more comparable group. Gustafsson (2011) has shown that one important reason why boys and girls drop out are academic difficulties. Thus, similarly to the study by Spaull and Makaluza (2019), the female observations in this paper were ordered by mathematics test score from the weakest to the best performing girls and the weakest performing females were excluded until equal proportions of girls and boys were left in the sample. Since 52.01% of the ninth-grade learners are female compared to 47.99% males, the weakest 638 female observations or 4.01% of the female observations were excluded until there were equal proportions of ninth-grade boys and girls in the sample. More specifically, the weakest performing girls are not dropped from the sample. Instead, a dummy variable was created and every girl that belongs to the group of weakest performing girls has a value of one in the 'gender balance' variable.

It should be noted that the exact gender differences cannot be known, because the exact male dropout rate is unknown, and some boys might have dropped out due to reasons other than weak school performance, so that assuming that their female counterparts in the sample are those at the bottom of the distribution may be an exaggeration.

Figures 12 and 13 illustrate the mean achievement by gender and over-age (dark blue and dark red) and as discussed above additionally after accounting for gender differences in dropouts in Grade 9 (lighter blue and lighter red). Table 4 in the next section reports the corresponding significances.

Figure 12: Mean Achievement by Gender & Over-age, Grade 5

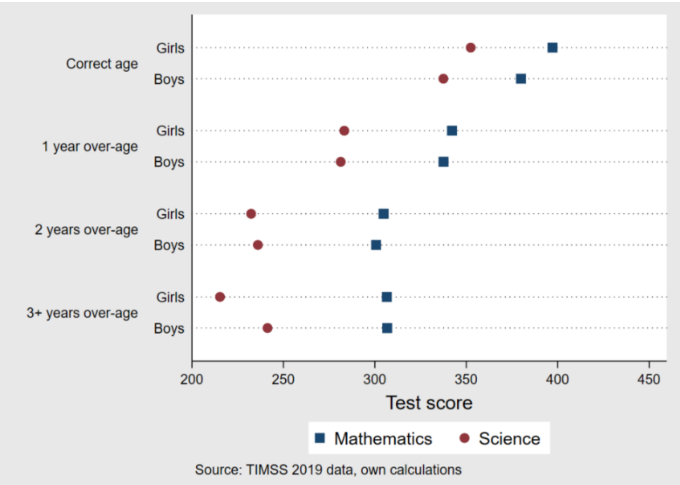
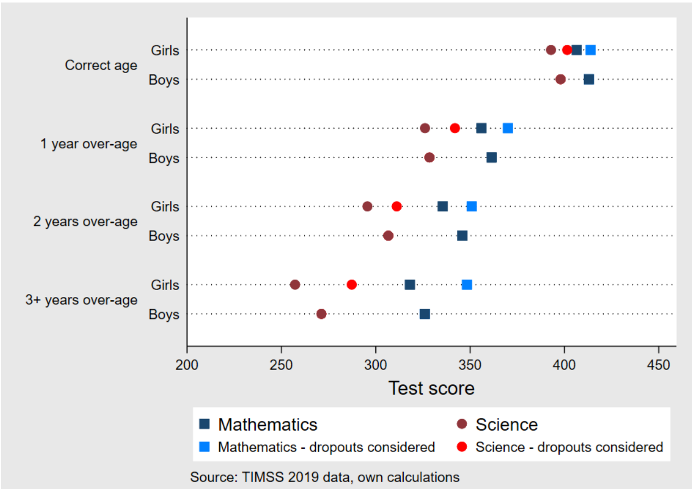


Figure 13: Mean Achievement by Gender & Over-age, Grade 9



The figures show several interesting trends. Firstly, learners at the appropriate age for Grades 5 and 9 have a higher average test score compared to over-age learners and more years of over-age are associated with a lower mathematics and science achievement. For example, fifth-grade girls with the appropriate age have an average mathematics test score of 397, while girls that are one year over-age have an average mathematics test score of 342. The respective numbers for boys are 380 and 338.

This is in line with the literature that finds that repetition is associated with worse subsequent school performance (Hofmeyr, 2020; Isdale et al., 2017).

Secondly, in each age group girls and boys perform better in mathematics than science. Thirdly, Figure 12 and Table 4 show that fifth-grade girls still perform slightly better in most age groups compared to fifth-grade boys, but most pro-girl gaps are no longer statistically significant. The only statistically significant pro-girl gap is the 17-test point mathematics gap and 15-test point science gap favouring girls that are the appropriate age for Grade 5. Interestingly, fifth-grade boys that are two- or three years over-age perform slightly better in science compared to the girls in those age categories, but the differences are not statistically significant. In addition, it should be noted that very few fifth-grade girls are two or more years over-age, hence any gender comparisons for those age groups are questionable from a sample size perspective.

Moreover, Figure 13 illustrates that ninth-grade girls no longer outperform ninth-grade boys if one compares the achievement by age groups. In fact, Table A2 in the appendix shows that boys that are the correct age for Grade 9 and boys that are one year-, and two years over-age significantly outperform girls in the same age groups in mathematics. In science, boys also outperform girls in most age groups, except in the one-year over-age group. This result contrasts with the study by Zuze et al. (2017) who find no significant gender differences in mathematics and science in the different age groups using TIMSS 2015 data.

It should be emphasized that these results do not account for higher male dropouts and hence likely overestimate the performance of boys relative to girls. After excluding the weakest performing female learners in the Grade 9 sample, as discussed earlier in this subsection, the gender gaps reverse again and girls either significantly outperform boys or gender differences are not statistically significant.

Since several pro-girl gaps are smaller or statistically insignificant after controlling for gender differences in over-age, the results seem to suggest that part of the pro-girl gap in Grades 5 and 9 can be attributed to the female advantage in school progression. Moreover, the findings suggest that the average test scores for each age group would be biased if one does not consider higher male dropout rates.

4.2.5 Gender Differences in Mathematics and Science Performance for Various Subgroups After Considering Gender Differences in Repetition and Dropouts

This section reports descriptive statistics about gender differences in mathematics and science achievement after considering gender differences in over-age in Grades 5 and 9 and additionally after adjusting for gender differences in dropouts in Grade 9, as in the section before, but for the subgroups from section 4.2.3. As discussed in the previous section, the observed gender differences may not be fully accurate after accounting for gender differences in dropouts by marginally reducing the girl's sample, because this method, as any other method to account for truncated samples, requires strong assumptions.

Tables 4 to 6 show the results after considering gender differences in repetition in both grades and additionally after limiting the Grade 9 girl's sample by dropping the weakest performing girls.[20] The Tables show that across all subgroups the correct aged learners in Grades 5 and 9 have higher mathematics and science test scores than over-age learners in both grades, and that the test scores tend to get smaller with increasing frequencies of repetitions. Similarly to the previous analysis, girls outperform boys in various subgroups, but fewer gender differences are significant if one compares the achievement for the different age groups and in addition adjusts for differences in dropout rates in Grade 9. Moreover, there are some significant pro-boy gaps both in Grades 5 and 9, and they seem to be more likely with increasing years of over-age in Grade 5. In contrast, the significant pro-girl gaps in Grade 9 tend to get larger with increasing years of over-age.

In Grades 5 and 9, correct aged female and male learners that mostly speak the test language at home have the highest test score of all age- and home language groups. This is followed by learners that rarely speak the test language at home and are the correct age for Grades 5 and 9. In both correct-age home language groups, fifth-grade girls significantly outperform fifth-grade boys. Furthermore, the gender differences in Grade 5 for the other home language groups are not statistically significant.

Contrastingly to Grade 5, ninth-grade boys that are the correct age for Grade 9 and mostly speak the test language at home significantly outperform ninth-grade girls of the same age in mathematics. This significant pro-boy gap remains even after adjusting the sample for the higher male dropout rates. There are several other significant pro-boy gaps in Grade 9 in the different home language and age groups, but they become either insignificant or statistically significant pro-girl gaps after controlling for higher male dropout rates. Thereafter, five out of eight gender gaps are statistically significant pro-girl gaps in mathematics and four out of the eight gaps are statistically significant pro-girl gaps in science.

[20] The full tables with standard errors are reported in Tables A1 and A2 in the appendix. Moreover, Table A2 shows the average achievement for Grade 9 after adjusting stepwise for differences in repetition and then differences in repetition and dropouts as discussed in the text.

Table 4: Average Mathematics and Science Achievement for Grades 5 and 9 by Gender, Over-age, and Subgroup (Part1)

	Mathematics - Grade 5			**Science - Grade 5**			**Mathematics - Grade 9**			**Science - Grade 9**		
Subgroup	**Girls** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls*** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls*** Mean Testscore	**Boys** Mean Testscore	**Gap**
Average - correct age (ca)	397.14	379.94	17 ***	352.41	337.48	15 ***	413.89	412.9332	1	401.45	397.9716	3
Average - 1 year overage (oa)	342.21	337.54	5	283.28	281.35	2	370.04	361.3829	9 ***	341.97	328.4731	13 ***
Average - 2 years overage	304.80	300.71	4	232.35	236.04	-4	350.82	345.8163	5	311.11	306.6711	4
Average - 3+ years overage	306.57	306.72	0	215.32	241.32	-26	348.35	325.9889	22 ***	287.28	271.2112	16 **
Mostly Speak Test Language at Home - ca	439.50	416.89	23 ***	418.02	396.91	21 **	448.38	456.40	-8 **	456.26	463.10	-7
Rarely Speak Test Language at Home - ca	376.68	362.92	14 ***	319.86	309.15	11 **	397.65	393.60	4 **	375.60	368.93	7 **
Mostly Speak Test Language at Home - 1 year	350.92	356.20	-5	307.67	316.43	-9	387.33	380.90	6	375.39	362.84	13
Rarely Speak Test Language at Home - 1 year	339.70	330.72	9 *	273.54	266.96	7	364.44	356.89	8 **	330.72	319.97	11 **
Mostly Speak Test Language at Home - 2	301.06	299.09	2	241.34	241.49	0	357.66	358.95	-1	341.76	328.02	14
Rarely Speak Test Language at Home - 2	312.96	304.53	8	236.28	237.97	-2	349.16	343.30	6 *	303.65	302.67	1
Mostly Speak Test Language at Home - 3+	306.82	295.56	11	233.10	252.90	-20	348.70	323.10	26 ***	305.47	277.69	28 *
Rarely Speak Test Language at Home - 3+	318.05	315.90	2	227.68	240.34	-13	347.84	327.17	21 ***	284.61	270.92	14 **
Rural - ca	365.54	346.54	19	307.63	289.59	18 ***	394.02	387.296	7 ***	369.64	360.504	9 ***
Urban - ca	440.37	427.81	13 ***	414.61	406.44	8	438.86	447.23	-8 **	441.12	447.39	-6
Rural - 1 year oa	323.28	313.69	10	257.39	248.36	9 *	361.35	349.38	12 ***	326.91	310.37	17 ***
Urban - 1 year oa	378.17	382.42	-4	332.48	343.52	-11	383.98	383.96	0	367.98	362.99	5
Rural - 2 years oa	298.85	297.22	2	221.49	228.99	-8	348.18	339.64	9 ***	307.19	295.57	12 **
Urban - 2 years oa	320.05	325.90	-6	255.71	271.05	-15	354.51	361.03	-7	318.00	334.01	-16 *
Rural - 3+ years oa	305.97	308.45	-2	211.99	244.95	-33	347.59	322.45	25 ***	282.82	261.72	21 ***
Urban - 3+ years oa	310.49	291.29	19	236.79	209.05	28	352.88	345.28	8	312.65	320.45	-8

Note: Own Calculations. Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. The full tables with standard errors and the female results without adjusting for dropouts are reported in the appendix. Girls* = adjusted for dropouts, by dropping the weakest performing girls. Red font = below low benchmark (400). Light blue font = pro-male gap. Grade 9: underlined = significant pro-male gap with and without adjusting for dropouts. Grade 9: light red font = no longer (after adjusting for dropouts) significant pro-male gap instead significant pro-girls gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,613 - 11,857 in Grade 5 and between 20,535 - 20,786 in Grade 9.

The figures for school location are fairly similar to the figure of home language. For example, girls and boys of the correct age that go to schools in urban locations have very similar test scores as correct age learners that mostly speak the test language at home. They perform above 400 in both grades and subgroups. Moreover, learners in urban areas perform on average better than learners in rural areas across most age groups and both grades. Furthermore, most gender differences in Grade 5 by school location and over-age are not statistically significant.

At the Grade 9 level, boys tend to outperform girls in several urban age subgroups, such as the correct age subgroup. In contrast, girls in rural areas significantly outperform their male peers in mathematics and science across all age groups, after adjusting for differences in dropouts. All other pro-boy gaps become insignificant thereafter.

Table 5 shows, as in the analysis before, that mathematics and science test scores increase with the school quintile and decrease with over-age. Moreover, more than half of the gender differences by school quintile and age are not statistically significant in Grades 5 and 9.

Table 5: Average Mathematics and Science Achievement for Grades 5 and 9 by Gender, Over-age, and Subgroup (Part 2)

Subgroup	Girls Mean Testscore	Boys Mean Testscore	Gap	Girls Mean Testscore	Boys Mean Testscore	Gap	Girls* Mean Testscore	Boys Mean Testscore	Gap	Girls* Mean Testscore	Boys Mean Testscore	Gap
Q1 School - ca	352.90	331.02	22 ***	290.26	268.20	22 ***	382.07	372.87	9 ***	350.25	341.16	9 **
Q2 School - ca	357.88	340.40	17 ***	292.74	278.62	14 *	391.22	385.01	6 *	365.97	356.57	9 *
Q3 School - ca	375.59	355.93	20 ***	325.86	304.64	21 ***	391.36	388.43	3	371.30	363.62	8 **
Q4 School - ca	411.51	389.18	22 **	380.45	357.12	23 **	423.19	427.39	-4	419.79	420.50	-1
Q5 School - ca	500.47	490.72	10	493.67	492.86	1	473.05	484.11	-11 **	488.97	497.54	-9
IS - ca	478.88	469.78	9	460.65	459.62	1	485.17	481.54	4	501.09	498.23	3
Q1 School - 1 year oa	312.17	306.12	6	235.08	237.38	-2	356.66	342.75	14 *	315.78	295.48	20 **
Q2 School - 1 year oa	324.62	310.66	14 *	254.66	241.26	13	362.75	348.28	14 ***	326.60	308.62	18 ***
Q3 School - 1 year oa	326.34	326.49	0	267.64	267.77	0	363.81	354.28	10 **	336.11	322.31	14 **
Q4 School - 1 year oa	371.81	353.66	18 ***	333.15	306.66	26 ***	379.91	382.10	-2	363.01	358.44	5
Q5 School - 1 year oa	447.44	448.87	-1	427.81	436.69	-9	412.28	406.22	6	401.73	398.19	4
IS - 1 year oa	420.08	431.68	-12	397.40	405.28	-8	428.09	430.18	-2	451.33	424.31	27 *
Q1 School - 2 years oa	300.50	292.53	8	228.21	219.38	9	348.96	336.01	13 ***	292.34	287.26	5
Q2 School - 2 years oa	304.89	278.05	27 **	229.00	209.58	19 *	353.23	340.51	13 **	312.50	298.63	14
Q3 School - 2 years oa	298.94	299.04	0	226.77	232.69	-6	343.12	337.61	6	308.82	296.92	12 *
Q4 School - 2 years oa	281.52	329.85	-48 ***	187.88	275.23	-87 ***	360.80	364.22	-3	335.69	338.55	-3
Q5 School - 2 years oa	418.37	402.08	16	411.32	405.25	6	361.40	394.86	-33 *	333.58	373.01	-39
IS - 2 years oa	361.77	355.69	6	342.15	286.63	56 ***	371.09	375.95	-5	362.69	394.22	-32
Q1 School - 3+ years oa	313.41	310.01	3	231.01	243.38	-12	353.41	314.95	38 ***	286.01	248.57	37 **
Q2 School - 3+ years oa	302.41	264.84	38	189.29	188.34	1	341.42	324.82	17 ***	282.24	265.64	17
Q3 School - 3+ years oa	288.31	337.42	-49	193.53	283.88	-90	350.11	330.10	20 **	291.03	277.35	14
Q4 School - 3+ years oa	473.99	383.80	90	506.54	350.03	157	352.33	341.26	11 *	301.08	316.60	-16
Q5 School - 3+ years oa							345.11	349.72	-5	291.87	371.11	-79 **
IS - 3+ years oa							419.39	397.16	22	363.92	338.77	25

Note: Own Calculations. Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. The full tables with standard errors and the female results without adjusting for dropouts are reported in the appendix. Girls* = adjusted for dropouts, by dropping the weakest performing girls. Red font = below low benchmark (400). Light blue font = pro-male gap. Grade 9: underlined = significant pro-male gap with and without adjusting for dropouts. Grade 9: light red font = no longer (after adjusting for dropouts) significant pro-male gap instead significant pro-girls gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,613 - 11,857 in Grade 5 and between 20,535 - 20,786 in Grade 9.

Fifth-grade girls statistically outperform fifth-grade boys in seven out of 24 school category groups in mathematics and science, and especially in the correct age learner group, while boys statistically outperform girls only in one of the 24 groups. All other fifth-grade gender differences are not statistically significant.

At the Grade 9 level, boys tend to perform better in several Quintile 5 school age subgroups and two out of those four pro-boy gaps are statistically significant after adjusting for higher male dropouts. Nevertheless, after accounting for those, most other pro-boy gaps become insignificant. Moreover, girls then statistically outperform boys in eleven out of the 24 school category groups in mathematics and in science in nine out of the 24 groups. Across all age groups and after accounting for differences in dropout rates, girls in Quintile 1 and 2 schools have significantly higher mathematics scores than the respective boys. This confirms what has been found by Hofmeyr (2020), that pro-girl gaps are found in lower school quintiles and pro-boy gaps are found in higher school quintiles.

