

Moderation of Access to School Resources on the Relationship Between Students' Perceptions and Their Mathematics Achievement

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Abstract

Student achievement in mathematics is an ongoing concern and a critical area of study across various countries. This research used data from the TIMSS 2019 U.S. eighth-grade student assessment to investigate the relationship between student perceptions and their mathematics achievement. The study examined six key factors: student perceptions of mathematics, mathematics teachers, classroom environment, school, self-confidence, and the value of mathematics, and it also highlighted the moderating role of school-related socioeconomic status in the relationship between these factors and student achievement. Exploratory factor analysis, confirmatory factor analysis, path analysis, and moderation analysis were conducted using IBM SPSS and AMOS version 29. The results showed that positive student perceptions of the classroom environment, mathematics teachers, and mathematics itself predict achievement, while three other factors negatively affect student performance. The results also showed that self-confidence in mathematics emerged as the strongest predictor, albeit in a negative direction. Access to school resources significantly moderated the relationship between students' perceptions of school and classroom environment and achievement. In contrast, the interaction effects showed that access to school resources did not significantly moderate the relationships between achievement and perceptions of mathematics, mathematics teachers, self-confidence, and the value of mathematics. Finally, the study recommends that mathematics educators and policymakers prioritize fostering positive student perceptions across all six factors and ensure resourceful school and classroom environments for effective mathematics teaching and learning.

Keywords: Student achievement, student perceptions, moderation effect, school resources, TIMSS

MSC Classification: 51F30, 51F99, 97D60, 97K80

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1. Introduction

The Trends in International Mathematics and Science Study (TIMSS) has taken place every four years since its inception in 1995. The International Association for the Evaluation of Educational Achievement (IEA) administers it across different participating countries. TIMSS measures student achievement in math and science for fourth- and eighth-grade students, and also administers surveys to students, teachers, and school administrators about background and support factors that may relate to student achievement. Such factors include the school and home environments, student attitudes and confidence, and teacher development and instruction. Our work here will focus on the 2019 TIMSS U.S. mathematics assessment data and analysis, which included 46 participating entities from six continents worldwide in grade 8.

Educational researchers have used the achievement and survey data from TIMSS in a variety of ways, such as focusing on particular factors from the surveys to hypothesize that they are correlated with student achievement. The research may focus on a particular country's data, compare countries, or identify factors contributing to student achievement worldwide. Decision-makers can use the results to design new initiatives, assess the effectiveness of school systems in participating countries, identify and address gaps in learning opportunities, and determine teacher training needs.

We first discuss some history of articles that focused on factors affecting student achievement. Researchers have examined different factors that can predict students' achievement in mathematics using TIMSS data (e.g., Topcu et al., 2016; Wardat et al., 2022). One such factor was identified in an article involving a study using TIMSS 2019 data that found a significant gap in achievement in students who arrive at school hungry all or almost all of the time versus those who never arrive hungry (Canbolat et al., 2023). From the TIMSS 2011 and 2019 data from Hong Kong, it was determined that socioeconomic status (such as possession of desks, books, computers, and internet at home as well as parental education levels) significantly and positively affected student achievement (Qiu & Leung, 2022). This relationship was also observed in a study of the 2007 TIMSS data comparing American and Japanese student performance (Yoshino, 2012). Socioeconomic factors were also significant in the TIMSS 2015 fourth-grade data (Ersan & Rodriguez, 2020). Mitigating factors to this relationship include instructional quality and school readiness (Akinsola & Olowojaiye, 2008). These were found to be both positive and significant in that study. The TIMSS U.S. data from 2015 were analyzed by researchers studying the academic performance of African, Latinx, and Asian-American students across ethnicity, gender, grades, and socioeconomic variables (Moon et al., 2022). They found that parents' involvement significantly predicted student success across grades and ethnicity and that engaging teaching significantly predicted student success across grades for Latinx-American students. Other factors, such as gender and bullying, showed varying levels of achievement across student groups. A study of the TIMSS 2015 and 2019 data in Norway found a decrease in student achievement in this period (Nilsen et al., 2022). The data analysis showed that declines in a safe school environment and student self-concept were associated with a decline in student achievement.

