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Growing apart: Tracking the pro-girl achievement gap across early grades in South African primary schools

Author
Gabrielle Wills &
Rosalind Clayton

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Gabrielle Wills[a*] and Rosalind Clayton[b1]

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Abstract

South Africa recorded the largest pro-girl gap in Grade 4 reading and Grade 5 mathematics among participating countries in the 2021 Progress in International Literacy and Reading Study and the 2023 Trends in International Mathematics and Science Study. This paper examines whether these gaps reflect an initial female advantage at school entry, widening gender differences during the early grades, or both. Using parametric and non-parametric methods, we analyse longitudinal administrative data on student marks for more than half a million public school students across six South African provinces from Grades 1 to 4. We find substantial pro-girl gaps across the entire Grade 1 mark distribution in both language and mathematics. In language - and to a lesser extent in mathematics - these gaps widen over the first four grades, particularly in less resourced schools. Girls' marks move progressively ahead of boys' marks, with no evidence of convergence between Grades 1 and 4. Divergence is evident across the achievement distribution but is stronger in language than in mathematics. Pro-girl gaps in language and especially mathematics in more resourced schools show less divergence across grades than in less resourced schools. Overall, the findings suggest that South Africa's large pro-girl achievement gaps in international assessments reflect both an early female advantage at school entry and the cumulative widening of this gap within the schooling system during the foundation and intermediate phases.

Keywords: gender achievement gaps; learning; language; mathematics; socio-economic status; South Africa

[1] [a]Researcher at Research on Socio-Economic Policy and Senior Lecturer in the Department of Economics, Stellenbosch University, Stellenbosch, South Africa. [b]PhD student with Research on Socio-Economic Policy in the Department of Economics, Stellenbosch University, Stellenbosch, South Africa. *Corresponding author: gabriellewills@sun.ac.za; CGW Schumann Building, Bosman Street, Stellenbosch, 7602, South Africa.

1. Introduction

Internationally research shows that gender gaps in school achievement are not homogenous; they vary by context, subject and grade (Meinck & Brese, 2019), often reflecting deep-rooted social norms, classroom practices, and institutional biases. In general girls tend to outperform boys in reading from early grades, while boys more often hold an advantage in mathematics and science (Cobb-Clark & Moschion, 2017; OECD, 2025; UNESCO, 2020); but these patterns are not universal. South Africa is somewhat of an exception: across every national and international assessment in which it has participated since 2011, girls have consistently outperformed boys irrespective of grade or subject (Spaull & Makaluza, 2019). In the 2021 Progress in International Reading and Literacy Study (PIRLS), South Africa recorded the largest pro-girl gap in Grade 4 reading among all 57 participating countries: a 57-point pro-girl gap[2] (equivalent to a year of learning) compared to the international average of just 18 points (Mullis et al., 2023). A similar, though less extreme, trend is evident in mathematics: South Africa's Grade 5 pro-girl gap in the 2023 Trends in International Mathematics and Science Study (TIMSS)[3] was not only statistically significant but also the largest of all participating countries at 29 TIMSS points (von Davier et al., 2024). South Africa's pro-girl reading gap has also grown over time and in the past decade a pro-girl gap in mathematics and science in secondary school has also become evident (von Davier et al., 2024).

These patterns raise questions about why and when gender[4] gaps in achievement emerge. Hofmeyr (2022) argues that the large unexplained portion of South Africa's pro-girl gap in Grade 5 TIMSS and Grade 4 PIRLS achievement is due to gender differences in cognitive and non-cognitive skills at earlier grades or before school starts. This is implied in more recent assessments among children aged 50-59 months in early learning programmes in South Africa where girls display stronger emergent literacy and numeracy skills than boys (Giese et al., 2022). But a key question emerges as to whether South Africa's pro-girl gap at the start of school is being augmented through the grades?

Reflecting on the international literature on gender gaps, Borgonovi et al. (2021, p. 1) note that "little is known about the moment in which such gaps emerge, how they evolve, and if this evolution differs across countries." In developed countries, more evidence has emerged on this issue in recent years (Borgonovi et al., 2021; Giofrè et al., 2020; Martinot et al., 2025; Reardon et al., 2019; Thomas et al., 2023), but it remains a less studied topic

[2] Across PIRLS cycles in 2011, 2016, and 2021, the only country to have ever reported a larger pro-girl gap was Saudi Arabia in 2016.

[3] South Africa is one of only a handful of countries participating in TIMSS that test Grade 5 rather than Grade 4 students.

[4] The term 'gender' is preferred over 'sex' when distinguishing between boys and girls. Whereas sex refers to biological differences, gender captures the social and cultural norms linked to being male or female, shaping how children are perceived and what is expected of them. Using gender is therefore more suitable for analysing developmental outcomes, as it reflects the wider social influences that may lead to differences between boys and girls.

in low- and middle-income country (LMIC) contexts (Bharadwaj et al., 2012; Das & Singhal, 2023; Singh & Krutikova, 2017) despite a well-developed literature on gender gaps in school achievement.

Using a large longitudinal administrative dataset of over half a million Grade 1 students enrolled in public schools in 2019 in six of nine South African provinces, this study examines gender gaps in student marks and how they grow across early grades. The overarching research questions framing the inquiry include:

1. What is the magnitude of the pro-girl gap in student marks in Grades 1-4?
2. Does the pro-girl gap differ by subject and how do these gaps evolve between Grades 1-4?
3. How does the pro-girl gap in student marks, and how it evolves across grades, differ by the socio-economic status of the school attended?

We are also sensitive to how gender gaps in mean achievement can obscure heterogeneity in the gender gap across the mark distribution (Meinck & Brese, 2019). It can be useful to know whether achievement gaps exist among high achievers, among students who struggle, or across the entire distribution. This presents a fourth research question:

4. At what point in the distribution of student marks do girls have a larger relative advantage to boys and relatedly, does the evolution of the gender gap differ across the distribution of initial marks?

In a context where girls already outperform boys by a substantial margin, if boys experience less upward movement than girls, the prospects for convergence in schooling outcomes between genders are limited. It is therefore necessary to complement an analysis of achievement gaps in levels with an understanding of the dynamics in how boys and girls traverse through the student mark distribution across grades (McDonough, 2015). Therefore, we aim to answer a fifth related research question:

5. How does the persistence and rank movement of boys and girls compare in the distribution of school marks from one grade to the next?

Following McDonough's (2015) approach in exploring the dynamics of the black-white academic achievement gap in the United States, we apply two non-parametric estimates of distributional mobility – staying probabilities and directional rank mobilities (Bhattacharya & Mazumder, 2011; Mazumder, 2011) – to our dataset of student marks to quantify the probability that girls or boys will move upward, downward or not at all through the distribution of student marks.

Our results relate to a large literature studying gender-based inequalities in academic achievement in developing countries (Bharadwaj et al., 2016; Das & Singhal, 2023; Evans et al., 2021; Singh & Krutikova, 2017; UNESCO, 2020) as well as growing literature on inequalities in learning trajectories within countries (Bau et al., 2021; Kaffenberger &

Pritchett, 2021). Our study contributes to knowledge on gender gaps in early grades in a middle-income country context and adds to a growing evidence base on South Africa's female-advantage in schooling (Hofmeyr, 2022; Spaull & Makaluza, 2019; van Broekhuizen & Spaull, 2017; Zuze & Beku, 2019). The specific contribution of this study is to examine not just whether there are gender gaps in school achievement, but how these grow across early grades, and how these patterns vary across the distribution, by subject and school socio-economic status.

In brief, our results from six South African provinces reveal large pro-girl gaps in student marks at the start of school that typically grow to Grade 4 at almost all points in the initial mark distribution. On average, a pro-girl gap of about 0.4 standard deviations (SD) in Home Language and 0.33 SD in First Additional Language in term 4 of Grade 1 each increase to 0.58 SD by Grade 4. A pro-girl gap of 0.33 SD in Mathematics in Grade 1 increases by far less to 0.39 SD by Grade 4. Gaps also increase between the start and end of the Grade 1 year. But these averages hide differences by school socio-economic status, with much larger pro-girl gaps and larger growth in these gaps evident in less resourced school contexts compared to wealthier schools. Non-parametric predictions of subsequent marks conditional on prior performance, along with staying probability and directional rank mobility estimates, reveal that girls experience greater positive movement through the achievement distribution than boys. Overall, there is no evidence of convergence in the pro-girl gap in student marks from Grade 1-4, although in Quintile 5 schools gaps remain relatively stable in mathematics from Grade 1-4.

These results help to locate the source of the large South African pro-girl gap in reading and mathematics in PIRLS and TIMSS not just to an initial girl advantage at the start of school, but to the augmentation of the pro-girl gap within the schooling system over the first four years of school.

In the next section we provide background on gender gaps in school achievement, and their evolution across grades, drawing on global and South African evidence. Sections three and four describe the data used and the empirical strategy. Results are presented in section five while section six concludes.

2. Background

2.1 International literature

Understanding how gender gaps in school achievement evolve across school grades is important for identifying when and why inequalities emerge. Although it is clear from existing research that gender gaps in school achievement evolve systematically over the course of schooling, these patterns differ by subject and context.

In mathematics, gaps are generally smaller or non-existent at school entry and in early primary grades (ages 5–8) across both high-income and low- to middle-income countries (Borgonovi et al., 2021; Das & Singhal, 2023; Singh & Krutikova, 2017). As students progress through primary and early secondary grades, a pro-boy gap in mathematics often emerges and grows. For example, in Italy and Chile, boys increasingly outperform girls in mathematics from the middle grades onwards, with the largest disparities appearing by early adolescence (Bharadwaj et al., 2012, 2016; Giofrè et al., 2020). In France, minimal gender gaps in mathematics at school entry move in favour of boys within the first year of schooling (Martinot et al., 2025). In rural India, pro-boy gaps at age 8 in mathematics continue to diverge through age 16 (Das & Singhal, 2023). In high-income contexts, the small male advantage in numeracy at age 10 tends to continue into late adolescence and early adulthood (Borgonovi et al., 2021).

