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# Do instructional leadership practices drive educational improvement gap in South Africa? Evidence from Oaxaca-Blinder decomposition analysis of TIMSS 2015 and 2019 study

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# Do instructional leadership practices drive educational improvement gap in South Africa?
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## Abstract

Quality school leadership and management is an important determinant of quality teaching and learning, especially in low-resourced schools. According to South Africa's national development plan (NDP), principals should provide both administrative and curriculum leadership at schools. This paper investigates the improvement between 2015 and 2019 Grade 9 mathematics scores in South Africa and explores the extent to which the difference in performance can be related to instructional leadership practices among schools. Using the Oaxaca-Blinder (OB) decomposition technique, the performance gap has been decomposed into the part that can be explained by difference in endowments of educational inputs, such as student, teacher and school/principal characteristics, and the part that is due to the returns to the educational inputs invested, which could be related to a factor such as school discipline. It was found that the TIMSS improvement in mathematics achievement was largely explained by the efficiency of the educational inputs, including those related to instructional leadership. Findings also revealed that instructional leadership variables were not instrumental in determining improvement in low-resourced schools. This means that there are other important factors that are working in the general schooling system, and policy should focus on low-resourced schools to assist them in anchoring instructional leadership practices.

## 1. Introduction

Quality education is central to the improvement of people's lives and for sustainable development (UNICEF, 2016). An important determinant of quality teaching and learning, especially in low-resourced schools, is quality school leadership and management (SLM) (Zuze and Juan, 2020). The role of principals in the past was to serve as managers and administrators (Bush and Glover, 2016; Wills, 2015). However, according to South Africa's national development plan (NDP), principals should be providing both administrative and curriculum leadership at schools (Republic of South Africa, 2011: 266). The NDP and the Department of Basic Education (DBE) (2015) view the school principal's role as that of creating a conducive environment for teaching to take place in the school as it ought to, in accordance to the national curriculum (Republic of South Africa, 2011: 265; DBE, 2020: 18). This implies that the NDP and DBE now regard the role of principals as bigger and different than before.

Currently, however, there is limited evidence on the impact of instructional leadership on learning outcomes in South Africa and the research that is available tends to be small scale in nature and relies on relatively small samples (Bush, Joubert, Kiggundu, and van Rooyen, 2010; Hallinger, 2019; Kruger, 2003). One recent systematic review study on educational leadership and management in South Africa concluded that the country's leadership studies were mostly descriptive rather than explanatory (Hallinger, 2019). Although such studies provide useful insights, they do not provide a holistic and policy-focused South African perspective on the relationship between instructional leadership and educational outcomes. This strengthens the rationale for the current research. Moreover, using the data from Trends in International Mathematics and Science Study (TIMSS) 2015 and 2019 cycles, this research serves as an expansion to the author's earlier work (Hompashe, 2018) on instructional leadership and student outcomes by updating the analysis and examining trends over time with a stronger focus on policies and an emphasis on the reasons that triggered the improvements.

The aim of the working paper is to investigate the improvement between 2015 and 2019 Grade 9 mathematics scores in South Africa and explore the extent to which this performance gap can be related to instructional leadership practices among schools. In an effort to gauge its progress in the quality of schooling over the years, South Africa has been participating in TIMSS, as one of the most recognised international benchmarking studies. South Africa has been assessing mathematics and science performance among Grade 8 and 9 students since 1995, conducting TIMSS every four years (except for 2007) ( Reddy et al., 2016). Using the data from the Grade 9 TIMSS 2015 and 2019 studies, this research investigates the following research questions:

- What is the association between instructional leadership and student learning outcomes in South Africa?
- How is the increase in South African Grade 9 mathematics students' learning outcomes from TIMSS 2015 to 2019 associated with changes in instructional leadership?

The paper is structured as follows: Section 2 provides a background on the trends of improvement on mathematics achievement in South Africa. A brief theoretical framework and empirical literature on instructional leadership is presented in section 3. The data and methodology employed in the analysis are subsequently explained in section 4. Thereafter, summary statistics, descriptive statistics and the threefold Oaxaca-Blinder decomposition analysis are presented in section 5. The discussion and interpretation of results is provided in section 6. Section 7 concludes and provides suggestions for future research.

## 2. Trends in South Africa's learning improvement

The South African government has made remarkable strides in its commitment to strengthen the accountability of principals and schools (Wills, 2015). Such strides include the following three important high-level policies, which deal specifically with the accountability of school principals for learning outcomes: (1) Sections 16A[1] and 58B[2] of the South African Schools Act; (2) the Whole School Evaluation[3]; and (3) the school principal sections of the Quality Management System. This commitment has been followed by improved learning outcomes as reflected in the three international standardised testing programmes in which South Africa participates (DBE, 2020): the

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[1] Section 16A of the South African Schools Act (SASA) makes provision for the principal of a public school to prepare an annual report in respect of the academic performance of the school in relation to minimum outcomes and standards and procedures for assessment determined by the Minister in terms of Section 6A. Moreover, Section 16A provides for the principal of a public school that has been identified by the Head of Department (HOD) in terms of section 58B to prepare an academic improvement plan at the beginning of each year and present it to the HOD and the school governing body (SGB) meeting.

[2] Section 58B of SASA provides for the HOD to annually identify any public school that is underperforming based on the report contemplated in Section 16A (1) (b) and from other relevant reports. The section provides for the HOD to issue a written notice to the school if he or she believes that the standard of performance of students is below the standard prescribed by the National Curriculum Statement and is likely to remain so unless he or she exercises his or her power in terms of the Act.

[3] Policy on Whole School Evaluation (WSE) provides for external moderation, on a sampling basis, of the results of self-evaluation carried out by the schools. The policy evaluates the effectiveness of a school in terms of the national goals, using national criteria with the aim of increasing the level of accountability within the education system.

Grade 9 Trends for International Mathematics and Science Study (TIMSS) (2011 to 2015), the Grade 4 Programme in International Reading Literacy Study (PIRLS) (2011 to 2016), and the Grade 6 Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) (2007 to 2013).

