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Safety factors associated with mathematics achievement in South African primary schools

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Abstract

According to the South African Constitution, all children have a right to equitable education which is free from harm (Republic of South Africa (RSA), 1996a). According to the Children's Amendment Act No. 41 of 2007 (RSA, 2008), it is a legal requirement that cases of violence against schoolchildren be reported to law enforcement officials. Still, news of horrendous incidents in schools continues to grab South African news headlines. The creation of a safe environment conducive to learning is vitally important in the academic achievement of learners. All learners have the right to basic education as a fundamental human right, and this can only be fulfilled when all learners have access to education in a safe school environment. Safety factors associated with Grade 5 South African mathematics achievement was investigated. A quantitative design was followed as well as a deductive approach, a positivism philosophical stance and a secondary data analysis study design. This study analysed TIMSS 2019 data for respondents from South Africa and proposed a model containing 10 constructs; 9 independent variables (gender, socio-economic status and 7 variables related to safety aspects in schools) and one independent variable (mathematics achievement). The multilevel analysis using HLM software showed that not feeling safe at school, property being stolen or purposefully damaged, being hit, hurt or threatened, living in an impoverished area, having a shortage of or inadequate school buildings and grounds and intimidation or verbal abuse of teachers or staff were the best predictors of Grade 5 learner mathematics achievement. The article concludes with recommendations and a summary.

Keywords: HLM, mathematics achievement, school safety, TIMSS 2019

INTRODUCTION

There is growing global concern regarding South African mathematics learner achievement in schools. Studies such as Trends in International Mathematics and Science Studies (TIMSS) intend to explore aspects of mathematics achievement. In South Africa, poor learner mathematics achievement has occupied the centre stage yet again with the release of the TIMSS 2019 results. South Africa participated in TIMSS 2019 on Grade 5 and Grade 9 level, respectively; the focus of this study is at Grade 5 level and, at this level, 64 countries participated, with South Africa being amongst the lowest of the 64 countries with an achieved score of 374 which is well below the international benchmark of 500 points (Reddy et al., 2020). TIMSS sets the low benchmark at 400 points, with a score above 400 indicating that learners acquired basic mathematical knowledge. Reddy et al. (2020) reported that only 37% of South African learners acquired basic mathematical knowledge (score above 400), meaning that 63% of South African learners have not acquired basic mathematical knowledge. These results are alarming, given that South Africa has had many intervention programmes aimed at improving the educational system over the last few years (Zenex Foundation, 2020). Research studies have explored socio-economic status (SES) and school safety aspects related to learners' mathematics achievement, finding both to be strong predictors of learner achievement; SES (Brännlund & Edlund, 2020; Laukaityte & Rolfsman, 2020; Olszewski-Kubilius & Corwith, 2018; Romero, Hall, Cluver, & Steinert, 2018; Spaull, 2015; Visser, Juan & Feza, 2015) and school safety aspects (Anton-Erxleben, Kibriya & Zhang, 2016; Hendricks, 2019; Ncontsa & Shumba, 2013; Singh & Steyn, 2013; Vilalta & Fondevila, 2018). Hence, an unsafe school environment (which are typically found in areas with lower SES) plays a role in poor learner performance. When teaching and learning takes place in an unsafe environment, it infringes on learners' educational rights as both the Constitution of the Republic of South Africa (RSA, 1996a) and the South African Schools Act (RSA, 1996b) state that every South African learner should have access to learning and teaching, similar facilities, and equal educational opportunities. Thus, the focus of this study is to explore how measures of safety, as identified in TIMSS 2019, are associated with South African Grade 5 learner mathematics achievement since learning mathematics in an unsafe school environment results in a violation of the basic rights of learners who have the right to equal educational opportunities.

Rationale of the Study

Safety issues in South African schools are becoming a growing concern (Mayeza, 2021; Palm, 2019); although research has been conducted addressing safety and its association with learner achievement in mathematics, very few of these have considered the varying hierarchical levels that is typically found in an educational setting. Hierarchical Level Modeling (HLM) is a complex form of ordinary least square regression that is used to analyse variance in the dependent variable when the predictors are at varying hierarchical levels, i.e. it accounts for shared variance in hierarchically structured data which is a structure that educational data frequently takes on since there is, for example, a learner level and a school level (Woltman, Feldstain, MacKay & Rocchi, 2012). In this study, the varying hierarchical levels are considered when examining how school safety in South African schools relates to mathematics achievement using TIMSS 2019 data, which fills this gap in the literature as, to the best of our knowledge, such a study has not been conducted to date.

Research Questions

The primary research question is: How are the measures of safety, as identified in TIMSS 2019, associated with South African Grade 5 mathematics learner achievement?