We shall next give some of the studies that used the TIMSS data to analyze student perceptions that were determined to affect student achievement. The study mentioned earlier of the 2007 TIMSS data from the U.S. and Japan showed that students' math self-concept was positively correlated with student achievement in both the U.S. and Japan (Yoshino, 2012). A more recent study from the 2015 TIMSS data focused on student factors affecting achievement in Abu Dhabi Emirate Schools (Wardat et al., 2022). They found that the parents' background, peer influence, and learning and studying skills positively affect achievement. Another study using the 2019 TIMSS data for Turkey determined that in-

structional quality and clarity, instructional climate, students' sense of school belonging, academic emphasis, and participation in professional development contributed significantly and positively to student achievement (Sahin et al., 2022). Another study used three cycles of TIMSS data within and between countries and focused on three measures of self-perceptions of students: how they like the subjects, perceived self-confidence in the subjects, and perceived easiness of subjects (Shen & Tam, 2008). They concluded that the within-country data give a positive relationship between these factors and achievement. However, and perhaps paradoxically, the between-country analysis showed that there is a negative correlation between these self-perceptions and achievement in both math and science. This result has been corroborated in other studies as well. They offer a possible explanation of higher (or lower) academic standards in the higher (respectively, lower) performing countries. Relating to that article, another study on the 1999 TIMSS data notes this conundrum. However, on an individual level, when control factors such as the number of books at home, school resources, and school management are factored in, these three measures of student self-perception show positive effects on achievement in most countries (Shen & Talavera, 2002). An analysis of the TIMSS data from 2011 in Turkey revealed that the factors of being bullied at school, confidence, being engaged in math, and parental involvement had significant effects on student achievement for both fourth- and eighth-grade students (Yalcin et al., 2017). Another study of the same data demonstrated a relationship between student achievement and both students' confidence and teachers' confidence in their area of expertise (Yildirim & Demir, 2014). Finally, a revealing study of the 2007 TIMSS data on 8th graders from Jordan focused on the student perception factors of students' educational aspiration, attitude, success attribution, confidence in ability, and their own perception of the importance of math (Sabah & Hammouri, 2010). It was concluded that these factors contributed significantly and positively to mathematics achievement.

Although each of these factors has received attention in earlier TIMSS-based research, the present study differs from the earlier works in three key aspects. First, most of the past studies have modeled students' perceptions as direct predictors of achievement. The current study treats access to school resources as a moderator that may influence the relationship between student perceptions and achievement in mathematics. Second, the six perceptual factors are estimated within a single structural equation model rather than in isolation from each other, adjusting the estimates in relation to each other. Third, the study draws on the TIMSS-US data for grade eight mathematics that assesses each factor item through exploratory factor analysis followed by confirmatory factor analysis, path analysis, and final moderation analysis in a sequence. This sequence of analytical approaches provides more robust outcomes compared to individual isolated factor models and direct regression analysis. This way, the current study extends the prior works (e.g., Belbase & Roblee, 2025; Belbase et al., 2025; Shen & Talavera, 2002; Shen & Tam, 2008; Wardat et al., 2022) by identifying the classroom and school resource conditions under which students' perceptions of mathematics are translated into their mathematical achievement in the U.S. context. This study is a foundation for further studies on TIMSS-US mathematics achievement with respect to different predictors and moderators from the 2023 cycle and the upcoming 2027 cycle.

Our focus here is the TIMSS U.S. data from 2019 for eighth-grade students. In particular, we focus not only on the factors that correlate with student achievement but also on how data from students' perceptions relate to achievement and how their access to resources can moderate this relationship. Specifically, we seek answers to the following three questions through analysis of TIMSS eighth-grade mathematics data:

1. What are the perceptual factors influencing eighth-grade students' achievement in mathematics in TIMSS 2019 (U.S.)?
2. How do eighth-grade students' perceptions of school, classroom environment, mathe-

mathematics, mathematics teacher, self-confidence, and value of mathematics predict their achievement in TIMSS 2019 (U.S.)?