By contrast, literacy gaps generally favour girls and appear earlier in schooling. Evidence from Australia, the United States, and other high-income countries shows that girls tend to outperform boys across literacy measures from the early grades, with the most rapid widening in the pro-girl gender gap occurring between late primary and early secondary school (Reardon et al., 2019; Thomas et al., 2023). Evidence from international assessments indicates that pro-girl gaps in literacy peak during adolescence but tend to narrow by early adulthood (Borgonovi et al., 2021). In LMICs, there is some evidence from India, Vietnam, Peru and Ethiopia that literacy gaps tend to emerge slightly later, during adolescence, but persist once established, with the direction of the gap varying across contexts (Singh & Krutikova, 2017).

Overall, these findings highlight that gender disparities in academic achievement are both subject- and age-specific. Generally, mathematics gaps tend to grow in favour of boys across primary and secondary schooling, whereas literacy gaps develop early, are more likely to favour girls, and often peak in adolescence before narrowing in adulthood. However, the magnitude and timing of these gaps may be moderated by contextual factors, including local socio-economic conditions (Reardon et al., 2019).

2.2 South African context

There is a growing evidence base on South Africa's pro-girl gap in schooling (Hofmeyr, 2022; Spaull & Makaluza, 2019; van Broekhuizen & Spaull, 2017; Zuze & Beku, 2019). At every grade level, especially in reading and to a lesser extent mathematics and science, there is a pro-girl advantage. In the 2021 PIRLS assessment, South Africa exhibited the largest pro-girl gap in Grade 4 reading among 57 countries – a gap equivalent to roughly one year of learning - and was the only country to record a significant pro-girl gap in Grade 4/5 mathematics in TIMSS 2023. Pro-girl gaps are more pronounced in lower-socio-economic environments and in African languages than in English or Afrikaans (Böhmer & Wills, 2025).

There are only a few studies in South Africa following the academic or learning trajectories of the same sample of girls and boys over time. Tracking a Grade 12 cohort into tertiary studies, Van Broekhuizen & Spaull (2017) find that the female academic achievement advantage widens from the final year of school (Grade 12) into tertiary education. In the earlier grades, Wills et al. (2022) and Qvist (2023) using a longitudinal student sample from no-fee charging schools in North West find that the pro-girl advantage in reading fluency may grow across the primary grades (Grade 1-7).

Less clear from the empirical evidence is why these gaps emerge. Drawing on international theoretical frameworks, a widening pro-girl achievement gap may result due to the interaction of gender socialisation, school engagement, and structural opportunity conditions (Eccles, 1994; Fredricks et al., 2004; Morris, 2012). Gender socialisation theories argue that from early childhood, girls are often rewarded for behaviours that align with school success - persistence, compliance, and verbal engagement - while boys may be socialised toward forms of masculinity that discourage help-seeking and academic identification (Morris, 2012). These differences could shape behavioural, emotional, and cognitive engagement in school (Fredricks et al., 2004). Small early differences in engagement can also accumulate over time through reinforcing loops (Skinner et al., 2008). In South Africa, weak instructional quality, high grade repetition, high rates of father absence and limited labour market opportunities – especially in lower socio-economic contexts - could potentially intensify these processes (Ratele et al., 2024; van der Berg et al., 2017). The result may be earlier disengagement among boys and progressively widening pro-girl learning gaps.

Although international frameworks can provide clues as to why gender gaps in learning emerge, South African quantitative and qualitative studies have been limited in their ability to detect the source of these gaps. Hofmeyr (2022) can explain less than 40% of the pro-girl gap in PIRLS Grade 4 reading and less than 25% in Grade 5 mathematics. Factors that account for the explained portion include the higher likelihood of boys being overage than girls – the result of grade failure due weak foundational learning skills – and differences in attitudes towards school with girls scoring higher on self-efficacy, enjoyment and engagement in reading. Girls in South Africa demonstrate cognitive and socio-emotional advantages over boys before school starts (Giese et al., 2022). This aligns with international literature identifying gender differences in test scores as early as kindergarten (DiPrete & Jennings, 2012; Fidjeland et al., 2023). The early disparity between boys and girls in their test scores, especially in lower socio-economic environments, is concerning because learning builds on itself. This means that initial gaps in achievement can augment across grades (Spaull & Kotze, 2015). This warrants a closer comparison of learning trajectories across boys and girls.

2.3 Methodological challenges

Empirically, however, studying how achievement gaps change over time presents some methodological challenges.

A key issue in the South African context is that grade repetition (otherwise referred to as grade retention) rates are highly gendered (Van der Berg et al., 2019). Boy samples become increasingly selective with each grade due to higher repetition and dropout rates among boys at each grade. For this reason, making judgements about whether (and the extent to which) gender gaps grow overtime requires longitudinal data.

Achievement gaps across groups may also shrink over time, not just because learning trajectories align across groups, but because test scores themselves decay or fade in persistence (Andrabi et al., 2011). Imperfect persistence of test scores occurs when learner's performance on a test in one grade does not perfectly predict their performance in a later grade. This can occur due to differences in test difficulty, test formats, and measurement error. Imperfect persistence of test scores means gaps in achievement may appear to shrink even if underlying learning differences remain (Singh & Krutikova, 2017). Whether any significant gap changes across age or grades depends both on test score decay (which drives gaps toward zero) and the difference in learning trajectories between boys and girls.[5] For this reason, one should avoid comparing learning gains across groups and analyses of how achievement gaps across groups evolve across time or by age should be sensitive to this methodological concern (Bond & Lang, 2013).

3. Data

The data used in this study form part of the Data Driven Districts (DDD) initiative and draw on 2019-2023 student results data from the South African School Administration Management System (SA-SAMS) across six of nine South African provinces: Eastern Cape, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, and North West.[6] Each learner is assigned a unique identifier, enabling longitudinal tracking across time, even when learners transfer between schools. For this paper, we construct a balanced panel of learners from public ordinary schools comprising 261 919 girls and 257 162 boys who started Grade 1 in 2019 at the appropriate age and were observed for four subsequent years (until 2023).

Table 1 and 2 show the number and proportion of Grade 1 girls and boys in the sample respectively reaching a subsequent grade in each year. About 87.3% of the 2019 Grade 1 cohort of girls reached Grade 4 by 2022 (without repetition); while 12.7% of girls repeated once in the Foundation Phase (Grades 1-3). Boys are more likely to repeat, with just 74.8% reaching Grade 4 without repeating and 25.2% repeating once.

[5] For example, in the Young Lives study, a pro-girl gap at age 15 in Vietnam disappears by age 19 - not because boys progress more, but because both groups' earlier scores become less predictive over time (Singh & Krutikowa, 2017).

[6] Data could not be obtained for the Western Cape, Northern Cape and the Free State. The raw DDD data learner counts closely align with learner counts reported in official sources such as School Realities.

Table 1: Transition matrix of the female sample (2019 - 2023)

	Grade				
Year	**1**	**2**	**3**	**4**	**Total**
2019	261 919	0	0	0	**261 919**
	100%	0%	0%	0%	**100%**
2020	17 563	244 356	0	0	**261 919**
	6.71%	93.29%	0%	0%	**100%**
2021	0	25 577	236 342	0	**261 919**
	0%	9.77%	90.23%	0%	**100%**
2022	0	0	33 236	228 683	**261 919**
	0%	0%	12.69%	87.31%	**100%**
2023	0	0	0	33 236	**33 236**

Source: DDD balanced panel of students (2019-2023) of the correct age in Grade 1 in six of nine South African provinces.

Table 2: Transition matrix of the male sample (2019 - 2023)

	Grade				
Year	**1**	**2**	**3**	**4**	**Total**
2019	257 162	0	0	0	**257 162**
	100%	0%	0%	0%	**100%**
2020	34 632	222 530	0	0	**257 162**
	13.47%	86.53%	0.00%	0.00%	**100%**
2021	0	49 127	208 035	0	**257 162**
	0	19.1%	80.9%	0%	**100%**
2022	0	0	64 889	192 273	**257 162**
	0	0	25.2%	74.8%	**100%**
2023	0	0	0	64 889	**64 889**

Source: DDD balanced panel of students (2019-2023) of the correct age in Grade 1 in six of nine South African provinces.

Among correct-age students enrolled for the first time in Grade 1 in 2019, the balanced panel constitutes 72% of the raw DDD data. Those not in the balanced panel may have had missing marks in Grades 2-4 years, may have left the public school system moving to private schools, immigrating or may have dropped out of school. We cannot observe the reasons for panel attrition. Shown in Table 3, students excluded from the balanced panel are slightly weaker academically, scoring on average 5.4 percentage points lower in Grade 1 Mathematics than those in the balanced panel and are more likely to be female (50.5% versus 47.3%). As a result, estimates of the pro-girl gap are likely to be biased downwards. We assess the sensitivity of the estimated results to attrition using inverse probability weights.

Table 3: Characteristics comparison of students in and out of the balanced panel

Variable	In balanced panel	Not in balanced panel	Difference	p-value
% Female	50.460	47.270	3.190	0.000
	(0.080)	(0.140)	(0.160)	
Mean age at start of Grade 1	6.103	6.107	-0.004	0.201
	(0.002)	(0.003)	(0.003)	
Mean Grade 1 (term 4) Mathematics mark (%)	71.510	66.100	5.410	0.000
	(0.100)	(0.190)	(0.200)	
N students	**519 081**	**204 092**		

Source: DDD balanced panel of students (2019-2023) of the correct age in Grade 1 in six of nine South African provinces. Notes: Standard errors in parentheses are clustered at the school level.