The secondary research questions that support the primary research question are:

1. How is violence in schools associated with Grade 5 mathematics learner achievement?
2. How are safety aspects relating to a shortage of inadequacy of school buildings and grounds in schools associated with Grade 5 mathematics learner achievement?

It should be noted that violence can take place in many forms (e.g. bullying, physical injury), and in this article, we adopt the definition of violence given by the World Health Organization 2002 report on violence and health as: “The intentional use of physical force or power, threatened or actual, (against oneself), another person, or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation” (Krug, Dahlberg, Mercy, Zwi & Lozano, 2002, paragraph 4). A safe school is defined by the South African Council for Educators (SACE), relating to educators, as “Educators have the right to work in an environment in which they feel valued and respected, where they may actively support learners’ development and learning and where they are free from fear, threat and harm” (SACE, 2021, p. 30). Xaba (2014) reviewed the literature on school safety and security in South African schools and defined a safe school

environment as "one that is not dangerous and that poses no threats to the school occupants in terms of their physical, emotional and psychological well-being" (p. 1583).

LITERATURE REVIEW

The fact that 63% of South African learners have not acquired basic mathematical knowledge (Reddy et al., 2020) is alarming, given that South Africa has had many intervention programmes aimed at improving the educational system over the last few years (Zenex Foundation, 2020). As mentioned earlier, research studies have explored school safety aspects related to mathematics learner achievement, finding it to be a strong predictor of learner achievement. At an international level, much research has been conducted on the association of unsafe schools and learner achievement and a few examples are discussed here. Ojukwu (2017), who studied the relationship of insecurity of school environment and learner performance by analysing 1000 questionnaires completed by learners in secondary schools in Nigeria, found it a significant predictor for learners' academic performance. Vilalta and Fondevila (2018), who conducted a quantitative study on vandalism prevention using multilevel modelling on data from 22345 learners from 249 Mexican schools, stated that vandalism has a negative impact on education levels. Burns, Martin, Collie and Mainhard (2021) studied the 2015 Programme for International Student Assessment (PISA) data of 14530 Australian learners and found that classroom disruptions, which are often due to misbehaving learners, was a significant predictor for learners' science achievement.

There are many South African studies conducted on the association of unsafe schools and learner achievement. Ncontsa and Shumba (2013) used a mixed-methods research approach involving questionnaires and interviews and 5 principals, 80 learners and 20 educators in South African schools and found that school violence leads to learners' loss of concentration and poor academic performance. Singh and Steyn (2013), who conducted interviews in five rural South African secondary schools about learner aggression, stated that acts of violence, perpetrated by learners with aggression problems, negatively impact the ethos of the school, which, in turn, impacts effective teaching and learning taking place in the classroom. Mncube and Madikizela-Madiya (2014), who conducted a mixed-methods study by conducting interviews and distributing questionnaires in six provinces in South Africa, concluded that school-based violence (through gangsterism specifically) led to reduced school attendance, impaired

concentration and a diminished ability to learn. Mncube and Steinmann (2014), who also conducted a study on gang-related violence in South African schools using a mixed-methods approach, found that fear of gang-related violence in schools resulted in a loss of concentration in classrooms, learners avoiding schools or even dropping out. A similar finding (of gangsterism affecting learners' school attendance) was found by Magidi, Schenk and Erasmus (2016) who conducted focus group and individual interviews with 18 learners aged between 16 and 18 from South African secondary schools. In the policy brief published by the Human Sciences Research Council (HSRC), who together with the Department of Basic Education, is in charge of releasing the results of South African participation in TIMSS, reported that "Schools where there were fewer discipline or safety problems achieved better results" (Zuze, Reddy, Juan, Hannan, Visser and Winnaar, 2016, p. 1). Taole (2016), who explored the gendered nature of violence in South African schools by conducting focus group interviews with learners aged between 13 and 17 years who were either perpetrators or victims of violence, concluded that gender violence in schools has "serious implications for the educational attainment" of learners (p. 42). Makota and Leoschut (2016), in their perspective paper on South Africa's NSSF's approach to preventing school violence, stated that consequences associated with learner victimisation negatively impact learners' performance at school. Hendricks (2018) interviewed 25 learners in the Eastern Cape Province of South Africa about gang violence in schools and found that it leads to a lower academic progression of learners as it interferes with their ability to learn. Juan, Zuze, Hannan, Govender and Reddy (2018), who analysed the Grade 9 TIMSS 2015 South African data, reported that school bullying is a complex phenomenon that negatively affects the psychological well-being of learners as well as the teaching and learning culture of schools. Hendricks (2019), who conducted focus-group interviews with 25 learners and individual interviews with 5 social workers, 5 educators and 5 community members in the Eastern Cape, found that exposure to violence within the school environment impairs learners' cognitive functions.