3. How does eighth-grade students' access to resources moderate the relationship between perceptual factors and their mathematics achievement in TIMSS 2019 (U.S.)?

2. Literature Review

Student Perception of Mathematics

Mathematics, as a discipline, occupies a pivotal role across various academic and professional domains, making it both challenging and indispensable for students (Etuk et al., 2013). While some students find joy in mathematics due to its logical structure and problem-solving aspects, others grapple with fear or frustration, often stemming from past negative encounters or low self-confidence (Grootenboer et al., 2016). Despite its undeniable significance in daily life, many students struggle to grasp the multitude of mathematical concepts and skills required (Hagan et al., 2020). Hagan et al. (2020) emphasize that mathematics fosters higher-order cognitive abilities and logical reasoning.

However, the emotional landscape of mathematics learning is far from straightforward. Unfortunately, some students develop anxiety and aversion toward math during classroom learning, leading them to avoid math-related tasks and even forgo careers in the field (Kanafiah & Jumadi, 2013). Such avoidance may hinder their financial prospects and overall life satisfaction (Kanafiah & Jumadi, 2013). Kasmin et al. (2019) shed light on the unpleasant feelings that can surface during mathematical study, including anxiety, impatience, and dread. These emotional blocks often arise from feeling overburdened and pressured by mathematical activities (Kasmin et al., 2019).

Mata et al. (2012) further underscore the impact of prior experiences on students' emotional responses to mathematics. Negative encounters, stressful exams, and societal perceptions that mathematics is inherently difficult exacerbate these feelings (Mata et al., 2012). Ampadu (2012) highlights that students who genuinely enjoy learning mathematics in the classroom tend to exhibit higher motivation and are willing to invest additional effort.

Beyond mere behavior, Ferreira and Santoso (2008) and Kunwar (2021) emphasize that students' attitudes and perceptions of mathematics play a pivotal role in shaping student behavior and determining their achievement. External factors, such as the school environment, teacher attitudes, teaching methods, and parental perspectives, contribute significantly to students' overall outlook on mathematics (Asante, 2012). These external influences can either foster a positive attitude or perpetuate negative perceptions. Despite the recognized importance of students' attitudes, Vionita and Purboningsih (2017) reveal room for improvement in this critical area.

Student Perception of School

Students' perceptions of schools are shaped by various factors that significantly influence their overall experience and academic outcomes (Hagan et al., 2020). These perceptions can vary based on elements such as educational quality, the school environment, and the level of support provided. Over time, the issue of inadequate mathematical performance among students has expanded beyond specific nations to become a global concern (Hagan et al., 2020). Academic achievement, often considered a primary outcome of learning, relies heavily on schools as the primary providers of formal education (Bahar, 2016). However, in economically disadvantaged nations, effective schooling remains scarce. Notably, approximately 60% of the variance in student performance can be attributed to school effects beyond classroom dynamics, with the remaining 40% stemming from student characteristics (Bahar, 2016).

While teachers' instructional methods significantly influence students' attitudes toward mathematics, the school environment itself plays a crucial role in shaping and modifying these attitudes (Yang, 2013). Smith et al. (1987) found significant positive correlations

among attitudes, affect, and behavior indices related to regular education and students' perceived control in the school context. This view suggests that students' overall experience within the school environment—whether they feel empowered or constrained—directly impacts their attitudes toward learning, including mathematics.

Teachers and schools must possess effective classroom management skills to foster a positive atmosphere (Konti, 2011). By providing accurate information, facilitating education, and maintaining a supportive atmosphere, teachers contribute to students' overall perception of mathematics (Konti, 2011). Interestingly, Konti (2011) also highlights a favorable correlation between middle school students' attitudes toward mathematics and their learning environment. When schools prioritize a positive, engaging atmosphere, students are more likely to view mathematics as approachable and relevant. However, challenges persist. Ugurlu et al. (2015) note that teachers consistently encounter undesirable societal behaviors, which can disrupt classroom discipline. Balancing discipline with a nurturing environment remains essential for shaping students' attitudes and fostering a love for mathematics.