In addition to reported gender[7], we know the students' age in months. To measure gender gaps in school achievement, we rely largely on term 4 student marks for each student in Home Language (HL), First Additional Language (FAL)[8], and Mathematics (MTH) in Grades 1-4. These marks reflect the average obtained across various assessments and exams written during the term. While some schools may write the same assessments and there is one national, grade-specific curriculum followed across public schools which contains guidelines for what should be assessed each term, student marks are not strictly standardised. Without standardised test scores vertically linked across grades, there may be some uncertainty that the underlying latent construct captured by student marks represents learning. Within a school, student marks may also be influenced by teacher grading practices if teachers systematically reward behaviours such as compliance, effort, and classroom conduct - traits that may be more commonly associated with girls (Ferman & Fontes, 2022; Zanga & De Gioannis, 2023). But we argue that even if widening gender gaps in student marks cannot be used to say gender gaps in 'learning' widen, the gendered patterns in student marks reveal what the public school system is measuring with respect to gender gaps in school achievement and what is being communicated to students and their families in this regard.

A combination of z-scores, percentage student marks and percentile ranks of student marks are used in the analysis. Z-scores and percentile ranks are calculated within a year for a specific grade using the full cross-sectional DDD data as opposed to only the balanced panel.

[7] There are only male or female categories in the data.

[8] A first additional language is predominately English, but it could also be any of the other 12 official languages in South Africa including African languages and Afrikaans.

4. Method

Our analysis starts with the descriptives of unconditional gender gaps in student marks. Then we use ordinary least squares regressions with school fixed effects to examine gender gaps and how they change across grades as expressed in the following equation:

$$\mathrm{Y}_{igs} = \beta_0 + \beta_1 \mathrm{Female}_{igs} + \beta_2\ \mathrm{Age}_{igs} + \gamma_s + \epsilon_{igs} \qquad (1)$$

The mark of student *i* in Grade g in school s (Y_{igs}) is expressed as a function of being female (1 or 0 male), age upon entering Grade 1, and school fixed effects γ_s. The error term is represented by ϵ_{igs}. Although the balanced panel is constructed for Grade 1 students of the correct age, we control for any remaining differences in age between boys and girls when they start school, while school fixed effects serve as a control for unobserved school characteristics and variation in assessment practices and marking standards across schools.

To examine how gender gaps vary by socio-economic status, we estimate the coefficient on female across school 'Quintiles'. The 'Quintile' system[9] is a way of classifying public schools according to their socio-economic status to help determine the level of funding and resources they receive. Quintile 1-3 schools are typically no-fee charging schools, Quintile 4 schools may charge some fees and Quintile 5 schools usually charge higher fees.

To investigate gender gaps at different parts of the student mark distribution, we use a quantile regression (Koenker & Bassett, 1978) allowing for a linear effect of female on *Y*, but that could vary across the mark distribution where we focus on the 10th, 25th, 50th, 75th and 90th percentiles. We also follow Rios-Avila et al (2024) who extend Machado & Santos Silva's (2019) method of moments-quantile regression to estimate conditional quantiles, incorporating school fixed effects.

Exploiting the panel nature of our data, we also use non-parametric methods to study differences in student mark trajectories between boys and girls based on their percentile ranks in the mark distribution. We predict student marks at a later grade (e.g. Grade 2) based on prior performance (e.g. Grade 1) without assuming a particular functional form.

4.1 Staying probabilities and directional rank mobilities

As another approach to examine whether gender gaps in student marks diverge or converge across grades we follow the approach by McDonough (2015) in analysing racial gaps in student achievement. By calculating staying probabilities, we identify whether students tend to stay in the same relative position in the mark distribution as they move from one grade to the next. Our staying probabilities express how likely it is that a student

[9] The DBE 'Quintiles' divide schools into five groups, from Quintile 1 (the poorest) to Quintile 5 (the wealthiest) but they are not equal in school numbers or student numbers with the year 2023 student population in public schools split across Quintiles as follows: Quintile 1 (23%), Quintile 2 (23%), Quintile 3 (28%), Quintile 4 (13%) and Quintile 5 (13%).

who was in a particular part of the mark distribution in Grade 1 (for example, the bottom 25%, the middle 25%–50%, or the top 25%) is still in that same part of the distribution by Grade 4. Staying probabilities can be expressed in the following way. Let $F_{g_0}(\cdot)$ and $F_{g_1}(\cdot)$ represent the cumulative distribution functions (CDFs) of students' marks at two different grade levels, g_0 and g_1, where $g_0 < g_1$. Let Y_{g_0} and Y_{g_1} denote a student's mark at these respective grade levels. The probability that a student remains within a specific quantile range - say between the k_1^{th} and k_2^{th} quantiles - of the score distribution in Grade g_1, conditional on having been in the same quantile range in Grade g_0, is defined as:

$$\pi^{g_0,g_1} = \frac{\Pr\left[k_1 \le F_{g_1}\left(Y_{g_1}\right) \le k_2, k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]}{\Pr\left[k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]} \qquad (3)$$

While staying probabilities are useful, they only tell us whether students' marks remain within a particular quantile (for example, the bottom 25% or top 25%). They neither show movement within those quantiles nor do they tell us where students end up if they move out of given quantile. A student in the bottom quartile of the mark distribution, might move from the very bottom of that quantile to the very top of that same quantile. To identify these movements along the achievement distribution, we use directional rank mobilities. These measures identify the likelihood of students moving up or down the mark distribution as they progress from one grade to the next. By comparing these measures across boy and girls, we identify if boys' marks are improving or whether they are falling further behind girls as they progress from one grade to the next grade.

As before, let Y_{g_0} and Y_{g_1} represent a student's marks at two grade points, with corresponding cumulative distribution functions $F_{g_0}(\cdot)$ and $F_{g_1}(\cdot)$. In this context, upward rank mobility across grades can be defined as:

$$\theta_\delta^{g_0,g_1} = \frac{\Pr\left[F_{g_1}\left(Y_{g_1}\right) - F_{g_0}\left(Y_{g_0}\right) > \delta, k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]}{\Pr\left[k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]} \qquad (4)$$

where $\delta \in [0, 1 - k_2]$, $0 \le k_1 < k_2 \le 1$. In essence, $\theta_\delta^{g_0,g_1}$ captures the probability that students who begin within a given quantile range of the student mark distribution improve their relative position by more than δ as they advance from one grade to the next. The same approach and underlying logic can be applied to construct measures of downward rank mobility, by reversing the direction of the comparisons in equation (4), yielding:

$$\psi_\delta^{g_0,g_1} = \frac{\Pr\left[F_{g_0}\left(Y_{g_0}\right) - F_{g_1}\left(Y_{g_1}\right) > \delta, k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]}{\Pr\left[k_1 \le F_{g_0}\left(Y_{g_0}\right) \le k_2\right]} \qquad (5)$$

5. Results

5.1 The magnitude of the pro-girl gap in student marks and how it evolves across grades

Table 4 summarizes the average age, repetition status and student marks of the balanced panel by gender and grade. Girls are similarly aged to boys at the start of Grade 1 (6.07 vs. 6.11 years) but they are half as likely to repeat Grade 1 (6.7%) than boys (13.5%). Girls are also less likely to repeat Grade 2 and 3, but gender differences in repetition rates are starkest in Grade 1.

Table 4: Descriptive statistics - age, repetition status and term 4 student marks by grade and gender

	Male (A)		Female (B)		Female - male			
					Difference (B-A)	expressed in z-scores	expressed in percentile rank	K-S test (pvalue)
Age	6.110	(0.002)	6.096	(0.002)	-0.014			
Repeated Grade 1	0.135	(0.001)	0.067	(0.002)	-0.068			
Repeated Grade 2	0.056	(0.001)	0.031	(0.001)	-0.025			
Repeated Grade 3	0.061	(0.001)	0.029	(0.001)	-0.032			
Grade 1 HL result (%)	63.990	(0.087)	70.511	(0.094)	6.521	0.382	11.685	0.000
Grade 2 HL result (%)	64.921	(0.080)	71.728	(0.081)	6.807	0.421	12.913	0.000
Grade 3 HL result (%)	64.408	(0.074)	72.677	(0.080)	8.269	0.498	15.038	0.000
Grade 4 HL result (%)	62.215	(0.071)	71.116	(0.077)	8.901	0.576	17.612	0.000
Grade 1 FAL result (%)	65.370	(0.109)	70.827	(0.113)	5.457	0.324	9.676	0.000
Grade 2 FAL result (%)	63.104	(0.094)	68.993	(0.095)	5.889	0.369	11.024	0.000
Grade 3 FAL result (%)	62.871	(0.082)	70.540	(0.088)	7.669	0.463	13.701	0.000
Grade 4 FAL result (%)	57.330	(0.081)	66.561	(0.087)	9.231	0.576	16.988	0.000
Grade 1 MTH result (%)	68.571	(0.095)	74.387	(0.106)	5.816	0.321	9.744	0.000
Grade 2 MTH result (%)	67.567	(0.087)	72.791	(0.092)	5.224	0.315	9.463	0.000
Grade 3 MTH result (%)	65.626	(0.083)	71.387	(0.090)	5.761	0.350	10.312	0.000
Grade 4 MTH result (%)	60.322	(0.087)	66.452	(0.091)	6.130	0.383	11.213	0.000
N	**257 162**		**261 919**					

Source: DDD balanced panel of students (2019-2023) of the correct age in Grade 1 in six of nine South African provinces. Standard errors in parentheses clustered at the school level. In all comparisons of the CDF of student marks of girls vs boys, the Kolmogorov–Smirnov (K-S) test is rejected at a P-value < 0.000. HL = Home Language, MTH = Mathematics, FAL = First Additional Language.

Table 4 also provides the first suggestion that there is not only a pro-girl gap evident in the first year of school (Grade 1) but that this gap widens to Grade 4. Differences in student marks across girls and boys are expressed in percentage points (pp), standard deviations (SD) as well as percentile ranks. Grade 1, Term 4 marks reveal an advantage to girls of 0.38 SD (6.52 pp) in Home Language, 0.32 SD (5.46 pp) in First Additional Language and 0.32 SD (5.82 pp) in Mathematics. By the end of Grade 2, the pro-girl gaps are slightly larger in

Home Language (0.42 SD or 6.81 pp) and First Additional Language (0.37 SD or 5.89 pp) but similar in Grade 2 Mathematics (0.32 SD or 5.22 pp). From Grade 2-3, and Grade 3-4, the pro-girl gap grows considerably in Home Language and First Additional Language, but only slightly in Mathematics. By Grade 4, the average pro-girl gap, is as large as 0.58 SD (8.9 pp) in Home Language, 0.58 SD (9.23 pp) in First Additional Language and 0.38 SD (6.13 pp) in Mathematics.