Unlike the averages, most gender differences in Grade 5 by age groups and provinces are not statistically significant, as shown in Table 6. At the Grade 5 level, boys only statistically outperform girls in one out of the 36 province- and over-age subgroups in mathematics and in two subgroups in science, while girls statistically outperform boys in nine out of the 36 subgroups in mathematics and three out of the 36 subgroups in science. The majority of the statistically significant gender differences are in the correct age learner group.

At the Grade 9 level, Table 6 shows that more gender differences are statistically significant compared to Grade 5, and particularly more of the pro-boy gaps. Without controlling for higher male dropout rates, boys statistically outperform girls in 15 of the 36 subgroups in mathematics, while there is no statistically significant pro-girl gap. Contrastingly, after adjusting for the differences in dropouts, boys statistically outperform girls in five out of 36 subgroups in mathematics and girls score statistically higher in ten out of 36 subgroups in mathematics. The trends are almost identical in science. The majority of the statistically significant pro-boy gaps occur in the Western Cape. This confirms the findings from the analysis before; in the Western Cape ninth-grade boys perform better than ninth-grade girls in mathematics and science even after controlling for differences in over-age and repetition.

This section has shown that out of the 76 considered subgroups at the Grade 5 levels, there are 20 pro-girl gaps and two pro-boy gaps in mathematics and there are 14 pro-girl gaps and three pro-boy gaps in science. The above-mentioned gender gaps are statistically significant. Contrastingly, at Grade 9 levels after adjusting for higher male dropout rates, around one-third of the considered gender comparisons are statistically significant pro-girl gaps and one-eighth are statistically significant pro-boy gaps. Thus, girls perform significantly better than boys. Nevertheless, since again relatively fewer pro-girl gaps are statistically significant in the subgroups after controlling for age differences, this seems to reinforce that part of the pro-girl gap in Grade 5 and Grade 9 can be attributed to the female advantage in school progression.

Table 6: Average Mathematics and Science Achievement for Grades 5 and 9 by Gender, Over-age, and Subgroup (Part 3)

	Mathematics - Grade 5			Science - Grade 5			Mathematics - Grade 9			Science - Grade 9		
Subgroup	**Girls** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls*** Mean Testscore	**Boys** Mean Testscore	**Gap**	**Girls*** Mean Testscore	**Boys** Mean Testscore	**Gap**
Eastern Cape - ca	392.63	358.89	34	342.19	304.06	38	393.56	391.13	2	370.66	359.04	12
Free State - ca	402.36	415.16	-13	347.19	372.70	-26	426.16	419.32	7	416.15	412.47	4
Gauteng - ca	427.57	413.35	14 *	398.78	385.99	13	436.11	436.72	-1	441.61	441.00	1
KwaZulu-Natal - ca	378.68	363.23	15 **	323.73	316.20	8	402.52	401.21	1	382.60	379.03	4
Limpopo - ca	356.33	329.91	26 ***	302.33	273.73	29 ***	389.97	381.09	9 *	363.40	353.59	10
Mpumalanga - ca	363.53	346.46	17 *	304.61	297.12	7	400.08	393.39	7	378.82	366.19	13
North West - ca	381.28	364.15	17 ***	334.38	312.58	22 ***	404.88	408.78	-4	388.81	392.98	-4
Northern Cape - ca	394.78	383.71	11	357.09	351.46	6	392.64	401.55	-9 *	376.90	386.53	-10 *
Western Cape - ca	465.17	449.25	16 **	447.16	426.00	21 **	455.39	476.31	-21 ***	456.02	480.97	-25 ***
Eastern Cape - 1 year oa	324.80	314.85	10	263.85	253.11	11	361.82	341.73	20 **	326.27	303.52	23 *
Free State - 1 year oa	346.82	341.49	5	279.74	277.02	3	374.38	380.90	-7	350.38	357.11	-7
Gauteng - 1 year oa	372.98	389.32	-16	330.08	356.49	-26	384.63	383.97	1	373.46	366.47	7
KwaZulu-Natal - 1 year oa	345.87	325.62	20 *	280.67	256.99	24	365.03	341.40	24 **	333.11	297.86	35 **
Limpopo - 1 year oa	289.62	297.33	-8	216.21	236.29	-20 *	349.69	345.71	4	304.76	299.18	6
Mpumalanga - 1 year oa	322.74	311.19	12	263.30	247.32	16	373.23	357.57	16 *	346.79	328.48	18 *
North West - 1 year oa	313.01	326.19	-13	237.79	257.98	-20	369.73	382.56	-13 *	340.60	352.10	-12
Northern Cape - 1 year oa	344.94	343.89	1	289.79	301.69	-12	369.93	376.77	-7	335.48	349.36	-14
Western Cape - 1 year oa	385.28	391.54	-6	346.39	359.32	-13	387.88	402.04	-14 ***	370.22	385.35	-15 ***
Eastern Cape - 2 years oa	294.46	281.05	13	207.50	210.13	-3	341.33	326.42	15 **	287.01	272.48	15
Free State - 2 years oa	334.44	324.53	10	263.97	245.94	18	354.18	359.25	-5	308.97	327.87	-19 *
Gauteng - 2 years oa	323.46	326.23	-3	271.42	258.04	13	362.74	357.37	5	325.91	334.57	-9
KwaZulu-Natal - 2 years oa	309.07	288.74	20	229.58	230.13	-1	345.78	337.38	8	309.77	298.16	12
Limpopo - 2 years oa	291.56	275.85	16	235.46	210.69	25	331.55	342.00	-10	283.58	297.71	-14
Mpumalanga - 2 years oa	274.77	318.81	-44 *	188.32	261.89	-74 **	360.70	346.72	14	337.84	303.60	34 **
North West - 2 years oa	294.63	297.98	-3	216.02	229.31	-13	361.46	348.63	13	320.13	305.86	14
Northern Cape - 2 years oa	325.81	310.68	15	285.99	253.88	32	354.68	350.33	4	335.13	318.93	16 **
Western Cape - 2 years oa	316.23	338.47	-22	233.99	273.82	-40	365.09	374.79	-10 *	327.40	345.55	-18 **
Eastern Cape - 3+ years oa	290.44	315.22	-25	181.89	235.65	-54	346.62	318.26	28 ***	280.16	245.92	34
Free State - 3+ years oa	323.59	332.32	-9	233.17	233.48	0	349.40	348.65	1	306.33	304.58	2
Gauteng - 3+ years oa	298.75	401.98	-103	203.44	385.45	-182	360.77	339.59	21	320.42	304.04	16
KwaZulu-Natal - 3+ years	424.02	300.26	124	393.75	216.23	178	360.94	316.63	44 **	258.82	274.51	-16
Limpopo - 3+ years oa	276.57	268.51	8	230.20	209.84	20	337.73	322.43	15 **	280.05	260.59	19 **
Mpumalanga - 3+ years oa	353.36	293.21	60 *	250.26	230.36	20	344.53	331.29	13	295.83	269.97	26
North West - 3+ years oa	262.84	242.43	20 **	170.86	168.88	2	346.86	320.33	27 ***	280.61	264.44	16
Northern Cape - 3+ years oa							359.83	339.10	21 ***	325.59	292.43	33 *
Western Cape - 3+ years oa							346.62	358.82	-12	294.29	329.36	-35 ***

Note: Own Calculations. Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. The full tables with standard errors and the female results without adjusting for dropouts are reported in the appendix. Girls* = adjusted for dropouts, by dropping the weakest performing girls. Red font = below low benchmark (400). Light blue font = pro-male gap. Grade 9: underlined = significant pro-male gap with and without adjusting for dropouts. Grade 9: light red font = no longer (after adjusting for dropouts) significant pro-male gap instead significant pro-girls gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,613 - 11,857 in Grade 5 and between 20,535 - 20,786 in Grade 9.

5 What Correlates May Explain Gender Differences in Mathematics and Science Performance?

In addition to the South Africa specific factors such as school quintile, provinces, location and home language and differences in repetition and dropping out, there are several other explanations for gender differences in learners' achievement. Despite similar mathematics and science achievements, international evidence suggests that boys often report having more positive mathematics and science attitudes (Meinck and Brese, 2019). The question that remains is, do South African girls currently also report lower levels of confidence and other less positive attitudes about mathematics and science although they achieve better average results and across more subgroups compared to boys? Moreover, if there are statistical differences, do they correlate with the gender differences in achievement and hence do they change the previous findings?

5.1 Gender Differences in Attitudes

Besides the student achievement data, TIMSS also asks students about their attitudes towards mathematics and science such as "liking-, valuing-, and being confident in mathematics/science" and their attitudes towards school in general. The latter include perceptions of the school climate and safety and whether students like being in school. For example, the TIMSS student background questionnaire includes questions about the frequency and intensity of student bullying and disorderly behaviour during mathematics lessons.

Most questions have four response options, and students have to state the extent to which they agree with a statement from "disagree a lot" to "agree a lot" or they have to rank the frequency of an event such as bullying on a four-point scale from "never" to "at least once a week". TIMSS aggregates these individual constructs to several indices, all with scores between 1 (low) and 3 (high).[21] This section analyses gender differences in five TIMSS mathematics and school attitudes indices.[22]

The 'Students' Sense of School Belonging Index' includes five questions such as "I like being in school" and "I feel like I belong at this school" and the responses were aggregated to "little-, some-, and high sense of school belonging".

Table 7 shows that a larger proportion of Grade 5 learners compared to Grade 9 learners have a high sense of school belonging and girls have a higher sense of school belonging compared to boys in both

[21] This analysis uses the official TIMSS indices. See Mullis et al. (2020) for more details on the indices and the full list of index items.
[22] This analysis reports only the mathematics indices due to lack of space and because there are more indices for mathematics.

grades. Both pro-girl gaps are statistically significant.[23] This is in line with the findings of Hofmeyr (2020) who uses TIMSS 2015 data and finds that girls have a higher sense of school belonging in Grade 5.

Table 7: Responses to Selected TIMSS Attitude Indices, by Gender and Grade

Students Sense of School Belonging Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
Some sense of school belonging	39.17%	32.91%	-6.26%	44.40%	42.10%	-2.30%
High sense of school belonging	51.00%	60.28%	9.28%	45.50%	49.96%	4.46%
Student Bullying Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
About Monthly	43.00%	46.62%	3.62%	46.09%	47.80%	1.71%
About Weekly	33.51%	25.01%	-8.50%	20.57%	16.55%	-4.02%
Students Like Learning Mathematics Lessons Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
Somewhat like learning mathematics	45.66%	39.47%	-6.19%	45.31%	43.28%	-2.03%
Very much like learning mathematics	40.26%	50.91%	10.65%	36.46%	36.06%	-0.40%
Disorderly Behavior during Math Lessons Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
Some Lessons	67.79%	67.19%	-0.60%	71.90%	70.67%	-1.23%
Most Lessons	23.04%	23.50%	0.46%	18.90%	19.59%	0.69%
Student Confident in Mathematics Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
Somewhat confident in mathematics	52.29%	53.00%	0.71%	41.96%	38.27%	-3.69%
Very confident in mathematics	15.44%	18.27%	2.83%	6.76%	6.84%	0.08%
Students Value Mathematics Index						
Proportion that answered	Grade 5 Boys	Grade 5 Girls	Gender-gap (propotion)	Grade 9 Boys	Grade 9 Girls	Gender-gap (propotion)
Somewhat mathematics				29.68%	25.36%	-4.32%
Strongly value mathematics				64.61%	70.28%	5.67%

Note: Own Calculations, Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. light blue font = pro-male gap. gray background= more variation in the responses.

Student bullying is another typical example of gender differences. The 'Student Bullying Index' is the aggregate of eleven questions in Grade 4/5 and fourteen questions in Grade 8/9. The index includes questions such as "how often have other students from your school made fun of you …" and

[23] The significances are reported in the correlation matrices (Tables A3 and A4) in the appendix.

“how often have other students from your school hit or hurt you”. The frequencies were aggregated to “never or almost never”, “about monthly” and “about weekly”.

Fifth-grade learners report experiencing bullying more frequently than ninth-grade learners and boys report experiencing bullying more frequently than girls across both grades. Both “pro-boy” gaps are statistically significant. These results are in line with the findings by Zuze and Beku (2019) that use TIMSS 2015 data and found that boys were at greater risk to be bullied than girls.

A pleasant working environment, structured classroom procedures and students who follow the lessons are important for student learning (Mullis et al., 2020). Moreover, some studies have shown that boys are affected more adversely by disruptive behaviour than girls (Machin and McNally, 2005). TIMSS collects information on how frequently students experience disorderly behaviour during mathematics lessons. The ‘Disorderly Behavior during Math Lessons Index’ includes six questions such as “students do not listen to what the teacher says” and “it is too disorderly for students to work well”. The frequencies are aggregated to “few or no-, some-, and most lessons”.

Slightly more girls across both grades report disruptive behaviour during most lessons compared to boys, but the gender differences are not statistically significant. This result seems to contrast with the international evidence mentioned above.

TIMSS uses the following three indices to determine students’ attitudes about mathematics: ‘Students Like Learning Mathematics Index’, ‘Student Confident in Mathematics Index’ and the ‘Students Value Mathematics Index’. It should be noted that the attitude indices are related, but all measure different concepts.[24]

The first index is measured with nine intrinsic motivation items such as “I enjoy learning mathematics”, and “mathematics is one of my favourite subjects”. The item responses are aggregated to “do not-, somewhat-, and very much like” mathematics.

More Grade 5 learners report very much like learning mathematics compared to Grade 9 learners. Interestingly, fifth grade girls are more likely to report very much like learning mathematics compared to fifth-grade boys, while in Grade 9 slightly more boys than girls fall into this response category. Both the pro-girl gap in Grade 5 and the pro-boy gap in Grade 9 are statistically significant. The results are partly in line with the finding by Hofmeyr (2020) who finds that being female is associated with a higher ‘Students Like Learning Mathematics Index’ in Grade 5 in 2015.

The ‘Students Confident in Mathematics Index’ includes nine statements about how well learners think they can do mathematics including “I usually do well in mathematics” and “I am good at

[24] See the correlation matrices A3 and A4 in the appendix.

working out difficult mathematics problems". The responses are combined into the three categories "not-, somewhat-, and very confident" at mathematics. While more than a third of learners report to like mathematics a lot, few South African learners report to be very confident at mathematics. In addition, more Grade 5 learners report to be highly confident compared to Grade 9 learners. These results are in line with the findings by Zuze et al. (2017).

Moreover, slightly more girls report being highly confident in mathematics in Grade 5 than the boys, while in Grade 9 similar proportions of boys and girls responded to be very confident in mathematics. Overall being female is associated with a statistically higher student confidence index in Grade 5 and a statistically lower confidence index in Grade 9. The latter results are in line with the literature that finds that girls are less confident at mathematics even though they perform equally well or better at mathematics, and that the gap is wider at secondary school levels (Zuze and Beku, 2019).

For Grade 8/9 learners TIMSS reports the 'Students Value Mathematics Index'. The index combines nine statements about student extrinsic motivation such as "I need mathematics to learn other school subjects" and "I need to do well in mathematics to get the job I want" and the responses are combined to "do not-, somewhat-, and strongly value mathematics". Tables 7 and A4 shows that being female is associated with a statistically higher Students Value Mathematics Index.

In sum, this section has shown that larger proportions of Grade 5 learners fall into the highest category of every index compared to Grade 9 learners and that being female is associated with more positive mathematics attitudes in Grade 5 and relatively fewer positive attitudes in Grade 9.

5.2 Multivariate Model

The previous sections have shown that boys are disadvantaged in terms of grade repetition and dropout and girls perform on average significantly better than boys and in more subgroups. Moreover, the previous results seem to suggest that part of the pro-girl gap in Grade 5 and 9 can be attributed to the female advantage in school progression. The question that remains is, do the initial conclusions about gender differences in achievement hold even after expanding the models by school quintile, region, repetition, dropout, and other factors simultaneously?

Furthermore, the first subsection of this section has shown that there are significant gender differences in attitudes. Thus, the second question that remains is, are the observed gender differences in attitudes correlated with the gender differences in achievement? This part of the analysis investigates these questions by employing ordinary least squares (OLS) regressions. Additionally, research has shown that teacher gender is correlated with gender differences in some contexts. The following multivariate analysis will study whether this is also the case in TIMSS 2019.

Several identification issues may bias the conventional ordinary least square estimations. First, there might be unobserved student and teacher factors that are a potential source of endogeneity (Shepherd, 2017). To reduce the bias, the following control variables and proxy variables are included: South Africa specific factors such as school quintile, province, home language, location, an asset index of student wealth (which is a proxy for SES), and in addition parental education and class size. In addition, school fixed effects are included to control for unobserved characteristics of schools such as school quality and functioning.[25] Those results are reported in the appendix.

Moreover, the TIMSS data in the South African context is likely to suffer from selection bias due to gender differences in repetition and dropout as discussed in the previous sections. Both issues will be addressed by controlling for (over-)age and controlling for the weakest performing girls (gender balance dummy) as discussed ins section 4.2.3.

Furthermore, there might be reverse causality in attitudes and achievement. Learners with negative attitudes might approach mathematics and science subjects with less enthusiasm, which then can lead to lower achievement. Simultaneously, learners that fail mathematics tests might think more negatively about the subject after failing (Foley et al., 2017). Moreover, it could be that attitudes are not directly related to achievement but instead with other factors such as the learning environment (Zuze et al., 2017). Thus, it is not clear whether there is a reverse causality problem.

Ideally one would need an instrumental variable to address the mentioned endogeneity issues, but such a variable is not available. Moreover, several other important factors might explain gender differences such as prior achievement, gender norms, and labour market prospects which are not available in the data set. Thus, it cannot be ruled out that the results are unbiased and hence that the OLS model does not allow drawing causal conclusions.

