Chapter #32

BULLYING AS DRIVER OF LOW MATHEMATICS AND SCIENCE ACHIEVEMENT IN SOUTH AFRICAN SCHOOLS IN A CHALLENGED CONTEXT

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ABSTRACT
All children deserve safe, decent schooling; but school bullying dominates South African news. We used Bronfenbrenner's ecological theory to examine bullying and Grade 9 math and science achievement in public schools without tuition. We used a quantitative positivist approach using TIMSS 2019 data to develop multi-level models, each with 20 predictors and maths and science achievement as the outcomes. Unsurprisingly, learners who were refused to talk to, had their family insulted, forced to do things they didn't want to do, shared nasty or hurtful messages or embarrassing photos about them online and were physically hurt, performed significantly worse. Principals' views on learner intimidation and verbal abuse were significant predictors. Surprisingly, learners who reported being stolen from significantly outperformed those who reported being stolen from less or not at all. This seems counterintuitive, but we offer some explanations. In the maths model only, learners who had mean things said about their physical appearance outperformed those who had this happen less often, and in the science model only, learners who had lies spread about them significantly outperformed those who did not (again, we provide suggestions for these counterintuitive results). Recommendations are provided for future research.

Keywords: bullying, mathematics achievement, science achievement, TIMSS, socio-economic status, challenged context.

1. INTRODUCTION

Bullying in childhood and adolescence, whether as bullies, victims, or spectators, has long-term effects, including negative behaviour, mental health disorders, financial concerns, low psychological well-being, low social adjustment, coping difficulties, psychological distress, and suicide risk (Xue, Hu, Chai, Han, & Sun, 2022; Yosep, Hikmat, Mardhiyah, Hazmi, & Hernawaty, 2022) and poor academic achievement (Dias-Viana, Noronha, & Valentini, 2023; Tiauzon & Malquisto, 2019). We link traditional and cyberbullying to mathematics achievement (MA) and science achievement (SA), as the Trends in International Mathematics and Science Study (TIMSS) 2019 results indicated poor results for these important subjects for South African learners. TIMSS studies are undertaken at the fourth and eighth-grade levels, but due to poor performance, South Africa conducted it at fifth and ninth-grade levels (Reddy et al., 2015); this study considers the latter. At Grade 9 level, 39 countries participated, and South Africa was second to last in MA and last in SA (Reddy et al., 2021). These results are alarming, and we investigated how bullying is associated with MA and SA and discussed implications for researchers, such as suggestions for future bullying intervention programs.

2. RATIONALE

The 2022 UNICEF "Disrupting Harm Study" found that 70% of South African children engage in risky online behaviour, such as cyberbullying, without parental consent. Bullying has been linked to learner MA and SA, but few studies have considered the hierarchical levels of an educational setting, such as the learner-level and the school-level (Woltman, Feldstain, MacKay, & Rocchi, 2012), and, to the best of our knowledge, no such study has been done on South African learners in disadvantaged communities. Low-SES learners were chosen because South African education literature shows that they are bullied more often (Johansson, Myrberg, & Toropova, 2022). It is hypothesised that South African learners in poor communities in less-researched environments (Global South) who are bullied in traditional or online means perform worse in math and science. We also considered bullying interventions, because of the uniqueness of South African no-fee-paying schools in poor communities, instead of simply employing generic bullying interventions, targeted interventions must be used to address specific problem areas. Thus, the current study contributes to the literature on resilience, bullying, and school interventions for underserved youth by recommending targeted interventions to improve MA and SA in low-SES South African schools.