First order stochastic dominance of the Grade 1-4 student mark distribution for girls relative to boys is confirmed by Kolmogorov-Smirnov (K-S) tests, with p-values close to 0 in all three subjects, and cumulative distribution frequencies (CDF) of girls' marks lying above the CDF of boys' marks in Figure A 1 in all four grades and three subjects. At no point do girls' and boys' CDFs of student marks cross in Grades 1-4 in any of the three subjects. In other words, the student mark achievement advantage is unequivocally in favour of girls.

OLS estimates controlling for slight differences between girls and boys in their age at Grade 1 entry and including school fixed effects - accounting for school differences in assessment and marking practices - also support a widening pro-girl gap from Grades 1 to 4 (see Tables 5–7). The estimated gaps are similar in magnitude to the descriptive results. The regression results are reported in Tables 5-7 for the three subjects. Considering the school fixed effects results, in Home Language the gap increases from 0.40 SD in Grade 1 to 0.58 SD in Grade 4 (Table 5); in First Additional Language from 0.33 SD to 0.58 SD (Table 6). The gap in Mathematics grows more modestly, from 0.33 in Grade 1 to 0.39 SD in Grade 4 (Table 7).

Table 5: Linear estimation of Home Language marks (in z-scores), balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.382*** (0.003)	0.396*** (0.003)	0.421*** (0.003)	0.430*** (0.003)	0.498*** (0.003)	0.506*** (0.003)	0.576*** (0.003)	0.582*** (0.003)
Age at the start of Grade 1		0.524*** (0.004)		0.276*** (0.004)		0.220*** (0.004)		0.181*** (0.004)
Constant	-0.092*** (0.005)	-3.296*** (0.028)	-0.098*** (0.005)	-1.788*** (0.027)	-0.148*** (0.005)	-1.496*** (0.027)	-0.179*** (0.005)	-1.288*** (0.027)
Adjusted R-squared	0.04	0.26	0.05	0.22	0.07	0.20	0.09	0.23
N (learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
School fixed effect	N	Y	N	Y	N	Y	N	Y

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors (SE) clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = fixed effect.

Table 6: Linear estimation of First Additional Language marks (in z-scores), balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.324*** (0.003)	0.332*** (0.003)	0.369*** (0.003)	0.376*** (0.003)	0.463*** (0.003)	0.469*** (0.003)	0.576*** (0.003)	0.582*** (0.003)
Age at the start of Grade 1		0.461*** (0.004)		0.258*** (0.004)		0.207*** (0.004)		0.186*** (0.004)
Constant	-0.072*** (0.007)	-2.890*** (0.026)	-0.086*** (0.006)	-1.662*** (0.026)	-0.145*** (0.005)	-1.413*** (0.027)	-0.198*** (0.005)	-1.335*** (0.026)
Adjusted R-squared	0.03	0.36	0.04	0.28	0.06	0.22	0.09	0.25
N (learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
School fixed effect	N	Y	N	Y	N	Y	N	Y

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors (SE) clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = fixed effect.

Table 7: Linear estimation of Mathematics marks (in z-scores), balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.321*** (0.003)	0.333*** (0.003)	0.315*** (0.003)	0.322*** (0.003)	0.350*** (0.003)	0.356*** (0.003)	0.383*** (0.003)	0.388*** (0.003)
Age at the start of Grade 1		0.520*** (0.004)		0.288*** (0.004)		0.237*** (0.004)		0.203*** (0.004)
Constant	-0.064*** (0.006)	-3.243*** (0.027)	-0.059*** (0.006)	-1.818*** (0.027)	-0.093*** (0.005)	-1.541*** (0.028)	-0.113*** (0.006)	-1.353*** (0.028)
Adjusted R-squared	0.03	0.28	0.03	0.24	0.03	0.21	0.04	0.23
N (learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
School fixed effect	N	Y	N	Y	N	Y	N	Y

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors (SE) clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = fixed effect.

The main analysis so far has focused on term 4 marks, though to be clear the gender gap is already present in term 1 of Grade 1. Using a subsample of the balanced panel with term 1 data, Table 8 estimates show a significant pro-girl gap of 0.32 SD in Home Language, 0.26 SD in First Additional Language and 0.27 in Mathematics. The positive and significant interaction between 'female' and 'term 4' indicates that these gaps widen by 0.07–0.08 SD between terms 1 and 4.

Table 8: Linear estimation of Grade 1 marks (in z-scores) in term 4 and term 1, balanced panel of students

	Grade 1 Home Language		Grade 1 First Additional Language		Grade 1 Mathematics	
	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.308*** (0.003)	0.320*** (0.003)	0.256*** (0.003)	0.264*** (0.003)	0.256*** (0.003)	0.266*** (0.003)
Term: Term 4 (Ref: Term 1)	-0.016*** (0.004)	-0.016*** (0.004)	-0.018*** (0.004)	-0.018*** (0.004)	-0.016*** (0.004)	-0.016*** (0.004)
Female x Term 4	0.084*** (0.002)	0.084*** (0.002)	0.077*** (0.002)	0.077*** (0.002)	0.072*** (0.002)	0.072*** (0.002)
Age at the start of Grade 1		0.527*** (0.004)		0.450*** (0.004)		0.506*** (0.004)
Constant	-0.087*** (0.006)	-3.330*** (0.027)	-0.069*** (0.007)	-2.836*** (0.025)	-0.056*** (0.006)	-3.163*** (0.027)
Adjusted R-squared	0.034	0.262	0.024	0.332	0.024	0.266
N (learners)	994 144	994 144	994 144	994 144	994 144	994 144
School fixed effect	N	Y	N	Y	N	Y

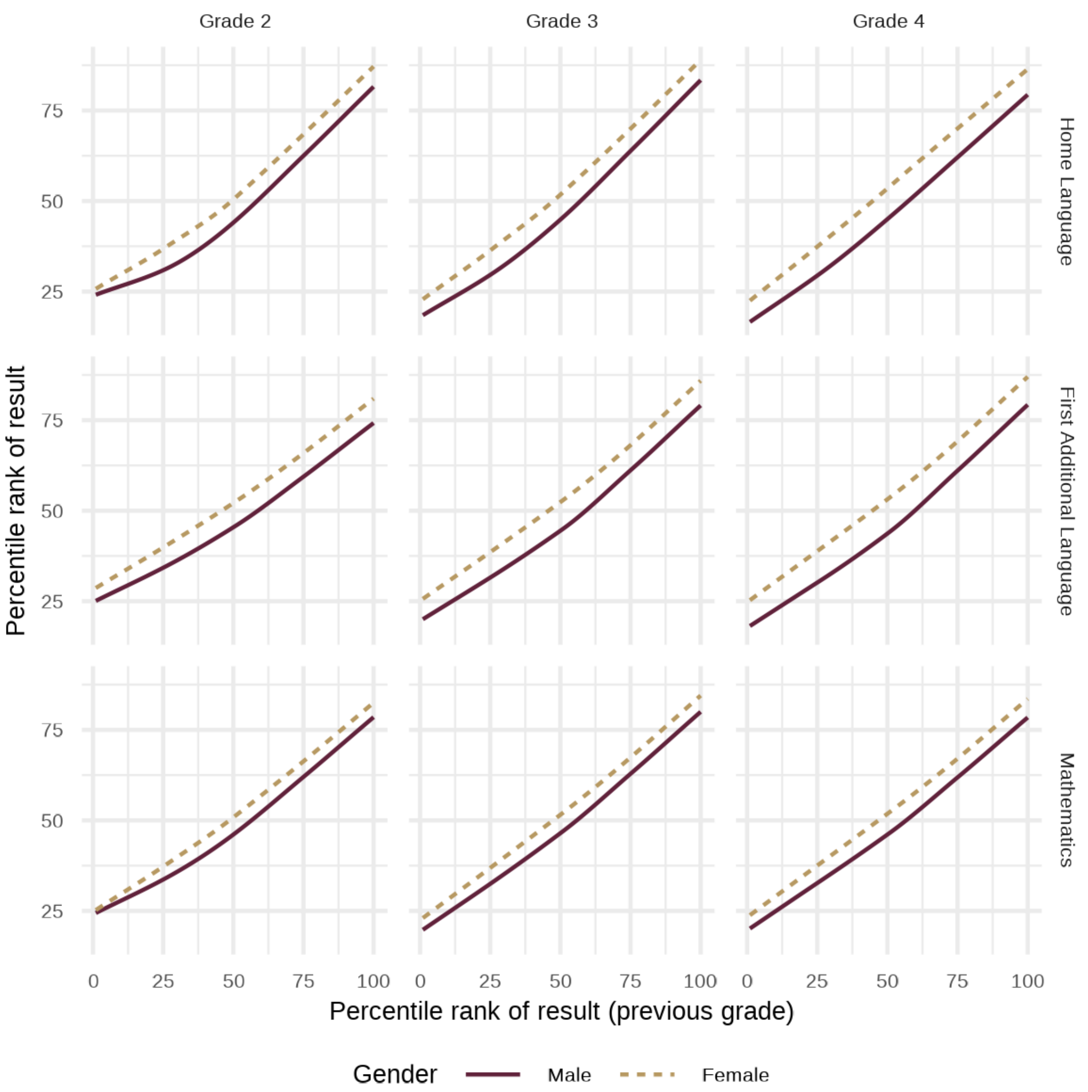
Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces that also have term 1 Grade 1 marks. Notes: Standard errors (SE) in parentheses are two-way clustered at the learner and school levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = fixed effect. The data is in long format, with two observations (term 1 and 4) per learner.