For TIMSS in particular, South Africa improved its mathematics score by 67 TIMSS points between 2003 and 2011 (Reddy et al., 2014) and the country obtained an improvement of 20 TIMSS points in its mathematics score between 2011 and 2015 (Reddy et al., 2015). The upward trend continued between 2015 and 2019 as average mathematics scores increased by 17 TIMSS points (Reddy et al., 2020). This has placed South Africa on a trajectory to achieve its long-range TIMSS mathematics target of an average of 472 points in 2029 rather than an initial aim of 2019 (DBE, 2020: 31; DBE, 2015: 52). It is, however, encouraging that most of the gains in the South African TIMSS results were strongest among the most disadvantaged students, and this indicates a notable contribution in the reduction of inequalities (Reddy et al., 2020).

To sustain these improvements it is crucial to understand why this upward trajectory in learning outcomes has occurred. Most importantly, insights into which instructional leadership characteristics may have been associated with the improvement would be particularly beneficial for policy.

### 2.1 Between-school inequalities

Despite South Africa's lower rankings in TIMSS assessment, the country showed noteworthy improvement at both the lower end and top end of achievement distribution. We want to understand why there is such improvement. Previous evidence (Reddy et al., 2016; Woessmann, 2016) and analysis presented here highlight the importance of between school differences and so we want to explore this in more detail, focusing in particular on the bottom four quintiles[4].

As stated in the TIMSS 2015 national report, the ideal is a situation where there are minimal quality differences between schools[5] (Reddy et al., 2016). The report

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[4] SES asset quintiles based on student on the asset-based index of SES constructed by using principal component analysis (PCA) as described below. Students were grouped into one of five SES quintiles, with quintile 1 identifying the lowest SES and quintile 5 the highest.

[5] The South African education system is divided into three tiers: primary school, which consists of grade 0/1 to grade 7 (compulsory); secondary school which comprises grade 8 to 9 (compulsory) and grade

highlights South Africa's high level of inequality across schools relative to other developing countries. **Error! Reference source not found.** presents measures of the proportion of total inequality[6] existing between schools, as opposed to within schools, with respect to 2015 and 2019 TIMSS scores at the Grade 8/9 level. Developing countries tend to have more between-school inequality than developed countries. However, in the TIMSS 2015 and 2019 data, the share of overall inequality attributable to between-school differences in South Africa emerges as extremely high for a developing country, at least compared to Iran and Egypt. In Table 1, developed countries refer to Singapore, Ireland, USA, Japan and South Korea, while developing countries include Iran, South Africa and Egypt[7]. South Africa's between-school inequality with respect to Grade 9 mathematics, stayed the same between 2015 and 2019.

***Table 1: Degree of between-school inequality at senior phase***

| TIMSS | All schools 2015 | All schools 2019 | Just bottom four student-weighted quintiles of schools 2015 | Just bottom four student-weighted quintiles of schools 2019 |
|---|---|---|---|---|
| South Africa | 0.51 | 0.51 | 0.21 | 0.18 |
| Iran | 0.47 | 0.39 | 0.22 | 0.21 |
| Egypt | 0.33 | 0.37 | 0.16 | 0.24 |
| Ireland | 0.21 | 0.18 | 0.16 | 0.13 |
| Japan | 0.18 | 0.12 | 0.04 | 0.02 |
| Korea | 0.09 | 0.11 | 0.03 | 0.04 |
| Singapore | 0.53 | 0.46 | 0.40 | 0.32 |
| USA | 0.37 | 0.44 | 0.28 | 0.32 |

*Note: Statistics are intraclass correlation coefficients calculated from the Grade 9 TIMSS datasets.*

*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*

10 to 12 (non-compulsory); and tertiary education that is made up of universities and technical colleges (Churr, 2015).

[6] Between-school inequality was calculated based on intra-class correlation coefficients (ICC), which were based on both the 2015 and 2019 Grade 9 mathematics scores.

[7] The distinction between developed and developing countries is based on the United Nations Human Development Report 2020 ranking of countries. The countries were ranked based on their Human Development Indices (HDI). Any score that is 80 or higher is developed and anything lower is developing.

In terms of the analysis presented below, the key finding in **Error! Reference source not found.** is that between-school differences have been persistently high in South Africa, meaning school-level variables, and particularly instructional leadership variables, describing what occurs in schools deserve special attention. The high between-school differences suggest that South Africa's high *overall* statistic for between-school inequality (in Table 1) is driven largely by the large socioeconomic inequalities between, roughly, the top quintile and the bottom four quintiles[8] schools of the country. It appears beneficial to devote a part of the analysis of the data to just the bottom four quintiles, as in many ways the challenge is to understand how historically disadvantaged schools improved. This might be best done by excluding the data from the top quintile in the modelling. After excluding the top quintile of schools, in terms of performance, South Africa's proportion of between-school inequality emerges as typically low for a developing country.

### 2.2 South African achievement based on TIMSS International Benchmarks[9]

Figure 1 shows that in 2015, about 19 percent of South African Grade 9 mathematics students achieved a score of between 400 and 475 points (the low TIMSS International Benchmark)[10]. This increased to 25 percent in 2019, an increase of 6 percentage points. A similar pattern occurred in higher TIMSS benchmarks, as the proportion of students who achieved a score between 475 to 550 points (the intermediate TIMSS benchmark) increased from 10.8 percent in 2015 to 15.9 percent in 2019. There has also been a notable decline in the proportion of students who achieved a score below 400 points from 2015 to 2019. In 2015, 67.2 percent of Grade 9 mathematics students scored below 400 points, while in 2019, only 53.9 percent of students scored below the lowest TIMSS benchmark.

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[8] School quintiles in South Africa are based on the socioeconomic status of a school and determined by measures of average income, unemployment rates, and general literacy level in the school's geographical area (Dass and Rinquest, 2017). According to Hall and Giese (2008), Quintile 1 schools refer to those in the most economically disadvantaged (poorest) geographical areas, while Quintile 5 ones are those in the most economically advantaged (affluent) geographical areas.

[9] TIMSS International Benchmarks provide an interpretation of the TIMSS results in relation to the students' performance on the assessment items. TIMSS describes achievement at four points along the scale as International Benchmarks: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400).

[10] These TIMSS International benchmarks are described as follow for mathematics achievement: Low benchmark - students have some knowledge of whole numbers and basic graphs; Intermediate benchmark - students can apply basic mathematical knowledge in a variety of situations; High benchmark - students can apply understanding and knowledge in a variety of relatively complex situations; Advanced benchmark - students can apply and reason in a variety of problem situations, solve linear equations, and make generalisations (Mullis et al., 2016).