The multivariate analysis includes four different models. Only the most important results are shown here, namely mathematic test scores for Grades 5 and 9. Model 1 is the standard model that will be extended in the other three models. Model 1 includes all the South Africa specific control variables as discussed in the ‘data and methodology’ section. The previous analysis has shown that boys outperform girls in Quintile 5 schools and in Grade 9 additionally in Western Cape schools, thus certain results will be reported for those subsamples.

[25] The asset index was calculated using nine home possession variables and applying principal component analysis. See Hofmeyr (2020) and Spaull and Pretorius (2019) for more details.

5.3 Results

Model 1

Tables 8 and 9 report different variations of Model 1 using the mathematics test score as the dependent variable and female as the main explanatory variable for Grade 5 and Grade 9 respectively. Column (1) shows the model with all control variables but without controlling for over-age. The control variables have the expected coefficient signs. On average, across both grades, there is a significant gender difference in mathematics test scores of 19.63 test points in Grade 5 and 4.65 test points in Grade 9 favouring girls, ceteris paribus. Moreover, the pro-girl gaps are smaller after including the control variables.

Column (2) includes over-age. Both pro-girl gaps become smaller after controlling for over-age, which seems to reinforce that part of the pro-girl gap in Grades 5 and 9 can be attributed to the female advantage in school progression, even after controlling for SES and other factors. While the pro-girl gap in Grade 5 reduces to 14.52, the female coefficient in Grade 9 becomes negative and indicates that boys significantly outperform girls who progressed through school at the same pace by 4.86 test points. In addition, the models clearly show that over-age learners have on average significantly lower test scores than appropriate age learners. For example, being one year over-age in Grade 9 is associated with 38.81 lower test scores on average in mathematics, ceteris paribus, which is equivalent to roughly one year of learning.

Column (3) shows that the pro-girl gap in Grade 5 is not statistically significant in Quintile 5 schools and in Grade 9 the pro-boy gap in Quintile 5 schools is statistically larger than in the full sample. The regression in column (4) of Table 9 is equivalent to the regression in column (3) but uses the subsample of Western Cape schools for Grade 9. Similarly, as in the previous sections and Quintile 5 schools, there is a statistically significant pro-boy gap in the Western Cape.

The following three model specifications in columns (5) – (7) of Table 9 analyse whether the observed pro-boy gaps in Grade 9 remain after by controlling for the weakest performing girls (‘gender balance’ dummy) that would have dropped out if they were boys. While the pro-boy gap in the full sample alters to a statistically significant pro-girl gap after controlling for higher male dropouts, the pro-boy gaps remain statistically significant in Quintile 5 and Western Cape schools. Being female is then associated on average with 3.97 lower test points, ceteris paribus.

The ‘gender balance’ dummy coefficient is large and has a negative sign by construction and is statistically significant across all model specifications. Moreover, the results seem to suggest that only in Quintile 5 and in Western Cape schools a larger class size is associated with lower mathematics achievement. Furthermore, the R-square increases between three and six percentage points after controlling for over-age and gender differences in dropouts (gender balance) which suggests that the regressions with over-age and 'gender balance' fit the data better.

Tables A5 and A6 in the appendix show the fixed effect results.[26] The results for Grade 5 show that the coefficients are fairly similar in Model 1 with and without school fixed effects. Contrastingly in Grade 9, Table A6 shows that the pro-girl gaps are no longer statistically significant after controlling for school fixed effects. Thus, on average, boys and girls perform equally well in Grade 9. Moreover, the pro-boy gaps in the Western Cape and Quintile 5 schools become larger after controlling for school fixed effects. The remaining coefficients are fairly similar in the model with and without fixed effects.

These fixed effect results seem to suggest that there are school factors that explains the pro-girl gaps, which are not captured in other observed school-level variables. However, those factors are unknown, because fixed effects are essentially a black box and it is not clear which biases are eliminated with them (Collischon and Eberl, 2020). It is also noteworthy that those results might be biased due to other omitted variables.

Interestingly, the fixed effect results are in line with the findings by Shepherd (2017). She uses classroom fixed effects and finds a pro-boy gap in Quintile 5 schools and no significant differences in the full sample, but her pro-boy gap is larger.

In summary, the results seem to suggest that without controlling for over-age, one would over-estimate the pro-girl mathematics gap and without controlling for differences in dropout, one would over-estimate the pro-boy gap at least in the full sample. Finally, the results show that while the pro-girl gaps become insignificant in Grade 9 after controlling for fixed effects, the pro-girl gaps are statistically significant in Grade 5 and similar in the model with and without fixed effects.

[26] It is noteworthy that the variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using school fixed effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table 8: OLS Model 1 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)
VARIABLES	Full sample	Full sample	Q5 Schools
Female	**19.63*** **	**14.52*** **	**2.489**
	(2.018)	(2.034)	(4.937)
Q2 Schools	7.714	6.752	
	(5.840)	(5.852)	
Q3 Schools	13.12*	10.90	
	(6.741)	(6.744)	
Q4 Schools	30.16***	27.91***	
	(7.526)	(7.612)	
Q5 Schools	93.00***	89.66***	
	(9.708)	(9.733)	
Independent Schools	88.39***	84.58***	
	(13.66)	(13.78)	
Asset index (std)	15.03***	13.70***	20.51***
	(1.681)	(1.594)	(2.330)
Free State	20.74**	19.57**	-29.55*
	(10.11)	(9.870)	(15.99)
Gauteng	2.107	-0.374	-17.69*
	(10.47)	(10.27)	(8.999)
KwaZulu-Natal	-3.441	-6.256	-34.66***
	(8.581)	(8.605)	(4.909)
Limpopo	-19.53*	-24.24**	-21.01***
	(10.14)	(10.01)	(4.775)
Mpumalanga	-6.984	-7.529	-99.15***
	(9.980)	(10.17)	(18.01)
North West	2.386	0.352	-36.12*
	(8.746)	(8.716)	(18.95)
Northern Cape	-1.039	-1.381	-76.30***
	(11.10)	(11.08)	(20.39)
Western Cape	31.04***	28.01***	-14.76
	(9.823)	(9.655)	(9.615)
Rarely speak test language at home	-9.431***	-10.11***	-26.77***
	(3.111)	(3.007)	(5.399)
Urban	17.95***	16.68***	-22.12
	(6.270)	(6.076)	(16.39)
Parent has at least matric	35.32***	32.49***	23.03***
	(2.785)	(2.692)	(4.412)
Parental education (missing)	-9.403***	-8.170***	-10.89*
	(2.823)	(2.671)	(6.201)
Class size*	-0.214	-0.206	-3.806***
	(0.155)	(0.157)	(0.845)
1 year over-age		-33.42***	-33.71***
		(2.142)	(7.327)
2 years over-age		-50.72***	-50.10***
		(3.902)	(16.45)
3+ years over-age		-41.02***	-70.29***
		(11.42)	(13.44)
Constant	342.5***	359.4***	653.4***
	(10.23)	(10.23)	(28.62)
Observations	11,080	11,080	1307
R-squared	0.384	0.412	0.343

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). See the 'data and methodology section' for more details about the variables. Class size* is an imputed variable using the mean class size for missing observations. There are many missing observations of parental education in Grade 5. The dummy variable 'parental education (missing)' takes a value of 1 if there are missing observations of parental education.

Table 9: OLS Model 1 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Full sample	Full sample	Q5 Schools	Western Cape	Full sample	Q5 Schools	Western Cape
Female	**4.653*** **	**-4.858*** **	**-8.396** **	**-11.93*** **	**3.968*** **	**-6.028* **	**-8.986*** **
	(1.383)	(1.323)	(3.282)	(2.860)	(1.397)	(3.110)	(2.928)
Q2 Schools	7.752	7.124		-12.86	6.352		-12.97
	(5.402)	(5.175)		(8.929)	(4.326)		(7.981)
Q3 Schools	5.984	5.758		-0.111	4.022		-1.369
	(4.947)	(4.411)		(9.399)	(3.725)		(8.533)
Q4 Schools	29.97***	28.06***		-11.95	25.37***		-12.44
	(7.874)	(7.030)		(10.25)	(6.417)		(9.477)
Q5 Schools	68.48***	63.82***		49.06***	61.12***		47.78***
	(7.580)	(6.977)		(11.97)	(6.674)		(11.43)
Independent Schools	82.75***	76.28***		71.29***	72.66***		70.15***
	(10.16)	(9.985)		(21.52)	(9.688)		(21.30)
Asset index (std)	8.207***	6.533***	15.16***	9.220***	6.163***	15.38***	9.020***
	(1.211)	(1.104)	(3.046)	(1.674)	(1.029)	(2.764)	(1.643)
Free State	15.34**	20.38***	10.13		16.85***	9.219	
	(7.385)	(6.655)	(9.408)		(5.938)	(9.262)	
Gauteng	8.942	7.957	-18.24***		5.192	-18.61***	
	(7.539)	(6.924)	(5.310)		(6.279)	(5.213)	
KwaZulu-Natal	-0.838	-2.390	-29.67***		-2.677	-29.08***	
	(8.248)	(7.578)	(4.911)		(6.617)	(4.638)	
Limpopo	0.550	1.260			-0.867		
	(7.822)	(7.280)			(6.358)		
Mpumalanga	0.170	3.285	-40.37***		0.000973	-36.61***	
	(8.147)	(7.409)	(4.073)		(6.499)	(5.019)	
North West	9.883	11.98*			10.56*		
	(7.520)	(6.827)			(5.916)		
Northern Cape	0.447	5.316	-70.43***		1.254	-68.45***	
	(7.804)	(7.266)	(9.719)		(6.447)	(9.594)	
Western Cape	26.06***	27.00***	11.07*		24.00***	10.50*	
	(7.912)	(7.211)	(6.315)		(6.631)	(6.320)	
Rarely speak test language at home	-17.11***	-15.36***	-21.35***	-6.851	-14.49***	-21.63***	-7.212*
	(2.471)	(2.180)	(4.887)	(4.373)	(2.075)	(4.653)	(4.208)
Urban	11.46**	9.696**	13.22	14.44**	8.684**	12.43	14.73**
	(4.831)	(4.276)	(10.63)	(7.193)	(4.057)	(10.39)	(6.985)
Parent has at least matric	7.881***	4.997***	3.961*	16.21***	4.641***	2.980	15.93***
	(1.467)	(1.280)	(2.310)	(2.704)	(1.246)	(2.593)	(2.663)
Class size*	-0.128	-0.0963	-2.316***	-1.589***	-0.109	-2.224***	-1.566***
	(0.140)	(0.131)	(0.321)	(0.346)	(0.117)	(0.318)	(0.341)
1 year over-age		-38.81***	-54.55***	-43.51***	-35.27***	-53.31***	-41.28***
		(1.896)	(5.123)	(2.532)	(1.836)	(4.861)	(2.529)
2 years over-age		-51.31***	-57.81***	-58.28***	-47.43***	-53.73***	-52.66***
		(2.079)	(11.49)	(3.891)	(1.954)	(10.43)	(3.736)
3+ years over-age		-62.09***	-77.33***	-61.68***	-53.99***	-71.46***	-56.40***
		(2.974)	(16.67)	(6.458)	(2.648)	(19.75)	(6.662)
Gender balance					-100.7***	-126.2***	-105.4***
					(2.245)	(11.28)	(5.019)
Constant	373.2***	392.4***	536.3***	478.1***	394.1***	534.3***	477.2***
	(10.68)	(9.750)	(8.769)	(13.58)	(8.741)	-8.182	(13.20)
Observations	20,113	20,113	3,451	5,173	20,113	3,451	5,173
R-squared	0.317	0.390	0.411	0.500	0.453	0.430	0.518

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). See the 'data and methodology section' for more details about the variables. Class size* is an imputed variable using the mean class size for missing observations.

Model 2

Model 1 is extended in Model 2 by the attitude indices as discussed in section 5.1 and by two additional dummy variables which are based on two TIMSS indices: namely the 'Instructional Clarity in Mathematics Lessons Index' and the 'Home Resources for Learning Index'. Model 2 includes the highest values of these indices ("high clarity of instruction" and "many resources") as dummy variables.[27]

Tables 10 and 11 summarise the Model 2 results by adding one index after the other for Grade 5 and Grade 9 respectively. The fixed effect results are reported in Tables A7 and A8 in the appendix. The attitude indices are added as categorical variables, with a value between one (low) and three (high).[28]

The results show, that across all model specifications the pro-girl gaps are statistically significant in Grade 5 and similar in the model with and without fixed effects. The pro-girl gap in Grade 5 is between 8.34 and 15.46 mathematics test points. As shown in Model 1, the pro-girl gaps in Grade 9 are no longer significant in the model with school fixed effects.

Moreover, the results of all four tables show that each index is statistically significant, but once they are added all together in the last column of each table some indices become insignificant.

Furthermore, the results show that all indices have the expected relationship with the mathematics test score, except for the 'high clarity of instruction' dummy in Grade 9, in the model with all indices. It is not clear why this is the case.

Overall, Grade 5 learners that report having high clarity of instruction have a higher mathematics score on average, ceteris paribus, as well as learners that have many home resources in both grades. Additionally, learners that have a higher 'sense of belonging index' across both grades perform statistically better, as well as learners that like learning mathematics, that are confident in mathematics and additionally that value mathematics in Grade 9.

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[27] The "Instructional Clarity in Mathematics Lessons Index" includes the responses to seven statements such as "I know what my teacher expects me to do" and "my teacher is good at explaining mathematics". The item responses are aggregated to "low-, moderate-, and high clarity" of instruction. Model 2 includes the highest value as a dummy variable. The 'Home Resources for Learning Index' is another measure for students SES besides the asset index and is the aggregate of five students' questions such as the number of children's books at home, and the parents' levels of education. The aggregated index is divided into three categories and the highest score "many resources" was included as a dummy variable in model 2. Moreover, Model 2 also includes the binary variable 'parent has matric' which is based on the parents' levels of education variable, as the home resource index. Since both variables are weekly correlated Model 2 includes both variables (see correlations matrix).

[28] The medium and high categorical values are shown in the tables, while the low value is the omitted category.

Table 10: OLS Model 2 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**11.75*** **	**15.43*** **	**13.20*** **	**12.61*** **	**9.990*** **	**15.46*** **	**13.83*** **	**8.342*** **
	(2.003)	(2.019)	(2.038)	(2.099)	(1.801)	(2.043)	(1.893)	(1.805)
High clarity of instruction	38.48***							14.11***
	(2.845)							(2.963)
Many home resources*		62.24***						55.59***
		(12.52)						(12.34)
Some sense of School belonging			12.77***					3.129
			(3.283)					(3.149)
High sense of School belonging			31.65***					3.422
			(3.485)					(3.277)
Student bullying - about monthly				-21.16***				-11.88***
				(2.964)				(2.567)
Student bullying - about weekly				-46.97***				-27.73***
				(3.443)				(2.984)
Somewhat like learning mathematics					15.11***			8.864***
					(3.123)			(3.204)
Very much like learning mathematics					62.54***			34.81***
					(3.765)			(3.733)
Disorderly behavior during some math lessons						-7.702*		10.79***
						(4.175)		(3.714)
Disorderly behavior during most math lessons						-16.91***		4.188
						(4.918)		(4.285)
Somewhat confident in mathematics							30.14***	19.28***
							(1.935)	(1.832)
Very confident in mathematics							80.44***	53.36***
							(3.332)	(3.110)
Constant	326.0***	355.2***	333.4***	374.8***	322.0***	363.0***	326.1***	305.4***
	(11.30)	(10.32)	(11.16)	(11.05)	(11.44)	(10.77)	(10.50)	(12.59)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,240	10,240	10,240	10,240	10,240	10,240	10,240	10,240
R-squared	0.445	0.420	0.428	0.444	0.479	0.418	0.485	0.530

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices are discussed in the text. Model 2 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 2 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources.

Table 11: OLS Model 2 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**3.030****	**3.140****	**2.809****	**2.613***	**3.507*****	**3.131****	**4.280*****	**2.468***	**3.508*****
	(1.365)	(1.348)	(1.359)	(1.333)	(1.323)	(1.356)	(1.325)	(1.319)	(1.228)
High clarity of instruction	4.214***								-6.904***
	(1.282)								(1.337)
Many home resources		39.70***							33.95***
		(5.207)							(4.493)
Some sense of School belonging			5.934**						2.079
			(2.410)						(2.181)
High sense of School belonging			11.45***						2.041
			(2.467)						(2.337)
Student bullying - about monthly				-8.102***					-5.460***
				(1.142)					(1.079)
Student bullying - about weekly				-24.46***					-19.53***
				(1.666)					(1.634)
Somewhat like learning mathematics					7.958***				1.095
					(1.524)				(1.536)
Very much like learning mathematics					26.97***				6.776***
					(1.721)				(1.944)
Disorderly behavior during some math lessons						-11.96***			-4.928**
						(2.340)			(2.350)
Disorderly behavior during most math lessons						-20.75***			-11.00***
						(3.024)			(2.941)
Somewhat confident in mathematics							18.55***		14.91***
							(1.319)		(1.432)
Very confident in mathematics							66.29***		57.26***
							(2.350)		(2.602)
Somewhat value mathematics								16.41***	15.69***
								(2.749)	(2.556)
Strongly value mathematics								29.92***	22.56***
								(2.606)	(2.511)
Constant	393.8***	395.2***	388.4***	405.1***	383.2***	407.0***	378.6***	373.0***	372.4***
	(8.740)	(8.560)	(8.876)	(8.583)	(8.785)	(8.998)	(8.716)	(8.954)	(9.562)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,268	19,268	19,268	19,268	19,268	19,268	19,268	19,268	19,268
R-squared	0.449	0.455	0.451	0.460	0.468	0.453	0.498	0.460	0.519

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices are discussed in the text. Model 2 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 2 includes both variables.