As a robustness check of the main results, Appendix Tables A1-A3 re-estimate Tables 5-7 using inverse probability weight adjustments to account for attrition. Coefficients on female are only slightly larger across all grades. In Grades 2-4, weighted estimates exceed unweighted estimates by 0.003–0.005 SD but are not statistically different from the unweighted estimates in Tables 5-7. In Grade 1, the weighted coefficient on female is statistically significantly larger by about 5-6% (or 0.02 SD) than the unweighted coefficient. Based on these results, sample attrition is likely to result in a slight underestimation of the pro-girl gap.

Complementing Tables 5-7, a non-parametric approach examines how the gender gap evolves across grades by comparing shifts in the distribution of girls' and boys' marks. Figure 1 presents local polynomial regression plots comparing boys' and girls' percentile ranks in the student mark distribution in Grades 2, 3 and 4 with their percentile rank in the previous grade's mark distribution. In all subjects, across almost the entire prior grade's percentile rank, girls move upward relative to boys who started at the same percentile rank, indicating a systematic improvement in girls' relative achievement across grades. This is seen in how the girl plot is an upward shifted version of the plot for boys. However, the divergence is smaller below the 25th percentile in the Grade 1–2 transition. Gender divergence in student achievement is also seen in Mathematics from Grade 1-2 despite similar coefficients on 'female' in regressions of Grade 1 and 2 Mathematics marks reported in Table 7. This suggests imperfect persistence in student marks from one grade to the next (Singh & Krutikova, 2017, p. 21). In section 5.4 we further quantify divergence in the gender gap from Grade 1-4 across quartiles of the mark distribution.

PIRLS data suggest that gender gaps widened during COVID-19 (Böhmer & Wills, 2025), raising the possibility that the large gaps observed here reflect pandemic-related disruptions affecting the 2019 Grade 1 cohort. To assess this, we replicated the analysis in Tables 5-7 using a 2017 Grade 1 cohort that did not experience COVID-19 disruptions in Grades 2 and 3 (see supplementary appendix tables). Results are remarkably similar to Tables 5-7, suggesting that the findings are not driven by COVID-19-related impacts.

Figure 1: Local polynomial regression plots of girls' and boys' percentile rank in a grade (y-axis) relative to their percentile rank in the previous grade (x-axis) by subject, balanced panel of students



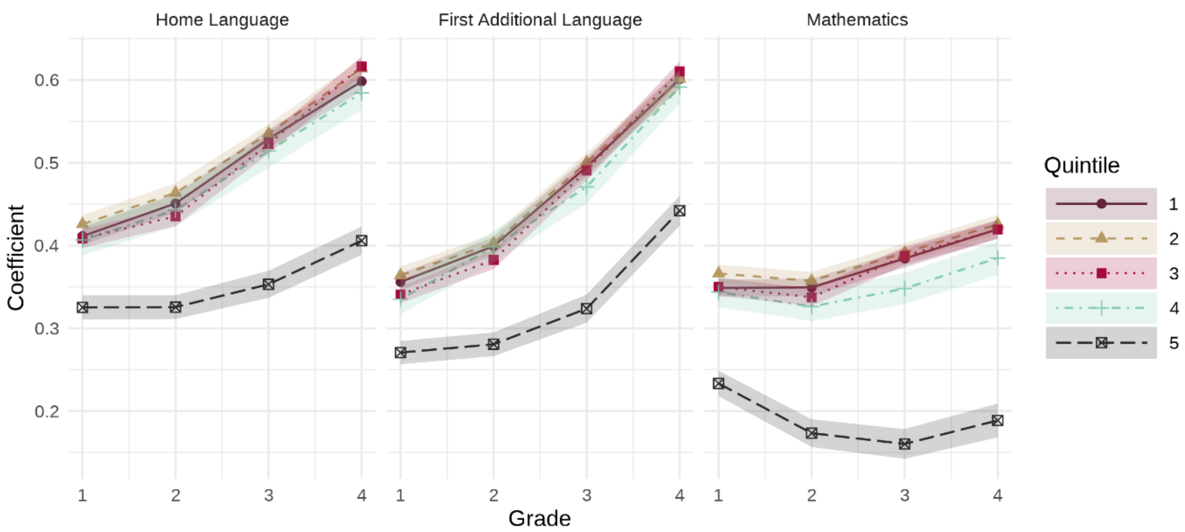
Source: DDD balanced panel of students at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Local polynomial smoothed lines using epanechnikov kernel of degree 1. Percentile ranks are calculated within a year and within a grade on the raw DDD data. Grades shown on top of the figure. The previous grades are Grade 1 (left panel), Grade 2 (middle panel) and Grade 3 (right panel).

5.2 Socio-economic differences in the gender gap and its growth across grades

Socio-economic differences in the pro-girl gap are well documented in South Africa, with larger gaps in poorer (Quintile 1–3) schools and smaller or negligible gaps in wealthier (Quintile 5) schools (Böhmer & Wills, 2025; Hofmeyr, 2022; Reddy et al., 2022). To examine this in our data, we re-run the school fixed effects regressions of Tables 5-7 for each school Quintile and plot the estimated within-school gender gaps (and associated confidence intervals in the shaded areas) in Figure 2. We obtain substantively similar results when interacting female with school Quintile in pooled regressions of student marks, as shown in the supplementary appendix.

Across Grades 1–4, pro-girl gaps are larger and grow more steeply in Quintile 1–4 schools than in Quintile 5 schools. In Home Language (the left panel of Figure 2), the pro-girl gap increases from about 0.4 SD in Grade 1 to roughly 0.6 SD in Grade 4 across Quintile 1–4 schools, compared to a smaller rise from 0.33-0.41 SD in Quintile 5 schools. In Mathematics, across all school Quintiles pro-girl gaps are smaller than gaps in Home Language, but the magnitude of the gaps are much smaller in Quintile 5 schools than in Quintile 1-4 schools (see right panel of Figure 2).

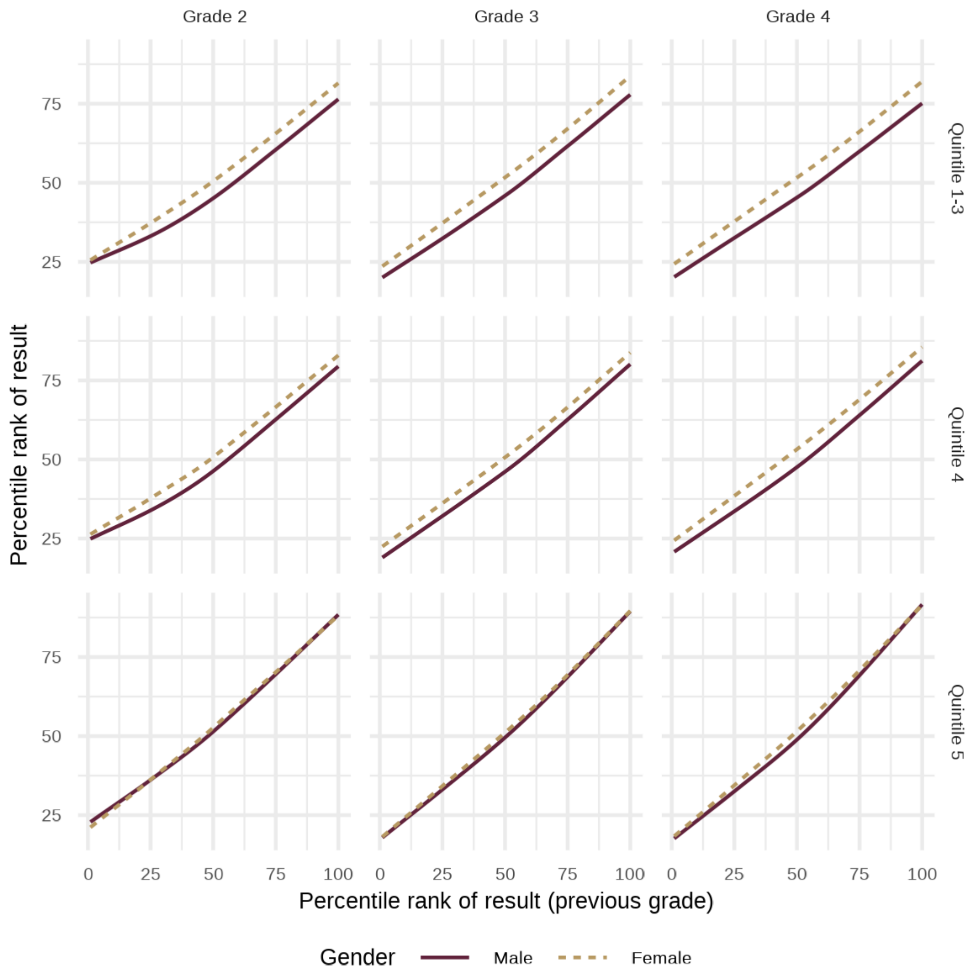
Figure 2: Pro-girl gaps (in z-scores) by grade, subject and school Quintile



Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Notes: The graphs plot the coefficients on female from school fixed effects regressions (by grade, subject and school Quintile) which also control for age. The 95% confidence intervals by the shaded areas shown are based on standard errors clustered at the school level.

In Quintile 5 schools, unlike Quintile 1–4 schools, pro-girl gaps in Mathematics do not widen with grade: the Grade 1 gap of 0.24 SD is slightly smaller at 0.19 SD by Grade 4. This apparent convergence in Quintile 5 schools may reflect downward bias on the coefficient on female at higher grades rather than reflecting a true narrowing of the gap because the underlying panel-based trajectories for boys and girls are similar. This is seen in Figure 3 - local polynomial regression plots showing the association between percentile rankings in Mathematics in a grade relative to percentile rankings in Mathematics in the previous grade. In the bottom panel of Figure 3, boys' and girls' percentile trajectories from Grades 1-2, 2-3 and 3-4 largely overlap in Quintile 5 schools, indicating a stable gap, whereas clear divergence is observed in Quintile 1–4 schools, reflecting a widening pro-girl gap across grades. In the discussion section, we consider potential reasons for why these patterns differ so starkly across less and more resourced schools.

