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Traditional bullying and cyberbullying as main drivers of low mathematics achievement in South African schools: Evidence from TIMSS 2019

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ABSTRACT

South African children have a right to equitable education free from harm. Still, news of school bullying incidents continues to grab South African news headlines. Creating a safe environment conducive to learning is vital in learners' mathematics achievement (MA). We investigated the association between bullying and Grade 9 MA in South African schools. We followed a quantitative design with a research paradigm of positivism and a secondary data analysis study design. We analysed TIMSS 2019 data and proposed a model containing 21 constructs; 20 independent variables (gender, socio-economic status (SES) and 18 variables about bullying) and one dependent variable (MA). The multi-level analysis showed refusing to talk to learners, insulting their families, making them do things they didn't want to do, sending nasty, hurtful messages or embarrassing photos of them online, physically hurting them, saying mean things about their physical appearance, stealing from them, physical injury to other learners and SES are significant predictors of MA. Learners must be reminded that there are clear regulations in place to penalise bullies. Due to the exponential growth of e-Learning over the past two years as a result of COVID-19, we recommend the incorporation of cyber-safety and cyber-protection techniques into every learner-teacher training.

Introduction

According to the South African Constitution, all children have a right to equitable education free from harm (Republic of South Africa, 1996). Still, news of school incidents continues to grab South African news headlines, specifically regarding bullying. Creating a safe environment favourable to learning is vital to learners' mathematics achievement (MA). 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 where they are not subjected to bullying. Bullying at school is a serious social issue that affects the well-being of all parties involved, including victims, perpetrators, and bystanders. The literature generally agrees that bullying during

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childhood and adolescence, whether as bullies, victims, or witnesses, has harmful and long-term consequences, including negative social and behavioural outcomes, as well as health and financial issues (Camodeca & Nava, 2022; Chester, Spencer, Whiting, & Brooks, 2017; Khan, 2021; Man, Liu, & Xue, 2022). Many studies have shown that schoolchildren that are victims of bullying suffer academically because of it (Davis et al., 2018; Laith & Vaillancourt, 2022). Man, Liu, and Xue (2022), who conducted a study using 12–17-year-olds in 65 countries, found the highest prevalence of bullying to be in African countries. In fact, Man, Liu, and Xue (2022) have deemed bullying a "global public health problem" that "should attract sufficient policy concern and practical intervention" (p. 14). Bullying methods are always changing as society and technology advance, leading to an area where we not only witness traditional bullying, but also cyberbullying. We link traditional and cyberbullying to MA, as the Trends in International Mathematics and Science Study (TIMSS) 2019 results indicated poor results for this important subject for South African learners. TIMSS studies are conducted on Grade 4 and Grade 8 levels. South African learners tried participating on the Grade 4 and Grade 8 level, but due to low performance changed the participants to Grade 5 and Grade 9 level (Reddy et al., 2015); this study considers the 9th grade data. LaRoche and Foy (2020) state that the South African government decided to assess learners at a higher grade to match the assessments' demands better. TIMSS 2019 can be divided into low (under 400), intermediate (under 475), high (under 550), and advanced (under 625) benchmarks (Reddy et al., 2021). Only 5% of all countries achieved the advanced benchmark in Grade 8/9 MA. South Africa did not reach the low benchmark. Almost 90% of countries (87%) reached the low benchmark, and 56% of the countries reached the intermediate benchmark.

The Grade 9 South African TIMSS 2019 mathematics scores were 389, which is below the TIMSS centerpoint of 500 (Reddy et al., 2021). TIMSS sets the low benchmark at 400 points, with a score above 400 indicating that learners acquired basic mathematics knowledge. Reddy et al. (2021) reported that only 41% of South African learners acquired basic mathematics knowledge (score above 400). These results are alarming, and we investigated how bullying is associated with MA. Studies have explored socio-economic status (SES), which will be controlled for in the multi-level model, and bullying aspects related to MA, finding both to be strong predictors of learner achievement (Brännlund & Edlund, 2020; Farhangpour, Maluleke, & Mutshaeni, 2019; Muzamil & Shah, 2016; Peled, 2019; Visser, Juan, & Feza, 2015).

Rationale

Bullying in South African schools is becoming a growing concern (Govender & Young, 2018; Oshin, 2019). Although research has been conducted connecting bullying with learner achievement in mathematics, very few of these have considered the varying hierarchical levels typically found in an educational setting. Multi-level modelling 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 the current study, the

varying hierarchical levels are considered when examining how bullying in South African schools relates to MA 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

Primary research question: What is the association between traditional bullying and cyberbullying and Grade 9 MA in South African schools?