Moreover, it should be noted that there are large differences in the mathematics performance between learners with "medium" and "high" values of the attitude indices. For example, compared to fifth-grade learners that are not confident in mathematics have fifth-grade learners that are somewhat confident in mathematics 30 test points higher mathematics achievement on average, ceteris paribus, and fifth-grade learners that are very confident in mathematics have on average 80 test points higher mathematics score ceteris paribus compared to learners that are not confident.

Contrastingly, experiencing bullying monthly or weekly or disorderly behaviour during some or most mathematics lessons is associated in both grades with statistically lower mathematics performance, ceteris paribus.

Finally, Model 2 indicates that fifth-grade girls perform statistically better than fifth-grade boys, even after controlling for gender differences in over-age, mathematics- and school attitudes, and fixed effects. In contrast, the gender differences in Grade 9 are no longer statistically significant after controlling for fixed effects. Moreover, including all indices simultaneously increases the explanatory power of the model, thus this model specification will be extended in Model 3.

Model 3

Model 2 is extended by interactions with the highest value of the attitude indices from section 5.1 in Model 3 to study whether the gender differences in the attitudes are correlated with the gender differences in achievement.[29] Moreover, the previous analysis has shown that boys outperform girls in Quintile 5 schools and in Grade 9 additionally in Western Cape schools, thus, this section analyses whether there are differences that may explain the pro-boy gaps. Tables 12 to 16 report the results for Grades 5 and 9 for different samples respectively. The fixed effects results are reported in the appendix.

Tables 12 and 13 show that no interaction effect is statistically significant in Grade 5, both for the full sample and the Quintile 5 school sample. Furthermore, the pro-girl gaps hardly change in Grade 5 and are around 8.32 and 9.7 test points in the full model. The fixed results for Model 3 are similar, except for the disorderly behaviour interaction effect which is statistically significant and negative. Thus, gender differences in attitudes are not correlated with the gender differences in mathematics achievement in most cases in Grade 5.

Contrastingly, in Grade 9 more interaction effects are statistically significant. The female interaction with the 'weekly bullying'-, 'very much liking mathematics'-, 'strongly valuing mathematics'-, and

[29] The highest value was selected because Table 7 in section 5.1 has shown that more variation in proportions is found in the highest score categories of most indices.

‘being very confident in mathematics’ dummies are statistically significant in some model specifications, both in the model with and without fixed effects.

For example, Tables 14 and 16 show that ninth-grade girls are less affected by weekly bullying in the full sample and the Western Cape school subsample, both in the model with and without fixed effects. Moreover, the results for the Western Cape show a 13.2 or 9 mathematics test score difference of being very confident in mathematics between girls and boys in the model with and without fixed effects respectively. Thus, among girls that are very confident in mathematics, the test performance increases by 68.05 points compared to 81.25 test points among boys. This would imply that girls in the Western Cape with similar test scores as boys are less confident in mathematics.

Moreover, the Tables show that the statistically significant interaction effects are correlated with the gender gaps in achievement and depending on the attitude index either increase or decrease the magnitude of the pro-girl gaps relative to the models before.

The pro-girl gap becomes insignificant (in the model without fixed effects), after controlling for the female interaction with ‘weekly bullying’. Moreover, in the Western Cape, where boys statistically outperform girls, the pro-boy gap becomes larger after controlling for gender differences in weekly bullying. Contrastingly, the pro-boy gap becomes slightly smaller in the Western Cape sample after including the ‘being very confident in mathematics’ interaction term, which suggests that differences in confidence are correlated with the pro-boy achievement gap in the Western Cape subsample.

Furthermore, in all three samples and the fixed effects regressions, the female dummy becomes larger relative to the other model specifications after including the ‘valuing mathematics’ interaction term.[30] Moreover, the pro-girl gap becomes slightly larger after including the ‘very much liking mathematics’ interaction term in the full sample model with and without fixed effects.

Finally, since most considered interaction terms are not statistically significant in Grade 5, it seems that gender differences in attitudes are more important in higher grades. Moreover, although some interaction effects are statistically significant in Grade 9, it is noteworthy that the interaction effects contribute little to the explanatory power of the different model specifications. Nevertheless, the results regarding the attitudes show that gender plays out in different ways, hence ignoring gender differences in attitudes would lead to results that are not sensible.

[30] More precisely, the female dummy is larger but statistically insignificant in Quintile 5 and Western Cape schools, while the female dummy becomes positive and statistically significant in the full sample model with fixed effects.

Table 12: OLS Model 3 Results of Mathematics Achievement – Grade 5, Full Sample

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)
VARIABLES	Full sample	Full sample	Full sample	Full sample
Female	**9.656*****	**9.376*****	**9.698*****	**8.320*****
	(2.147)	(2.277)	(1.994)	(1.971)
High clarity of instruction	14.15***	14.06***	14.05***	14.11***
	(2.961)	(2.960)	(2.968)	(2.972)
Many home resources*	55.58***	55.62***	55.55***	55.60***
	(12.35)	(12.36)	(12.31)	(12.32)
Some sense of School belonging	3.132	3.124	3.173	3.129
	(3.146)	(3.150)	(3.164)	(3.150)
High sense of School belonging	3.425	3.402	3.466	3.421
	(3.277)	(3.279)	(3.289)	(3.281)
Student bullying - about monthly	-11.85***	-11.90***	-11.86***	-11.88***
	(2.570)	(2.568)	(2.567)	(2.570)
Student bullying - about weekly	-25.54***	-27.74***	-27.71***	-27.74***
	(3.529)	(2.983)	(2.981)	(2.983)
Somewhat like learning mathematics	8.809***	8.821***	8.796***	8.865***
	(3.203)	(3.196)	(3.202)	(3.206)
Very much like learning mathematics	34.74***	35.88***	34.74***	34.81***
	(3.732)	(4.047)	(3.740)	(3.734)
Disorderly behavior during some math lessons	10.74***	10.78***	10.77***	10.79***
	(3.707)	(3.716)	(3.718)	(3.714)
Disorderly behavior during most math lessons	4.213	4.171	7.112	4.189
	(4.275)	(4.289)	(4.584)	(4.285)
Somewhat confident in mathematics	19.23***	19.34***	19.31***	19.28***
	(1.828)	(1.826)	(1.829)	(1.834)
Very confident in mathematics	53.34***	53.42***	53.40***	53.29***
	(3.108)	(3.109)	(3.096)	(4.133)
Girls#Student bullying - about weekly	-4.802			
	(3.589)			
Girls#Very much like learning mathematics		-2.171		
		(3.105)		
Girls# Disorderly behavior during most math lessons			-5.756	
			(4.216)	
Girls#Very confident in mathematics				0.126
				(4.688)
Constant	304.8***	304.9***	304.7***	305.4***
	(12.57)	(12.55)	(12.61)	(12.53)
Student controls	Yes	Yes	Yes	Yes
Observations	10,240	10,240	10,240	10,240
R-squared	0.530	0.530	0.530	0.530

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices and interaction terms are discussed in the text. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources.

Table 13: OLS Model 3 Results of Mathematics Achievement – Grade 5, Quintile 5 Schools

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)
VARIABLES	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools
Female	**4.043**	**6.215**	**6.316***	**3.767**
	(3.847)	(6.037)	(3.255)	(4.717)
High clarity of instruction	6.482	6.591	6.430	6.480
	(6.512)	(6.563)	(6.670)	(6.440)
Many home resources*	24.69**	24.97**	24.76**	24.55**
	(12.15)	(12.24)	(12.14)	(12.28)
Some sense of School belonging	11.47**	11.09**	11.84**	11.09**
	(5.467)	(5.278)	(5.837)	(5.371)
High sense of School belonging	13.23**	12.77**	13.86**	12.95**
	(5.393)	(5.254)	(5.704)	(5.380)
Student bullying - about monthly	-11.52***	-11.53***	-11.29***	-11.50***
	(3.878)	(3.946)	(3.855)	(3.895)
Student bullying - about weekly	-27.03**	-32.82***	-32.60***	-32.74***
	(10.88)	(8.169)	(8.214)	(8.213)
Somewhat like learning mathematics	0.352	0.219	-0.0786	0.299
	(6.513)	(6.576)	(6.549)	(6.583)
Very much like learning mathematics	6.570	10.27	5.866	6.489
	(6.623)	(9.428)	(6.706)	(6.582)
Disorderly behavior during some math lessons	10.98*	10.48*	11.46*	10.76*
	(6.058)	(5.919)	(6.196)	(6.029)
Disorderly behavior during most math lessons	2.297	1.704	9.456	2.072
	(6.821)	(6.634)	(8.498)	(6.863)
Somewhat confident in mathematics	22.78***	23.48***	23.40***	23.03***
	(5.336)	(4.993)	(5.360)	(5.241)
Very confident in mathematics	60.14***	60.42***	60.69***	63.23***
	(5.774)	(5.510)	(5.749)	(6.310)
Girls#Student bullying - about weekly	-14.35			
	(13.59)			
Girls#Very much like learning mathematics		-8.117		
		(8.614)		
Girls# Disorderly behavior during most math lessons			-15.22	
			(9.704)	
Girls#Very confident in mathematics				-6.567
				(9.398)
Constant	576.9***	577.0***	574.2***	578.2***
	(28.25)	(28.08)	(29.61)	(28.21)
Student controls	Yes	Yes	Yes	Yes
Observations	3,376	3,376	3,376	3,376
R-squared	0.455	0.454	0.455	0.454

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices and interaction terms are discussed in the text. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources.

Table 14: OLS Model 3 Results of Mathematics Achievement – Grade 9, Full Sample

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**2.000**	**4.551*** **	**3.632*** **	**3.486*** **	**11.93*** **
	(1.317)	(1.535)	(1.336)	(1.236)	(1.766)
High clarity of instruction	-6.934***	-6.912***	-6.911***	-6.904***	-6.953***
	(1.341)	(1.337)	(1.335)	(1.337)	(1.347)
Many home resources	34.08***	34.00***	33.94***	33.95***	34.07***
	(4.485)	(4.495)	(4.487)	(4.494)	(4.506)
Some sense of School belonging	2.096	1.999	2.081	2.082	1.858
	(2.182)	(2.195)	(2.178)	(2.184)	(2.172)
High sense of School belonging	2.076	1.935	2.043	2.044	1.734
	(2.339)	(2.354)	(2.335)	(2.340)	(2.330)
Student bullying - about monthly	-5.467***	-5.452***	-5.461***	-5.459***	-5.480***
	(1.079)	(1.078)	(1.079)	(1.080)	(1.081)
Student bullying - about weekly	-23.91***	-19.52***	-19.54***	-19.53***	-19.46***
	(2.530)	(1.631)	(1.634)	(1.634)	(1.623)
Somewhat like learning mathematics	1.160	1.174	1.093	1.093	1.320
	(1.541)	(1.544)	(1.537)	(1.538)	(1.551)
Very much like learning mathematics	6.818***	8.321***	6.767***	6.773***	6.858***
	(1.945)	(2.417)	(1.944)	(1.944)	(1.942)
Disorderly behavior during some math lessons	-4.944**	-4.913**	-4.926**	-4.926**	-4.935**
	(2.354)	(2.347)	(2.349)	(2.350)	(2.350)
Disorderly behavior during most math lessons	-10.92***	-11.02***	-10.65***	-11.00***	-11.05***
	(2.944)	(2.936)	(3.264)	(2.939)	(2.939)
Somewhat confident in mathematics	14.97***	14.90***	14.91***	14.91***	14.91***
	(1.433)	(1.432)	(1.432)	(1.433)	(1.430)
Very confident in mathematics	57.29***	57.27***	57.27***	57.11***	57.10***
	(2.606)	(2.604)	(2.602)	(3.566)	(2.592)
Somewhat value mathematics	15.70***	15.66***	15.70***	15.69***	15.49***
	(2.562)	(2.553)	(2.557)	(2.556)	(2.548)
Strongly value mathematics	22.49***	22.49***	22.57***	22.57***	28.58***
	(2.516)	(2.512)	(2.510)	(2.516)	(2.761)
Girls#Student bullying - about weekly	**8.995*** **				
	(2.945)				
Girls#Very much like learning mathematics		-2.796			
		(2.271)			
Girls# Disorderly behavior during most math lessons			-0.648		
			(2.436)		
Girls#Very confident in mathematics				0.289	
				(4.191)	
Girls#Strongly value mathematics					**-12.19*** **
					(2.128)
Constant	373.4***	371.9***	372.3***	372.4***	368.4***
	(9.535)	(9.614)	(9.585)	(9.573)	(9.508)
Student controls	Yes	Yes	Yes	Yes	Yes
Observations	19,268	19,268	19,268	19,268	19,268
R-squared	0.520	0.520	0.519	0.519	0.521

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text.

Table 15: OLS Model 3 Results of Mathematics Achievement – Grade 9, Quintile 5 Schools

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools
Female	**-5.062***	**-6.978*****	**-5.112**	**-4.787***	**2.937**
	(2.950)	(2.525)	(3.152)	(2.625)	(3.875)
High clarity of instruction	-9.475***	-9.417***	-9.475***	-9.456***	-9.633***
	(2.724)	(2.721)	(2.716)	(2.725)	(2.768)
Many home resources	26.67***	26.49***	26.68***	26.72***	26.89***
	(5.214)	(5.222)	(5.176)	(5.170)	(5.238)
Some sense of School belonging	0.222	0.349	0.225	0.168	0.163
	(3.562)	(3.549)	(3.587)	(3.566)	(3.561)
High sense of School belonging	-2.046	-1.880	-2.041	-2.103	-2.146
	(3.925)	(3.971)	(3.926)	(3.956)	(3.917)
Student bullying - about monthly	-8.525***	-8.349***	-8.526***	-8.528***	-8.893***
	(2.470)	(2.435)	(2.480)	(2.462)	(2.437)
Student bullying - about weekly	-17.58**	-17.81***	-17.81***	-17.82***	-17.85***
	(8.134)	(4.866)	(4.854)	(4.862)	(4.801)
Somewhat like learning mathematics	4.458	4.421	4.465	4.467	4.537
	(2.820)	(2.818)	(2.833)	(2.807)	(2.881)
Very much like learning mathematics	0.894	-3.040	0.894	0.918	1.019
	(3.579)	(4.628)	(3.555)	(3.578)	(3.515)
Disorderly behavior during some math lessons	-11.51**	-11.66**	-11.52**	-11.56**	-11.61**
	(4.668)	(4.727)	(4.672)	(4.689)	(4.624)
Disorderly behavior during most math lessons	-16.75**	-16.77**	-16.78**	-16.84**	-16.79**
	(7.647)	(7.592)	(8.073)	(7.628)	(7.648)
Somewhat confident in mathematics	30.76***	30.81***	30.76***	30.76***	30.77***
	(3.534)	(3.481)	(3.467)	(3.518)	(3.495)
Very confident in mathematics	79.78***	79.62***	79.79***	81.34***	79.56***
	(5.003)	(4.959)	(5.015)	(5.682)	(5.050)
Somewhat value mathematics	11.65**	11.51**	11.65**	11.68**	11.90**
	(4.849)	(4.857)	(4.867)	(4.838)	(4.750)
Strongly value mathematics	12.11**	11.92**	12.10**	12.10**	19.09***
	(4.799)	(4.828)	(4.814)	(4.821)	(7.020)
Girls#Student bullying - about weekly	-0.461				
	(9.644)				
Girls#Very much like learning mathematics		7.297			
		(5.951)			
Girls# Disorderly behavior during most math lessons			0.0558		
			(5.434)		
Girls#Very confident in mathematics				-2.840	
				(6.657)	
Girls#Strongly value mathematics					**-12.52****
					(6.094)
Constant	514.5***	515.4***	514.5***	514.3***	508.9***
	(10.55)	(10.52)	(10.53)	(10.58)	(10.74)
Student controls	Yes	Yes	Yes	Yes	Yes
Observations	3,368	3,368	3,368	3,368	3,368
R-squared	0.557	0.557	0.557	0.557	0.558

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text.

Table 16: OLS Model 3 Results of Mathematics Achievement – Grade 9, Western Cape Schools

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape
Female	**-7.576*** **	**-6.402** **	**-5.854** **	**-4.299***	**-1.279**
	(2.418)	(2.730)	(2.720)	(2.382)	(3.720)
High clarity of instruction	-10.29***	-10.28***	-10.27***	-10.21***	-10.36***
	(2.558)	(2.562)	(2.564)	(2.548)	(2.569)
Many home resources	44.42***	44.29***	44.31***	44.25***	44.37***
	(5.509)	(5.494)	(5.475)	(5.545)	(5.488)
Some sense of School belonging	8.213*	8.399**	8.353**	8.442**	8.149*
	(4.181)	(4.240)	(4.247)	(4.288)	(4.239)
High sense of School belonging	7.520	7.530	7.495	7.658	7.347
	(4.825)	(4.889)	(4.893)	(4.923)	(4.884)
Student bullying - about monthly	-0.573	-0.661	-0.632	-0.557	-0.582
	(1.764)	(1.765)	(1.767)	(1.764)	(1.769)
Student bullying - about weekly	-26.66***	-17.66***	-17.61***	-17.64***	-17.55***
	(5.104)	(3.371)	(3.384)	(3.385)	(3.380)
Somewhat like learning mathematics	2.677	2.663	2.689	2.632	2.840
	(2.462)	(2.462)	(2.458)	(2.465)	(2.456)
Very much like learning mathematics	5.911*	4.563	6.124*	6.183*	6.234*
	(3.210)	(4.134)	(3.209)	(3.216)	(3.217)
Disorderly behavior during some math lessons	-13.29***	-13.12***	-13.12***	-13.14***	-13.10***
	(4.394)	(4.349)	(4.345)	(4.348)	(4.333)
Disorderly behavior during most math lessons	-26.01***	-25.80***	-26.51***	-25.76***	-25.72***
	(5.438)	(5.400)	(5.570)	(5.405)	(5.390)
Somewhat confident in mathematics	29.63***	29.39***	29.43***	29.54***	29.46***
	(2.617)	(2.611)	(2.621)	(2.622)	(2.617)
Very confident in mathematics	74.69***	74.32***	74.38***	81.25***	74.36***
	(3.699)	(3.704)	(3.708)	(4.446)	(3.687)
Somewhat value mathematics	9.595**	9.778**	9.755**	9.666**	9.661**
	(3.930)	(3.902)	(3.916)	(3.926)	(3.951)
Strongly value mathematics	11.87***	12.11***	12.10***	11.91***	15.72***
	(4.516)	(4.459)	(4.470)	(4.487)	(5.181)
Girls#Student bullying - about weekly	**17.73*** **				
	(5.531)				
Girls#Very much like learning mathematics		2.964			
		(3.763)			
Girls# Disorderly behavior during most math lessons			1.257		
			(4.143)		
Girls#Very confident in mathematics				**-13.20*** **	
				(4.940)	
Girls#Strongly value mathematics					**-6.777***
					(3.896)
Constant	448.3***	447.5***	447.2***	446.0***	444.7***
	(13.75)	(13.86)	(13.83)	(13.83)	(14.11)
Student controls	Yes	Yes	Yes	Yes	Yes
Observations	4,950	4,950	4,950	4,950	4,950
R-squared	0.630	0.629	0.629	0.630	0.629

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text.