Student Perception of Classroom Environment

Students' perceptions of the mathematics classroom are influenced by several critical factors, each shaping their overall experience and academic outcomes. Ampadu (2012) highlights that students' satisfaction often hinges on how effectively teachers explain subject matter and whether help is readily accessible. Moreover, Angier and Povey (1999) emphasize specific elements contributing to a positive mathematics classroom. Conversely, dissatisfaction and anxiety arise in poorly organized classrooms where subjects are inadequately explained and assistance is lacking (Angier & Povey, 1999).

Well-organized math classes that promote a growth mindset and create a supportive environment are ideal for students to learn effectively and overcome challenges (Boaler, 1993). Students' views on the classroom setting are multifaceted, influenced by their personal experiences and their subsequent impact on learning (Skaalvik et al., 2017). Hagan et al. (2020) emphasize that students thrive in a friendly and supportive classroom. Factors such as disorganization, disruptive behavior, or lack of assistance impede students' passion for studying (Hagan et al., 2020).

Skaalvik et al. (2017) highlight the importance of an environment that promotes academic growth and nurtures students' personal development. Dorman et al. (2003) further emphasize that the classroom environment serves as a backdrop for student characteristics. Investigating students' opinions on the academic effectiveness of mathematics activities in the classroom is crucial (Dorman et al., 2003). Bahar (2016) extends this perspective, emphasizing that various classroom factors indirectly influence students' ability, motivation, and receptivity to teaching. These include the classroom atmosphere, positive stimulation from the home environment, and peer support.

Student Perception of Self-Confidence in Mathematics

Students' confidence plays a pivotal role in their mathematical performance during examinations and in-class activities (Kaur & Prendergast, 2022). According to Kaur and Prendergast (2022), confidence levels are directly related to factors such as preparation, prior experiences, and the support they receive. Teachers can enhance students' confidence in the classroom through consistent practice, clear explanations, and positive feedback (Kung, 2009). When students feel capable and well-prepared, they approach mathematical problems with a more positive and relaxed attitude during tests (Kunhertanti & Santosa, 2018).

However, the reverse is also true. Students who struggle to grasp mathematical concepts or receive negative feedback may experience increased anxiety and reduced confidence before an exam. To foster self-confidence in mathematics, educators must create a supportive learning environment that prioritizes comprehension and offers ongoing assistance (Mazana et al., 2019). Interestingly, self-confidence has been identified as a powerful non-cognitive predictor of academic achievement, surpassing measures such as self-efficacy and self-concept

(Stankov et al., 2014).

Students who possess technological knowledge are better equipped to face future challenges. This proficiency provides them with relevant abilities that enhance both their academic and professional competencies (Karatas et al., 2017). However, students' perceptions of self-confidence in mathematics are multifaceted. These perceptions are influenced by their experiences with the subject, the teaching methods employed, and the overall academic environment (Sultra et al., 2018).

High self-confidence in mathematics is closely tied to positive experiences. Students' confidence grows when they understand mathematical concepts, solve problems successfully, and receive encouragement from teachers and peers. Consequently, they develop a more positive attitude toward learning math (Waini et al., 2014). Conversely, repeated difficulties, lack of understanding, and negative feedback can erode self-confidence, leading students to perceive math as a challenging and discouraging subject (Kvedere, 2014).

Conceptual comprehension varies among students, emphasizing the importance of tailored learning experiences (Sultra et al., 2018). However, challenges arise when students encounter unidentified difficulties, such as teachers misinterpreting their work. These situations can lead to misunderstandings and misconceptions as students attempt to integrate new material into their cognitive framework (Sultra et al., 2018). Therefore, accurate conceptual understanding remains crucial for fostering students' self-confidence in mathematics.