School safety is a phenomenon of great social interest; the importance of the phenomenon derives from the consequences it produces: poor academic achievement, anxious-depressive syndromes, sleeping disorders, behavioural disorders, verbal aggression, school absences, dropping out of school, suicidal behaviour, delinquency, post-traumatic stress disorder, psychosomatic symptoms and substance abuse, among others (Bauman, Toomey & Walker, 2013; Lereya, Copeland, Zammit, & Wolke, 2015; Rad, Roman, Dughi, Demeter, & Rad, 2020;

SACE; 2021; Williford, Fite, Diaz & Singh, 2021). School safety is a pervasive global issue which goes beyond feeling unsafe, fights and bullying, to name a few; it even goes so far as violence to loss of life. Each year, around the world, approximately 246 million children experience violence in and around school (United Nations Educational, Social and Cultural Organization [UNESCO], 2017). According to the United Nations International Children's Emergency Fund (UNICEF)'s #ENDviolence Youth Manifesto (UNISEF, 2019) of learners worldwide aged 13 to 15, about half reported having experienced peer violence in and around school, more than a third have experienced some form of bullying and around one in three has been involved in physical fights. And it's not just the learners that experience all these school safety issues, but teachers are also harassed, intimidated and bullied (McMahon et al., 2014; Ozkilic & Kartal; 2012; Soldaat, 2019).

Safety in schools also includes the state of school buildings and grounds, for instance, dilapidated school buildings or a lack of toilets, which is the case in many South African rural schools (Du Plessis & Mestry, 2019; Thaba-Nkadimene, 2020), contribute to an unsafe school environment. Inadequate or a lack of infrastructure can be dangerous; for example, South African learners have died from falling into pit latrines (Chaskalson, 2021) and collapsed school buildings (Dlamini, 2019). Du Plessis and Mestry (2019) conducted a study in rural schools in the Mpumalanga province of South Africa and found that most schools do not have water, sanitation or electricity, the classrooms are in a terrible state, and this directly influences the quality of education available to these learners which, in turn, negatively influences learners' academic performance. Thaba-Nkadimene (2020) also conducted a study in rural schools (this study was conducted in the Limpopo province of South Africa), and found that there is inadequate strategic infrastructure, water and sanitation, which leads to demotivated teachers and learners, which, in turn, leads to poor learner outcomes. These findings also hold internationally; for example, the study of Cuesta, Glewwe and Krause (2016), who focussed their literature review on school infrastructure in Latin America, found that having access to adequate sanitation facilities increased learner performance. Visser et al. (2015), who analysed the South African TIMSS 2011 data, found that the condition of the school buildings is a significant predictor of learners' mathematics performance. Inadequate strategic infrastructure also impacts negatively on school climate, which, in turn, negatively impacts learner achievement (Bhunia, Shit & Duary, 2012; Filardo, Vincent & Sullivan, 2019); with school climate being defined as the quality and the atmosphere of school life (Petrie, 2014). Many researchers have reported that school climate plays a major role in learner achievement

(Banerjee, 2016; Kutsyuruba, Klinger, & Hussain, 2015; Maxwell, Reynolds, Lee, Subasic, & Bromhead, 2017; Reddy et al., 2020), and school climate is directly linked to school safety.

Globally, there is much research done on school safety; however, the focus of this article is only within a South African context at primary school level. In South Africa, the National School Safety Framework (NSSF) was developed to address safety issues in schools (Department of Basic Education & Centre for Justice and Crime Prevention, 2015). The NSSF requires teachers to perform many roles, such as creating and maintaining a safe school environment (Makota & Leoschut, 2016) and promoting school safety (Hanaya, MacDonald & Balie, 2020). However, the NSSF mechanisms seem to be falling short as violent attacks in South African schools is on the rise (Palm, 2019). In South Africa, violence in schools violates learners' constitutional right to "freedom and security of the person, which includes the right to be free from all forms of violence" (Constitution of the Republic of South Africa, Act 108 of 1996; RSA, 1996a).

To achieve academic excellence, learners must be free from the unsafe learning environment (Masitsa, 2011). Teachers and learners tend to focus on their safety instead of teaching and learning when they feel unsafe (Makungo, 2012). This could possibly ultimately translate into poor academic achievement as the attention has shifted from teaching and learning. Schools should be a safe haven where teaching and learning takes place, free from crime, violence and intimidation (Zhang, Musa-Gillette & Oudekerk, 2016). The Centre for Justice and Crime Prevention (CJCP) summarises the consequences of school violence succinctly as: "Experience and exposure to violence in any environment at a young age increases the risk of later victimisation, as well as perpetration of violence and other antisocial behaviour. Schools, if considered holistically, are environments where children not only acquire scholastic knowledge but also where they learn to know, to be, to do and to live together. Violence in schools impacts negatively on all these processes, creating instead, a place where children learn fear and distrust, where they develop distorted perceptions of identity, self and worth, and where they acquire negative social capital, if the violence and safety-related threats are not effectively managed. Thus, school safety is a fundamental precondition for learning rather than being an addition" (CJCP, 2016, p.6).