Secondary research questions:

What is the extent of traditional bullying and cyberbullying in South African high schools?

What factors related to traditional bullying and cyberbullying are associated with Grade 9 MA of Grade 9 South African learners?

Literature review

Bullying is defined as hostile, deliberate actions by individuals(s)/group(s) against a victim who can not easily defend themselves and cyberbullying has a similar definition, but it happens electronically via social networking services (SNSs) and gaming platforms (Can & Alatas, 2021). SACE, which stands for "South African Council for Educators" officially launched a handbook titled "Teachers' Safety and Security in South African Schools" in April 2021 (SACE, 2021). This handbook mentions that cyberbullying and online violence, in a South African context, includes "sending rude, offensive or insulting messages, posting cruel and hurtful rumours, sending or posting personal or embarrassing secrets online, posting online threats, hacking messaging accounts and sending fake messages, distributing naked or sexually explicit images without permission" (SACE, 2021, p. 19). Even with these clear definitions being available, researchers have shown that teachers and parents lack the ability to differentiate bullying from non-bullying, have different perceptions regarding the severity of the bullying incident and do not feel comfortable to act when such incidents occur (Campbell, Whiteford, & Hooijer, 2019; Yot-Domínguez, Guzmán Franco, & Duarte Hueros, 2019). In a study conducted in the Eastern Cape, South Africa, Cilliers and Chinyamurindi (2020) found that only two-thirds of South African student teachers had received training on cyberbullying while studying at university, indicating that sufficient training is lacking. Research on bullying and cyberbullying is growing at an exponential pace globally. Matos, Vieira, Amado, Pessoa, and Martins (2018) conducted a quantitative study involving 3,525 Grade 6, 8 and 11 learners in 23 Portuguese schools and found that 7.6% of these learners have been victimised, with the most frequent medium of bullying being websites and the most frequent type of bullying behaviour being sending offensive messages. These websites are many times SNSs, and literature has shown that there are policy gaps in SNSs that leave SNS users vulnerable to bullying (Gordon, 2021; Mutula, 2013). Ahlström (2010) conducted a study that involved 2,128 Swedish 9th-grade learners and found that schools, where learner participation was high, had lower levels of bullying. Hinduja and Patchin (2019) conducted a study in the United States (US) on 2,670 learners between the ages of 12 and 17 and found that learners that were victims of bullying were more likely to have suicidal thoughts and attempts. Cho and Lee

(2018), who also conducted a study in the US ($n = 14,627$ learners), found that learners associated with delinquent peers were more likely to be bullies and victims. In another American study, Davis et al. (2018) followed 1,875 learners over two years and found that early bullying victimisation led to many problems such as poor academic achievement and problematic drinking. Folayan, Oginni, Arowolo, and El Tantawi (2020) conducted a study on 1,001 Nigerian learners using a survey and found a significant negative correlation between self-esteem and bullying, i.e. the more a learner was bullied, the lower their self-esteem. Varela, Zimmerman, Ryan, and Stoddard (2018) used multi-level modelling on data from 8,237 Chilean Grade 7 learners to examine learner-level and school-level predictors of bullying perpetration and found significant predictors to be prior victimisation, interpersonal relationships and gender.

Within a South African context, Oshin (2019) conducted a study on mobile bullying in female learners and found that independent schools, which are typically the more affluent schools, had significantly higher levels of mobile bullying than public schools, which could be attributed to expensive mobile devices having advanced masking systems in place. In another South African study, Farhangpour, Maluleke, and Mutshaeni (2019) conducted a survey on 80 learners in a rural high school in Limpopo and found that more than half of the learners were cyberbullied, with the most frequent type being sexual offences. These scholars found these incidences negatively affected learners both emotionally and academically. Poor academic achievement is a possible outcome linked with bullying, considering the victims may lack focus and get detached from their schoolwork and academic responsibilities and feel depressed. Wang et al. (2014) used multi-level modelling and found, in their Ottawa-based Canadian study with 1,023 fifth-grade learners, that cyber-victimisation had a significant negative association with academic achievement. Torres, D'alessio, and Stolzenberg (2020) used data from 4,610 American learners aged between 12 and 18 and found that bullying negatively impacts academic performance. Muzamil and Shah (2016) analysed data from 610 Pakistani learners in Grades 9 and 10 and found that bullying negatively impacts learner achievement. In an American study, Konold, Cornell, Jia, and Malone (2018) conducted a multi-level analysis on data from 60,441 learners and 11,442 teachers and found that learner support (which included support to learners when being a victim of bullying) is associated with academic achievement. Laith (2019) used data from a longitudinal study on learners in Ontario, Canada, where 654 learners were followed annually from Grade 5 to Grade 12 and found that being bullied in Grade 7 predicted poor academic outcomes in Grade 8, experiences of peer victimisation in Grade 8 predicted poor performance and absences in Grade 9, and experiences of peer victimisation in Grade 9 predicted poor academic achievement in Grade 10, amongst many of the complex patterns of associations that they found. Anton-Erxleben, Kibriya, and Zhang (2016) used two international questionnaires (TIMSS 2011; PIRLS 2011) to look at the bullying of Grade 4 and 8 learners in Botswana, Ghana and South Africa, respectively. Their study found that around half of the learners were bullied either physically or through social media in all three African countries, which impacted their academic achievement negatively. Since all these researchers and many others have shown that bullying negatively impacts learner performance, it is important to investigate this issue, especially relating to MA, as South African learners are struggling in these subjects (Reddy et al., 2021); this article