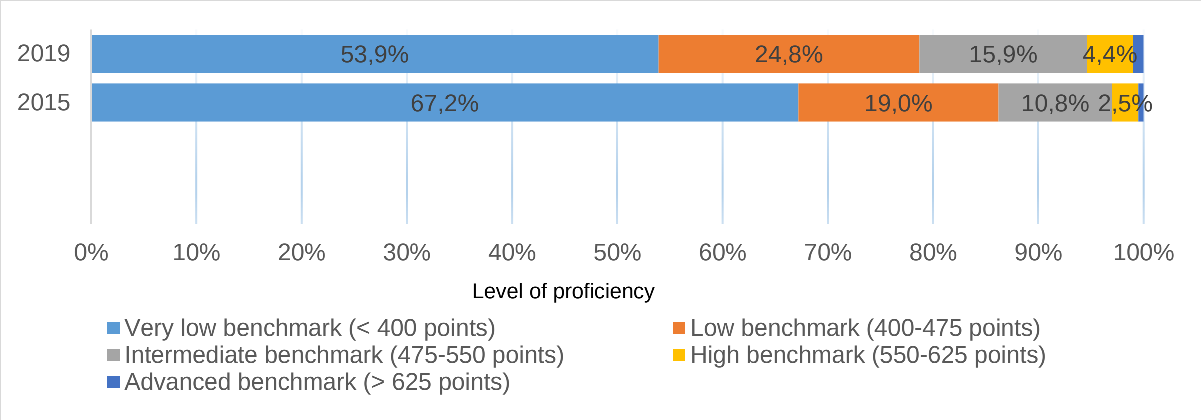


**Figure 1: Levels of proficiency in South African Grade 9 TIMSS study**

*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*

## 3. Theoretical framework

Hallinger and Murphy (1985) and Hallinger (2011) suggested a model popularly known as PIMRS framework after the associated instrument (that is, the Principal Instructional Management Rating Scale) which proposed three dimensions of leadership, namely, defining the school goal, managing the instructional programme, and promoting a positive school learning climate. These three dimensions comprise ten separate functions that describe in detail the roles and responsibilities of instructional leaders in the school. The leadership model is as shown in Figure 2.

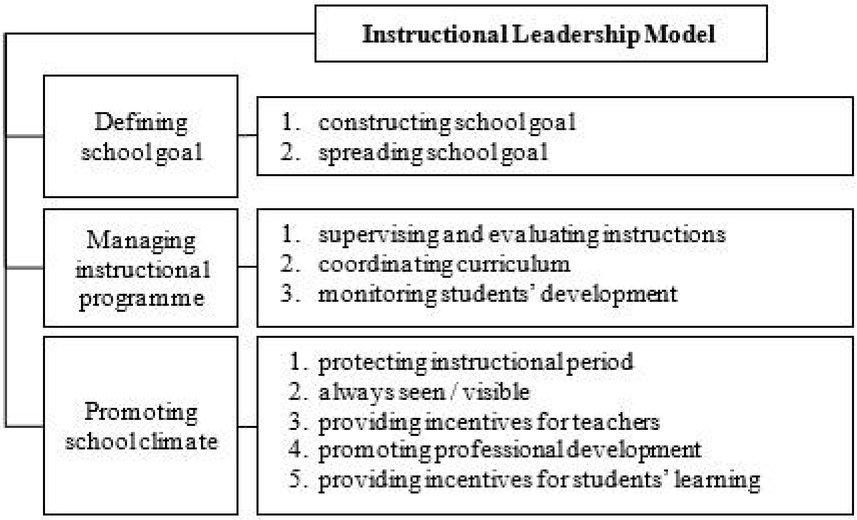


**Figure 2: Hallinger's Instructional Leadership Model (2011)**

*Source: Hallinger (2011)*

The first dimension, defining the school goal, consists of two functions, namely: (1) constructing school goal, and (2) spreading or communicating school goal. The second dimension, managing instructional programme, has three functions; (1) supervising and evaluating instructions, (2) coordinating curriculum, and (3) monitoring students' development. The third dimension is promoting school climate and consists of the following five functions: (1) protecting instructional time, (2) always being seen or visible, (3) providing incentives for teachers, (4) promoting professional development, and (5) providing incentives for students' learning.

Hoadley et al's (2009) theoretical perspective on instructional leadership was shaped by themes such as principal's pedagogical expertise; distributed leadership; linkages between management and instruction; and context, which is absent in Hallinger's model. The principal's pedagogical expertise refers to the importance of the principal's understanding of the learning process and the impact that this might have on teaching (Hoadley et al., 2009). Our understanding of distributed leadership is in the exercise of leadership where the principal is assisted by other actors in the school. In the context of South Africa such actors refer to the deputy principals and heads of departments (HODs). When it comes to linkages between management and instruction, Hoadley et al. (2009) base their research on the degree to which the curriculum is managed, the extent of the principal's involvement in curriculum management, and whether the principal's influence is felt when he/she is involved. Some of the contextual factors that are important in the study of instructional leadership include the school's geographical location; level of schooling; size of the school; student enrolment; the historical context and the policy context (Hoadley et al., 2009).

In their paper, Zuze and Juan (2020) base their definition of instructional leadership on the common thread in literature that an effective principal can make a difference to teaching and learning relative to an ineffective one who is working in a similar socioeconomic context. Their conceptual framework consists of three characteristics of school leadership and management (SLM): (1) instructional leadership, (2) ensuring an orderly and supportive environment through management, and (3) the experience and training of the school principal. These are three key areas where the relationship between SLM and educational outcomes have been shown to be strong and consistent in both the South African and international literature. Zuze and Juan (2020) describe instructional leadership as linking effective principals to the quality of education at the school. The hypothesis is that students who are taught well have teachers who are themselves guided by competent instructional leaders. Ensuring an orderly and supportive environment through management refers to how well the school is functioning at an operational level. The current study is similar to that of Zuze and

Juan (2020), basing its framework on research findings about effective leadership in difficult environments (Bush and Glover, 2016; Taylor, 2011).