Theoretical framework

Bronfenbrenner's ecological model of micro-, meso-, exo-, macro- and chrono-systems was utilised to interpret the way systems influenced school safety and mathematics achievement (Bronfenbrenner, 1977). Bronfenbrenner (1979) stated that "In ecological research, the properties of the person and of the environment, the structure of environmental settings, and the processes taking place within and between them must be viewed as interdependent and analysed in systems terms" (Bronfenbrenner, 1979, p. 41). This statement means that we must not only look at the learner and their immediate environment, but also at the interaction with larger environments as well. Bronfenbrenner and Ceci (1994) revised Bronfenbrenner's theory by considering the role of biology in his model and named it the "Bioecological model", and this model was adapted to the field of school violence and school climate by Espelage and Swearer (2010). The microsystem represents the learner's immediate environment as it contains all the structures that the child has direct access to, for example, family and school. The mesosystem represents the connection between the structures of the learner's microsystem, for example, the connection between a learner's teacher and their parents. The mesosystem is where the focus of my study lies, since is it where a learner's individual microsystems do not function independently but are interconnected and assert influence upon one another. The exosystem represents a larger social system where the learner does not function directly but can have an impact on some structures on their microsystem, for example, parents' economic situation. The macrosystem consists of broader things such as ideologies of a culture and laws. The chronosystem is the dimension of time, e.g. as learners get older, they will react differently to changes.

METHOD

A quantitative design was followed, with a positivism philosophical stance, as this stance is typically associated with quantitative research. The research hypothesis of this study is that poor safety in schools is associated with poor Grade 5 South African learner mathematic achievement. With the positivist paradigm, the researcher focuses on observable and measurable facts, and the researcher is detached, neutral and independent of what is researched (Saunders, Lewis, Thornhill, 2016). The latter is the case in this study, as we've analysed TIMSS 2019 data which are observed and measured values; we are detached, as we did not

collect the data or interact with the participants. Regarding the research strategy, for the quantitative phase, a secondary data analysis was used. Secondary data analysis refers to a research design that mostly use existing data, mostly quantitative data to reapply and reanalyse such data to test hypotheses or to validate models (Mouton, 2001).

Participants

At Grade 5 level, 64 countries participated in TIMSS 2019. TIMSS 2019 made use of a two-stage stratified cluster sampling design (LaRoche et al., 2020) of Grade 4, who represented four years of formal schooling, but South Africa chose fifth-graders to "provide a better match with the demands of the assessments" (LaRoche & Foy, 2020, p. 196). Firstly, schools were sampled according to their size with province and school type serving as stratification variables and secondly, one or more intact classes from the target grade of each participating school were selected (LaRoche et al., 2020). For South Africa, the realised sample was 297 schools, 294 mathematics and science teachers, 11903 learners and 11720 parents/guardians at Grade 5 level (Reddy et al., 2020). No permission was needed to analyse the TIMSS 2019 data, as the database is available for public use on the International Association for the Evaluation of Educational Achievement (IEA)'s website (Fishbein et al., 2021).

Data Collection, Instruments and Quality Assurance

The data collection for TIMSS 2019 in South Africa took place in October 2018 (HSRC, 2021). The TIMSS 2019 developers went through many rigorous steps in developing the TIMSS 2019 achievement instruments. "The assessment frameworks cannot drastically change from cycle to cycle but are routinely updated to keep up with fresh ideas and current information about curricula, standards, and instruction in mathematics and science education around the world" (Cotter, Centurino & Mullis, 2020, p. 1.9). The interested reader is referred to Cotter et al. (2020) for a detailed account of this process. In terms of quality assurance, TIMSS 2019 put various measures in place to ensure the reliability and validity of the assessment. For the steps undertaken by TIMSS 2019, the interested reader is referred to Cotter et al. (2020) and LaRoche et al. (2020). For quality assurance, from our side, we conducted a Missing Value Analysis to correctly address concerns that may have been caused due to incomplete data. We also checked whether the data met the assumptions of the chosen statistical techniques; for example, multi-

collinearity was checked by examining the correlation matrix between the predictor variables before conducting the statistical analysis.