Figure 3: Local polynomial regression plots of girls' and boys' percentile rank in Mathematics in a grade (y-axis) relative to their percentile rank in Mathematics in a previous grade (y-axis) by school Quintile



Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Notes: Percentile ranks are calculated within a year and within a grade on the raw DDD data. The previous grades in question are Grade 1 (left panel), Grade 2 (middle panel) and Grade 3 (right panel).

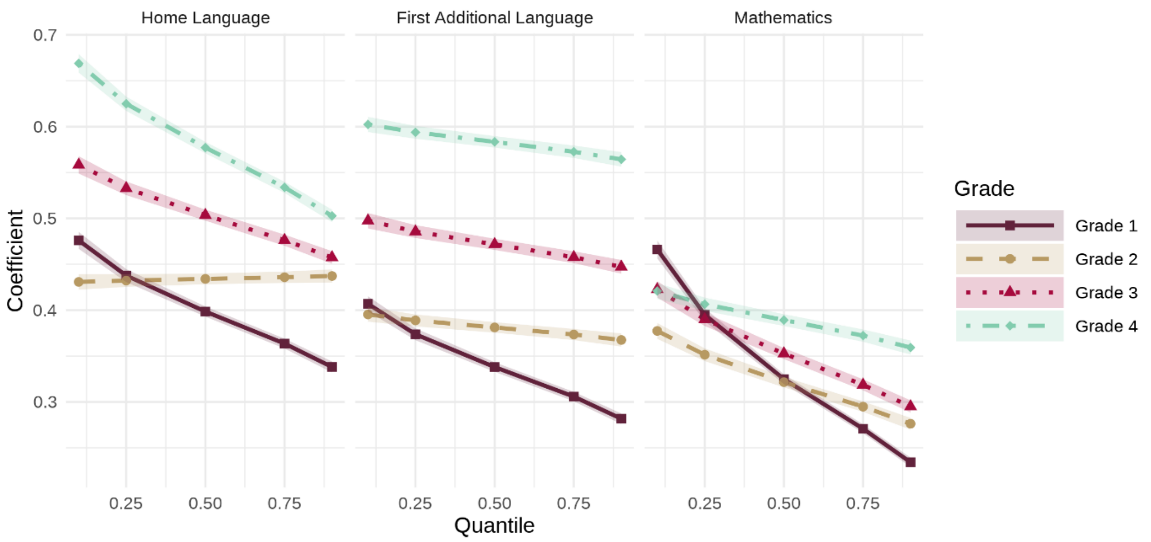
5.3 Gender gaps across the student mark distribution

It is already evident from Figure 1 that girls outperform boys across the entire mark distribution. But to more precisely address research question four, "at what point in the distribution of student marks (within schools) do girls have a larger relative advantage to boys, and how does this vary by subject?", we estimate quantile regressions by grade and subject.

Appendix Table A4 reports the coefficient on female, expressed in z-scores, at the 10th, 25th, 50th, 75th and 90th percentiles. Panel A of Table A4 presents quantile regression estimates without school fixed effects, while Panel B controls for between-school differences following Rios-Avila et al. (2024). The results from panel B of Table A4 are visualised in Figure 4.

The pro-girl gap is large and sizeable across the distribution of student marks in all four grades and in three subjects. A relatively consistent pattern is that the pro-girl gap narrows as one moves up the mark distribution, especially in Grade 1 (all subjects) and in Grade 4 Home Language.

Figure 4: Pro-girl gaps expressed in z-scores across the school mark distribution by subject and grade, quantile regression results.



Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. The figure plots the coefficients on female from quantile regression results in the second panel of Table A4, which control for between-school differences following the approach by Rios-Avila et al. (2024).

Consistent with these findings, nationally representative results from TIMSS and PIRLS also show pro-girl gaps across the full distribution of Grade 4 Home Language and Grade 5 Mathematics scores (see Appendix Figure A2). In both assessments, gaps are substantially larger in Home Language reading than in Mathematics. However, the distributional pattern varies across assessment years. For example, the 2016 PIRLS results show the largest reading gaps at the lower end of the distribution, whereas in 2021 the gaps are greatest around the middle of the distribution. These differences may reflect the effects of COVID-19 on learning and assessment (Böhmer & Wills, 2025).

5.4 How students move through the student mark distribution

This section addresses research question five by examining persistence and rank movement in student marks across grades, comparing boys and girls.

5.4.1 Staying probabilities

Table 9 reports the probability of remaining in the same quartile of the mark distribution from Grade 1 to Grade 4 by gender and subject. The table also identifies the female-male (F-M) difference in the estimated staying probabilities and whether they are statistically significantly different.

Table 9: Grade 1 to 4 staying probabilities by gender for three subjects - Home Language, First Additional Language and Mathematics, balanced panel of students

Home Language								
	Female			Male				
Quartile	Prob.	SE	N	Prob.	SE	N	F-M	p-value
1	0.373	0.003	48637	0.562	0.003	81947	-0.189	0.000
2	0.292	0.002	61037	0.315	0.002	69439	-0.023	0.000
3	0.331	0.002	72077	0.292	0.002	60577	0.039	0.000
4	0.619	0.004	80168	0.412	0.004	45199	0.208	0.000
First Additional Language								
	Female			Male				
Quartile	Prob.	SE	N	Prob.	SE	N	F-M	p-value
1	0.341	0.004	49552	0.538	0.003	76873	-0.197	0.000
2	0.283	0.002	66759	0.311	0.002	73014	-0.027	0.000
3	0.301	0.002	69623	0.258	0.002	59583	0.043	0.000
4	0.582	0.004	75985	0.371	0.004	47692	0.211	0.000
Mathematics								
	Female			Male				
Quartile	Prob.	SE	N	Prob.	SE	N	F-M	p-value
1	0.406	0.004	51683	0.505	0.003	80366	-0.098	0.000
2	0.301	0.002	58725	0.312	0.002	63808	-0.011	0.002
3	0.305	0.002	71614	0.283	0.002	62216	0.022	0.000
4	0.565	0.004	79897	0.451	0.004	50772	0.114	0.000

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Jack-knifed standard errors (SE). Prob. = probability estimate.

Across all quartiles, gender differences in staying probabilities are statistically significant and in favour of girls, with the largest differences at the bottom and top quartiles - especially in Home Language and First Additional Language. By Grade 4, girls are statistically significantly more likely to remain in the upper quartiles (3 and 4), while boys are statistically significantly more likely to remain in the lower quartiles (1 and 2). For example, in Home Language boys have a 41.2% probability of remaining in the 4th quartile (i.e. 76-100th percentile) of the mark distribution by Grade 4 if they had been in that quartile in Grade 1, compared to 61.9% for girls – a statistically significant gap of 21 percentage points. A similar pattern is observed in First Additional Language. At the lower end of the mark distribution, the reverse holds: boys are around 19–20 percentage points more likely than girls to remain in the bottom quartile in both language subjects.

Gender differences in staying probabilities are smaller in Mathematics than Language, suggesting greater upward mobility for boys in Mathematics than Language. Boys in the bottom (1st) quartile of the Mathematics mark distribution in Grade 1 are about 10 percentage points more likely than girls to remain in that 1st quartile by Grade 4. Boys in the top (4th) quartile of the Mathematics mark distribution in Grade 1 are about 11 percentage points less likely to remain there by Grade 4 compared to their girl peers.

5.4.2. Directional rank mobilities

Across all Grade 1 quartiles and subjects, girls exhibit greater upward mobility by Grade 4 than boys, while boys are more downwardly mobile. Table 10 presents these estimates, showing upward mobility estimates in panel A and downward mobility estimates in panel B at quartiles of the mark distribution. Consistent with the staying probabilities, estimates are conditioned on initial achievement, restricting the estimates to those whose marks fall within a specific quartile in Grade 1 and Grade 4, respectively. Students with any positive rank change ($\delta \geq 0$) are classified as upwardly mobile. With δ set to zero, the downward mobility estimates are equal to one minus the estimates for the upward rank mobilities (McDonough, 2015, p. 26). Results are reported for all three subjects.

The directional rank mobility measures are unequivocally in favour of girls at every quartile. In Home Language, girls are more upwardly mobile than boys by a magnitude of about 12, 19, 21 and 13 percentage points in the 1st to 4th quartiles respectively. Similar results hold in First Additional Language. In Mathematics, girls are also more upwardly mobile than boys by a magnitude of about 6, 10, 11 and 6 percentage points in the 1st to 4th quartiles respectively. Across all quartiles, girls' advantage over boys in these measures of persistence and rank movement appear larger in language subjects than in mathematics.

Overall, both staying probabilities and directional rank mobility measures reveal that girls pull further ahead of boys between Grades 1 and 4, with no evidence of convergence in the gender gap across the mark distribution.

Table 10: Grade 1 to 4 upward and downward rank mobility estimates by gender for three subjects - Home Language, First Additional Language and Mathematics ($\delta = 0$), balanced panel of students

A. Upward rank mobility

	Female			Male				
Quartile	**Prob.**	**SE**	**N**	**Prob.**	**SE**	**N**	**F-M**	**p-value**
Home language								
1	0.812	0.003	39480	0.694	0.003	56895	0.117	0.000
2	0.630	0.003	38435	0.436	0.003	30310	0.193	0.000
3	0.512	0.004	36872	0.307	0.003	18567	0.205	0.000
4	0.310	0.004	24863	0.181	0.003	8187	0.129	0.000
First Additional Language								
1	0.849	0.002	42066	0.733	0.003	56378	0.116	0.000
2	0.665	0.003	44386	0.462	0.003	33708	0.203	0.000
3	0.507	0.004	35315	0.307	0.003	18286	0.200	0.000
4	0.295	0.004	22394	0.166	0.003	7912	0.129	0.000
Mathematics								
1	0.784	0.003	40537	0.729	0.003	58584	0.055	0.000
2	0.613	0.004	35991	0.511	0.004	32603	0.102	0.000
3	0.484	0.004	34684	0.372	0.004	23173	0.112	0.000
4	0.284	0.004	22697	0.228	0.004	11555	0.056	0.000

B. Downward rank mobility

	Female			Male				
Quartile	**Prob.**	**SE**	**N**	**Prob.**	**SE**	**N**	**F-M**	**p-value**
Home language								
1	0.188	0.003	9157	0.306	0.003	25052	-0.117	0.000
2	0.370	0.003	22602	0.564	0.003	39129	-0.193	0.000
3	0.488	0.004	35205	0.693	0.003	42010	-0.205	0.000
4	0.690	0.004	55305	0.819	0.003	37012	-0.129	0.000
First Additional Language								
1	0.151	0.002	7486	0.267	0.003	20495	-0.116	0.000
2	0.335	0.003	22373	0.538	0.003	39306	-0.203	0.000
3	0.493	0.004	34308	0.693	0.003	41297	-0.200	0.000
4	0.705	0.004	53591	0.834	0.003	39780	-0.129	0.000
Mathematics								
1	0.216	0.003	11146	0.271	0.003	21782	-0.055	0.000
2	0.387	0.004	22734	0.489	0.004	31205	-0.102	0.000
3	0.516	0.004	36930	0.628	0.004	39043	-0.112	0.000
4	0.716	0.004	57200	0.772	0.004	39217	-0.056	0.000

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Jack-knifed standard errors (SE). Prob. = probability estimate.