Contextual factors play an important role in students' academic achievement, especially in South Africa's unequal society. According to Munna (2021), students who come from low socioeconomic status backgrounds are generally academically "unprepared" and thus their learning in a school setting may be very little. Evidence from 2019 South African TIMMS study suggests that students from middle SES homes performed lower in mathematics than those from high SES households, while those in low SES homes achieved even much lower (Reddy et al., 2022). However, as described in Zuze and Juan (2020), a good instructional leader can be distinguished from a bad one who works in the same socioeconomic context.

## 4. Data and methodology

### 4.1 Data and variables

TIMSS is an international assessment of mathematics and science knowledge of Grade 4 and 8 students. It was developed by the International Association for the Evaluation of Educational Achievement (IEA) and managed by the TIMSS and PIRLS International Study Centre at Boston College in the United States. TIMSS' main aim is to aid countries in the monitoring and evaluation of their mathematics and science teaching and learning, as well as their achievement outcomes, over time and across different grades. TIMSS cycles have been conducted in intervals of four years since 1995, and TIMSS 2015 and 2019 assessments were the sixth and seventh cycles of TIMSS, respectively. TIMSS also collects background information on the home and school contexts in which teaching and learning occurs. This information is collected through questionnaires for students, parents, mathematics and science teachers, school principals, and curriculum specialists.

In South Africa, the Human Sciences Research Council (HSRC) has conducted TIMSS since 1995. The country participated at Grade 8 in the 1995, 1999 and 2003 cycles, and at Grade 9 in the 2003, 2011, 2015 and 2019 cycles. Thus TIMSS 2003 included both Grade 8 and 9 students, and the country has a mathematics and science achievement trend measure from 1995 to 2019. The change from testing Grade 8 to Grade 9 was due to South Africa's low achievement in the previous rounds of the study. The shift allowed for a better match between content knowledge presented to students in TIMSS and South Africa's curriculum coverage (Reddy et al., 2015: 3).

In TIMSS, the students' achievements are summarised with five plausible values (Wiberg, 2019) emanating from a matrix sampling approach used to create student achievement booklets, where students completed only a sample of the total TIMSS assessment. This sample is comprised of approximately 70 mathematics items. The plausible values are generated from item response theory (IRT) scaling methods to estimate the competency levels of students. The IRT estimates - or scale scores - are dependent on student ability (correct responses) and item parameters like item difficulty, discrimination and guessing (in the case of multiple options). In TIMSS, several achievement scores were imputed for each student, using complex statistical methods and demographic variables. The design seeks to obtain relatively few responses from each sampled student, while maintaining a wide range of content representation when responses are combined across all students. However, with this approach the benefit of estimating population parameters is offset by the inability to make accurate statements about individuals. Therefore, TIMSS can only report findings for particular groups of students, not for individual students (Reddy et al., 2022).

The analytic framework of this paper was adapted from Zuze and Juan (2020) in which school leadership quality was measured based on TIMSS-derived indicators of: (a) instructional leadership, (b) promoting an orderly and supportive environment, and (c) the principal's experience and training. These variables were based on self-reported information from the student contextual questionnaire, and the mathematics teacher, and principal questionnaires. Some examples of instructional leadership scale include school's emphasis on academic success (as reported by both principals and teachers), and examples for promoting an orderly and supportive environment include the discipline and safety principal-reported scale.

We used the principal-reported and teacher-reported TIMSS-derived school's emphasis on academic success scale for instructional leadership indicator. The school's emphasis on academic success scale was based on 13 statements from which school principals were asked to respond. These statements included attitudes of teachers, parents and students at the school with references to teachers' understanding of the curriculum, parental and teachers' expectations, parental involvement, students' commitment to academic standards and students' respect for classmates who excel in school (Reddy et al., 2016; Martin, Mullis and Hooper, 2016). Feedback to these statements were utilised by the IEA to formulate a scale of school's emphasis on academic success. The scale's values ranged from 'very high' for the highest values to a 'medium emphasis' for the lowest values (Martin et al., 2016).

For the promotion of an orderly and supportive environment, we used the principal-reported TIMSS-based discipline and safety scale. Regarding the school discipline scale, school principals were asked 11 questions about Grade 9 students at their school and their responses were used to create a school discipline problems scale (Reddy et al., 2016). The questions used in the scale included students' absenteeism, arriving late at school, classroom disturbances, cheating, profanities, vandalism, theft, intimidation, and physical injuries to teachers. The values on the school discipline scale ranged from 'hardly any' problems to 'moderate to severe' problems.

In the case of principal's experience, we used the total years in which the individual principal was appointed as a principal irrespective of the current school. Principal's training refers to educational qualifications of the principal and is coded as the highest level of formal education the principal has completed, for example: a bachelor's or honours' degree, a master's degree, or a doctoral degree.

This study also included control variables for background factors of students, teachers and schools. These variables include student gender, student's fluency in the language of the test (either Afrikaans or English), individual student's socioeconomic status (index based on the availability of several assets in a student's home[11]), and principal-reported school location. Teacher characteristics include years of teaching experience, teacher's gender, teacher's age, and whether the teacher majored in mathematics. These variables are included because they have been found to be related to achievement differences in South African schools (Setati and Adler, 2000; Van der Berg et al., 2011; Zuze and Juan, 2020). The summary statistics of the control variables is provided in Table A1 in the Appendix.

### 4.1.1 Selection and transformation of variables

The 2015 and 2019 TIMSS data for the national sample consisted of 12,514 students in 292 schools and 20,829 students in 519 schools, respectively. The data used were those available through the international TIMSS and PIRLS Website of Boston College in the United States[12].

The outcome variable in this analysis is mathematics achievement, which is taken to be the first plausible value of mathematics achievement as provided by TIMSS datasets. It is well-known that when selecting a single plausible value, or the average of all available plausible values, some information of the students' performance is not captured (Mislevy, Beaton, Kaplan and Sheehan, 1992). However, some researchers of large-scale assessment data argue that using one or five plausible values in a large sample does not lead to a considerable difference (OECD, 2009). A study to determine whether considering all the information provided by plausible values can lead to

[11] Assets in students' homes were one's own study desk; one's own room; one's own mobile phone; one's own dictionary; access to electricity at home; and presence of running tap water at home
[12] https://timssandpirls.bc.edu

different results than those obtained when using traditional methods revealed that both approaches obtain similar results (Aparicio, Cordero and Ordiz, 2021).