Student Perception of the Value of Mathematics

The study, teaching, and learning of mathematics are deeply intertwined with values and valuing (Zhang, 2019). Three complementary value pairs play a significant role in shaping students' perceptions: mystery and openness, control and development, and rationalism and objectivism (Zhang, 2019). Moreover, students' recognition of mathematical values is influenced not only by textbook content but also by teachers' characteristics and instructional methods (Opdenakker & Damme, 2006). Keitel (2003) further asserts that students respect mathematics for reasons beyond its real-world utility. They appreciate its well-organized structure, exactness, and ability to provide unambiguous answers. Mathematics serves as a vital tool for honing cognitive abilities, logical thinking, and problem-solving skills. Whether in vocational pursuits or daily life, students recognize how mathematics enhances their understanding of the world and equips them to navigate it more efficiently.

In the context of teaching and learning mathematics, the concept of valuing plays a crucial role. Valuing refers to the will and desire that drive individuals to continue along their chosen path of action (Barkatsas et al., 2018). Within the mathematics classroom, values intersect during interactions between instructors and students, reflecting what is significant to each individual. The overall classroom environment significantly influences how students perceive mathematics. Positive experiences, engaging activities, and supportive interactions foster a sense of value and appreciation for the subject (Bishop, 2012).

Effective teaching practices, teacher enthusiasm, and the ability to connect mathematical concepts to real-life situations all impact students' attitudes toward mathematics. When teachers convey the relevance and applicability of mathematical ideas, students are more likely to value the subject (Bishop, 2012). Opdenakker and Damme (2006) highlight various aspects that contribute to the value of the mathematics classroom: teaching approach, competence, relationship, time management, and assessments. Unfortunately, low participation and success rates among girls in mathematics have often been attributed to negative attitudes toward the subject (Farooq & Shah, 2008). Addressing these attitudes and promoting a positive view of mathematics is essential for fostering equitable learning experiences.

3. Method of Study

Data on the mathematics achievement of a sample of 8,698 U.S. eighth-grade students, and on their perceptions of mathematics, the mathematics teacher, school, classroom environment, self-confidence, and the value of mathematics, together with other demographic variables were retrieved from the TIMSS 2019 International Database. The SPSS data were downloaded from the database and cleaned by removing variables outside the scope of this study.

TIMSS 2019 U.S. grade eight mathematics data had two parts: 1. Data from the student questionnaire (accessible at <https://timssandpirls.bc.edu/timss2019/questionnaires/index.html>) and 2. Data on student achievement in mathematics (available at <https://timss2019.org/international-database/>). The student questionnaire had 27 parts. This study included items from parts 13, 16, 17, 18, 19, and 20 of the student questionnaire, along with five plausible values of students' mathematics achievement.

To answer the first research question, an exploratory factor analysis with principal component analysis was performed in SPSS version 29 to examine the alignment of items related to students' perceptions of school (coded as BSBG13A–BSBG13E), perceptions of mathematics (coded as BSBM16A–BSBM16I), perceptions of mathematics teacher (coded as BSBM17A–BSBM17G), perceptions of classroom environment (coded as BSBM18A–BSBM18F), self-confidence (coded as BSBM19A–BSBM19I), and value of mathematics (coded as BSBM20A–BSBM20I). The results of exploratory factor analysis were obtained with a Kaiser–Meyer–Olkin measure of sampling adequacy of 0.959 (high) and Bartlett's test of sphericity (Approx. Chi-square value of 194318.16, $df = 990$, and $p < 0.001$). The cumulative percentage of variance explained by the six components was 63.67% (acceptable), with the initial eigenvalues for the individual components greater than 1 (satisfactory). The rotation method using Varimax with Kaiser Normalization yielded six components after six iterations, achieving convergence. Any item with factor loading coefficients less than 0.5 was dropped from further analyses. Altogether, 43 out of 45 items were included in further analysis and interpretation. The six principal components of factor analysis are presented in Table 1.

The overall reliability coefficient (Cronbach's alpha) was 0.919 for the 43 items in the student questionnaire selected for the analysis. The factor level reliability coefficients were 0.824 for students' perceptions of their schools (5 items), 0.938 for students' perceptions of mathematics (9 items), 0.912 for students' perceptions of math teachers (7 items), 0.916 for students' perceptions of classroom environment (6 items), 0.904 for students' self-confidence in mathematics (8 items), and 0.887 for students' value of mathematics (8 items). Then, confirmatory factor analysis was performed in IBM AMOS to evaluate the robustness of factors with an evaluation of fit indices.