3. LITERATURE AND FRAMEWORK

3.1. Literature Review

Bullying and its impact on learners' academic achievement has been the subject of extensive global research conducted in numerous countries and diverse educational settings over many years. Tiauzon and Malquisto (2019) conducted a study in the Philippines using 1,000 Grade 7 learners and found a negative association between achievement and bullying. Djunaid, Puluhulawa, and Yusuf (2019) conducted a study in Indonesia using data from 68 learners and found that bullying and achievement were significantly associated. Samara Da Silva Nascimento, El-Asam, Hammuda, and Khattab (2021) conducted a systematic review and a meta-analysis to address the question "How can bullying victimization lead to lower academic achievement?" (p. 1) using literature between January 2000 and January 2020 by considering mediating factors between bullying and academic achievement. They specifically focused on cognitive-motivational factors (e.g., self-concept and self-esteem) and found that bullying victimisation was negatively related to cognitive-motivational factors which, in turn, was associated with poorer academic achievement. In the next year, Laith and Vaillancourt (2022) published a review paper on the literature on relationships between bullying victimisation, academic achievement and school attendance, with a specific focus on longitudinal studies, and concluded that far more longitudinal studies need to be conducted to fully understand the complex patterns of associations between these three factors, but that, overall, bullying victimization can function as both antecedent and consequence of poor academic achievement and engagement. More recently, Dias-Viana et al. (2023) used data from 428 Brazilian learners and found a direct significant effect between being bullied and performance. The further mediation analysis revealed that the influence of being bullied on MA was entirely mediated by positive emotions experienced at school. Graham (2023) conducted a secondary study of South African Grade 9 TIMSS 2019 data to test for a significant association between bullying and MA. The multi-level analysis revealed that certain bullying behaviours, such as learners refusing to engage in conversation with other learners, insulting their families, coercing them into activities against their will, sending

hurtful messages or sharing embarrassing photos of them online, inflicting physical harm, making derogatory comments about their physical appearance and causing physical harm to other learners, were all significantly associated with MA.

Many studies focus on reducing or eliminating bullying in schools altogether; however, many of the recommended interventions are expensive and unrealistic to implement for schools in economically disadvantaged areas. It may be argued that the government can pay for these interventions; however, government funding is limited, and for some of these interventions, it's not as simple as reimbursing, say, a specialist for their time spent on presenting a workshop as some interventions include the printing of material and the need to purchase specialised gear (e.g., karate clothes). Examples of interventions where materials must be printed are, for example, the social cognitive theory (SCT)-based intervention (Salimi et al., 2019) which involves providing education about bullying. This study was conducted in elementary schools in deprived and semi-deprived areas of Kermanshah City, west of Iran, and was based on socio-cultural characteristics that focused on the SCT theory to reduce and potentially eliminate bullying in schools. Salimi et al. (2019) carried out four training sessions over six weeks with learners, four 20-minute sessions and one 90-minute session with school personnel and parents, and materials, which included "a booklet, two posters, texts and messages for speech, and five scenarios of role- playing" (Salimi et al., 2019, p. 3) had to be created and printed. Another example of where there are printing costs are problematic is the study by Scott, Wang and Cheong (2023), who focused on low-SES Latinx learners, where an intervention was employed using bibliotherapy as a means to enhance learners' capacity to recognise instances of bullying, interpret such situations as emergencies, and cultivate greater empathy towards the victims, thus fostering a greater willingness to intervene. Examples of interventions where specialised gear must be purchased include sports-based mental health interventions using karate (Greco, Fischetti, Cataldi, & Latino, 2019) and martial arts, meditation, breathing exercises and stretching activities (Moore, Woodcock, & Dudley, 2019); all activities that have shown to increase resilience and self-efficacy. Greco et al. (2019) held a 12-week karate-based intervention in Italy that consisted of 25 learners doing karate for one hour once per week. Moore et al. (2019) conducted a study in Australia where 282 participants participated in ten 50-minute sessions once per week for 10 weeks, that involved martial arts, meditation, breathing exercises and stretching activities. Although both studies had successful outcomes, it should be noted that Greco et al. (2019) conducted their study with learners whose SES is reported as high average, and the SES for the participants in Moore et al.'s (2019) study were low to low-average (45.1%) and high-average to high (54.9%); thus, the majority being from the higher SES side.

As mentioned above, bullying leads to poor academic performance, and many bullying prevention interventions are expensive and may not be feasible for South African no-fee-paying schools in disadvantaged areas, which cannot collect fees or raise funds (Dass & Rinquest, 2017).