Data Analysis

For the quantitative phase of this study, considering the hierarchical structure of the TIMSS data, HLM version 7 was used to perform a multilevel analysis. Table 1 provides a list of the predictors (learner and school variables) used in this study. A level of significance of 5% is used for all statistical analysis. Learners answered the student questionnaire (StuQ), teachers responded to the teacher questionnaire (TQ), and principals completed the school questionnaire (SchQ).

Table 1: Learner and school variables

Variable name **Questionnaire** **Respondents**	**Variable description**	**Original response options**	**Re-coded**
Learner-level			
ASBG01 StuQ Learners	"Are you a girl or a boy?"	1 = Girl 2 = Boy	0 = Girl 1 = Boy
ASBG10B StuQ Learners	"What do you think about your school? I feel safe when I am at school."	1 = Agree a lot 2 = Agree a little 3 = Disagree a little 4 = Disagree a lot	0 = Agree a little or a lot 1 = Disagree a little or a lot
ASBG11D StuQ Learners	"During this school year, how often have other students from your school done any of the following things to you? Stole something from me."	1 = At least once a week 2 = Once or twice a month 3 = A few times a year 4 = Never	0 = At least once a week or once or twice a month 1 = A few times a year or never
ASBG11E StuQ Learners	"During this school year, how often have other students from your school done any of the following things to you? Damaged something of mine on purpose."		

ASBG11F StuQ Learners	"During this school year, how often have other students from your school done any of the following things to you? Hit or hurt me."		
ASBG11K StuQ Learners	"During this school year, how often have other students from your school done any of the following things to you, including through texting or the Internet? Threatened me."		
School-level			
ATBG07A TQ Teachers	"Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. This school is located in a safe neighborhood."	1 = Agree a lot 2 = Agree a little 3 = Disagree a little 4 = Disagree a lot	0 = Agree a little or a lot 1 = Disagree a little or a lot
ATBG07B TQ Teachers	"Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. I feel safe at this school."		
ATBG07C TQ Teachers	"Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. This school's security policies and practices are sufficient."		
ATBG07F TQ Teachers	"Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. The students respect school property."		

ACBG03A SchQ Principals	"Approximately what percentage of students in your school have the following backgrounds? Come from economically disadvantaged homes."	1 = 0 to 10% 2 = 11 to 25% 3 = 26 to 50% 4 = More than 50%	0 = 0 to 25% 1 = 26% to 100%
ACBG13AC SchQ Principals	"How much is your school's capacity to provide instruction affected by a shortage or inadequacy of the following? General School Resources: School buildings and grounds"	1 = Not at all 2 = A little 3 = Some 4 = A lot	0 = Not at all or a little 1 = Some or a lot
ACBG15F SchQ Principals	"To what degree is each of the following a problem among Grade 5 students in your school? Vandalism"	1 = Not a problem 2 = Minor problem 3 = Moderate problem 4 = Serious problem	0 = Not a problem to a minor problem 1 = Moderate to serious problem
ACBG15G SchQ Principals	"To what degree is each of the following a problem among Grade 5 students in your school? Theft"		
ACBG15H SchQ Principals	"To what degree is each of the following a problem among Grade 5 students in your school? Intimidation or verbal abuse among students"		
ACBG15I SchQ Principals	"To what degree is each of the following a problem among Grade 5 students in your school? Physical fights among students"		
ACBG15J SchQ Principals	"To what degree is each of the following a problem among Grade 5 students in your school? Intimidation or verbal abuse of teachers or staff"		

Typically, continuous or dichotomised variables are used in HLM analysis and, accordingly, the response categories have been collapsed to two response categories per variable. All detail

is provided in Table 1, but for illustration, consider the variables with four response options "1 = Agree a lot", "2 = Agree a little", "3 = Disagree a little" and "4 = Disagree a lot". It makes sense to group the levels of agreement (1 and 2) and the levels of disagreement (3 and 4). Note that all dichotomise variables have been coded 0 and 1 (and not 1 and 2) as the coding of dichotomous predictors as 1 and 2 does not make sense because the intercepts are interpreted as the 0 values of the predictor, which would be a group that does not exist. Accordingly, the already dichotomous variable gender has also been re-coded. In the HLM analysis, the learner-level (level-1) centering was "uncentered" and the school-level (level-2) centering was "grand-mean centered" as per recommendations when using dichotomous variables (Raudenbush & Bryk, 2002). For the dependent variable, mathematics achievement, it should be noted that TIMSS uses item response theory (IRT) scaling approaches to create a set of "plausible values" (ranging from 0 to 1000 with 500 being the centrepoint); this is done to obtain achievement scores in mathematics for all learners since it's not feasible for each learner to answer every assessment item (Reddy et al., 2020).