aims to address this gap in terms of bullying prevention to improve South African learner achievement. Both traditional bullying and cyberbullying are considered here, as both occur, and the latter is increasing since COVID-19 has "forced" many schools to teach online during periods when schools were closed, even turning to the use of social media to teach, which Lubua, Semlambo, and Pretorius (2017) have pointed out is "a suitable platform for the extension of traditional classes … provided that users are aware of maintaining their safety" (p. 1).

As a final note, since South Africa is classified as an upper-middle-income economy (World Bank, n.d.) and not a high-income economy, SES is an important consideration. In the South African context, some research shows that learners are separated by SES in schools (Graham, Mokgwathi, & de Villiers, 2021; Mampane, 2014; Wills & Hofmeyr, 2019). Consequently, in high-achieving schools, the effect of SES on the level of success of learners has been identified (Mampane, 2014; Wills & Hofmeyr, 2019). This result indicates that learner background traits, such as SES, still impact academic achievement to some extent and that the concern of SES inequalities in results may differ across national boundaries. Other South African studies employing TIMSS data discovered that learners from high-SES backgrounds who spoke the test's language at home performed better in mathematics (Mensah, 2020; Visser, Juan, & Feza, 2015). Additionally, they found that SES, as measured by school infrastructure like school buildings, positively impacts learners' achievement (Mensah, 2020; Visser, Juan, & Feza, 2015). Some experts note that a school's SES has a significant impact on learner achievement (Depren & Depren, 2022; Korous, Causadias, Bradley, Luthar, & Levy, 2022; Yeung, King, Nalipay, & Cai, 2022).

Theoretical framework

Bronfenbrenner (1977)'s ecological theory was well developed during the 1970s and is still used in the 21st century. It involved five systems referred to as the "microsystem", "mesosystem", "exosystem", "macrosystem" and "chronosystem" (the "chronosystem" was only brought in, in 1994 by Bronfenbrenner and Ceci called it the bio-ecological model). In 1994, Bronfenbrenner and Ceci (1994) extended Bronfenbrenner's ecological model to create a bio-ecological model which focuses specifically on the gene-environment interactions in human development. The model proposed assessments of mechanisms called "proximal processes" to capture genetic material (Bronfenbrenner & Ceci, 1994).

The **microsystem** is the child's immediate environment, which includes the learner itself. The **mesosystem** represents the relationships and reciprocal interactions between the different microsystems. These microsystems included the learner's school, friends and the learner, which all influence the learner's holistic development. The **exosystem** "involves links between a social setting in which the individual does not have an active role and the individual's immediate context" (Christensen, 2010, p. 118). These environments could be formal institutions, such as the parents' work environment, school environment, the media, religious and judicial institutions, availability of health care and social institutions/networks. If the learner is from an economically disadvantaged home, the learner's development could be affected and accordingly, the SES was considered in the multi-level model. The **macrosystem** "describes the overall societal

culture in which individuals live. Cultural contexts include developing and industrialised countries, socioeconomic status, poverty and ethnicity" (Christensen, 2010, p. 118). We link our study to the theoretical framework in the Discussion section.

Method

Research design and participants

A quantitative design was followed, with a positivism research paradigm, as this paradigm is typically associated with quantitative research. With the positivist paradigm, there is objectivity and an absence of bias due to possible researcher influence, as we were neutral and detached from what was researched (Park, Konge, & Artino, 2020). The latter is the case in the current 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. SDA was used as research strategy, where SDA stands for "secondary data analysis" which is a research design that uses existing data to reapply and reanalyse such data to test hypotheses (Mouton, 2001). In South Africa, a total of 519 schools participated in TIMSS 2019, with 20,829 learners, 543 mathematics teachers and 519 school principals completing the TIMSS questionnaires. Items from the TIMSS 2019 student questionnaire, which learners answered, were used at learner-level/level-1, and items from the TIMSS 2019 school questionnaire, which principals answered, and from the TIMSS 2019 teacher questionnaire, which teachers answered, were used at the school-level/level-2.