Model 4

As mentioned in the literature review, the teacher gender is correlated with gender differences in mathematics achievement in some contexts. Shepherd (2017) uses TIMSS 2011 data and finds that having a female teacher with a mathematics background is negatively associated with girls' performance in wealthier schools in South Africa, but not in poorer schools. To study whether the teacher gender is another correlate of the gender differences in students' performance in the most recent TIMSS data, Model 1 is extended in Model 4 by the high clarity of instruction dummy from Model 2, teacher gender (in Columns (1) – (3)), interactions with teacher gender (in Column (4) – (5)), and teacher controls (in Columns (6) – (8)). The results for Model 4 are presented in Tables 17 and 18 and the fixed effect results are reported in the appendix. It is noteworthy that there are more female teachers in Grade 5 compared to Grade 9. According to the TIMSS 2019 data, 63.6% of the teachers in Grade 5 are female, compared to 49.7% of the teachers in Grade 9.

The results in Tables 17 and 18 show that having a female teacher is associated on average with a statistically higher mathematics test scores in Grade 5, but not in Grade 9 and not after controlling for fixed effects in Grade 5. Both results apply to the full sample as well as the Quintile 5 school subsample. Moreover, the regressions with the interaction effects show that having a female teacher is associated with higher mathematics achievement for girls, but exclusively for fifth-grade girls in Quintile 5 schools. Both results apply to the model with and without fixed effects. In contrast, in Grade 9 the interaction effect is not statistically significant. Thus, the Grade 9 result contrasts with the findings by Shepherd (2017).

Moreover, most results do not change after extending the regressions by teacher controls. This shows that the results are not driven by other teacher characteristics. Furthermore, the grade-five pro-girl achievement gaps in the full model hardly change in each model specification and are around 11.3 test points in Grade 5 with and without fixed effects. Although the female dummy is not statistically significant in Quintile 5 schools in Grade 5, the pro-boy gap (negative female dummy) becomes larger after including the teacher gender interaction effect.

As in the models before, the gender gaps in Grade 9 in the full model are statistically insignificant after controlling for fixed effects, and the pro-boy gaps in Quintile 5 schools become larger after including the interaction effect.

Finally, the explanatory power increases little after including the female teacher dummy and the interaction effect in both grades, hence teacher gender does not seem too important for the overall fit to the data.

Table 17: OLS Model 4 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Q5 Schools	Full sample	Q5 Schools	Full sample	Full sample	Q5 Schools
Female	**11.45******	**11.37******	**1.749**	**11.68******	**-11.49**	**11.32******	**11.29******	**-11.99**
	(2.023)	(2.023)	(4.947)	(2.852)	(8.091)	(2.066)	(2.903)	(8.127)
High clarity of instruction	39.95***	39.59***	26.44***	39.59***	26.53***	39.12***	39.12***	26.98***
	(2.725)	(2.685)	(5.719)	(2.683)	(5.852)	(2.707)	(2.705)	(5.759)
Female teacher		**7.154***	**18.09******	**7.391***	10.51	**7.296***	7.267	**14.17***
		(3.953)	(6.661)	(4.232)	(8.041)	(4.125)	(4.449)	(8.111)
Girls#Female teacher				-0.484	**16.47***		0.0588	**17.20****
				(3.681)	(8.888)		(3.706)	(8.577)
Constant	324.4***	320.3***	603.0***	320.2***	610.0***	317.0***	317.0***	577.0***
	(11.17)	(11.62)	(25.88)	(11.78)	(26.11)	(17.00)	(17.11)	(33.40)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher controls	No	No	No	No	No	Yes	Yes	Yes
Observations	10,535	10,535	1,266	10,535	1,266	10,190	10,190	1,266
R-squared	0.442	0.443	0.353	0.443	0.355	0.446	0.446	0.363

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. Teacher controls include the teacher age, years of teaching, and the highest level of teacher qualifications.

Table 18: OLS Model 4 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Q5 Schools	Full sample	Q5 Schools	Full sample	Full sample	Q5 Schools
Female	**3.506****	**3.451****	**-6.574****	**2.904***	**-11.23****	**3.039****	**3.136***	**-10.23****
	(1.375)	(1.385)	(3.283)	(1.650)	(4.875)	(1.424)	(1.717)	(4.991)
High clarity of instruction	4.514***	4.554***	5.366*	4.549***	5.436*	4.950***	4.952***	7.219**
	(1.305)	(1.301)	(2.993)	(1.300)	(3.031)	(1.320)	(1.319)	(3.262)
Female teacher		2.218	6.881	1.642	3.209	1.519	1.623	4.041
		(2.249)	(5.449)	(2.628)	(6.258)	(2.348)	(2.687)	(6.308)
Girls#Female teacher				1.100	6.964		-0.198	5.257
				(2.219)	(5.155)		(2.286)	(5.017)
Constant	391.6***	390.1***	524.0***	390.4***	526.6***	364.2***	364.2***	457.4***
	(9.044)	(9.252)	(8.851)	(9.124)	(8.827)	(13.73)	(13.55)	(22.38)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher controls	No	No	No	No	No	Yes	Yes	Yes
Observations	19,551	19,551	3,391	19,551	3,391	17,842	17,842	3,263
R-squared	0.453	0.453	0.430	0.453	0.431	0.465	0.465	0.444

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Teacher controls include the teacher age, years of teaching, and the highest level of teacher qualifications.

In summary, Model 4 shows that the pro-girl gaps in Grade 5 achievement remain in the full sample and the pro-boy gaps in Grades 5 and 9 remain in Quintile 5 schools, even after controlling for school quintile, region, repetition, dropout, teacher gender, teacher controls, fixed effects, and other factors. Moreover, the results seem to suggest that having a female teacher matters exclusively in Quintile 5 schools in Grade 5 and thus teacher gender is not correlated with gender differences in mathematics achievement in most South African contexts.

6 Conclusion

This paper analyses current gender differences in mathematics and science outcomes in South Africa using the most recent TIMSS data from 2019. Moreover, since grade repetition and dropouts are very common in South Africa and affect the magnitude of gender gaps, the first part of the descriptive analysis studies current gender differences in grade repetition and dropout using GHS and TIMSS 2019 data. This section confirms findings by earlier studies. South African boys are more likely to repeat a grade and to drop out of school compared to South African girls. The following section shows that fifth-grade girls outperform fifth-grade boys on average by 22 test points in mathematics and science and ninth-grade girls outperform ninth-grade boys on average by approximately seven test points in mathematics and 13 test points in science. This suggests that the pro-girl advantage declines at higher grades. Nevertheless, in contrast to previous studies using TIMSS data, the pro-girl gap is still statistically significant in Grade 9.

Moreover, the paper looks at gender differences between population groups, location, school quintile, and provinces and finds that girls significantly outperform boys in the majority of the considered subgroups. The only exception is in the Western Cape in Grade 9, where boys significantly outperform girls in Grade 9. Moreover, following other South African studies, pro-girl gaps are more likely to be found in lower school quintiles and pro-boy gaps are more likely to be found in higher school quintiles.

Because of gender differences in repetition and dropout the sample of boys is more selective compared to the girls' sample and hence one should account for the sample selection process. Thus, an important contribution of this paper to the South African literature is the section that analyses gender differences in achievement after adjusting for gender differences in repetition in both grades and additionally dropout in Grade 9. Following Spaull and Makaluza (2019), this paper uses a simple method to create a more comparable group in Grade 9: namely the weakest performing girls were excluded until there were equal proportions of ninth-grade boys and girls in the sample. The results show that without controlling for over-age one would over-estimate the pro-girl mathematics gap in both grades, and without controlling for differences in dropout one would under-estimate the pro-girl gap in Grade 9 (in the full sample). This demonstrates how important it is to control for gender differences in repetition and dropout rates in countries with high rates such as South Africa. After controlling for over-age and dropout, several gender differences were smaller or insignificant. These results seem to suggest that part of the pro-girl gap in Grade 5 and Grade 9 can be attributed to the female advantage in school progression. Nevertheless, given that girls repeat and drop out less and still statistically outperform boys, we can conclude that they learn more with the same amount of schooling, on average.

Another focus of the paper is to identify potential sources of the gender gaps beside the South African specific factors and gender differences in repetition and dropout. This paper shows that there are significant gender differences in some attitudes towards mathematics and school in general. Unlike what the literature often suggests, fifth-grade girls have higher levels of self-confidence and other more positive attitudes about mathematics compared to fifth-grade boys. Contrastingly, the findings for Grade 9 are in line with the international evidence finding that girls are less confident and enjoy learning mathematics less than boys although they achieve equal or better average results compared to boys.

The multivariate analysis employing an ordinary least squares (OLS) regression with interaction effects and school fixed effects shows that most considered interaction effects are not statistically significant in Grade 5, but several ones are significant in Grade 9. Thus, while the gender differences in attitudes are correlated with gender differences in achievement in Grade 9, they are not correlated in Grade 5. The Grade 9 results indicate that girls are less affected by weekly bullying and, depending on the sample, the pro-girl gaps become insignificant or larger pro-boy gaps after including this interaction effect. Moreover, gender differences in very much liking mathematics and strongly valuing mathematics are associated with larger pro-girl gaps. In addition, the results regarding the attitudes show that gender plays out in different ways, hence ignoring gender differences in attitudes would lead to results that are not sensible. Nevertheless, the results seem to suggest that the most important part explaining gender differences in this analysis are gender differences in over-age and dropout.

Overall, fifth-grade girls statistically outperform fifth-grade boys and boys statistically outperform girls across both grades in Quintile 5 schools, even after controlling for school quintile, region, repetition, dropout, attitudes, teacher gender, teacher controls and fixed effects. The fixed effect results show that after controlling for fixed effects, the gender gaps in Grade 9 are no longer significant in the full sample, while the pro-girl gaps in Grade 5 remain fairly similar. Thus, the fixed effect results seem to suggest that there are unobservable school factors that explains the pro-girl gaps.

Finally, the results show clearly that South African girls and boys face different challenges during their school careers, which both need equal attention.

Although the results are an important step towards understanding the female advantage in mathematics and science, we need more studies that explain why girls are less likely to enrol in STEM degrees and why the pro-girl advantage in education does not result in a female advantage in the labour market. Some studies demonstrate that one potential explanation is that girls have a comparative advantage in specific subjects such as reading (Breda and Napp, 2019; Stoet and Geary, 2018). Thus, although girls perform equally well in mathematics than boys, they strongly outperform boys in reading and other subjects. The matric results from 2018 show that pro-girl gaps are particularly large in accounting, business studies and English, and smaller in mathematics (Spaull and Makaluza, 2019), which suggests that this could be a potential reason why few South African women become physicians or engineers. This calls for more research into this area.

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Appendix

Table A 1: Average Mathematics and Science Achievement for Grade 5 by Gender, Over-age, and Subgroup

Grade 5	Mathematics					Science				
Subgroup	Girls Mean Testscore	Girls SE	Boys Mean Testscore	Boys SE	Gap	Girls Mean Testscore	Girls SE	Boys Mean Testscore	Boys SE	Gap
Average - correct age (ca)	397.14	4.82	379.94	5.14	17 ***	352.41	6.59	337.48	6.94	15 ***
Average - 1 year over-age (oa)	342.21	4.15	337.54	4.78	5	283.28	5.58	281.35	6.43	2
Average - 2 year over-age (oa)	304.80	5.93	300.71	4.59	4	232.35	7.56	236.04	6.55	-4
Average - 3+ year over-age (oa)	306.57	20.31	306.72	14.04	0	215.32	32.43	241.32	19.76	-26
Mostly Speak Test Language at Home - ca	439.50	7.91	416.89	8.35	23 ***	418.02	10.21	396.91	10.83	21 **
Rarely Speak Test Language at Home - ca	376.68	3.46	362.92	3.93	14 ***	319.86	4.74	309.15	5.23	11 **
Mostly Speak Test Language at Home - 1 year oa	350.92	7.86	356.20	8.98	-5	307.67	9.95	316.43	11.98	-9
Rarely Speak Test Language at Home - 1 year oa	339.70	4.44	330.72	4.39	9 *	273.54	6.18	266.96	5.79	7
Mostly Speak Test Language at Home - 2 year oa	301.06	9.05	299.09	9.19	2	241.34	13.97	241.49	13.14	0
Rarely Speak Test Language at Home - 2 year oa	312.96	7.50	304.53	5.18	8	236.28	9.31	237.97	6.66	-2
Mostly Speak Test Language at Home - 3+ year oa	306.82	25.72	295.56	33.95	11	233.10	60.23	252.90	33.60	-20
Rarely Speak Test Language at Home - 3+ year oa	318.05	26.90	315.90	15.92	2	227.68	40.53	240.34	20.50	-13
Rural - ca	365.54	4.35	346.54	4.72	19	307.63	5.85	289.59	6.17	18 ***
Urban - ca	440.37	7.39	427.81	8.99	13 ***	414.61	9.86	406.44	12.15	8
Rural - 1 year oa	323.28	4.27	313.69	4.50	10	257.39	6.05	248.36	5.90	9 *
Urban - 1 year oa	378.17	8.82	382.42	8.36	-4	332.48	11.67	343.52	11.75	-11
Rural - 2 year oa	298.85	7.45	297.22	5.35	2	221.49	8.93	228.99	7.82	-8
Urban - 2 year oa	320.05	12.71	325.90	7.38	-6	255.71	18.01	271.05	11.26	-15
Rural - 3+ year oa	305.97	21.64	308.45	15.22	-2	211.99	34.81	244.95	21.50	-33
Urban - 3+ year oa	310.49	57.64	291.29	25.22	19	236.79	83.16	209.05	28.23	28
Q1 School - ca	352.90	5.70	331.02	5.90	22 ***	290.26	7.37	268.20	7.74	22 ***
Q2 School - ca	357.88	6.18	340.40	5.73	17 ***	292.74	9.53	278.62	7.72	14 *
Q3 School - ca	375.59	7.48	355.93	7.18	20 ***	325.86	9.89	304.64	9.03	21 ***
Q4 School - ca	411.51	7.77	389.18	9.57	22 **	380.45	10.54	357.12	14.67	23 **
Q5 School - ca	500.47	10.66	490.72	11.19	10	493.67	14.50	492.86	14.25	1
IS - ca	478.88	18.00	469.78	17.97	9	460.65	22.42	459.62	23.02	1
Q1 School - 1 year oa	312.17	5.62	306.12	6.65	6	235.08	8.69	237.38	8.18	-2
Q2 School - 1 year oa	324.62	7.31	310.66	7.27	14 *	254.66	9.21	241.26	9.08	13
Q3 School - 1 year oa	326.34	7.00	326.49	7.15	0	267.64	9.90	267.77	9.89	0
Q4 School - 1 year oa	371.81	11.28	353.66	9.01	18 ***	333.15	14.55	306.66	11.42	26 ***
Q5 School - 1 year oa	447.44	12.05	448.87	10.74	-1	427.81	16.87	436.69	15.33	-9
IS - 1 year oa	420.08	20.43	431.68	18.43	-12	397.40	27.28	405.28	30.00	-8
Q1 School - 2 year oa	300.50	8.85	292.53	5.56	8	228.21	13.87	219.38	7.28	9
Q2 School - 2 year oa	304.89	12.88	278.05	6.21	27 **	229.00	12.64	209.58	7.07	19 *
Q3 School - 2 year oa	298.94	7.58	299.04	8.85	0	226.77	12.93	232.69	11.35	-6
Q4 School - 2 year oa	281.52	11.98	329.85	11.97	-48 ***	187.88	16.72	275.23	13.67	-87 ***
Q5 School - 2 year oa	418.37	39.95	402.08	10.33	16	411.32	45.19	405.25	14.61	6
IS - 2 year oa	361.77	34.73	355.69	23.11	6	342.15	48.01	286.63	36.63	56 ***