6. Discussion

Drawing on public school assessment data from six of South Africa's nine provinces, this paper demonstrates that the pro-girl achievement gap emerges early in schooling and widens over the first four years of primary school. Girls outperform boys across the student mark distribution in both mathematics and language in Grade 1, and this advantage becomes more pronounced by Grade 4, particularly in language and in less-resourced school contexts. While many countries have pro-girl gaps in literacy and pro-boy gaps in mathematics that develop later in schooling, South Africa exhibits large pro-girl gaps in both subjects in Grades 4 and 5 as reflected in PIRLS and TIMSS (Mullis et al., 2023; von Davier et al., 2024). Using longitudinal data on student marks from six provinces, we show that these gaps are already present at the start of Grade 1 and continue to widen to Grade 4.

Furthermore, the data shows that the pro-girl gap is evident across the entire student mark distribution – a finding confirmed in 2016 and 2021 PIRLS Grade 4 Home Language reading assessments and in 2019 and 2023 TIMSS Grade 5 Mathematics assessments. The magnitude of the pro-girl gap in student marks is also found to be larger in less-resourced schools, consistent with evidence from PIRLS and TIMSS (Böhmer & Wills, 2025; Hofmeyr, 2022).

Across a range of methods - including regression analysis, non-parametric regression plots, and measures of staying probabilities and rank mobility - the results show that girls move progressively ahead of boys across grades. This occurs across the initial achievement distribution but is more evident in language than in mathematics.

The widening of the pro-girl gap is also significantly more pronounced in Quintiles 1–4 schools than in Quintile 5 schools. In Mathematics, the pro-girl gap widens in Quintiles 1–4 schools but remain stable in Quintile 5 schools. A possible reason for these differences is that in less-resourced schools, weaker instruction, larger classes, less structured learning environments, and limited remedial support may make it harder for learners who fall behind - disproportionately boys - to recover foundational skills (van der Berg et al., 2017). Under these conditions small early gaps would widen over time (Spaull & Kotze, 2015). In contrast, Quintile 5 schools typically provide stronger instructional environments and higher quality assessment to diagnose and remediate learning gaps, which may prevent these early differences from compounding. While our data cannot directly test these mechanisms, the divergence across school Quintiles strongly suggests that the widening pro-girl gap is not simply an individual-level phenomenon but is shaped by the interaction between gender and school context.

These findings indicate that South Africa's very large pro-girl gap in international assessments is not only a feature of differences at school entry but is amplified during the schooling process itself. These findings help to explain why South Africa displays such a large pro-girl advantage in international assessments of Grade 5 mathematics and especially Grade 4 reading.

While the DDD data used in this study provides a very large longitudinal dataset to assess gender gaps, it has limitations, most notably that student marks are not standardised across schools and grades. Our understanding of gender gaps in learning would be better supported through standardised assessment data using Item Response Theory scaling, especially if gender gaps are concentrated on items of specific difficulty. While school fixed effects may absorb some unobserved differences in assessment and marking practices across schools, within-school grading biases could still play a role if teachers tend to reward students with higher marks based on behaviours or attitudes – such as more positive attitudes to reading, classroom compliance, and attentiveness that are more common among girls (Ferman & Fontes, 2022). However, explaining the widening gap through grading bias alone would require the additional assumption that such bias increases across grades, for which we have no evidence.

Despite these limitations, the results provide a clear picture of how gendered performance is reflected and reinforced within South African public schools, with various cross-sectional patterns in gender gaps in student marks also observed in TIMSS and PIRLS data. Even if we cannot fully separate learning from biases introduced through teachers' assessment practices, the results are a clear indication that in South African public schools, girls achieve higher mark rankings than boys and increasingly move ahead of boys between Grades 1 and 4. These student marks reflect not only what is being measured and rewarded within schools, but shape the signals that schools transmit to learners, their families and society at large about the relative achievement of girls and boys.

The administrative data also contains limited background information on students and their teachers so that we cannot answer pressing questions such as why such large pro-girl gaps emerge and what factors may account for why these gaps grow across grades. Nonetheless, our evidence shows that boys are falling behind in the primary grades. This has had implications for school leaving results. For example, in the 2024 National Senior Certificate (NSC) over 70 000 more females than males achieved a pass and over 51 000 more females than males achieved an NSC bachelors pass which supports access to tertiary education. By comparison in 2017, these gender differences were substantially smaller, with less than half as many additional female NSC passes and around 15 000 more bachelor passes among females.

A clearer understanding of why boys are falling behind girls is needed before crafting appropriate social and schooling responses to this problem. At the school-level, potential explanations for this could lie in gendered teacher-child interactions (Rakshit & Soham, 2023); gendered differences in school readiness (Giese et al., 2022); pedagogies and classroom practices that may not align with boys' learning needs; weak early diagnostic assessment; and limited structured remediation to address learning gaps (Hoadley, 2025). At a broader societal level, explanations could lie in gendered cultural norms (Das & Singhal, 2023); societal beliefs about appropriate skills for boys versus girls; and high rates of father absence in South African households (Ratele et al., 2024). A combination of qualitative and quantitative research will be needed to better understand the contributing mechanisms to South Africa's boy disadvantage, particularly in relation to literacy development.

Future research should extend this DDD panel to later grades to determine whether these gaps continue to widen in favour of girls into adolescence and adulthood. Evidence from several LMICs indicates that gender gaps may expand into secondary schooling and adolescence (Bharadwaj et al., 2016; Singh & Krutikova, 2017), while in some high-income countries improvements in numeracy performance among males at later ages may narrow or reverse gaps in favour of males (Borgonovi et al., 2021). Understanding these dynamics may also shed more light on why pro-girl gaps in school achievement have not yet translated into greater parity in labour market outcomes. A male advantage persists in the South African labour market with men more likely to find employment and by their mid-20s earning more than women in the workplace (Bassier & Gautham, 2025; Statistics South Africa, 2025, p. 12).

Finally, it is important to situate the magnitude of the pro-girl gap within South Africa's much larger and more consequential socio-economic learning divide, which also widens across the grades (Spaull & Kotze, 2015). In Grade 5 TIMSS 2019, for example, the pro-girl gap in Quintile 1 schools was just 13% of the size of the learning divide between learners in the poorest and richest school deciles (Wills, 2025). Moreover, the majority of both girls and boys in Quintile 1 to 3 schools do not reach minimum grade-level competencies or low international benchmarks (Department of Basic Education, 2024; Mullis et al., 2023). By implication, tackling inequality in learning in South Africa requires giving attention to low levels of learning for both boys and girls, especially in poorer Quintile 1 to 3 schools. In such settings, both boys and girls are affected by weak foundational instruction, but boys may be more vulnerable to early disengagement, leading to widening gender gaps within already low-performing environments. By implication, educational equity policies must address both socioeconomic and gender disparities simultaneously, rather than treating them in isolation.

7. References

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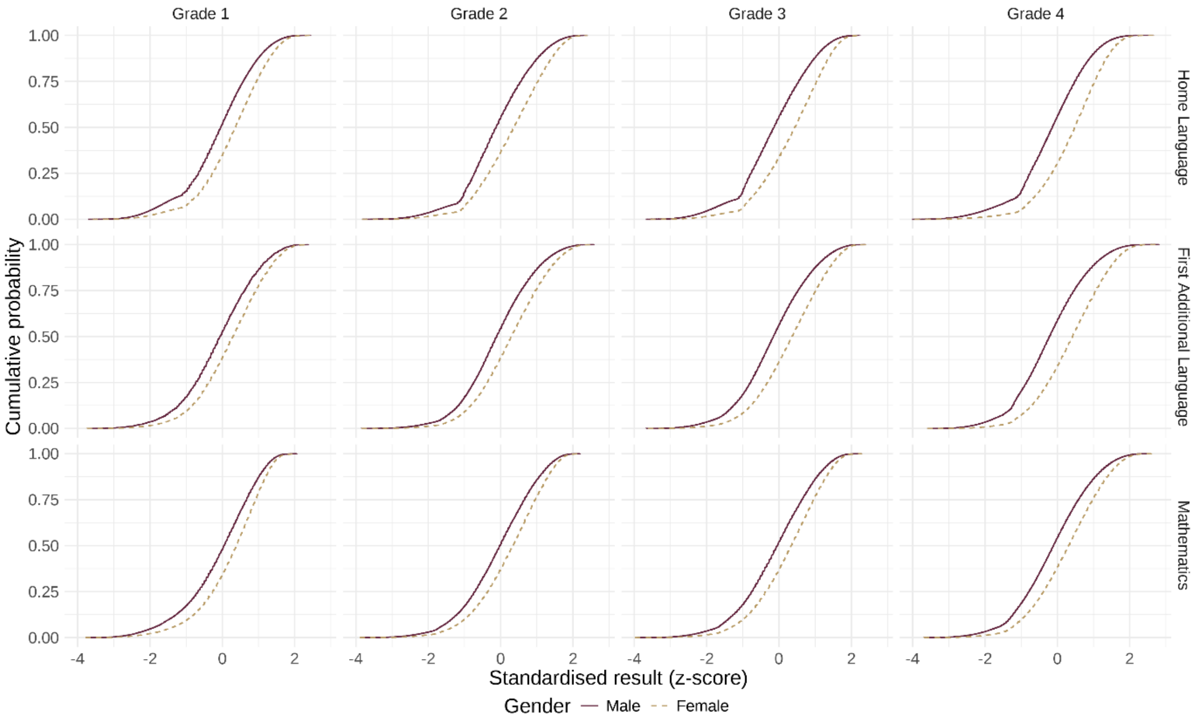
Appendix

Figure A 1: Cumulative distribution frequencies of student marks in Grades 1 to 4 for males and females in Home Language, First Additional Language and Mathematics



Source: Data Driven Districts data for six provinces, own calculations.