Data collection, instruments and quality assurance

The data collection for TIMSS 2019 in South Africa took place in September 2018 (Cotter, Centurino, & Mullis, 2020). The TIMSS 2019 developers went through many rigorous steps in developing the TIMSS 2019 achievement instruments and ensuring the reliability and validity of their assessments; we refer readers to Cotter, Centurino, and Mullis (2020) and LaRoche, Joncas, and Foy (2020) for more details on this. For quality assurance, from our side, we conducted a Missing Value Analysis using SPSS version 27.0 and used multiple imputation (MI) to replace missing values. There are contrary views in the literature about doing this, with Sterne et al. (2009) stating that if the data is not missing at random, MI may give misleading results. However, Van Ginkel, Linting, Rippe, and Van der Voort (2020) have recently published a paper on the misconceptions about MI as a method for handling missing data and concluded that "regardless of the missingness mechanism, MI is always to be preferred over listwise deletion" (p. 302). 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

Considering the hierarchical structure of the TIMSS data, Hierarchical Level Modeling (HLM) version 7 was used to perform a multi-level analysis. The

dependent variable is MA, and TIMSS 2019 uses five plausible values for this and the HLM software uses all five plausible values in its computations. Table 1 provides a list of the predictors used in the current study, along with their response options. In the Appendix, a more detailed table is provided where the percentage per response option is provided. Note that the latter percentage is the percentage after MI was used to replace the missing values. The percentage of missing values, before MI was performed, is given below each variable name in the Appendix. A level of significance of 5% is used for all statistical analysis. Although all variables in Table 1 (except gender (BSBG01), which is binary and BSBGHER, which is continuous) are ordinal variables, they are treated as continuous variables (Robitzsch, 2020). For continuous variables, it is typical to use group centring at Level-1 (learner-level) and grand centring at Level-2 (school-level) (Raudenbush & Bryk, 2002), and this is what we have done. The reasoning for the group centring at Level-1 involves the fact that each learner is nested within different schools. The bullying behaviour

Table 1. Learner-level and school-level variables for MA.

Variable description	Response options
Learner-level/Level-1	
"Are you a girl or a boy?"*	1 = "Girl"
	2 = "Boy"
"Home educational resources"**	<8.4 "few resources"
	8.4–12.2 "some resources"
	> 12.2 "many resources"
"Said mean things about my physical appearance (e.g. my hair, my size)"	1 = "At least once a week"
"Spread lies about me"	2 = "Once or twice a month"
"Shared my secrets with others"	3 = "A few times a year"
"Refused to talk to me"	4 = "Never"
"Insulted a member of my family"	
"Stole something from me"	
"Made me do things I didn't want to do"	
"Sent me nasty or hurtful messages online"	
"Shared nasty or hurtful things about me online"	
"Shared embarrassing photos of me online"	
"Threatened me"	
"Physically hurt me"	
"Excluded me from their group (e.g. parties, messaging)"	
"Damaged something of mine on purpose"***	
School-level/Level-2	
"To what degree is each of the following a problem among students in your school? Intimidation or verbal abuse among students (including texting, emailing, etc.)"	1 = "Not a problem"
	2 = "Minor problem"
"To what degree is each of the following a problem among students in your school? Physical injury to other students"****	3 = "Moderate problem"
	4 = "Serious problem"
"Thinking about the current school, indicate the extent to which you agree or disagree with each of the following statements: This school has clear rules about student conduct"	1 = "Agree a lot"
	2 = "Agree a little"
	3 = "Disagree a little"
"Thinking about the current school, indicate the extent to which you agree or disagree with each of the following statements: This school's rules are enforced in a fair and consistent manner"*****	4 = "Disagree a lot"

* Direct quote from Trends in International Mathematics and Science Study (2018b, p. 3).
**Direct quote from Yin and Fishbein (2020, p. 16.168).
***Direct quote from Trends in International Mathematics and Science Study (2018b, p. 12).
****Direct quote from Trends in International Mathematics and Science Study (2018a, p. 7).
*****Direct quote from (Trends in International Mathematics and Science Study, 2018c, p. 3).

within a less affluent school (i.e. a school within a low-SES community) may be very different from the bullying behaviour within a more affluent school (i.e. a school within a high-SES community). Thus, we want to centre each learner's score relative to the school mean. The reason for using grand centring at Level-2 is that, by subtracting the grand mean (mean of the schools) a more representative value for the intercept is obtained.