Q1 School - 3+ year oa	313.41	27.97	310.01	22.50	3	231.01	37.77	243.38	34.02	-12
Q2 School - 3+ year oa	302.41	36.03	264.84	10.19	38	189.29	47.62	188.34	12.05	1
Q3 School - 3+ year oa	288.31	34.08	337.42	29.21	-49	193.53	60.20	283.88	43.59	-90
Q4 School - 3+ year oa	473.99	5.59	383.80	.	90	506.54	25.23	350.03	.	157
Eastern Cape - ca	392.63	20.10	358.89	14.30	34	342.19	26.43	304.06	19.53	38
Free State - ca	402.36	11.89	415.16	17.45	-13	347.19	17.21	372.70	24.71	-26
Gauteng - ca	427.57	10.15	413.35	12.96	14 *	398.78	14.25	385.99	17.85	13
KwaZulu-Natal - ca	378.68	9.16	363.23	11.29	15 **	323.73	13.54	316.20	16.57	8
Limpopo - ca	356.33	11.51	329.91	9.56	26 ***	302.33	13.96	273.73	12.38	29 ***
Mpumalanga - ca	363.53	11.23	346.46	13.00	17 *	304.61	15.84	297.12	16.61	7
North West - ca	381.28	9.13	364.15	9.34	17 ***	334.38	14.19	312.58	13.35	22 ***
Northern Cape - ca	394.78	10.50	383.71	16.10	11	357.09	13.95	351.46	20.25	6
Western Cape - ca	465.17	10.60	449.25	12.44	16 **	447.16	13.19	426.00	16.12	21 **
Eastern Cape - 1 year oa	324.80	9.45	314.85	10.16	10	263.85	12.41	253.11	14.48	11
Free State - 1 year oa	346.82	13.68	341.49	9.26	5	279.74	17.81	277.02	12.34	3
Gauteng - 1 year oa	372.98	13.46	389.32	13.81	-16	330.08	17.22	356.49	18.55	-26
KwaZulu-Natal - 1 year oa	345.87	9.74	325.62	8.72	20 *	280.67	15.27	256.99	10.77	24
Limpopo - 1 year oa	289.62	10.80	297.33	10.83	-8	216.21	12.43	236.29	15.01	**-20** *
Mpumalanga - 1 year oa	322.74	12.48	311.19	12.81	12	263.30	14.12	247.32	15.26	16
North West - 1 year oa	313.01	8.62	326.19	9.64	-13	237.79	10.92	257.98	15.36	-20
Northern Cape - 1 year oa	344.94	11.15	343.89	10.80	1	289.79	15.01	301.69	14.64	-12
Western Cape - 1 year oa	385.28	14.76	391.54	13.18	-6	346.39	19.63	359.32	19.81	-13
Eastern Cape - 2 year oa	294.46	9.03	281.05	9.75	13	207.50	16.67	210.13	13.64	-3
Free State - 2 year oa	334.44	16.45	324.53	12.20	10	263.97	18.08	245.94	17.27	18
Gauteng - 2 year oa	323.46	21.43	326.23	15.64	-3	271.42	30.57	258.04	18.88	13
KwaZulu-Natal - 2 year oa	309.07	16.74	288.74	7.09	20	229.58	15.89	230.13	11.54	-1
Limpopo - 2 year oa	291.56	17.58	275.85	5.74	16	235.46	21.71	210.69	9.09	25
Mpumalanga - 2 year oa	274.77	17.93	318.81	16.24	**-44** *	188.32	20.72	261.89	25.88	**-74** **
North West - 2 year oa	294.63	9.45	297.98	9.03	-3	216.02	15.10	229.31	14.46	-13
Northern Cape - 2 year oa	325.81	14.13	310.68	12.29	15	285.99	24.66	253.88	18.89	32
Western Cape - 2 year oa	316.23	14.99	338.47	11.90	-22	233.99	20.51	273.82	13.96	-40
Eastern Cape - 3+ year oa	290.44	46.91	315.22	21.67	-25	181.89	72.44	235.65	22.57	-54
Free State - 3+ year oa	323.59	47.89	332.32	20.50	-9	233.17	58.25	233.48	32.46	0
Gauteng - 3+ year oa	298.75	53.01	401.98	45.19	-103	203.44	83.21	385.45	65.90	-182
KwaZulu-Natal - 3+ year oa	424.02	.	300.26	10.73	124	393.75	.	216.23	22.40	178
Limpopo - 3+ year oa	276.57	2.35	268.51	15.82	8	230.20	11.57	209.84	29.16	20
Mpumalanga - 3+ year oa	353.36	35.59	293.21	31.21	60 *	250.26	72.74	230.36	36.10	20
North West - 3+ year oa	262.84	22.17	242.43	12.09	20 **	170.86	22.21	168.88	10.24	2

Note: Own Calculations. Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. Red font = below low benchmark (400). Light blue font = pro-male gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international. M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 11,603 - 11,857.

Table A 2: Average Mathematics and Science Achievement for Grade 9 by Gender, Over-age, and Subgroup

Grade 9	**Mathematics**								**Science**							
	Girls		**Girls - dropouts***		**Boys**		**Gap**	**Gap***	**Girls**		**Girls - dropouts***		**Boys**		**Gap**	**Gap***
Subgroup	Mean Testscore	SE	Mean Testscore	SE	Mean Testscore	SE	Diff.	Diff.	Mean Testscore	SE	Mean Testscore	SE	Mean Testscore	SE	Diff.	Diff.
Average - correct age (ca)	406.51	3.0	413.89	2.6	412.9332	3.39	-6 ***	1	392.88	4.1	401.45	3.7	397.9716	4.8	-5 *	3
Average - 1 year over-age (oa)	356.01	2.5	370.04	2.2	361.3829	2.69	-5 *	9 ***	326.09	3.5	341.97	3.3	328.4731	3.9	-2	13 ***
Average - 2 years over-age	335.50	2.6	350.82	2.4	345.8163	2.47	-10 ***	5	295.58	3.9	311.11	3.8	306.6711	3.6	-11 **	4
Average - 3+ years over-age	318.10	5.0	348.35	3.4	325.9889	3.07	-8	22 ***	257.25	5.7	287.28	5.4	271.2112	5.0	-14 **	16 **
Mostly Speak Test Language at Home - ca	444.96	4.1	448.38	3.9	456.40	4.66	-11 ***	-8 **	452.20	5.0	456.26	4.8	463.10	6.1	-11 **	-7
Rarely Speak Test Language at Home - ca	389.29	2.7	397.65	2.3	393.60	2.79	-4 **	4 **	366.27	3.6	375.60	3.2	368.93	3.9	-3	7 **
Mostly Speak Test Language at Home - 1 year oa	377.00	4.8	387.33	4.2	380.90	3.80	-4	6	364.83	5.8	375.39	5.6	362.84	6.3	2	13
Rarely Speak Test Language at Home - 1 year oa	349.74	2.5	364.44	2.1	356.89	2.98	-7 **	8 **	314.13	3.6	330.72	3.4	319.97	4.0	-6	11 **
Mostly Speak Test Language at Home - 2 years oa	341.96	6.6	357.66	6.4	358.95	5.98	-17 **	-1	321.13	9.3	341.76	8.2	328.02	8.4	-7	14
Rarely Speak Test Language at Home - 2 years oa	333.94	2.8	349.16	2.4	343.30	2.50	-9 **	6 *	289.41	4.1	303.65	4.3	302.67	3.6	-13 ***	1
Mostly Speak Test Language at Home - 3+ years oa	316.63	10.7	348.70	7.8	323.10	8.48	-6	26 ***	279.86	13.4	305.47	13.3	277.69	14.1	2	28 *
Rarely Speak Test Language at Home - 3+ years oa	318.44	5.3	347.84	3.7	327.17	2.84	-9	21 ***	254.48	6.1	284.61	5.8	270.92	4.6	-16 **	14 **
Rural - ca	384.41	3.3	394.02	2.7	387.296	3.27	-3	7 ***	358.95	4.3	369.64	3.9	360.504	4.6	-2	9 ***
Urban - ca	435.85	4.2	438.86	4.0	447.23	4.76	-11 ***	-8 **	437.70	5.4	441.12	5.1	447.39	6.5	-10 **	-6
Rural - 1 year oa	346.29	2.9	361.35	2.5	349.38	3.08	-3	12 ***	309.79	4.0	326.91	3.9	310.37	4.4	-1	17 ***
Urban - 1 year oa	372.97	3.7	383.98	3.2	383.96	4.67	-11 **	0	356.26	4.7	367.98	4.6	362.99	7.2	-7	5
Rural - 2 years oa	332.49	3.5	348.18	2.9	339.64	2.47	-7 *	9 ***	292.02	4.9	307.19	4.6	295.57	3.7	-4	12 **
Urban - 2 years oa	341.23	3.7	354.51	4.2	361.03	5.08	-20 ***	-7	304.33	6.5	318.00	7.2	334.01	6.2	-30 ***	-16 *
Rural - 3+ years oa	318.48	5.9	347.59	3.9	322.45	3.28	-4	25 ***	254.11	6.4	282.82	6.0	261.72	5.4	-8	21 ***
Urban - 3+ years oa	319.02	7.8	352.88	4.9	345.28	7.72	-26 ***	8	275.05	12.6	312.65	8.0	320.45	7.6	-45 ***	-8
Q1 School - ca	371.40	5.0	382.07	3.6	372.87	3.98	-1	9 ***	339.40	6.5	350.25	5.3	341.16	5.9	-2	9 **
Q2 School - ca	382.07	5.4	391.22	4.7	385.01	5.96	-3	6 *	355.62	7.1	365.97	6.4	356.57	8.4	-1	9 *
Q3 School - ca	384.69	3.2	391.36	2.7	388.43	3.32	-4	3	363.80	3.7	371.30	3.1	363.62	4.7	0	8 **
Q4 School - ca	419.83	6.2	423.19	5.7	427.39	6.80	-8 **	-4	416.18	7.3	419.79	6.9	420.50	9.2	-4	-1
Q5 School - ca	471.34	6.7	473.05	6.4	484.11	6.53	-13 ***	-11 **	487.10	8.4	488.97	8.0	497.54	8.5	-10 *	-9
IS - ca	484.42	9.2	485.17	9.0	481.54	13.01	3	4	500.06	10.8	501.09	10.6	498.23	15.2	2	3
Q1 School - 1 year oa	339.00	4.2	356.66	3.6	342.75	6.86	-4	14 *	294.79	5.3	315.78	4.9	295.48	9.2	-1	20 **
Q2 School - 1 year oa	347.71	5.1	362.75	4.1	348.28	3.84	-1	14 ***	310.60	6.7	326.60	6.3	308.62	5.4	2	18 ***
Q3 School - 1 year oa	349.87	4.0	363.81	3.5	354.28	3.57	-4	10 **	321.58	5.6	336.11	5.6	322.31	4.8	-1	14 **
Q4 School - 1 year oa	372.7821	5.5	379.91	5.1	382.10	6.47	-9 *	-2	355.2686	7.4	363.01	7.3	358.44	11.0	-3	5
Q5 School - 1 year oa	406.3645	11.3	412.28	8.2	406.22	7.76	0	6	396.3563	10.3	401.73	8.0	398.19	14.2	-2	4
IS - 1 year oa	423.3103	15.1	428.09	13.9	430.18	14.85	-7	-2	444.312	18.8	451.33	17.0	424.31	21.1	20	27 *
Q1 School - 2 years oa	335.791	4.9	348.96	4.1	336.01	3.70	0	13 ***	280.3219	8.0	292.34	7.4	287.26	5.5	-7	5
Q2 School - 2 years oa	332.6149	6.3	353.23	4.0	340.51	3.68	-8	13 **	291.5747	9.0	312.50	8.1	298.63	5.2	-7	14
Q3 School - 2 years oa	327.18	4.1	343.12	4.6	337.61	3.61	-10 **	6	294.5087	5.7	308.82	6.1	296.92	5.6	-2	12 *
Q4 School - 2 years oa	350.1142	5.5	360.80	6.8	364.22	5.43	-14 **	-3	319.8986	10.6	335.69	9.3	338.55	6.2	-19 *	-3
Q5 School - 2 years oa	345.2325	10.5	361.40	10.8	394.86	10.94	-50 ***	-33 *	316.8225	20.6	333.58	22.4	373.01	14.1	-56 **	-39
IS - 2 years oa	371.087	.	371.09	.	375.95	20.40	-5	-5	362.6914	.	362.69	.	394.22	24.1	-32	-32

Q1 School - 3+ years oa	318.4254	10.8	353.41	4.5	314.95	5.53	3	38 ***	252.2482	12.8	286.01	12.1	248.57	10.3	4	37 **
Q2 School - 3+ years oa	310.1574	8.3	341.42	5.6	324.82	4.45	-15 *	17 ***	250.9685	9.6	282.24	9.6	265.64	6.9	-15	17
Q3 School - 3+ years oa	319.5416	9.5	350.11	9.0	330.10	5.46	-11	20 **	260.1129	9.2	291.03	8.4	277.35	7.3	-17	14
Q4 School - 3+ years oa	335.1297	12.9	352.33	6.7	341.26	10.90	-6	11 *	282.1163	16.1	301.08	13.6	316.60	7.6	-34 ***	-16
Q5 School - 3+ years oa	317.3023	1.8	345.11	8.5	349.72	24.81	-32 **	-5	271.891	5.8	291.87	11.8	371.11	19.0	-99 ***	-79 **
IS - 3+ years oa	419.3906	.	419.39	.	397.16	4.56	22	22	363.918	.	363.92	.	338.77	5.4	25	25
Eastern Cape - ca	381.34	8.2	393.56	7.1	391.13	13.02	-10	2	356.69	9.6	370.66	8.6	359.04	16.9	-2	12
Free State - ca	423.87	12.8	426.16	12.7	419.32	9.14	5	7	413.67	16.6	416.15	16.6	412.47	12.4	1	4
Gauteng - ca	433.59	4.5	436.11	4.4	436.72	4.84	-3	-1	438.82	5.6	441.61	5.5	441.00	6.1	-2	1
KwaZulu-Natal - ca	391.56	8.4	402.52	7.3	401.21	8.42	-10 *	1	370.46	11.6	382.60	10.6	379.03	12.5	-9	4
Limpopo - ca	382.97	6.2	389.97	5.8	381.09	6.73	2	9 *	354.90	9.0	363.40	8.4	353.59	9.0	1	10
Mpumalanga - ca	394.75	6.1	400.08	5.8	393.39	7.06	1	7	373.47	9.6	378.82	9.2	366.19	10.5	7	13
North West - ca	395.49	6.7	404.88	5.9	408.78	6.76	-13 **	-4	378.31	9.5	388.81	8.6	392.98	10.2	-15 *	-4
Northern Cape - ca	389.79	3.4	392.64	3.1	401.55	5.83	-12 **	-9 *	373.57	5.3	376.90	4.9	386.53	7.0	-13 **	-10 *
Western Cape - ca	453.54	6.3	455.39	6.2	476.31	7.39	-23 ***	-21 ***	454.04	7.9	456.02	7.8	480.97	8.8	-27 ***	-25 ***
Eastern Cape - 1 year oa	345.8863	7.0	361.82	6.2	341.73	7.09	4	20 **	309.2838	9.3	326.27	9.0	303.52	9.6	6	23 *
Free State - 1 year oa	359.5775	8.8	374.38	8.3	380.90	6.01	-21 **	-7	337.4426	9.8	350.38	10.3	357.11	7.7	-20 **	-7
Gauteng - 1 year oa	373.7407	4.6	384.63	4.1	383.97	3.82	-10 **	1	361.984	6.2	373.46	6.0	366.47	5.6	-4	7
KwaZulu-Natal - 1 year oa	348.1878	6.1	365.03	5.7	341.40	5.73	7	24 **	313.117	8.1	333.11	8.7	297.86	8.4	15	35 **
Limpopo - 1 year oa	333.4384	5.7	349.69	4.9	345.71	5.68	-12	4	289.0535	8.5	304.76	8.9	299.18	8.3	-10	6
Mpumalanga - 1 year oa	364.8434	8.6	373.23	7.9	357.57	7.51	7	16 *	334.1069	12.4	346.79	10.5	328.48	10.1	6	18 *
North West - 1 year oa	355.4246	6.9	369.73	5.0	382.56	6.66	-27 ***	-13 *	321.8646	10.8	340.60	8.7	352.10	9.0	-30 **	-12
Northern Cape - 1 year oa	360.4955	7.3	369.93	5.2	376.77	6.02	-16 *	-7	324.8376	9.7	335.48	8.7	349.36	7.8	-25 **	-14
Western Cape - 1 year oa	381.0508	4.1	387.88	3.7	402.04	4.36	-21 ***	-14 ***	363.1109	5.1	370.22	5.0	385.35	6.4	-22 ***	-15 ***
Eastern Cape - 2 years oa	321.6907	7.1	341.33	8.2	326.42	6.89	-5	15 **	265.5293	11.8	287.01	11.0	272.48	10.4	-7	15
Free State - 2 years oa	343.7425	6.4	354.18	6.4	359.25	5.75	-16 ***	-5	299.613	10.5	308.97	11.7	327.87	7.9	-28 ***	-19 *
Gauteng - 2 years oa	343.1482	5.5	362.74	4.4	357.37	4.77	-14 ***	5	309.1994	7.4	325.91	7.3	334.57	6.4	-25 ***	-9
KwaZulu-Natal - 2 years oa	335.7098	4.7	345.78	4.8	337.38	7.70	-2	8	300.6039	7.9	309.77	8.0	298.16	9.7	2	12
Limpopo - 2 years oa	314.7286	6.8	331.55	4.7	342.00	4.22	-27 ***	-10	270.0265	11.5	283.58	13.6	297.71	7.3	-28	-14
Mpumalanga - 2 years oa	351.5955	10.3	360.70	9.5	346.72	7.52	5	14	322.8141	14.1	337.84	10.9	303.60	9.8	19	34 **
North West - 2 years oa	334.2845	14.5	361.46	10.9	348.63	5.36	-14	13	294.7159	17.2	320.13	14.7	305.86	9.9	-11	14
Northern Cape - 2 years oa	343.2478	6.8	354.68	5.9	350.33	7.14	-7	4	320.5922	10.0	335.13	7.2	318.93	9.8	2	16 **
Western Cape - 2 years oa	350.3222	4.5	365.09	3.8	374.79	4.56	-24 ***	-10 *	310.1827	7.2	327.40	6.9	345.55	5.6	-35 ***	-18 **
Eastern Cape - 3+ years oa	320.6497	13.9	346.62	10.2	318.26	11.53	2	28 ***	257.8066	18.4	280.16	21.6	245.92	18.3	12	34
Free State - 3+ years oa	324.3869	7.3	349.40	5.6	348.65	5.34	-24 **	1	279.2691	12.6	306.33	12.3	304.58	8.9	-25	2
Gauteng - 3+ years oa	331.0535	14.1	360.77	15.1	339.59	7.38	-9	21	300.9008	16.9	320.42	22.5	304.04	9.4	-3	16
KwaZulu-Natal - 3+ years oa	310.6289	17.0	360.94	14.1	316.63	6.55	-6	44 **	220.2313	12.1	258.82	14.6	274.51	12.0	-54 **	-16
Limpopo - 3+ years oa	306.3341	10.5	337.73	6.1	322.43	4.06	-16	15 **	245.0545	11.0	280.05	8.0	260.59	6.7	-16	19 **
Mpumalanga - 3+ years oa	322.134	6.9	344.53	5.8	331.29	7.94	-9	13	279.996	7.9	295.83	9.0	269.97	11.6	10	26
North West - 3+ years oa	317.2327	11.6	346.86	7.5	320.33	10.19	-3	27 ***	247.2991	16.0	280.61	15.4	264.44	12.8	-17	16
Northern Cape - 3+ years oa	351.891	7.2	359.83	4.2	339.10	7.56	13	21 ***	317.0529	11.9	325.59	10.6	292.43	14.7	25	33 *
Western Cape - 3+ years oa	336.7361	8.2	346.62	8.5	358.82	8.19	-22 **	-12	289.5996	9.4	294.29	10.2	329.36	10.0	-40 ***	-35 ***

Note: Own Calculations. Gender gaps are always reported as female achievement minus male achievement, such that a positive gap is pro-girl and a negative gap is pro-boy. The full tables with standard errors and the female results without adjusting for dropouts are reported in the appendix. Girls* = adjusted for dropouts, by dropping the weakest performing girls. Red font = below low benchmark (400). Light blue font = pro-male gap. underlined = significant pro-male gap with and without adjusting for dropouts. Light red font = no longer (after adjusting for dropouts) significant pro-male gap instead significant pro-girls gap. Asterisks indicate statistically significant gender differences at *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Number of observations (students) depends on the subgroup and the subject and is between 20,535 - 20,786 in Grade 9.