RESULTS

The subsequent sections explain the null- and final models of this study. The null model without any variables was created to show the variance between the schools in South Africa. Table 2 shows the results of this model. The variance at learner-level is 5103.27, which represents 52.62% of the total variance. The variance at school-level is 4595.67, which represents 47.38% of the total variance. Further, the variance at school-level is significantly different from zero (p-value < 0.001), which means mathematics achievement varied significantly across schools.

Table 2: The null model of South Africa

	Standard Deviation	**Variance Component**	**df**	χ^2	**p-value**
INTRCPT1, u0	67.80	4595.67	296	12055.50	<0.001
Level-1, r	71.43	5103.27			

The final model was created by removing all insignificant variables one at a time with only significant variables retained. Table 3 shows the results of the final model.

Table 3: The final model of South Africa

Random Effect	Standard Deviation	Variance Component	df	χ^2	p-value
INTERCPT, u0	54.06	2922.41	293	9004.29	<0.001
LEVEL-1	69.87	4882.48			

The variance at the learner-level is 4882.48, which signifies 62.56% of the total variance. The variance at the school-level (teacher and principal) is 2922.41 that represents 37.44% of the total variance, which is statistically significant (p-value < 0.001). The average reliability estimate was 0.96, indicating that sample averages reflected the true school means. The null model was used as a baseline to compute the percentage reduction in variance. By comparing the variance components of the final model to those of the null model, the percentage reduction in the variance at the learner-level was 4.33% ((5103.27-4882.48)/5103.27). The percentage reduction at the school-level was 36.41% ((4595.67-2922.41)/4595.67)). Table 4 provides the information on the significant predictors for the final model.

Table 4: The significant predictors of the final model

Variable name	Variable description	Re-coded options	Coefficient	Standard Error	p-value
Intercept			351.45	5.42	<0.001
Learner-level variables					
ASBG01	"Are you a girl or a boy?"	0 = Girl 1 = Boy	-15.57	2.21	<0.001
ASBG10B	"What do you think about your school? I feel safe when I am at school."	0 = Agree a little or a lot 1 = Disagree a little or a lot	-15.29	3.45	<0.001
ASBG11D	"During this school year, how often have other students from your school done any of the following things to you? Stole something from me."	0 = At least once a week or once or twice a month 1 = A few times a year or never	5.82	2.25	0.017
ASBG11E	"During this school year, how often have other students from your school done any of the following things to you? Damaged something of mine on purpose."		13.31	2.40	<0.001
ASBG11F	"During this school year, how often have other students from your		10.04	2.11	<0.001

	school done any of the following things to you? Hit or hurt me."				
ASBG11K	"During this school year, how often have other students from your school done any of the following things to you, including through texting or the Internet? Threatened me."		6.21	1.94	0.002
School-level variables					
ACBG03A	"Approximately what percentage of students in your school have the following backgrounds? Come from economically disadvantaged homes."	0 = 0 to 25% 1 = 26% to 100%	-101.28	18.79	<0.001
ACBG13AC	"How much is your school's capacity to provide instruction affected by a shortage or inadequacy of the following? General School Resources: School buildings and grounds"	0 = Not at all or a little 1 = Some or a lot	-21.85	8.62	0.012
ACBG15J	"To what degree is each of the following a problem among Grade 5 students in your school? Intimidation or verbal abuse of teachers or staff"	0 = Not a problem to a minor problem 1 = Moderate to serious problem	-21.91	9.08	0.017

Note that, although Table 4 show that girls (ß= -15.57, p-value <0.001) achieved significantly higher mathematics scores than boys, gender was only included as a control variable and a gender comparison was not the aim of this study; thus, this finding is not discussed in further detail.

Level-1/learner-level (Learner predictors):

- Learners who are in agreement "agree a little or a lot" that they feel safe when they are at school (ß = -15.29, p-value < 0.001) performed significantly better than learners who "disagreed a little or a lot" with this statement.
- Learners who stated that something was stolen from them "a few times a year or never" performed statistically significantly better (ß = 5.82, p-value = 0.017) than learners who were stolen from more often ("at least once a week or once a twice a month").
- Learners who stated that something of theirs was damaged on purpose from them "a few times a year or never" performed statistically significantly better (ß = 13.31, p-value < 0.001) than learners where something was damaged more often ("at least once a week or once a twice a month").
- Learners who were hit or hurt "a few times a year or never" performed statistically significantly better (ß= 10.04, p-value < 0.001) than learners reported being hit or hurt more often ("at least once a week or once a twice a month").
- Learners who were threatened "a few times a year or never" performed statistically significantly better (ß= 6.21, p-value = 0.002) than learners who reported being threatened more often ("at least once a week or once a twice a month").