The first step was to identify instructional leadership and other control variables which were possible predictors of the 2015 to 2019 improvement, and which also appeared in both years or with very similar questions asked. A few interesting background questions appeared in one year, but not the other. For example, in 2015 the school principal was asked whether incentives were used for mathematics teaching. This question was discontinued in 2019. The general principle followed was to change and recode variables as little as possible. Variables were not combined to create composite indicators, but rather two TIMSS-created instructional leadership scales were included in the analysis, namely: School's Emphasis on Academic Success - Principals' Reports (EAS) scale and the School Discipline Problems - Principals' Reports (DAS) scale.

While not combining variables and changing coding as little as possible reduces the predictive power of the background variables, this comes with the advantage of a more transparent analysis and a simpler discussion of the results.

The only variable that was generated through the combination of other variables was the student socioeconomic background variable using Principal Component Analysis[13]. This variable was generated from six binary indicators describing access to six household items as described above. The same household items were used for both 2015 and 2019 in creating the index, making values comparable across time.

The second step involved excluding background variables for which there was too much missing data. Based on the suggestion by Barrera-Osorio et al. (2011), variables with more than 5 percent missing values were not included in the analysis. However, there were very few variables with more than 5 percent of missing values. This means that the possibility of bias due to over (under) estimation of the coefficients was minimal. This cut-off also meant that each included variable had to display non-missing information in at least 95 percent of observations in both 2015 and 2019. Excluded variables were: the percentage of students at school who have the language of the test (English) as their native language, principal's experience, and the highest level of education completed by students' parents.

[13] Principal component analysis (PCA) is a technique for reducing the dimensionality of large datasets, increasing interpretability but at the same time minimizing information loss (Jollife and Cadima, 2016).

### 4.1.2 Description of the sample

The means for the variables that were used in the data analysis are provided in Table A1 in Appendix A. The missing values in the TIMSS data are mainly found among the principal-reported background variables as shown in Table A1. According to Little and Rubin (1987), in instances where a variable has more than 5 percent missing values it is not advisable to delete cases. This is to avoid losing information and making conclusions that may not be applicable to the population associated with all cases (Kang, 2013). As in Barrera-Osorio et al. (2011) there were few variables with missing values constituting more than 5 percent of the total. Generally, the 2015 sample decreased from 12,514 students to 9,578, while the 2019 sample declined from 20,829 students to 16,041.

To minimise the risk, we examined mean scores by variable for each sample in each year. In one sample, the regression sample, we excluded observations with missing values. In the second sample, we used all the observations, including the missing values. Table 2 indicates that the regression sample was not very different from the full TIMSS sample in terms of mean scores per variable. The variance per characteristic was in the range of between 1 point and 10 points.

## 4.2 Method

The first research question examined the association between instructional leadership and student learning outcomes in South Africa. To answer this question, descriptive statistics and multivariate regression analysis were conducted to account for variation in Grade 9 mathematics student performance in 2019 and the degree to which instructional leadership variables explained, in a statistical sense, the variance. The dependent variable was the TIMSS Grade 9 student mathematics scores, while the independent variables comprised of instructional leadership variables and other covariates obtained from the student, teacher, and school backgrounds.

The second research question considered the relationship between instructional leadership and the increase in mathematics students' learning outcomes from TIMSS 2015 to 2019. In addressing the second research question, the association of instructional leadership with the improvement of academic performance was analysed using the OB decomposition. Originally, the OB decomposition method was used in labour economics to identify discrimination. However, more recently the method has been used by education economists to examine gaps in learning outcomes, with respect to urban-rural status (Burger, 2011), gender divide (Cobb-Clark and Moschion, 2017; Kingdon, 2002) and student socioeconomic status (Selkirk, 2019). This approach enables one to separate the incremental gap in test scores into two components: (1) the "explained" component that can be explained due to differences in observable characteristics of students, and (2) the "unexplained" component, which means how the observable characteristics are better utilised (Barrera-Osorio, García-Moreno, Patrinos, and Porta, 2011). The latter component can be regarded as the efficiency by which the country is able to convert characteristics into student learning outcomes as measured by test scores (Barrera-Osorio et al., 2011). This second component may also indicate some unobserved family characteristics that are associated with achievement over time, such as family wealth (MENA-Regional Office, 2015).

The OB decomposition approach does not specify a cognitive production function per se, but rather a stochastic model in which student achievement is correlated with a set of household, school, teacher and classroom variables (Barrera-Osorio et al., 2011). The expected student achievement, $y$, is stated as a linear function of a vector $x$ that represents student, teacher, and school characteristics such that

$$E[y|x] = \beta_0 + \beta_1 x \quad (1)$$

where $\beta_0$ is a scalar constant and $\beta_1$is a vector of coefficients representing the association between each variable (component $x$) and learning achievement. The method of OB decomposition separates the gap in a dependent variable between two groups into three components ('threefold' decomposition), such that the OB decomposition can be expressed as:

$$\bar{y}_{t+1} - \bar{y}_t = (\beta_0^{t+1} - \beta_0^t) + \beta_1^t(\bar{x}_{t+1} - \bar{x}_t) + \bar{x}_{t+1}(\beta_1^{t+1} - \beta_1^t) \quad (2)$$

where $t$ indicates the year, and a macron over the variable denotes the mean for the stated year. According to equation 2, the variance in learning achievement is determined by: (i) the change or investment in inputs, $\beta_1^t(\bar{x}_{t+1} - \bar{x}_t)$, (ii) the changes in the returns of the inputs, $\bar{x}_{t+1}(\beta_1^{t+1} - \beta_1^t)$, and (iii) an increase in the constant term, $(\beta_0^{t+1} - \beta_0^t)$. The decomposition's role is to separate the contribution of (i) from (ii) and (iii) (Shepherd, 2013).

## 5. Results

### 5.1 Oaxaca-Blinder regressions

Table 2 shows regression outputs for two multivariate regression analyses following the selection of ten explanatory school leadership variables and some student-level variables. The aim here is to show the logic of OB decomposition.