Table A 1: Linear estimation of Home Language marks (in z-scores) with inverse probability weight adjustments, balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.404*** (0.003)	0.415*** (0.003)	0.426*** (0.003)	0.433*** (0.003)	0.503*** (0.003)	0.509*** (0.003)	0.581*** (0.003)	0.587*** (0.003)
Age at start of grade 1		0.543*** (0.005)		0.261*** (0.005)		0.207*** (0.005)		0.169*** (0.005)
Constant	-0.184*** (0.006)	-3.381*** (0.028)	-0.149*** (0.005)	-1.821*** (0.028)	-0.196*** (0.005)	-1.502*** (0.027)	-0.218*** (0.005)	-1.284*** (0.027)
N (Learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (Schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
Adj. R2	0.042	0.247	0.049	0.204	0.067	0.192	0.091	0.221
School FE	N	Y	N	Y	N	Y	N	Y
Inverse probability weight	Y	Y	Y	Y	Y	Y	Y	Y

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors (SE) clustered at the school level in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. FE = fixed effect.

Table A 2: Linear estimation of First Additional Language marks (in z-scores) with inverse probability weight adjustments, balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.345*** (0.003)	0.352*** (0.003)	0.375*** (0.003)	0.381*** (0.003)	0.470*** (0.003)	0.474*** (0.003)	0.582*** (0.003)	0.587*** (0.003)
Age at start of grade 1		0.480*** (0.005)		0.244*** (0.004)		0.196*** (0.005)		0.174*** (0.005)
Constant	-0.160*** (0.007)	-2.998*** (0.027)	-0.134*** (0.006)	-1.703*** (0.027)	-0.193*** (0.005)	-1.433*** (0.027)	-0.234*** (0.006)	-1.336*** (0.027)
N (Learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (Schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
Adjusted R-squared	0.030	0.336	0.037	0.258	0.058	0.211	0.088	0.241
School FE	No	Yes	No	Yes	No	Yes	No	Yes
Inverse probability weight	Y	Y	Y	Y	Y	Y	Y	Y

Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Notes: Standard errors (SE) clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = fixed effect.

Table A 3: Linear estimation of Mathematics marks (in z-scores) with inverse probability weight adjustments, balanced panel of students

	Grade 1		Grade 2		Grade 3		Grade 4	
	No FE	FE	No FE	FE	No FE	FE	No FE	FE
Gender: Female	0.346*** (0.003)	0.355*** (0.003)	0.321*** (0.003)	0.326*** (0.003)	0.355*** (0.003)	0.359*** (0.003)	0.387*** (0.004)	0.392*** (0.003)
Age at start of grade 1		0.544*** (0.005)		0.274*** (0.005)		0.225*** (0.005)		0.194*** (0.005)
Constant	-0.167*** (0.006)	-3.326*** (0.028)	-0.110*** (0.006)	-1.851*** (0.027)	-0.140*** (0.006)	-1.553*** (0.028)	-0.152*** (0.006)	-1.368*** (0.029)
N (Learners)	519 081	519 081	519 081	519 081	519 081	519 081	519 081	519 081
N (Schools)	13 124	13 124	13 124	13 124	13 124	13 124	13 124	13 124
Adjusted R-squared	0.031	0.262	0.028	0.219	0.033	0.199	0.039	0.217
School FE	No	Yes	No	Yes	No	Yes	No	Yes
Inverse probability weight	Y	Y	Y	Y	Y	Y	Y	Y

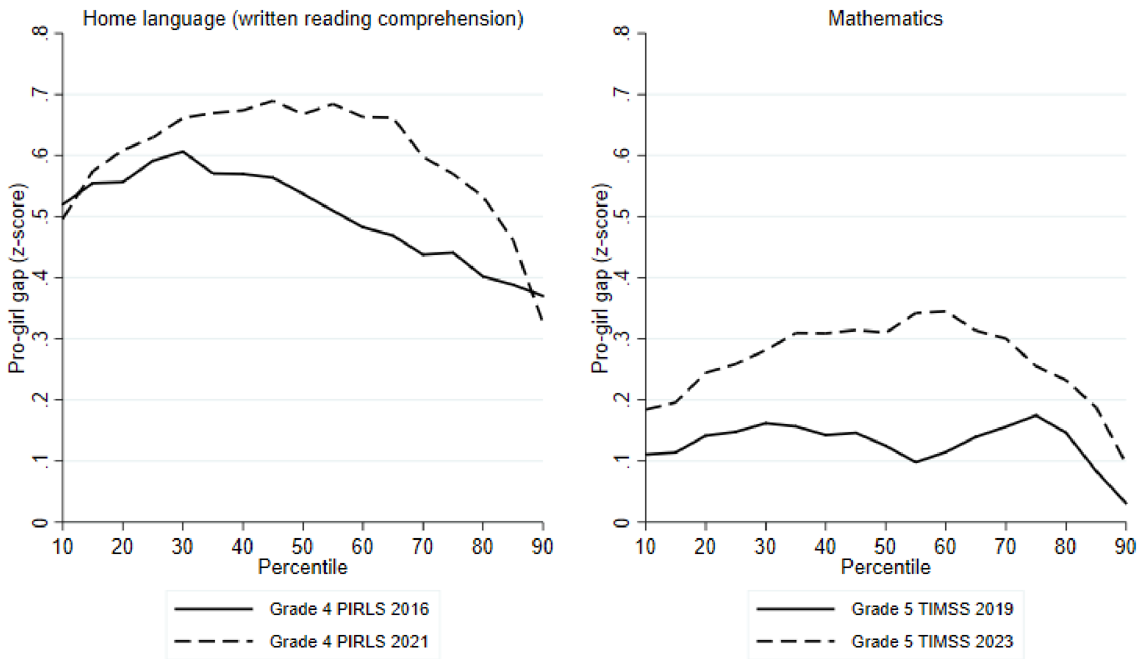
Source: DDD balanced panel of students (2019-2023) at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors (SE) clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. FE = Fixed effect

Table A 4: Quantile regressions by grade for three subjects: Home Language, First Additional Language and Mathematics

	Without fixed effects				With school fixed effects			
Home Language								
Quantile	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
0.1	0.59	0.27	0.48	0.59	0.48	0.43	0.56	0.67
	(0.010)	(0.005)	(0.017)	(0.014)	(0.005)	(0.004)	(0.005)	(0.005)
0.25	0.41	0.39	0.51	0.60	0.44	0.43	0.53	0.62
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)
0.5	0.41	0.50	0.58	0.62	0.40	0.43	0.50	0.58
	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
0.75	0.38	0.48	0.50	0.55	0.36	0.44	0.48	0.53
	(0.004)	(0.005)	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
0.9	0.30	0.36	0.36	0.44	0.34	0.44	0.46	0.50
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)
First Additional Language								
Quantile	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
0.1	0.39	0.35	0.48	0.50	0.41	0.40	0.50	0.60
	(0.006)	(0.005)	(0.005)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
0.25	0.36	0.37	0.48	0.60	0.37	0.39	0.49	0.59
	(0.004)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)
0.5	0.36	0.41	0.52	0.64	0.34	0.38	0.47	0.58
	(0.004)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
0.75	0.32	0.40	0.49	0.61	0.31	0.37	0.46	0.57
	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
0.9	0.25	0.34	0.38	0.49	0.28	0.37	0.45	0.56
	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)
Mathematics								
Quantile	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
0.1	0.50	0.36	0.42	0.35	0.47	0.38	0.42	0.42
	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)
0.25	0.41	0.36	0.39	0.41	0.40	0.35	0.39	0.41
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)
0.5	0.34	0.36	0.39	0.42	0.32	0.32	0.35	0.39
	(0.004)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
0.75	0.26	0.31	0.32	0.40	0.27	0.29	0.32	0.37
	(0.003)	(0.004)	(0.005)	(0.005)	(0.002)	(0.003)	(0.003)	(0.003)
0.9	0.18	0.22	0.24	0.32	0.23	0.28	0.30	0.36
	(0.003)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)	(0.004)

Source: DDD balanced panel of students at the correct age in Grade 1 in six of nine South African provinces. Term 4 marks. Notes: Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ levels. To estimate the simple quantile regression estimates, qreg2 in Stata was used, while mmqreg in Stata was used to estimate the model with school fixed effects.

Figure A 2: Plot of the coefficient on female from a quantile regression using PIRLS (2016, 2021) and TIMSS (2019, 2023)



Source: Own graphs using PIRLS Literacy 2016 data for South Africa; PIRLS 2021 data for South Africa, TIMSS 2019 and 2023 for South Africa.
Notes: National sample of learners used in regressions.
Coefficient plot from quantile regressions of achievement controlling for gender and age with student weights applied.

Data statement

The Data Driven Districts data used for this study was obtained with permission from the Michael and Susan Dell Foundation. Approval was sought to use this non-publicly available data for this study. The data was obtained in anonymous format.

AI statement

During the preparation of this work the authors used ChatGPT and the Google's AI tools to assist with the identification of relevant literature and to improve the grammar and readability of the text. Following the use of these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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