3.2. Theoretical Framework

The systems of Bronfenbrenner's (1977) ecological theory are: the "microsystem" (the learner), the "mesosystem" (the connection between the learner's microsystem, e.g., the learner and their friends), the "exosystem" (formal institutions, such as the parents' work and school environments), and the "macrosystem" (the learners' societal culture, e.g., SES and ethnicity). Multi-level models are considered ideal for analysing school data due to the nested structure inherent in educational settings where students are nested within classrooms, classrooms within schools, etc. Accordingly, multi-level modeling was used in this study

with learner-level and school-level variables, with the learner-level variables speaking to Bronfenbrenner's micro- and mesosystems (e.g., the learner and relationships between learners), and the school-level variables speaking to the exo- and macrosystems (e.g., the school environment, which of course, is tied to learners' societal culture as the latter encompasses the shared values, beliefs, norms, and practices of a society, and these elements significantly influence the educational system). In essence, this study recognises the holistic nature of Bronfenbrenner's ecological theory, emphasising that all its systems - microsystem, mesosystem, exosystem, and macrosystem - should be duly considered to comprehensively address the research question at hand.

4. METHOD

4.1. Research Design and Participants

A quantitative, secondary data analysis using TIMSS 2019 data was utilised, and only the data from non-fee-paying schools were used. The South African school funding model has five Quintiles (Q) 1–5 schools. These Q's determine government school funding. Top- Q's (Q4-Q5) charge tuition, while bottom-Q's (Q1-Q3) are free. Q1 are in the poorest neighbourhoods, whereas Q5 are in the wealthiest. No-fee schools receive all their money from the government and cannot charge fees. However, fee-paying institutions can raise funds and regulate operating revenue (Dass & Rinquest, 2017). The TIMSS 2019 learner questionnaire, which learners answered, was used at learner-level/level-1/L1), and the principal and teacher questionnaires, which principals and teachers answered, were used at school-level/level-2/L2.

4.2. Data Collection and Quality Assurance

South Africa's TIMSS 2019 data collection occurred in September 2018 (Cotter, Centurino, & Mullis, 2020). We recommend readers to Cotter et al. (2020) and LaRoche, Joncas and Foy (2020) for information regarding the rigour (e.g., reliability and validity) with which the TIMSS 2019 developers developed the TIMSS 2019 instruments.

4.3. Data Analysis

SPSSv.28.0 was used to replace missing values using multiple imputation (recommendation: Van Ginkel, Linting, Rippe, & Van der Voort, 2020), and HLMv.7 was used for multi-level analysis. The dependent variable is achievement (MA for the mathematics model and SA for the science model); the HLM software uses all five plausible achievement values. The predictors used at L1 were 14 bullying items: those in boldface in Tables 3 and 4 plus "Shared my secrets with others", "Threatened me", "Excluded me from their group (e.g., parties, messaging)", and "Damaged something of mine on purpose" TIMSS (2018a, p. 12). At L2, the principals had to indicate the severity of the problems: "Intimidation or verbal abuse among students (including texting, emailing, etc.)" and "Physical injury to other students" (TIMSS, 2018b, p. 7). Teachers had to indicate their level of agreement: "This school has clear rules about student conduct" and "This school's rules are enforced in a fair and consistent manner" (TIMSS, 2018c, p. 3).

As in many studies, gender and SES were controlled for in the L1 model (Graham, 2022; Xue et al., 2022). SES was controlled for since, though the focus of this study is on schools in a challenged context, there are substantive financial differences between the quintiles in terms of the funding they receive from the government, as Q1 (poorest) receives the highest allocation per learner, Q2 receives less and Q3 even less. All the predictors are

ordinal (except the control variables, gender (binary) and home educational resources (continuous)) and were treated as continuous variables (Robitzsch, 2020). For continuous variables, it is typical to use group centring at L1 and grand centring at L2 (Raudenbush & Bryk, 2002), and this is what we have done. Variable weighting was done as per the recommendations of Stancel-Piątak et al. (2013).