A preliminary examination of the OLS regressions for the TIMSS 2015 characteristics compared to those for 2019 reveals a number of differences. All the variables, except the socioeconomic status, have been transformed into binary variables. Almost all school leadership variables appear to have an especially large association with achievement in both years, with school's emphasis for academic success and school discipline having a stronger and more significant associations with achievement in 2019 than in 2015. Living in an urban area had a positive and significant association with better mathematics performance in both 2015 and 2019. The presence of a library in the school was also positively and significantly associated with higher mathematics achievements in both years. Moreover, being in schools where there was high emphasis on academic success and where there was discipline and safety was also positively and significantly related to achievement (See Table 2).

***Table 2: Summary statistics and regression outputs***

| | **Sample means** | | | **Regression sample** | | **Full TIMSS sample** | |
|---|---|---|---|---|---|---|---|
| | ***2015*** | ***2019*** | ***Diff.*** | ***2015 coeff.*** | ***2019 coeff.*** | ***2015 coeff.*** | ***2019 coeff.*** |
| Score/constant | 377 | 393 | 16 | 321.79*** | 359.39*** | 324.74*** | 361.09*** |
| | | | | (4.30) | (3.08) | (3.67) | (2.40) |
| *School-level variables* | | | | | | | |
| School located in advantaged area | 0.38 | 0.52 | 0.14 | 33.41*** | 34.17*** | 33.20*** | 34.83*** |
| | | | | (1.86) | (1.35) | (1.75) | (1.27) |
| School library | 0.42 | 0.48 | 0.06 | 6.89*** | 5.99*** | 9.66*** | 6.26*** |
| | | | | (1.75) | (1.31) | (1.64) | (1.24) |
| School's emphasis on academic success | 0.28 | 0.34 | 0.06 | 28.34*** | 13.39*** | 24.79*** | 12.00*** |
| | | | | (2.04) | (1.26) | (1.96) | (1.36) |
| Discipline and safety | 0.74 | 0.67 | -0.07 | 28.21*** | 18.95*** | 28.16*** | 16.40*** |
| | | | | (1.70) | (1.26) | (1.57) | (1.19) |
| Principal educational qualifications | 0.92 | 0.94 | 0.02 | 13.98*** | 1.84 | 9.25*** | 0.06 |
| | | | | (3.55) | (2.73) | (2.94) | (2.04) |
| *Student-level variables* | | | | | | | |
| Presence of internet at home | 0.55 | 0.43 | -0.12 | 24.30*** | 21.72*** | 26.41*** | 23.26*** |
| | | | | (1.78) | (1.33) | (1.67) | (1.27) |
| Female student | 0.52 | 0.54 | 0.02 | -3.50*** | -0.67 | -3.52*** | 0.57 |
| | | | | (1.71) | (1.23) | (1.61) | (1.17) |
| Student age: ref - appropriate age of student | 0.71 | 0.53 | -0.18 | -33.96*** | -27.06*** | -35.46*** | -28.53*** |
| | | | | (1.85) | (1.30) | (1.75) | (1.23) |
| Speak language of instruction regularly | 0.36 | 0.37 | 0.01 | 37.10*** | 34.78*** | 36.82*** | 34.52*** |
| | | | | (1.96 | (1.42) | (1.86) | (1.36) |
| Socioeconomic status | 0.01 | 0.02 | 0.01 | 10.07*** | 7.56*** | 9.77*** | 7.66*** |
| | | | | (0.89) | (0.65) | (0.84) | (0.61) |
| N | | | | 11,205 | 18,454 | 12,514 | 20,829 |
| R squared | | | | 0.335 | 0.278 | 0.335 | 0.282 |

*Note: *** indicates that the estimate is significant at the 1% level of significance, ** at the 5% level, and * at the 10% level (also applies to next table)*
*Robust clustered standard errors in parentheses.*
*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*

There was also a larger association between schools being located in advantaged areas and achievement in 2019 than in 2015. It seems that the issue of school location in South Africa is crucial for reducing existing inequalities in education and due to the apartheid legacy of homeland system many students are still unable to acquire relevant skills. This is because they continue to "face a particular form of poverty characterised by the inaccessibility of public facilities and jobs" (Department of Basic Education, 2020: 6).

### 5.2 Simple illustration of Oaxaca-Blinder decomposition

In the education context, the OB decomposition can be illustrated with a simple example as provided by Gustafsson and Taylor (forthcoming). Let's assume the principals' educational qualifications are strongly associated with better student test scores, in a statistical sense, and academic achievement improves over time, then two things might be expected. On the one hand, the number of better qualified principals in schools could have increased. This would be the 'explained' / 'endowment' part of the improvement. On the other hand, school principals could have better used their educational qualifications in managing their schools, meaning even with the same educational qualifications, improvements would have occurred. In other words, the difference between the scores of students with and without better qualified principals would have widened. The data are unlikely to reveal how principals' qualifications were better utilised, meaning this is the 'unexplained' portion. The OB decomposition provides a sense of how much of the change in the outcome is due to, say, the presence of highly qualified principals in schools and how much is due to better utilisation of those qualifications.

Table 3 provides the outputs of an OB decomposition. All the values, with the exception of the significance levels, can be calculated using **Error! Reference source not found.**. For instance, the change linked to school's emphasis on academic success endowments is the difference in the two means, multiplied by the 2015 coefficient:

$$\big(0.34 - (0.28)\big) \times 28.34 = 1.7 \qquad (1)$$

Thus, the gain in average emphasis on academic success of schools can be said to contribute almost around two TIMSS points to the country.

*Table 3: Oaxaca-Blinder decomposition outputs*

| | Endowments (explained) | Coefficients (unexplained) | Interaction | Overall |
|---|---|---|---|---|
| School-level variables | | | | |
| School located in advantaged area | 4.68*** | 0.29** | 0.11** | 5.07 |
| School library | 0.41** | -0.38 | -0.05 | -0.02 |
| School's emphasis on academic success | 1.70*** | -4.19*** | -0.90*** | -3.38 |
| Discipline and safety | -1.97*** | -6.85*** | 0.65*** | -8.18 |
| Principals' educational qualifications | 0.28 | -11.17* | -0.24* | -11.13 |
| Student-level variables | | | | |
| Presence of internet at home | -2.92*** | -1.42 | 0.31 | -4.03 |
| Female student | -0.07*** | 1.47*** | 0.06** | 1.46 |
| Student age | 6.11*** | 4.90*** | -1.24*** | 9.77 |
| Speak language of instruction regularly | 0.37** | -0.84** | -0.02 | -0.49 |
| Socioeconomic status | 0.10 | -0.03 | -0.17 | -0.09 |
| Constant | | 37.60*** | | 37.60 |
| Overall | 8.69*** | 19.39*** | -1.51* | 26.57 |

*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*

In computing the coefficients, or 'unexplained' component, column 2 of **Error! Reference source not found.** 3, the positive value for student age is the difference between the coefficients, multiplied by the 2015 mean:

$$\left(-27.06-(-33.96)\right)\times 0.71 = 4.90 \qquad (2)$$

This suggests that the impact on educational performance of being of appropriate age increased from 2015, to a relatively large impact in 2019. This was not substantially due to there being more students of appropriate age in 2019. Instead, the appropriate age of students had an effect in 2019 which was larger than the one in 2015.