Table A 3: Correlation Matrix - Grade 5

	female	overage_all	parent_matric	instructional_clarity_idx (high)	home_educ_resources_idx	belonging_idx	bullying_idx	like_math_idx	disorderly_idx	confidence_idx	female_teacher	teacher_qual	teacher_age	teacher_years_teaching
female	1													
overage_all	-0.1595	1												
	0													
parent_matric	0.021	-0.1272	1											
	0.0219	0												
instructional_clarity_idx (high)	0.106	-0.1327	0.0822	1										
	0	0	0											
home_educ_resources_idx (many)	0.0216	-0.0505	**0.2031**	0.0251	1									
	0.0184	0	0	0.0074										
belonging_idx	0.102	-0.0696	0.0459	0.3944	0.0185	1								
	0	0	0	0	0.0488									
bullying_idx	-0.1097	0.1306	-0.1381	-0.2094	-0.0945	-0.1343	1							
	0	0	0	0	0	0								
like_math_idx	0.1122	-0.1479	0.0956	0.507	0.0028	0.372	-0.2204	1						
	0	0	0	0	0.7615	0	0							
disorderly_idx	-0.0067	-0.0039	-0.0242	0.1011	-0.0287	0.0243	0.173	0.0176	1					
	0.4722	0.6766	0.0099	0	0.0022	0.0102	0	0.0613						
confidence_idx	0.0635	-0.1316	0.125	0.2269	0.0784	0.1543	-0.2278	**0.3967**	-0.129	1				
	0	0	0	0	0	0	0	0	0					
female_teacher	0.0198	-0.0139	0.033	0.0513	0.0544	0.0494	-0.0739	0.0161	-0.029	0.0423	1			
	0.0319	0.1307	0.0003	0	0	0	0	0.0864	0.0021	0				
teacher_qual	0.013	-0.0187	0.0036	0.036	0.0226	0.0178	-0.0003	0.0193	0.0171	0.0266	0.1301	1		
	0.1594	0.0427	0.6938	0.0001	0.0144	0.0598	0.973	0.0397	0.0695	0.0048	0			
teacher_age	0.0087	-0.0117	0.0047	-0.0008	0.0301	0.0208	-0.0031	-0.0051	-0.0345	-0.0043	-0.0433	-0.1571	1	
	0.3469	0.2037	0.6129	0.9302	0.0011	0.0278	0.738	0.5862	0.0003	0.6503	0	0		
teacher_years_teaching	0.0056	-0.0195	0.0167	0.0014	0.0522	-0.0028	-0.0182	-0.0092	0.007	0.0034	-0.0986	-0.1035	0.7569	1
	0.5486	0.0367	0.0739	0.883	0	0.7655	0.0553	0.3312	0.4649	0.7184	0	0	0	

Note: Own Calculations, second row below index= p-value, red font = significant (1%, 5% and 10%)

Table A 4: Correlation Matrix - Grade 9

	female	overage_all	gender_balance	parent_matric	instructional_clarity_idx (high)	home_educ_resources_idx (many)	belonging_idx	bullying_idx	like_math_idx	disorderly_idx	confidence_idx	value_math_idx	female_teacher	teacher_qual	teacher_age	teacher_years_teaching
female	1															
overage_all	-0.2089	1														
	0															
gender_balance	0.1666	0.0982	1													
	0	0														
parent_matric	0.0128	-0.1136	-0.0213	1												
	0.0641	0	0.0022													
instructional_clarity_idx (high)	0.0205	-0.0207	-0.0297	0.0099	1											
	0.0033	0.0031	0	0.155												
home_educ_resources_idx (many)	-0.002	-0.0574	-0.0189	**0.1705**	0.0096	1										
	0.7768	0	0.0064	0	0.1702											
belonging_idx	0.0529	-0.0056	-0.0009	-0.0384	0.2717	0.0028	1									
	0	0.4223	0.8996	0	0	0.6858										
bullying_idx	-0.0412	0.1829	0.0933	-0.0244	-0.0834	-0.0462	-0.0862	1								
	0	0	0	0.0005	0	0	0									
like_math_idx	-0.0353	-0.0281	-0.0482	0.0197	0.329	-0.0119	0.2857	-0.0143	1							
	0	0.0001	0	0.0047	0	0.089	0	0.0411								
disorderly_idx	-0.0005	0.0408	0.0325	0.0048	-0.0549	-0.0478	-0.0319	0.1731	-0.0197	1						
	0.9374	0	0	0.492	0	0	0	0	0.0049							
confidence_idx	-0.0399	-0.0728	-0.0539	0.0588	0.1885	0.0818	0.1155	-0.0816	**0.4617**	-0.116	1					
	0	0	0	0	0	0	0	0	0	0						
value_math_idx	0.0596	-0.1195	-0.0504	0.0309	0.2589	-0.0173	0.2214	-0.0616	**0.4116**	0.0578	**0.193**	1				
	0	0	0	0	0	0.0135	0	0	0	0	0					
female_teacher	0.0164	-0.0557	-0.0224	0.028	0.0051	0.0443	-0.014	-0.0499	-0.018	-0.0028	0.013	-0.01	1			
	0.0192	0	0.0013	0.0001	0.4669	0	0.0462	0	0.0104	0.6863	0.0658	0.219				
teacher_qual	0.0221	-0.0393	-0.0172	0.0332	-0.0182	0.0628	-0.0098	-0.0391	-0.0422	-0.022	0.008	-0.03	0.0441	1		
	0.0024	0	0.0176	0	0.0128	0	0.1798	0	0	0.0026	0.273	6E-04	0			
teacher_age	-0.0035	-0.0036	0.0033	0.0025	0.0175	0.0176	0.0202	-0.0068	0.0207	-0.0261	0.0194	0	-0.027	-0.1899	1	
	0.6187	0.6068	0.6354	0.7197	0.0132	0.0118	0.0042	0.335	0.0033	0.0002	0.006	0.933	0.0001	0		
teacher_years_teaching	-0.0084	-0.0117	-0.0013	-0.0021	0.018	0.0212	0.0049	-0.0182	-0.0005	-0.03	0.0177	-0.01	-0.03	-0.1767	0.8613	1
	0.2332	0.0939	0.858	0.7679	0.0108	0.0025	0.4871	0.01	0.9403	0	0.0121	0.185	0	0	0	

Note: Own Calculations, row below coefficient = p-value, red font = significant (1%, 5% and 10%)

Table A 5: School Fixed Effects Model 1 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)
VARIABLES	Full sample	Full sample	Q5 Schools
Female	**18.68*** **	**13.49*** **	**2.485**
	(1.806)	(1.758)	(3.878)
Asset index (std)	8.471***	7.530***	12.12***
	(1.236)	(1.170)	(2.274)
Rarely speak test language at home	0.224	-0.900	-17.53***
	(2.284)	(2.160)	(4.822)
Parent has at least matric	20.90***	18.76***	13.94***
	(2.272)	(2.231)	(3.843)
Parental education (missing)	-11.66***	-10.19***	-12.81**
	(1.913)	(1.775)	(6.047)
Class size*	-0.209**	-0.214**	0.597
	(0.0852)	(0.104)	(2.642)
1 year over-age		-34.23***	-39.43***
		(2.044)	(7.592)
2 years over-age		-51.96***	-47.02***
		(3.547)	(16.46)
3+ years over-age		-30.11***	-33.50***
		(10.22)	(6.016)
Constant	363.3	369.5	543.2
	(1.621e+06)	(1.687e+06)	(4.674e+06)
Fixed effects	Yes	Yes	Yes
Observations	11,080	11,080	1,307
R-squared	0.515	0.542	0.445

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). See the 'data and methodology section' for more details about the variables. Class size* is an imputed variable using the mean class size for missing observations. There are many missing observations of parental education in Grade 5. The dummy variable ‘parental education (missing)’ takes a value of 1 if there are missing observations of parental education. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 6: School Fixed Effects Model 1 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Full sample	Full sample	Q5 Schools	Western Cape	Full sample	Q5 Schools	Western Cape
Female	**0.403**	**-7.153*** **	**-11.82*** **	**-15.25*** **	**0.669**	**-9.572*** **	**-12.58*** **
	(1.150)	(1.101)	(3.134)	(1.721)	(1.143)	(2.915)	(1.742)
Asset index (std)	1.657**	0.776	4.998**	1.544	0.621	5.545***	1.344
	(0.704)	(0.687)	(1.996)	(1.061)	(0.665)	(1.700)	(1.039)
Rarely speak test language at hon	-11.21***	-10.22***	-11.13**	-10.69***	-9.258***	-12.22***	-10.57***
	(1.545)	(1.423)	(4.261)	(2.127)	(1.320)	(4.041)	(2.093)
Parent has at least matric	3.075***	1.441	1.040	3.711**	1.129	0.0828	3.811**
	(1.087)	(0.965)	(2.064)	(1.740)	(0.913)	(2.448)	(1.729)
Class size*	0.00978	0.0152	0.00910	-0.309*	-0.0250	0.0769	-0.291*
	(0.0920)	(0.0841)	(0.352)	(0.172)	(0.0814)	(0.356)	(0.173)
1 year over-age		-31.20***	-43.38***	-30.87***	-28.63***	-42.72***	-29.04***
		(1.551)	(5.251)	(2.217)	(1.511)	(4.975)	(2.167)
2 years over-age		-42.20***	-46.56***	-43.57***	-39.71***	-43.94***	-39.42***
		(1.810)	(9.419)	(2.943)	(1.720)	(8.580)	(2.831)
3+ years over-age		-53.19***	-73.23***	-54.64***	-47.85***	-69.72***	-50.77***
		(2.374)	(15.45)	(5.383)	(2.060)	(18.95)	(5.483)
Gender balance					-86.62***	-114.6***	-86.63***
					(2.062)	(10.25)	(4.227)
Constant	459.6	473.3	458.5	479.2	470.4	456.4	476.1
			(8.041e+06)	(5.836e+06)		(8.017e+06)	(5.674e+06)
Observations	20,113	20,113	3,451	5,173	20,113	3,451	5,173
R-squared	0.503	0.548	0.573	0.691	0.592	0.588	0.702

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). See the 'data and methodology section' for more details about the variables. Class size* is an imputed variable using the mean class size for missing observations. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 7: School Fixed Effects Model 2 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**11.32*****	**14.51*****	**12.62*****	**12.04*****	**9.352*****	**14.54*****	**13.02*****	**7.745*****
	(1.750)	(1.803)	(1.819)	(1.860)	(1.620)	(1.815)	(1.695)	(1.617)
High clarity of instruction	35.60***							13.16***
	(2.244)							(2.314)
Many home resources*		28.71**						21.59**
		(11.22)						(9.983)
Some sense of School belonging			12.04***					2.593
			(3.003)					(2.829)
High sense of School belonging			29.24***					4.201
			(3.191)					(3.098)
Student bullying - about monthly				-17.19***				-7.818***
				(2.348)				(2.011)
Student bullying - about weekly				-41.10***				-23.71***
				(2.594)				(2.335)
Somewhat like learning mathematics					17.38***			10.99***
					(2.912)			(3.013)
Very much like learning mathematics					63.97***			37.18***
					(3.307)			(3.409)
Disorderly behavior during some math lessons						-6.175*		8.928***
						(3.487)		(3.051)
Disorderly behavior during most math lessons						-11.83***		4.116
						(4.190)		(3.553)
Somewhat confident in mathematics							30.05***	20.42***
							(2.040)	(1.923)
Very confident in mathematics							76.51***	52.64***
							(2.741)	(2.684)
Constant	397.8	433.9	423.9	471.3	427.3	434.4	385.9	400.4
	(8.071e+06)	(8.312e+06)	(8.315e+06)	(8.864e+06)	(7.821e+06)	(8.740e+06)	(7.833e+06)	(7.165e+06)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,240	10,240	10,240	10,240	10,240	10,240	10,240	10,240
R-squared	0.563	0.542	0.551	0.561	0.597	0.542	0.601	0.635

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices are discussed in the text. Model 2 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 2 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 8: School Fixed Effects Model 2 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**-0.0210**	**0.124**	**-0.218**	**-0.128**	**0.750**	**0.176**	**1.429**	**-0.551**	**1.053**
	(1.145)	(1.149)	(1.143)	(1.135)	(1.077)	(1.150)	(1.098)	(1.100)	(1.035)
High clarity of instruction	7.221***								-3.626***
	(1.022)								(1.001)
Many home resources		16.45***							11.14***
		(4.180)							(3.589)
Some sense of School belonging			5.259**						0.281
			(2.100)						(1.919)
High sense of School belonging			10.17***						-0.788
			(2.177)						(2.095)
Student bullying - about monthly				-5.136***					-2.924***
				(1.032)					(0.961)
Student bullying - about weekly				-17.50***					-13.67***
				(1.494)					(1.415)
Somewhat like learning mathematics					11.74***				5.121***
					(1.407)				(1.385)
Very much like learning mathematics					32.37***				13.27***
					(1.457)				(1.571)
Disorderly behavior during some math lessons						-3.385*			2.525
						(1.812)			(1.855)
Disorderly behavior during most math lessons						-7.420***			0.359
						(2.299)			(2.188)
Somewhat confident in mathematics							19.38***		14.66***
							(1.150)		(1.192)
Very confident in mathematics							63.03***		52.70***
							(1.900)		(2.060)
Somewhat value mathematics								16.12***	12.96***
								(2.451)	(2.262)
Strongly value mathematics								31.25***	19.83***
								(2.205)	(2.073)
Constant	503.0	500.6	495.1	517.2	486.0	513.6	478.4	512.4	486.3
	(6.155e+06)	(6.528e+06)	(6.665e+06)	(6.483e+06)	(6.423e+06)	(5.966e+06)	(6.124e+06)	(6.363e+06)	(5.339e+06)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,268	19,268	19,268	19,268	19,268	19,268	19,268	19,268	19,268
R-squared	0.591	0.590	0.591	0.595	0.613	0.590	0.633	0.602	0.645

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics and science scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age and gender balance. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices are discussed in the text. Model 2 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 2 includes both variables. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 9: School Fixed Effects Model 3 Results of Mathematics Achievement – Grade 5, Full Sample