5. RESULTS

The null models without any variables were created to show the variance (var) between the schools (Table 1). The var at L2 is significantly different from zero ($p<0.001$) for both models, indicating significant achievement variation between schools.

Table 1.
Null models.

		var	*df*	χ^2	*p*
Mathematics	L2, intercept	733.83	279	3,801.13	<0.001
	L1, slope	3,061.58			
Statistics	L2, intercept	1,414.91	279	4,208.85	<0.001
	L1, slope	5,481.14			

After creating the null models, full models were created where all the predictors, control variables and achievement scores were entered. The final models were created by removing all insignificant predictors one at a time from the full model until only significant predictors remained (Table 2).

Table 2.
Final models.

		var	*df*	χ^2	*p*
Mathematics	L2, intercept	716.80	278	4,201.35	<0.001
	L1, slope	2,770.60			
Statistics	L2, intercept	1,369.99	278	4,945.16	<0.001
	L1, slope	4,589.78			

Table 2 reveals that L2 significantly differs from zero ($p<0.001$) for both models, indicating significant achievement variation between schools. By comparing the var components of the final models to those of the null model, the percentage reduction in the var at L1 was 9.5%, for L2 was 2.3% for the maths model and 16.3% (L1) and 3.2% (L2) for the science model. Tables 3 and 4 provide information on the significant predictors for MA and SA.

Table 3.
Significant predictors of MA.

Variable description	Response options	Coefficient	Standard Error	*t*	p
Intercept		357.70	2.41	148.62	<0.001*
	L1				
"Are you a girl or a boy?" TIMSS (2018a, p. 3)	1="Girl" 2="Boy"	1.38	1.32	1.03	0.312
"Home educational resources" Yin and Fishbein (2020, p. 16.168)	<8.4 "few resources" 8.4–12.2 "some resources" >12.2 "many resources"	0.34	0.44	0.78	0.444
"Said mean things about my physical appearance (e.g., my hair, my size)"	1="At least once a week" 2="Once or twice a month" 3="A few times a year" 4="Never"	-1.58	0.50	-3.16	0.003*
"Refused to talk to me"		1.73	0.49	3.49	0.001*
"Insulted a member of my family"		4.10	0.52	7.86	<0.001*
"Stole something from me"		-7.01	0.51	-13.63	<0.001*
"Made me do things I didn't want to do"		2.67	0.76	3.49	0.004*
"Sent me nasty or hurtful messages online"		1.61	0.65	2.52	0.014*
"Shared nasty or hurtful things about me online"		4.53	0.75	6.04	<0.001*
"Shared embarrassing photos of me online"		7.25	0.92	7.82	<0.001*
"Physically hurt me" TIMSS (2018a, p. 12)		3.59	0.78	4.62	0.001*
	L2				
"Intimidation or verbal abuse among students (including texting, emailing, etc.)" (TIMSS, 2018b, p. 7)	1="Not a problem" 2="Minor problem" 3="Moderate problem" 4="Serious problem"	7.09	1.76	4.02	<0.001*

*$p<0.05$

Unsurprising results:

L1: For learners who "refused to talk to me", "insulted a member of my family", "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 my online" and "physically hurt me", since all ß's positive and all $p<0.05$, those where these things happened to less frequently achieved higher scores than learners where these things happen more frequently.

Surprising results:

L1: The relationship between "said mean things about my physical appearance (e.g., my hair, my size)" and MA was significant (ß=-1.58, $p=0.003$), indicating for every unit increase in the predictor, with an increase indicating mean things being said happens less frequently, MA decreased on average by 1.58.

L1: The relationship between "stole something from me" and MA was significant (ß=- 7.01, $p<0.001$), indicating for every unit increase in this predictor, with an increase indicating it is happening less frequently, MA decreased on average by 7.01.

L2: The relationship between "Intimidation or verbal abuse among students (including texting, emailing, etc.)" and MA was significant (ß=7.09, $p<0.001$) indicating for every unit increase in this predictor, with an increase indicating the beliefs of the principals that the level of severity of the problem is a serious one, MA increased on average by 7.09.