Note that the words 'impact' and 'effect' must be used carefully. The OB results do not produce firm evidence of cause and effect. In particular, the appropriate age could be masking some other factor not captured in the data, which is what is actually bringing about the improvement in results.

The interaction values of the third column of **Error! Reference source not found.**3 represent contributions to the score change which are a result of the interaction between the explained and unexplained. The interaction for the variable describing the presence of a school library, is calculated as follows:

$$(0.48 - 0.42) \times (5.99 - (6.89)) = -0.05 = \quad (3)$$

The value for the constant, 37.60, in Table 3, is the difference between the two constant values in the**Error! Reference source not found.** two full-sample columns. Column totals in Table 3 provide the overall influence of changes attributable to endowments and the coefficients. Row totals provide the overall influence of each explanatory variable. Column totals, and row totals, each produce the same unweighted 26.57 value, which is the change in the country's TIMSS score, using just the few variables and observations included in the analysis (hence the 26.57 differs from the 17 TIMSS points). Clearly, changes in coefficients account for about 73% which constitutes most of the change within this demo model. This is followed by the endowment and the interaction portions which account for 33%% and -6% of the total change, respectively.

### 5.3 The Oaxaca-Blinder decomposition results

The purpose of decomposition was to investigate what changes may have occurred over time that would help explain the 17-point increase in TIMSS Grade 9 mathematics scores in South Africa between 2015 and 2019. A threefold interaction OB decomposition was estimated to discriminate the difference in mean predicted outcome into three components, namely, the explained part; unexplained part; and an interaction part. The first component referred to as endowment (explained) refers to the difference in the level of the covariates. The second component known as the coefficient part (unexplained) arises from the differential effect of all those covariates. The last component (interaction) involves an interaction resulting from the simultaneous group difference in the covariate levels and their coefficients.

*Table 4: Explained and unexplained statistics*

| | All schools | | Top quintile excluded | |
|---|---|---|---|---|
| | Endowments (explained) | Coefficients (unexplained) | Endowments (explained) | Coefficients (unexplained) |
| School-level variables | | | | |
| School located in advantaged area | 4.68*** | 0.29** | 1.85*** | 0.37 |
| School library | 0.41** | -0.38 | 0.13*** | 0.59 |
| School's emphasis on academic success | 1.70*** | -4.19*** | 0.15* | -0.46 |
| Discipline and safety | -1.97*** | -6.85*** | -1.38*** | -5.45*** |
| Principals' educational qualifications | 0.28 | -11.17 | 0.28** | -10.41 |
| Student-level variables | | | | |
| Presence of internet at home | -2.92*** | -1.42 | -2.17*** | -4.03*** |
| Female student | -0.07*** | 1.47*** | -0.02 | 0.60 |
| Student age | 6.11*** | 4.90*** | 1.02*** | 3.74*** |
| Speak language of instruction regularly | 0.37** | -0.84** | -0.31*** | -1.26** |
| Socioeconomic status | 0.10 | -0.03 | -0.10*** | 0.13*** |

*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*

In Table 4, the endowment values for school's emphasis on academic success and principals' education qualifications are positive which is to be expected. This shows that these instructional leadership variables were associated with better test scores in both years. The negative sign of the school emphasis on academic success in the unexplained portion of Oaxaca-decomposition analysis is associated with worse TIMSS results. Similarly, school discipline seemed to be associated with worse TIMSS results. This pattern is similar to that found in the lower school quintiles as reflected in the last two columns of Table 4.

It is surprising to note that the school's emphasis on academic success variable was not significant in the lower school quintiles for either year, while school discipline and safety for these schools was strongly negatively associated with test scores in both 2015 and 2019. This might point to a need for policy intervention in these lower-quintile schools to ensure that there is sustainability in the instructional leadership practices of school principals.

Other variables that had significant positive coefficients for the unexplained component include students who study in schools located in advantaged areas (0.29), students that are female (1.47), and students who are of the appropriate age (4.90). In the lower-quintile schools, the former two variables were positive but not significant, while the variable that represents students of the appropriate age was positive and significant. Schools located in advantaged areas have always been associated with better learning outcomes, and girls have always outperformed boys in most of the international assessments. However, in lower-quintile schools the benefits of studying in advantaged areas and that of being a girl are not reflected in the results. Finally, the positive and significant sign for students of the appropriate age in both the full and restricted samples indicate that mature students are able to cope effectively academically than their younger counterparts.

It is noteworthy that the home possessions, such as internet connection, had negative signs for both the explained and unexplained portions of the decomposition in both the full sample and the poorer schools. This reveals the inequality that exists between schools in the country where students in lower quintiles still have challenges in accessing some educational resources. This might also explain the insignificance of instructional variables in these schools, since there is evidence (Van der Berg, 2007) pointing to correlation of home resources with educational outcomes.

## 6. Discussion

It is a noteworthy finding that a greater proportion of the improvement gap between TIMSS 2015 and 2019 is explained by the unexplained portion of the OB decomposition technique. The analysis shows that characteristics, such as the school's emphasis on academic success, school discipline and safety, student being female, students of appropriate age and students who speak language of instruction, explain significant portions of the overall improvement gap in educational outcomes.
It is difficult to interpret the negative unexplained values for the school's emphasis on academic success and school discipline in Table 4. For the purpose of this paper the important thing is that the two instructional leadership variables explain much of the 2015 to 2019 achievement gain.