Level-2/school-level (School predictors):

- Learners enrolled at schools that accommodate more than a quarter (26% to 100%) of learners from economically disadvantaged homes achieved significantly lower mathematics results (ß= -101.28, p-value <0.001) than learners from schools that accommodate a quarter or less (0% to 25%) of learners from economically disadvantaged homes.
- Learners enrolled at schools where the principal indicated that the school's capacity to provide instruction is "some or a lot" affected by a shortage or inadequacy of school buildings and grounds achieved significantly lower mathematics results (ß= -21.85, p-value = 0.012) than those of learners whose principals indicated "not at all or a little".
- Learners who attended schools where the principal indicated that the intimidation or verbal abuse of teachers or staff (ß= -21.91, p-value = 0.017) is a "moderate to serious

problem" achieved significantly lower mathematics scores than learners where principals indicated that the problem is "minor or that there was no problem".

DISCUSSION

The results from the learner-level (level-1) are discussed first. The fact that learners whose property have been stolen, purposefully damaged, hit, hurt or threatened, perform significantly worse than learners that do not experience these things are not unexpected. As discussed earlier, many South African studies on gansterism in schools, which could lead to property being stolen, purposefully damaged, learners being hit, hurt or threatened, have serious implications for the educational attainment of learners (Mncube & Madikizela-Madiya, 2014; Mncube & Steinmann, 2014). The findings of this study align with that of other South African studies, for example, Hendricks (2019), Ncontsa and Shumba (2013) and Singh and Steyn (2013), who found that school violence negatively impacts academic achievement and Makota and Leoschut (2016) who found that victimisation negatively impacts it. In a study by Anton-Erxleben et al. (2016), it was found that, in developing countries such as South Africa, bullying led to school avoidance and poor attendance, an inability to concentrate, negative attitudes towards school, lack of academic engagement, depression and reduced self-esteem, and even physical health problems. Ndebele and Msiza (2014) conducted a study in the Eastern Cape province of South Africa on Grade 11 and 12 learners who indicated that they had been bullied and found that bullying had a negative association with learner performance as learners divert their attention away from learning to how to avoid being bullied. The findings of this study also align with findings from international studies, for example, that of Vilalta and Fondevila (2018), who found that vandalism[1] negatively impacts academic achievement in Mexican schools. All these variables (property have been stolen, purposefully damaged, hit, hurt or threatened) collectively contribute to insecurity of the school environment which Ojukwu (2017), in their study in Nigeria, showed to be a significant predictor of academic performance. A suggestion is to increase learner participation in school safety management because while most schools have a code of conduct condemning all forms of violence, Sarah Hoffman, a social media education specialist, emphasised these are "not meaningful or valuable if kids are not educated about the contents and meaning of the code or policy" (Mthethwa, 2021, p. 1). The findings of

[1] Vandalism links to our study's variable "purposely damaged"

Makota and Leoschut (2016) support our suggestion as they state that principals aren't solely responsible for school safety and that learners must also take some responsibility for it.

Next, the results from the school-level (level-2) are discussed. The findings at the school-level of SES being a significant predictor of learner mathematic achievement is not unexpected as several South African studies (Romero et al., 2018; Spaull, 2015; Visser et al., 2015) and several international studies (Brännlund & Edlund, 2020; Laukaityte & Rolfsman, 2020; Olszewski-Kubilius & Corwith, 2018) have also shown this to be the case. Economic inequality remains a prominent issue in South Africa and contributes to extreme poverty. All stakeholders and policymakers must make the inequality of educational opportunity in South Africa a priority as the situation is so dire that Spaull (2013) went as far as to declare that South Africa has two educational systems, a functional system for the wealthiest 25% of South African children and a dysfunctional system for the 75% majority of children from poorer families. South African researchers are pointing stakeholders and policymakers to possible solutions, as Visser et al. (2015), using TIMSS 2011 data, showed that for each additional educational asset a South African learner has at home, their mathematics achievement score increases by on average 10 points. To put into context how significant a 10-point increase is, the annual mathematics improvement for South Africa from TIMSS 2003 to TIMSS 2011 was 7.4 points, and from TIMSS 2011 to TIMSS 2019, it was only 4.6 points (HSRC, 2020). These results indicate that if poorer families can get access to only one more additional educational asset at home, their child's mathematics achievement, as measured by TIMSS, would increase on average by a significant amount of around 10 points. Stakeholders are urged to explore the findings and suggestions by South African researchers relating to SES and education.