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)
VARIABLES	Full sample	Full sample	Full sample	Full sample
Female	**8.702*** **	**8.545*** **	**9.708*** **	**7.479*** **
	(1.912)	(2.155)	(1.832)	(1.745)
High clarity of instruction	13.18***	13.13***	13.08***	13.18***
	(2.314)	(2.317)	(2.321)	(2.321)
Many home resources*	21.57**	21.63**	21.58**	21.66**
	(9.971)	(9.993)	(9.946)	(9.997)
Some sense of School belonging	2.595	2.594	2.652	2.588
	(2.831)	(2.831)	(2.845)	(2.829)
High sense of School belonging	4.196	4.191	4.242	4.192
	(3.103)	(3.102)	(3.113)	(3.101)
Student bullying - about monthly	-7.787***	-7.843***	-7.767***	-7.804***
	(2.012)	(2.014)	(2.006)	(2.009)
Student bullying - about weekly	-22.09***	-23.72***	-23.64***	-23.71***
	(2.822)	(2.337)	(2.322)	(2.335)
Somewhat like learning mathematics	10.94***	10.95***	10.88***	11.00***
	(3.012)	(3.007)	(2.999)	(3.017)
Very much like learning mathematics	37.11***	37.99***	37.05***	37.19***
	(3.407)	(3.789)	(3.410)	(3.414)
Disorderly behavior during some math lessons	8.884***	8.924***	8.835***	8.930***
	(3.043)	(3.049)	(3.057)	(3.051)
Disorderly behavior during most math lessons	4.121	4.110	8.225**	4.119
	(3.544)	(3.554)	(3.947)	(3.550)
Somewhat confident in mathematics	20.37***	20.46***	20.46***	20.42***
	(1.918)	(1.915)	(1.923)	(1.924)
Very confident in mathematics	52.62***	52.69***	52.70***	51.83***
	(2.683)	(2.686)	(2.678)	(3.328)
Girls#Student bullying - about weekly	-3.481			
	(3.268)			
Girls#Very much like learning mathematics		-1.675		
		(3.071)		
Girls# Disorderly behavior during most math lessons			**-8.235***	
			(3.571)	
Girls#Very confident in mathematics				1.509
				(3.821)
Constant	396.1	404.6	400.1	395.8
	(7.705e+06)	(6.522e+06)	(6.902e+06)	(7.409e+06)
Student controls	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
Observations	10,240	10,240	10,240	10,240
R-squared	0.635	0.635	0.636	0.635

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices and interaction terms are discussed in the text. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 10: School Fixed Effects Model 3 Results of Mathematics Achievement – Grade 5, Quintile 5 Schools

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)
VARIABLES	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools
Female	**4.172**	**6.885**	**7.092****	**4.941**
	(3.382)	(6.198)	(3.432)	(4.617)
High clarity of instruction	6.625	6.633	6.422	6.557
	(6.412)	(6.455)	(6.619)	(6.353)
Many home resources*	18.22	18.57	18.40	17.95
	(12.70)	(12.75)	(12.62)	(12.76)
Some sense of School belonging	11.12**	10.92**	11.61**	10.94**
	(5.180)	(5.062)	(5.411)	(5.084)
High sense of School belonging	10.71*	10.37*	11.38**	10.66*
	(5.476)	(5.393)	(5.561)	(5.425)
Student bullying - about monthly	-6.279*	-6.329	-6.101	-6.248
	(3.680)	(3.759)	(3.652)	(3.713)
Student bullying - about weekly	-15.95*	-19.94***	-19.77***	-19.75***
	(8.168)	(5.428)	(5.404)	(5.466)
Somewhat like learning mathematics	0.877	0.777	0.462	0.843
	(6.997)	(7.054)	(6.996)	(7.061)
Very much like learning mathematics	8.525	12.16	7.779	8.467
	(7.042)	(9.774)	(7.006)	(7.035)
Disorderly behavior during some math lessons	13.73**	13.21**	14.07**	13.51**
	(5.341)	(5.198)	(5.373)	(5.338)
Disorderly behavior during most math lessons	3.941	3.366	10.96	3.811
	(6.452)	(6.357)	(8.138)	(6.545)
Somewhat confident in mathematics	26.28***	26.98***	26.91***	26.54***
	(5.191)	(4.891)	(5.169)	(5.125)
Very confident in mathematics	64.33***	64.79***	65.09***	68.43***
	(5.579)	(5.453)	(5.555)	(6.365)
Girls#Student bullying - about weekly	-9.986			
	(13.00)			
Girls#Very much like learning mathematics		-7.998		
		(8.816)		
Girls# Disorderly behavior during most math lessons			-15.21	
			(9.756)	
Girls#Very confident in mathematics				-8.247
				(8.202)
Constant	462.8	469.2	477.9	443.5
	(3.999e+07)	(3.733e+07)	(3.881e+07)	(3.872e+07)
Student controls	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
Observations	1,244	1,244	1,244	1,244
R-squared	0.543	0.543	0.544	0.543

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. The measures for the attitude indices and interaction terms are discussed in the text. Model 3 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and many home resources dummy* which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. There are some missing observations for the many home resources dummy, thus missing observations are recoded as not having many home resources. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 11: School Fixed Effects Model 3 Results of Mathematics Achievement – Grade 9, Full Sample

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Full sample	Full sample	Full sample	Full sample	Full sample
Female	**-0.0958**	**2.851****	**0.813**	**1.121**	**8.137*****
	(1.159)	(1.339)	(1.141)	(1.067)	(1.480)
High clarity of instruction	-3.654***	-3.643***	-3.615***	-3.627***	-3.685***
	(1.004)	(1.001)	(0.999)	(1.000)	(1.007)
Many home resources	11.22***	11.23***	11.15***	11.14***	11.34***
	(3.583)	(3.580)	(3.587)	(3.588)	(3.591)
Some sense of School belonging	0.287	0.127	0.278	0.273	0.103
	(1.925)	(1.929)	(1.920)	(1.920)	(1.911)
High sense of School belonging	-0.772	-0.998	-0.792	-0.798	-1.039
	(2.103)	(2.113)	(2.096)	(2.098)	(2.091)
Student bullying - about monthly	-2.930***	-2.913***	-2.922***	-2.928***	-2.973***
	(0.960)	(0.963)	(0.960)	(0.960)	(0.965)
Student bullying - about weekly	-17.04***	-13.66***	-13.65***	-13.67***	-13.68***
	(2.352)	(1.416)	(1.412)	(1.415)	(1.409)
Somewhat like learning mathematics	5.158***	5.243***	5.126***	5.126***	5.277***
	(1.391)	(1.388)	(1.384)	(1.388)	(1.396)
Very much like learning mathematics	13.30***	15.90***	13.29***	13.28***	13.31***
	(1.572)	(2.019)	(1.569)	(1.575)	(1.574)
Disorderly behavior during some math lessons	2.530	2.557	2.532	2.522	2.470
	(1.854)	(1.852)	(1.856)	(1.856)	(1.861)
Disorderly behavior during most math lessons	0.439	0.321	-0.294	0.357	0.268
	(2.187)	(2.194)	(2.573)	(2.189)	(2.185)
Somewhat confident in mathematics	14.69***	14.65***	14.66***	14.66***	14.67***
	(1.194)	(1.191)	(1.191)	(1.191)	(1.189)
Very confident in mathematics	52.70***	52.72***	52.69***	53.19***	52.56***
	(2.060)	(2.065)	(2.058)	(2.869)	(2.052)
Somewhat value mathematics	12.96***	12.92***	12.95***	12.96***	12.80***
	(2.262)	(2.255)	(2.258)	(2.262)	(2.271)
Strongly value mathematics	19.78***	19.71***	19.82***	19.82***	24.86***
	(2.074)	(2.063)	(2.071)	(2.072)	(2.353)
Girls#Student bullying - about weekly	**6.873****				
	(2.855)				
Girls#Very much like learning mathematics		**-4.785****			
		(2.001)			
Girls# Disorderly behavior during most math lessons			1.241		
			(2.163)		
Girls#Very confident in mathematics				-0.928	
				(3.512)	
Girls#Strongly value mathematics					**-10.19*****
					(1.811)
Constant	488.8	480.7	484.3	479.2	485.8
	(5.869e+06)	(5.510e+06)	(6.555e+06)	(5.998e+06)	(7.099e+06)
Student controls	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	19,268	19,268	19,268	19,268	19,268
R-squared	0.646	0.646	0.645	0.645	0.646

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 12: School Fixed Effects Model 3 Results of Mathematics Achievement – Grade 9, Quintile 5 Schools

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools	Q5 Schools
Female	**-7.115****	**-7.191*****	**-6.916****	**-6.314*****	**0.334**
	(2.769)	(1.957)	(2.986)	(2.313)	(3.189)
High clarity of instruction	-6.316**	-6.282**	-6.287**	-6.314**	-6.500**
	(2.734)	(2.700)	(2.669)	(2.705)	(2.737)
Many home resources	11.74***	11.55***	11.63***	11.63***	11.80***
	(4.407)	(4.397)	(4.362)	(4.368)	(4.440)
Some sense of School belonging	-1.438	-1.431	-1.454	-1.504	-1.514
	(3.175)	(3.090)	(3.162)	(3.097)	(3.102)
High sense of School belonging	-6.768*	-6.766*	-6.845*	-6.874*	-6.954**
	(3.579)	(3.513)	(3.530)	(3.495)	(3.465)
Student bullying - about monthly	-4.295**	-4.238**	-4.353**	-4.312**	-4.622**
	(2.045)	(2.021)	(2.085)	(2.055)	(2.031)
Student bullying - about weekly	-17.13**	-12.78***	-12.73***	-12.76***	-12.76***
	(8.194)	(4.140)	(4.106)	(4.145)	(4.130)
Somewhat like learning mathematics	9.053***	8.915***	9.001***	8.933***	8.992***
	(2.606)	(2.641)	(2.633)	(2.634)	(2.659)
Very much like learning mathematics	8.022**	6.254	8.108**	8.021**	8.129**
	(3.506)	(4.905)	(3.513)	(3.552)	(3.493)
Disorderly behavior during some math lessons	2.428	2.395	2.466	2.470	2.273
	(3.972)	(4.036)	(3.982)	(3.994)	(3.906)
Disorderly behavior during most math lessons	0.236	0.182	-1.255	0.181	0.00701
	(6.163)	(6.108)	(7.213)	(6.131)	(6.176)
Somewhat confident in mathematics	29.01***	28.97***	28.87***	28.95***	28.96***
	(3.546)	(3.486)	(3.448)	(3.512)	(3.474)
Very confident in mathematics	71.37***	71.25***	71.32***	71.46***	71.15***
	(4.894)	(4.897)	(4.927)	(5.470)	(4.869)
Somewhat value mathematics	13.54***	13.51***	13.52***	13.59***	13.83***
	(4.131)	(4.112)	(4.105)	(4.125)	(4.088)
Strongly value mathematics	16.06***	16.08***	16.08***	16.18***	21.94***
	(4.511)	(4.594)	(4.478)	(4.564)	(6.375)
Girls#Student bullying - about weekly	8.925				
	(9.960)				
Girls#Very much like learning mathematics		3.276			
		(5.300)			
Girls# Disorderly behavior during most math lessons			2.700		
			(5.329)		
Girls#Very confident in mathematics				-0.274	
				(5.801)	
Girls#Strongly value mathematics					**-10.24***
					(5.228)
Constant	445.6	432.0	440.1	437.4	434.6
Student controls	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	3,368	3,368	3,368	3,368	3,368
R-squared	0.682	0.682	0.682	0.682	0.683

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable ‘whether the parent has matric’ which is based on the parents’ levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 13: School Fixed Effects Model 3 Results of Mathematics Achievement - Grade 9, Western Cape Schools

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)
VARIABLES	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape
Female	**-9.489*** **	**-7.541*** **	**-8.244*** **	**-7.085*** **	**-6.763*** **
	(1.610)	(1.601)	(1.748)	(1.518)	(2.248)
High clarity of instruction	-5.796***	-5.793***	-5.783***	-5.761***	-5.818***
	(1.623)	(1.629)	(1.629)	(1.631)	(1.628)
Many home resources	18.73***	18.69***	18.72***	18.68***	18.73***
	(3.769)	(3.774)	(3.776)	(3.784)	(3.775)
Some sense of School belonging	-0.0473	0.0439	0.0433	0.115	0.0121
	(2.547)	(2.548)	(2.561)	(2.574)	(2.566)
High sense of School belonging	-2.471	-2.530	-2.549	-2.399	-2.560
	(2.798)	(2.802)	(2.816)	(2.824)	(2.816)
Student bullying - about monthly	0.506	0.471	0.461	0.516	0.474
	(1.533)	(1.539)	(1.538)	(1.542)	(1.538)
Student bullying - about weekly	-16.65***	-9.640***	-9.664***	-9.662***	-9.654***
	(3.594)	(2.370)	(2.383)	(2.373)	(2.378)
Somewhat like learning mathematics	6.767***	6.816***	6.802***	6.763***	6.843***
	(2.021)	(2.028)	(2.023)	(2.021)	(2.026)
Very much like learning mathematics	11.41***	12.31***	11.60***	11.63***	11.63***
	(2.394)	(2.962)	(2.420)	(2.419)	(2.416)
Disorderly behavior during some math lessons	-0.761	-0.681	-0.688	-0.662	-0.707
	(2.690)	(2.683)	(2.674)	(2.661)	(2.682)
Disorderly behavior during most math lessons	-6.779**	-6.574**	-7.425**	-6.560**	-6.600**
	(3.088)	(3.075)	(3.678)	(3.057)	(3.074)
Somewhat confident in mathematics	24.77***	24.64***	24.62***	24.69***	24.63***
	(1.860)	(1.870)	(1.873)	(1.877)	(1.874)
Very confident in mathematics	62.31***	62.11***	62.05***	66.72***	62.06***
	(3.118)	(3.130)	(3.132)	(3.533)	(3.133)
Somewhat value mathematics	10.25***	10.31***	10.34***	10.30***	10.31***
	(3.598)	(3.604)	(3.601)	(3.617)	(3.603)
Strongly value mathematics	14.36***	14.48***	14.50***	14.39***	15.45***
	(3.705)	(3.689)	(3.682)	(3.704)	(4.020)
Girls#Student bullying - about weekly	**13.58*** **				
	(4.487)				
Girls#Very much like learning mathematics		-1.358			
		(2.852)			
Girls# Disorderly behavior during most math lessons			1.471		
			(3.542)		
Girls#Very confident in mathematics				**-8.959** **	
				(4.122)	
Girls#Strongly value mathematics					-1.794
					(2.690)
	457.2	457.0	460.3	460.0	458.1
Constant					
Student controls	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	4,950	4,950	4,950	4,950	4,950
R-squared	0.763	0.762	0.762	0.763	0.762

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Model 3 includes the binary variable 'whether the parent has matric' which is based on the parents' levels of education variable and the home resource index which is also partially based on this variable. Since both variables are weekly correlated model 3 includes both variables. The measures for the attitude indices and interaction terms are discussed in the text. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 14: School Fixed Effects Model 4 Results of Mathematics Achievement – Grade 5

Dependent Variable: Mathematics test score - G5	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Q5 Schools	Full sample	Q5 Schools	Full sample	Full sample	Q5 Schools
Female	**11.22***	**11.21***	**3.121**	**11.14***	**-8.945**	**11.23***	**10.99***	**-8.854**
	(1.738)	(1.740)	(4.099)	(2.900)	(7.564)	(1.782)	(2.940)	(7.529)
High clarity of instruction	36.86***	36.86***	26.52***	36.86***	26.51***	36.33***	36.33***	26.49***
	(2.083)	(2.083)	(5.941)	(2.082)	(6.034)	(2.078)	(2.076)	(6.057)
Female teacher		2.133	1.242	2.081	-5.733	1.534	1.340	-2.487
		(2.491)	(7.986)	(2.924)	(9.239)	(2.569)	(3.051)	(9.435)
Girls#Female teacher				0.103	**14.96***		0.387	**14.98***
				(3.635)	(8.315)		(3.652)	(8.283)
Constant	291.7	298.5	335.6	297.1	327.6	373.5	371.1	322.1
			(1.635e+06)		(3.402e+06)			(3.591e+06)
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher controls	No	No	No	No	No	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,535	10,535	1,266	10,535	1,266	10,190	10,190	1,266
R-squared	0.562	0.562	0.450	0.562	0.452	0.565	0.565	0.452

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size and over-age. See the 'data and methodology section' for more details about the variables. Teacher controls include the teacher age, years of teaching, and the highest level of teacher qualifications. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.

Table A 15: School Fixed Effects Model 4 Results of Mathematics Achievement – Grade 9

Dependent Variable: Mathematics test score - G9	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Full sample	Full sample	Q5 Schools	Full sample	Q5 Schools	Full sample	Full sample	Q5 Schools
Female	**0.351**	**0.356**	**-9.815***	**0.634**	**-11.32**	**0.00127**	**0.776**	**-11.23**
	(1.158)	(1.155)	(2.933)	(1.533)	(4.718)	(1.223)	(1.640)	(4.794)
High clarity of instruction	7.526***	7.523***	5.021*	7.525***	5.027*	7.777***	7.785***	4.577
	(1.029)	(1.028)	(2.667)	(1.028)	(2.679)	(1.088)	(1.087)	(2.887)
Female teacher		-1.106	-2.652	-0.811	-3.815	-1.360	-0.532	-5.567
		(1.220)	(3.005)	(1.587)	(4.259)	(1.234)	(1.666)	(4.198)
Girls#Female teacher				-0.563	2.249		-1.597	1.673
				(2.016)	(5.231)		(2.160)	(5.355)
Constant	528.1	517.8	599.4	525.9	598.3	422.3	421.2	468.1
	(6.770e+06)	(6.496e+06)	(1.648e+07)	(6.744e+06)	(1.678e+07)	(2.623e+06)	(2.670e+06)	
Student controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher controls	No	No	No	No	No	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,551	19,551	3,391	19,551	3,391	17,842	17,842	3,263
R-squared	0.593	0.593	0.588	0.593	0.588	0.603	0.603	0.591

Note: Own Calculations. Standard errors in parentheses. Sample weighting is considered. *** p<0.01, ** p<0.05, * p<0.1. Mathematics scores are measured by the first plausible value (scaled to an international M = 500 and SD = 100, based on the participating countries in the first round of TIMSS in 1995). Student controls include school quintiles, the standardised asset index (student SES), provinces, the dummy variable whether students rarely speak the test language at home, urban, whether parents have at least matric, class size, over-age and gender balance. See the 'data and methodology section' for more details about the variables. Teacher controls include the teacher age, years of teaching, and the highest level of teacher qualifications. The variables school quintiles, provinces and urban are fixed across learners within the same school and thus are omitted using fixed-effects. There are a few single-sex schools, hence some schools were not omitted using fixed effects. They are included for completeness because learners in these schools, although not different in their sex, do differ in the other variables of interest.