Regarding weighting variables needed for the analysis, as per recommendations of Neuschmidt (2013), the Level-1 weight was computed using WGTFAC2*WGTADJ2*WGTFAC3*WGTADJ and the Level-2 weight was computed using WGTFAC1*WGTADJ1 where WGTFAC1, WGTADJ1, WGTFAC2, WGTADJ2, WGTFAC3 and WGTADJ3 stand for school weight factor, school weight adjustment, class weight factor, class weight adjustment, student weight factor and student weight adjustment, respectively. Regarding the only continuous variable in the model, BSBGHER is the variable that represents the learners' socio-economic background, as the "Home Educational Resources" scale was created by using learners' responses regarding three resources ("Number of books in the home", "Number of home study supports" and "Highest level of education of either parent") (Yin & Fishbein, 2020, p. 16.168).

Results

The null model without any variables was created to show the variance (var) between the schools. For the mathematics model, Table 2 shows the var at learner-level is 3065.75, which represents 50.2% of the total var. The var at school-level is 3036.78, representing 49.8% of the total var. Further, the var at school-level is significantly different from zero ($p<0.001$), which means MA varied significantly across schools. The null model provided an intraclass correlation coefficient of 0.498, indicating that 49.8% of the variance is between the schools.

After creating the null model, a full model is created where all the predictors and the mathematics scores are entered into the model. The final model (also referred to as the parsimonious model) was created by removing all insignificant variables one at a time from the full model until only significant variables remained. Table 3 shows the results of the parsimonious model for MA.

The var at the learner-level is 2838.66, which signifies 48.9% of the total var. The var at the school-level is 2961.87 that represents 51.1% of the total var, which is statistically

Table 2. Null model for MA.

Random Effect	var	df	Chi-square	p
INTRCPT1, u0	3036.75	518	20676.96	<0.001
Level-1, r	3065.78			

Table 3. Parsimonious model for MA.

Random Effect	var	df	Chi-square	p
INTERCPT, u0	2961.87	517	21728.93	<0.001
LEVEL-1	2838.66			

significant ($p<0.001$). The average reliability estimate was 0.978, indicating that sample averages reflected the true school means. The null model was used as a baseline to compute the percentage reduction in *var*. By comparing the *var* components of the parsimonious model to those of the null model, the percentage reduction in the *var* at the learner-level was 7.4%. The percentage reduction at the school-level was 2.5%. Table 4 provides the information on the significant predictors for the parsimonious model for MA.

Table 4. Significant predictors of the parsimonious model for MA.

Variable description	Response options	Coefficient	Standard Error	t	p
Intercept		377.68	4.27	88.44	<0.001
Level-1 learner-level					
"Are you a girl or a boy?"	1 = "Girl"	2.24	1.23	1.82	0.076
	2 = "Boy"				
"Home educational resources"	Scale/continuous	1.15	0.43	2.63	0.011
	< 8.4 few resources				
	8.4–12.2 some resources				
	> 12.2 many resources				
"Said mean things about my physical appearance (e.g. my hair, my size)" (TIMSS, 2018b, p. 12)	1 = "At least once a week"	−1.64	.052	−3.17	0.002
"Refused to talk to me" (TIMSS, 2018b, p. 12)	2 = "Once or twice a month"	1.67	0.52	3.22	0.001
"Insulted a member of my family" (TIMSS, 2018b, p. 12)	3 = "A few times a year"	3.44	0.54	6.31	<0.001
"Stole something from me" (TIMSS, 2018b, p. 12)	4 = "Never"	−6.54	0.58	−12.88	<0.001
"Made me do things I didn't want to do" (TIMSS, 2018b, p. 12)		2.76	0.87	3.15	0.008
"Sent me nasty or hurtful messages online" (TIMSS, 2018b, p. 12)		2.49	0.78	3.16	0.002
"Shared nasty or hurtful things about me online" (TIMSS, 2018b, p. 12)		3.63	0.82	4.47	<0.001
"Shared embarrassing photos of me online" (TIMSS, 2018b, p. 12)		6.49	1.12	5.78	<0.001
"Physically hurt me" (TIMSS, 2018b, p. 12)		3.75	0.72	5.22	<0.001
Level 2 school-level					
"Physical injury to other students" (TIMSS, 2018a, p. 7)	1 = "Not a problem"	−11.62	4.92	−2.36	0.018
	2 = "Minor problem"				
	3 = "Moderate problem"				
	4 = "Serious problem"				

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

- Although gender is not a significant predictor of MA ($p = 0.076$), it was is included in the parsimonious model to control for gender.
- SES was included in the model as a control variable. The results show that learners with more home educational resources ($ß = 1.15$, $p = 0.011$) achieved higher mathematics results than learners with fewer home educational resources.