In its Action Plan to 2024, the DBE (2020) underscores the importance of strengthening management of existing school principals. The Action Plan to 2024 report points to a need for a holistic school accountability framework to bring together various strands and identify critical gaps. The report also mentions existing school accountability measures that schools undertake and these include the annual school improvement plan, each school's annual report, the increasing use of SA-SAMS school management system, and the Whole School Evaluation (WSE) programme conducted in certain provinces.

Some of the areas of delivery success that have been highlighted in the Action Plan to 2024 report, such as the CAPS tools designed to facilitate the implementation of the curriculum in the classroom, better access among students to high-quality books (national workbooks), and more focussed assessment practices, reflect improved implementation of management and leadership in schools. However, the challenge of the very large, between-school inequality observed in South Africa means that the impact of these areas of service delivery success are not equitably distributed to the entire schooling system. The OB decomposition findings at the lower quintiles schools mean that educational and home resources are hindering efforts for the realisation of educational equality.

## Conclusion

The paper was aimed at analysing the performance gap between 2015 and 2019 Grade 9 TIMSS mathematics scores in South Africa, and asking how much of the gap was due to the instructional leadership practices in schools. Using the OB decomposition technique, the performance gap has been decomposed into the part that can be explained by differences in endowments of educational inputs, and that part that is due to returns to the educational inputs invested. Arguably, the most important finding from the OB decomposition model is that the TIMSS improvement in mathematics achievement was largely explained by the efficiency of the educational inputs, which is students of appropriate age, students that are female, and students who study in schools situated in advantaged areas.

Detailed decomposition revealed that instructional leadership variables were not important contributors to the performance gap. Other educational inputs such students of appropriate age and students that are female seem to be driving the improvement in learning. This does not mean that instructional leadership variables are not important as these educational inputs are somewhat related to instructional leadership. This is critical for policy and means that there are important returns to some of the policy interventions that had been implemented years ago. The OB decomposition was further estimated at the lower-quintile end of the student distribution, where it was revealed that instructional leadership variables were also not instrumental in determining the improvement of the mathematics scores. Policies should focus on lower-quintile schools to assist them in anchoring instructional leadership at the centre of school management.

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## Appendix

### Table A1. Sample means for TIMSS 2015 and 2019 Grade 9, South Africa

| | TIMSS 2015 | | | | TIMSS 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| **Variables** | **Mean** | **St. Dev** | **Missing** | **N** | **Mean** | **St. Dev** | **Missing** | **N** |
| *Schools* | | | | | | | | |
| Affluent | 0.10 | 0.16 | 23.6% | 9553 | 0.08 | 0.15 | 15.9% | 17,516 |
| Percent who speak English | 0.19 | 0.33 | 9.5% | 11,331 | 0.23 | 0.36 | 6.8% | 19,404 |
| Advantaged area | 0.38 | 0.48 | 1.3% | 12,355 | 0.52 | 0.50 | 2.2% | 20,364 |
| School library | 0.42 | 0.49 | 0.2% | 12488 | 0.48 | 0.50 | 1.6% | 20,491 |
| Specialize in Math | 0.48 | 0.50 | 1.9% | 12279 | 0.48 | 0.50 | 2.9% | 20,213 |
| Academic success | 0.28 | 0.49 | 0.3% | 12,476 | 0.34 | 0.53 | 0.1% | 20,627 |
| School discipline | 0.74 | 0.62 | 1.5% | 12,327 | 0.67 | 0.63 | 1.2% | 20,581 |
| Principal experience | 5.9 | 7.8 | 7.7% | 11,554 | 3.82 | 6.19 | 7.7% | 19,219 |
| Principal experience at school | 4.6 | 6.9 | 8.7% | 11 423 | 0 | 0 | 4.6% | 19,875 |
| Principal Qualifications | 0.92 | .26 | 2.9% | 12,153 | 0.94 | 0.24 | 4.6% | 19,875 |
| *Teachers* | | | | | | | | |
| Teacher experience | 13.8 | 9.3 | 3.5% | 12,076 | 14.1 | 10.1 | 2.4% | 20,324 |
| Teacher is female | 0.45 | 0.48 | 1.2% | 12,363 | 0.47 | 0.50 | 1.3% | 20,566 |
| Teacher age | 36.0 | 9.0 | 0.6% | 12,436 | 37.0 | 10.0 | 1.8% | 20,443 |
| Teacher has tertiary education | 0.96 | 0.17 | 0.7% | 12,432 | 0.99 | 0.10 | 7.2% | 19,337 |
| Teacher specialize in Mathematics | 0.76 | 0.41 | 3.0% | 12,133 | 0.82 | 0.38 | 2.3% | 20,358 |
| Teacher asks for explanation | 0.99 | 0.09 | 1.2% | 12,364 | 0.99 | 0.08 | 2.5% | 20,308 |
| Teacher corrects homework | 0.99 | 0.10 | 3.9% | 12,021 | 0.99 | 0.08 | 7.2% | 19,320 |
| Teacher professional development hours | 0.79 | 0.40 | 1.5% | 12,328 | 0.74 | 0.44 | 2,5% | 20,308 |
| Safety and orderly | 1.00 | 0.73 | 0.3% | 12,475 | 0.89 | 0.66 | 0.6% | 20,700 |
| *Students* | | | | | | | | |
| Girl student | 0.52 | 0.50 | 0.1% | 12,506 | 0.54 | 0.50 | 0.2% | 20,786 |
| Often speaks English | 0.36 | 0.48 | 0.8% | 12,417 | 0.37 | 0.48 | 0.7% | 20,690 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School absence frequency | 0.65 | 0.48 | 2.6% | 12,185 | 0.1 | 0.29 | 1.29% | 20,560 |
| Student age | 15.7 | 1.22 | 0.8% | 12,412 | 15.6 | 1.06 | 1.2% | 20,584 |
| Assets | 0.01 | 1.00 | 2.2% | 12,237 | 0.02 | 1.00 | 1.7% | 20,484 |
| Possess internet | 0.53 | 0.50 | 3.0% | 12,141 | 0.43 | 0.50 | 2.7% | 20,259 |
| Amount of books | 0.20 | 0.40 | 1.1% | 12,377 | 0.19 | 0.39 | 0.9% | 20,649 |
| TIMSS score | 372 | | 0.0% | 12,514 | 389 | | 0.0% | 20,829 |

*Source: Author's own calculations based on TIMSS 2015 and 2019 datasets*