Table 4.
Significant predictors of SA.

Variable description	Response options	Coefficient	Standard Error	*t*	*p*
Intercept		323.37	3.87	83.66	<0.001*
	L1				
"Are you a girl or a boy?" TIMSS (2018a, p. 3)	1="Girl" 2="Boy"	-0.21	1.72	-0.12	0.902
"Home educational resources" Yin and Fishbein (2020, p. 16.168)	<8.4 "few resources" 8.4–12.2 "some resources" >12.2 "many resources"	1.72	0.71	2.40	0.022*
"Spread lies about me"	1="At least once a week" 2="Once or twice a month" 3="A few times a year" 4="Never"	-2.58	0.77	-3.35	0.001*
"Refused to talk to me"		4.12	1.12	3.69	0.004*
"Insulted a member of my family"		6.56	0.90	7.29	<0.001*
"Stole something from me"		-9.69	0.86	-11.28	<0.001*
"Made me do things I didn't want to do"		4.73	1.13	4.21	<0.001*
"Sent me nasty or hurtful messages online"		3.63	1.16	3.12	0.003*
"Shared nasty or hurtful things about me online"		8.96	1.09	8.19	<0.001*
"Shared embarrassing photos of me online"		12.39	1.11	11.17	<0.001*
"Physically hurt me" TIMSS (2018a, p. 12)		4.86	1.05	4.59	<0.001*
	L2				
"Intimidation or verbal abuse among students (including texting, emailing, etc.)" (TIMSS, 2018b, p. 7)	1="Not a problem" 2="Minor problem" 3="Moderate problem" 4="Serious problem"	11.50	4.36	2.64	0.009*

*p<0.05

Unsurprising results:

L1: For learners who "refused to talk to me", "insulted a member of my family", "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 my online" and "physically hurt me" happened less frequently achieved higher SA than learners where these things happen more frequently (since all ß's positive and all p<0.05).

Surprising results:

L1: The relationship between "spread lies about me", and SA was significant (ß=- 2.58, p=0.001), indicating for every unit increase in lying, with an increase in this variable indicating it is happening less frequently, SA decreased on average by 2.58.

L1: The relationship between "stole something from me" and maths achievement was significant (ß=-9.69, p<0.001), indicating for every unit increase in stealing, with an increase in this variable indicating it is happening less frequently, SA decreased on average by 9.69.

L2: The relationship between "Intimidation or verbal abuse among students (including texting, emailing, etc.)" and SA was significant (ß=11.50, p=0.009), indicating for every unit increase in intimidation/verbal abuse, with an increase in this variable indicating the beliefs of the principals that the level of severity of the problem is a serious one, SA increased on average by 11.50.

6. DISCUSSION

At L1, which links to Bronfenbrenner's micro- and mesosystem, refusing to talk to learners, insulting their families, forcing them to do things they didn't want to do, sharing nasty or hurtful messages or 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 MA and SA. Unexpectedly, the mathematics model revealed that learners who heard negative remarks about their physical appearance less frequently had much lower grades than those who heard such remarks more frequently. This surprising result could be attributed to the normalisation of obesity in South African schools, especially in economically disadvantaged areas as recent studies, for example, Verduci, Di Profio, Fiore, and Zuccotti (2022) pointed out that the prevalence of obesity in South African girls aged 10 to 19 years who eat lunch outside the home (typically at the school), is 60.2%. Many South African schools in economically disadvantaged areas provide lunch for learners (Ismail, Mda, & Mashiyi, 2022). Other recent studies on obesity in South African low-SES schools also emphasise the rising levels of obesity (Long et al., 2022; Seabi et al., 2021) and being obese has even been described as "normalised" among South Africa's urban poor (Day, Gray, Padayachee, & Cois, 2020, p. 252). This predictor is about physical appearance, including size; therefore, the exponential increase in obese South African youngsters may have distorted the results. For science, it was unexpected to find that learners who have had lies spread about them less frequently had significantly worse grades than those where lies spread more frequently. This result may be attributed to the resilient nature of South African learners in challenged contexts (Bandeira, Graham, & Ebersöhn, 2023; Theron, Ungar, & Höltge, 2022).