Predictors – unsurprising results:

- For learners where BSBG14D "refused to talk to me" ($ß = 1.67$, $p = 0.001$), BSBG14E "insulted a member of my family" ($ß = 3.44$, $p<0.001$), BSBG14 G "made me do things I didn't want to do" ($ß = 2.76$, $p = 0.008$), BSBG14 H "sent me nasty or hurtful messages online" ($ß = 2.49$, $p = 0.002$), BSBG14I "shared nasty or hurtful things about me online" ($ß = 3.63$, $p<0.001$), BSBG14J "shared embarrassing photos of my online" ($ß = 6.49$, $p<0.001$), and BSBG14 L "physically hurt me" ($ß = 3.75$, $p<0.001$) happened less frequently achieved higher mathematics scores than learners where these things happen more frequently.

Predictors – Surprising results:

- The relationship between BSBG14A "said mean things about my physical appearance (e.g. my hair, my size)" and MA was significant ($ß = −1.64$, $p = 0.002$), indicating for every unit increase in BSBG14A, with an increase in this variable indicating it is happening less frequently, MA decreased on average by 1.64. This surprising finding could be attributed to the normalisation of obesity in South African schools as Bosire et al. (2020) points out that, "South Africa's obesity epidemic has increased in both children and adults" (p. 1515) over the past decade so much so that being obese is becoming the norm. Since BSBG14A is about physical appearance and specifically mentions size as an example, the exponential growth in obese South African children may have skewed the results.
- The relationship between BSBG14F "stole something from me" and MA was significant ($ß = −6.54$, $p<0.001$), indicating for every unit increase in BSBG14F, with an increase in this variable indicating it is happening less frequently, MA decreased on average by 6.54. A possible explanation for this surprising finding could be that "stole something from me" can be interpreted in many different ways. Some learners might have felt that a pencil or an eraser going missing counts as theft, whereas others could have interpreted it as relating only to bigger items such as calculators or textbooks. In the next cycle of TIMSS, a suggestion is that the International Association for the Evaluation of Educational Achievement (IEA) change the question's wording to "stole something of value from me".
- We would not have found these surprising findings if we had used the bullying scale created by TIMSS by averaging over BSBG14A to BSBG14N. It's also of interest to note that some of the items in the bullying scale of TIMSS 2019 were

not found to be significant predictors (BSBG14B "Spread lies about me", BSBG14C "Shared my secrets with others", BSBG14K "Threatened me", BSBG14 M "Excluded me from their group (e.g. parties, messaging)", BSBG14N "Damaged something of mine on purpose"). This finding would also have been missed if we had simply used the TIMSS bullying scale.

Level-2/school-level:

- The relationship between BCBG16I "physical injury to other students" and MA was significant ($ß = -11.62$, $p = 0.018$) indicating for every unit increase in BCBG16I, with an increase in this variable indicating the severity of the problem is increasing, MA decreased on average by 11.62.

Discussion

The multi-level analysis using HLM software showed that, at level-1, which links to the micro- and mesosystem of Bronfenbrenner's ecological framework, refusing to talk to learners, insulting their families, making them do things they didn't want to do, sending nasty or hurtful messages online, sharing nasty or hurtful things about and embarrassing photos of them online, physically hurting them, saying mean things about their physical appearance and stealing from them were significant predictors of Grade 9 learner MA, respectively. It was unexpected to find that students who were told derogatory comments about their physical appearance less frequently had significantly worse grades than those who were told such things more frequently. This unexpected result may be attributable to the fact that the variable specifically lists "my size" as an example of physical appearance that relates to the normalisation of obesity in South Africa (Bosire et al., 2020); thus, the exponential growth in obese South African children may have skewed the results. Another surprise conclusion was that students who reported being stolen from less frequently had considerably worse achievement than those who reported being stolen from more frequently. This startling conclusion could be explained by the fact that "took something from me" can be construed in numerous ways. Some learners may have believed that a missing pencil or eraser constitutes theft, while others may have taken it as referring primarily to larger objects such as calculators or textbooks. At level-2, school environment in the form of physical injury to other learners being a problem is a significant predictor for MA, which links to the exosystem of Bronfenbrenner's ecological framework. SES, which also links to the exosystem, was also found to be a significant predictor of MA. These findings are not surprising, as many researchers have shown that bullying and poor SES negatively impact learner achievement (Anton-Erxleben, Kibriya, & Zhang, 2016; Farhangpour, Maluleke, & Mutshaeni, 2019; Muzamil & Shah, 2016; Torres, D'alessio, & Stolzenberg, 2020; Wang et al., 2014).