The finding that a shortage or inadequacy of school buildings and grounds (as reported by the principal) is a significant predictor of learner mathematic achievement is not unexpected as several South African studies (Du Plessis & Mestry, 2019; Thaba-Nkadimene, 2020; Visser et al., 2015) and several international studies (Bhunia et al., 2012; Filardo et al., 2019; Mokhtarmanesh & Ghomeishi, 2019) have also shown this to be the case. The findings of this study align with that of other South African studies; for example, in the study by Du Plessis and Mestry (2019), they found that most rural schools in South Africa don't have access to the very basics such as water, sanitation and electricity, and that classes are in a terrible state, and all this creates an ineffective learning environment. Again, South African researchers are pointing stakeholders and policymakers to possible solutions; for example, Thaba-Nkadimene

(2020) suggests that the Department of Education "should partner with private sector in addressing infrastructural backlog that ranges from installation of computers and internet; and building classrooms, toilets, library, laboratories, and playing grounds in rural public schools" (p. 179). The findings of this study also align with findings from international studies; for example, Filardo et al. (2019) who stated that "student learning is undermined in poorly designed and maintained buildings" (p. 27) in American schools and Cuesta et al. (2016) who found that having access to adequate sanitation facilities in Latin American schools increased learner performance. The shortage of or inadequacy of school buildings and grounds in South African schools is of great concern, as dilapidated school buildings should be fixed or replaced, and pit latrine toilets, which are common in rural South African schools, should be replaced with safe toilets. This suggestion is supported by the South African Democratic Teachers Union (SADTU), who commented that "It is unfortunate that the budget vote did not make any allocation for school safety" when the 2018/2019 Education budget vote was announced (SADTU, 2018, p. 1).

The finding that schools, where school principals indicated that the intimidation or verbal abuse of teachers or staff is a moderate to serious problem, achieved significantly lower mathematics scores than schools where principals did not view this as a problem, is not surprising, as many studies have found that associations between teacher-learner relationships and learners' academic performance (McCormick, O'Connor, Cappella, & McClowry, 2013; McMahon et al., 2014; Ozkilic & Kartal; 2012; Soldaat, 2019). In some South African schools, the levels of intimidation and verbal abuse are dire; for example, Soldaat (2019) who interviewed South African teachers, had a female teacher reporting that learners swore at her, spit on her and sexually harassed her which made it difficult for her to care, which in turn, negatively affects the teaching and learning environment in her classroom. This is not unique to South Africa, as McMahon et al. (2014) found, from analysing data from a national survey in the United States of America, that 80% of teachers reported at least one victimisation and of these teachers, 94% reported that learners were the perpetrators. Ozkilic and Kartal (2012), who conducted a study in Turkey on teacher victimisation of teachers by learners, found that teachers who were victimised by learners stated that it created a negative atmosphere in the classroom and that they had decreased expectations from their learners, which, in turn, negatively affects learner achievement.

CONCLUSION AND RECOMMENDATIONS

This study investigated the safety aspects, as identified by the TIMSS in 2019, associated with learner achievement in mathematics in South African primary schools. A secondary analysis of the TIMSS 2019 data was undertaken to explore the underlying aspects of learner achievement in mathematics. The results indicated that the following are significant predictors of mathematics academic achievement: learners not feeling safe at school, learners' property being purposefully stolen or damaged, learners being hit, hurt or threatened, living in an impoverished area, shortage or inadequate school buildings and grounds and teachers enduring verbal abuse. The findings of this research have far-reaching implications, in particular for policymakers and stakeholders, and, accordingly, some recommendations are provided.

To fully develop staff capacity and effectively implement school safety management, it is recommended that governments make school safety a policy and funding priority. This recommendation is based on the finding that inadequate or a lack of school buildings and grounds is associated with poor learner achievement and is supported by the statement issued by SADTU that the budget vote should have allocated funding for school safety (SADTU, 2018).

It is recommended that workforce capacity be developed and that learner and teacher participation in school safety management should be increased. Increasing learner participation in school safety management is important, as highlighted earlier in the statement of Sarah Hoffman, a social media education specialist, of learners needing to be educated about the contents and meaning of school safety policies (Mthethwa, 2021). This recommendation is based on the finding that although policies are in place, learners' property is still being stolen and damaged, and learners are being hit, hurt or threatened to such an extent that it is negatively related to their achievement. Makota and Leoschut (2016) support this finding by stating that principals aren't solely responsible for school safety and that it's a collective effort from all stakeholders, and this includes learners and teachers. They further state that learners and teachers need to be aware of the content of the school safety policies.

The final recommendation is to share information and data. To allow for evidence-based comprehensive school safety policy development, it is essential that data, as well as technical knowledge and skills, be shared between provinces, governments, stakeholders and schools.

The sharing of data is done, for example, by conducting a study like this one and sharing the findings. This recommendation is supported by Dube and Hlalele (2018), who conducted a study on safety in South Africa and concluded that dialogue between stakeholders should be improved and state that they hope that their paper will contribute to the ongoing debate about safety in South African schools.

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