For both models, another surprising result was that learners who reported being stolen from less frequently had considerably worse achievement than their counterparts. This startling conclusion could be explained by the fact that "stole 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 considered it primarily referring to larger objects such as calculators or textbooks. In the following cycle of TIMSS, it is suggested that the question's wording be changed to "stole anything of value from me". This suggestion is made, as researchers have noted that theft in South African schools is common (Obadire & Sinthumule, 2021) and that theft of small items, such as another child's lunch, is not uncommon (Mahabeer, 2020).

At L2, for both models, school environment in the form of intimidation or verbal abuse among learners being a problem is a significant predictor for MA and SA, which links to the exosystem of Bronfenbrenner's framework. The results showed that for learners in schools where principals felt that the severity of the problem was serious, both MA and SA increased. This surprising conclusion may be attributed to South African learners' resilience in challenging situations, according to Theron et al. (2022). We would not have found these startling results if we had employed the TIMSS bullying scale by averaging the bullying items. 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 ("Said mean things about my physical appearance (e.g., my hair, my size)" (SA only), "Spread lies about me" (MA only), "Shared my secrets with others" (MA and SA), "Threatened me" (MA and SA), "Excluded me from their group (e.g., parties, messaging)" (MA and SA), "Damaged something of mine on purpose" (MA and SA). Simply using the TIMSS bullying scale, we would have missed these findings.

7. LIMITATIONS

TIMSS is an International Large-Scale Assessment (ILSA), and Klemenčič and Mirazchiyski (2018) have pointed out the following limitations of ILSAs: "(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). Also, as TIMSS studies are cross-sectional, causation can't be proven. Furthermore, although some recommendations for interventions are provided, the study served as a foundational exploration, paving the way for subsequent research that focuses explicitly on effective anti-bullying interventions in the South African context and is not meant to offer solid solutions to eliminate bullying altogether, but rather, guidelines as to get there.

8. CONCLUSIONS AND RECOMMENDATIONS

The first recommendation is that the TIMSS team consider rephrasing the item phrased "stole something from me" to "stole anything of value from me", as the results showed unexpected results for this item. From the results, it is evident that predictors of both traditional and cyberbullying were significant predictors of academic achievement in low-SES schools. Evangelio, Rodríguez-González, Fernández-Río, and Gonzalez-Villora (2022) found that only two of 43 articles on cyberbullying from 2016 to 2020 focused on South African schoolchildren, highlighting the need for further research in South African schools. It should be acknowledged that their study only focused on the ages children start using mobile phones and social media and not on all schoolchildren. More studies on bullying in low-SES South African schools are needed, as literature on South African education has shown that learners from lower-SES schools reported being bullied more often than learners in higher-SES schools (Johansson et al., 2022). Regarding bullying interventions, we recommend that focused interventions be used with a focus on the predictors significantly negatively associated with achievement. Thus, directed workshops could be developed with an emphasis on teaching learners to respect each other's property and families, not to send (or share) nasty or hurtful messages or embarrassing photos online, not to hurt another learner physically, and that something that may appear harmless ("refused to talk to me") is considered bullying and is unacceptable. Learners must be informed that bullying policies have clear penalties. Due to COVID-19, e-Learning has risen dramatically in the previous two years. All learner-teacher training should include cyber-safety and cyber-protection measures. The study's conclusions affect more than South Africa's education system. Suppose bullying victimisation severely hurts learner academic performance. In that circumstance, widespread bullying may slow human capital growth and hurt students and South Africa's economic growth. This is why studies like these carry weight, and the recommendations should be taken seriously by the relevant stakeholders.

ETHICAL CONSIDERATIONS

No authorisation was required to analyse the TIMSS 2019 data, as it is publicly accessible online (Fishbein, Foy, & Yin, 2021).

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