Limitations

TIMSS is an International Large-Scale Assessment (ILSA). Although there are clear benefits to ILSAs, such as fostering interdisciplinary and international collaboration and providing

information on processes and contexts of education (Torney-Purta & Amadeo, 2013), Klemenčič and Mirazchiyski (2018) have pointed out the following limitations: "(1) ranking is relative to the other participating educational systems; (2) significant differences between the ranked systems are often insufficient; (3) the role of contextual factors related to student achievement is disregarded; (4) single number estimates are not representative of the whole spectrum of the distribution; and (5) non-cognitive (personality, psychological) aspects are ignored" (p. 321).

Conclusion and recommendations

A recommendation is that TIMSS add more cyberbullying items to the questionnaires, specifically in the teachers' and schools' questionnaires, as only one level-2 variable was found to be a significant predictor for MA. Although TIMSS focuses on bullying (and even has a bullying scale), there are very limited cyberbullying items.

Learners must be reminded that there are clear policies that punish perpetrators of bullying, including bullying. This recommendation is based on the finding that although policies are in place, bullying still occurs in South African schools. Another recommendation is to share information and data. To allow for evidence-based comprehensive school safety policy development (that covers traditional bullying and cyberbullying), it is essential that data and findings on safety and security, but especially on bullying, be shared between provinces, governments, stakeholders and schools. Our findings may also point to a role for community and the media to raise awareness about the consequences of bullying; again, pointing to the sharing of data. This recommendation of creating awareness around cyberbullying is in line with that of the literature where Cilliers and Chinyamurindi (2020), who conducted a study on cyberbullying in the Eastern Cape, found that more than 90% of their respondents felt that the Department of Basic Education should do more to promote awareness about cyberbullying. The hope is that this research will contribute to the ongoing debate about bullying in South African schools.

Since e-Learning has been "forced" upon us due to COVID-19, we urge the inclusion of cyber-safety and cyber-protection strategies in all student-teachers training. Without preventative measures to contest bullying, cyber-technology meant to assist learners during COVID (when South African schools have been closed for many months) might harm them.

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Disclosure statement

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Notes on contributor

Marien Alet Graham is a full professor at the University of Pretoria, South Africa. Her research is focused on generating a more detailed understanding of how learning and assessment opportunities for students at all levels of the formal education system (early learning, primary, secondary and tertiary) and their overall mental health and well-being can be improved.

Authors' contributions

M.A. Graham is the sole author of this publication and has done everything (write-up and data analysis).

Authors' information

From the start of her career, Prof. Marien Graham focused on developing new statistical techniques, specifically in the research area of statistical quality/process control. In the last few years, she has deepened that focus to generate a more detailed understanding of how learning and assessment opportunities for students at all levels of the formal education system (early learning, primary, secondary and tertiary) and their overall mental health and well-being can be improved. She uses sophisticated, novel statistical techniques to inform that understanding. She is a Full Professor at the University of Pretoria and has contributed to many fields, including education, healthcare, social issues, and agroforestry. She holds a doctoral degree in mathematical statistics from the University of Pretoria and is a Y1-rated researcher with the National Research Foundation (NRF), South Africa. Prof Graham is a co-author of the John Wiley & Sons book *Nonparametric Statistical Process Control* (2019) and also serves on the editorial advisory board of *Scientific Studies and Research, Series Mathematics and Informatics*. She has published nearly 100 articles in peer-reviewed journals and regularly presents her findings at national and international conferences.

Ethics approval and consent to participate

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, Foy, & Yin, 2021).
Fishbein, Foy, and Yin (2021). *TIMSS 2019 User Guide for the International Database*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls. bc.edu/timss2019/international-database/

Consent for publication

There is only one author (M.A. Graham), and I (M.A. Graham) give consent that this manuscript may be published.

Availability of data and materials

Datasets are available at: IEA TIMSS & PIRLS International Study Center repository (https:// timssandpirls.bc.edu/)

Geolocation information

All nine provinces in South Africa participated in TIMSS 2019.

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Appendix: Detailed predictor information

Learner-level and school-level variables for MA

Variable name	Variable description	Response options and percentage
Learner-level/Level-1		
BSBG01 (0.2%)	"Are you a girl or a boy?" (TIMSS, 2018b, p. 3)	1 = "Girl" (52.0%) 2 = "Boy" (48.0%)
BSBGHER (1.0%)	"Home educational resources" (Yin & Fishbein, 2020, p. 16.168)	Scale/continuous < 8.4 few resources (35.0%) 8.4–12.2 some resources (62.5%) > 12.2 many resources (2.5%)
BSBG14A (2.2%)	"Said mean things about my physical appearance (e.g. my hair, my size)" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (28.4%) 2 = "Once or twice a month" (17.3%) 3 = "A few times a year" (21.2%) 4 = "Never" (33.1%)
BSBG14B (2.1%)	"Spread lies about me" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (16.5%) 2 = "Once or twice a month" (19.5%) 3 = "A few times a year" (24.6%) 4 = "Never" (39.4%)
BSBG14C (2.4%)	"Shared my secrets with others" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (14.8%) 2 = "Once or twice a month" (14.1%) 3 = "A few times a year" (18.0%) 4 = "Never" (53.2%)
BSBG14D (2.5%)	"Refused to talk to me" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (19.8%) 2 = "Once or twice a month" (15.0%) 3 = "A few times a year" (17.0%) 4 = "Never" (48.2%)
BSBG14E (2.7%)	"Insulted a member of my family" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (14.8%) 2 = "Once or twice a month" (10.9%) 3 = "A few times a year" (14.3%) 4 = "Never" (60.0%)
BSBG14F (1.9%)	"Stole something from me" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (30.5%) 2 = "Once or twice a month" (20.4%) 3 = "A few times a year" (21.7%) 4 = "Never" (27.3%)

(*Continued*)

(Continued).

Variable name	Variable description	Response options and percentage
BSBG14 G (1.9%)	"Made me do things I didn't want to do" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (10.8%) 2 = "Once or twice a month" (12.3%) 3 = "A few times a year" (15.1%) 4 = "Never" (61.8%)
BSBG14 H (1.9%)	"Sent me nasty or hurtful messages online" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (10.4%) 2 = "Once or twice a month" (10.3%) 3 = "A few times a year" (14.0%) 4 = "Never" (65.3%)
BSBG14I (2.2%)	"Shared nasty or hurtful things about me online" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (8.1%) 2 = "Once or twice a month" (9.8%) 3 = "A few times a year" (12.2%) 4 = "Never" (69.9%)
BSBG14J (2.3%)	"Shared embarrassing photos of me online" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (5.8%) 2 = "Once or twice a month" (6.0%) 3 = "A few times a year" (8.2%) 4 = "Never" (79.9%)
BSBG14K (2.9%)	"Threatened me" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (10.6%) 2 = "Once or twice a month" (10.5%) 3 = "A few times a year" (17.6%) 4 = "Never" (61.2%)
BSBG14 L (2.9%)	"Physically hurt me" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (10.7%) 2 = "Once or twice a month" (10.9%) 3 = "A few times a year" (17.2%) 4 = "Never" (61.2%)
BSBG14 M (2.2%)	"Excluded me from their group (e.g. parties, messaging)" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (12.1%) 2 = "Once or twice a month" (13.1%) 3 = "A few times a year" (17.8%) 4 = "Never" (57.0%)
BSBG14N (1.8%)	"Damaged something of mine on purpose" (TIMSS, 2018b, p. 12)	1 = "At least once a week" (13.8%) 2 = "Once or twice a month" (13.6%) 3 = "A few times a year" (20.4%) 4 = "Never" (52.2%)

(*Continued*)

(Continued).

Variable name	Variable description	Response options and percentage
School-level/Level-2		
BCBG16 H (1.3%)	"To what degree is each of the following a problem among students in your school? Intimidation or verbal abuse among students (including texting, emailing, etc.)" (TIMSS, 2018a, p. 7)	1 = "Not a problem" (15.3%) 2 = "Minor problem" (40.7%) 3 = "Moderate problem" (28.4%) 4 = "Serious problem" (15.6%)
BCBG16I (1.4%)	"To what degree is each of the following a problem among students in your school? Physical injury to other students" (TIMSS, 2018a, p. 7)	1 = "Not a problem" (15.3%) 2 = "Minor problem" (40.7%) 3 = "Moderate problem" (28.4%) 4 = "Serious problem" (15.6%)
BTBG07 G (0.7%)	"Thinking about the current school, indicate the extent to which you agree or disagree with each of the following statements: This school has clear rules about student conduct" (TIMSS, 2018c, p. 3)	1 = "Agree a lot" (57.0%) 2 = "Agree a little" (33.5%) 3 = "Disagree a little" (7.5%) 4 = "Disagree a lot" (1.9%)
BTBG07 H (0.7%)	"Thinking about the current school, indicate the extent to which you agree or disagree with each of the following statements: This school's rules are enforced in a fair and consistent manner" (TIMSS, 2018c, p. 3)	1 = "Agree a lot" (44.5%) 2 = "Agree a little" (38.6%) 3 = "Disagree a little" (13.0%) 4 = "Disagree a lot" (4.0%)