To answer the second research question, path analyses were performed to assess the impact of predictor variables (perceptions and values) on the outcome variable (student achievement in mathematics). Students' perceptions of school, classroom environment, math teacher, mathematics, self-confidence, and value of mathematics were used as predictor variables, and their achievement in mathematics in TIMSS 2019 with five plausible values were used as the dependent (or outcome) variables. Path analysis was performed in IBM AMOS version 29 for the structural equation modeling of the relationship between the predictors and the predicted variables.

Then, to answer the third research question, the PROCESS macro developed by Andrew Hayes (embedded in SPSS) was used for the moderation analysis (Hayes, 2022). Students' access to school resources was considered a moderator. The mathematical equation of the moderation effect can be represented as $\hat{Y} = a + b_1X + b_2W + b_3XW$, where $\hat{Y}$ is the estimated value of the dependent variable, X is the independent or predictor variable, W is the moderating or intervening variable, and XW is the product of the predictor variable

Table 1. Results of Exploratory Factor Analysis (EFA)

Factor Items	Factor Components						Reliability (Cronbach's alpha)
	1	2	3	4	5	6	
BSBM16E	.793						0.938
BSBM16G	.788						
BSBM16F	.766						
BSBM16H	.764						
BSBM16A	.751						
BSBM16I	.737						
BSBM16D	.666						
BSBM16C	.638						
BSBM16B	.569						0.912
BSBM19H		.803					
BSBM19B		.797					
BSBM19C		.771					
BSBM19I		.741					
BSBM19E		.664					
BSBM19D		.633					
BSBM19A		.630					
BSBM19F		.596					
BSBM17D			.842				0.904
BSBM17C			.815				
BSBM17E			.799				
BSBM17B			.795				
BSBM17G			.776				
BSBM17F			.736				
BSBM17A			.598				
BSBM20G				.802			0.887
BSBM20F				.767			
BSBM20D				.757			
BSBM20C				.753			
BSBM20I				.735			
BSBM20H				.649			
BSBM20A				.615			
BSBM20B				.599			
BSBM18D					.860		0.916
BSBM18E					.857		
BSBM18B					.836		
BSBM18F					.820		
BSBM18A					.805		
BSBM18C					.789		
BSBG13E						.793	0.824
BSBG13C						.789	
BSBG13B						.727	
BSBG13A						.656	
BSBG13D						.593	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

X and the intervening or moderating variable W (Hayes, 2022).

Because TIMSS reports mathematics achievement as five plausible values rather than a single score, the way these values were handled may require further clarification. In the confirmatory factor analysis and in both path analyses, all five plausible values (BSMMAT01–BSMMAT05) were included in the model, and estimates were reported separately for each plausible value (in Tables 3 and 4), rather than a single averaged score, so that the variations across the five values remain visible. The estimates for the five plausible values represent the five parallel estimates of the same population of students under study, though samples for each PV were different in TIMSS 2019. We ran the analysis with each plausible value

as the dependent variable, one by one, in SPSS with Hayes's PROCESS macro. Then we computed the pooled values of estimates, SE, 95% confidence interval, and p-value for each predictor variable. Interaction coefficients for each plausible value and the pooled coefficient have been reported. TIMSS uses Jackknife Repeated Replication (JRR) with schools as samples chosen with probability proportional to size within strata, intact classes within schools, and students within those classes, with different sampling weights. This process deals with three kinds of variance: jackknife sampling variance, imputation variance, and total variance. The details of TIMSS sampling and sample weights can be found in Martin et al. (2020).

4. Results

The results section has three parts. The first part includes the results of the confirmatory factor analysis. The second part includes the results of path analysis for the effects of predictor variables on the outcome variables. The last part includes the results of the moderation analysis for the interaction of students' access to school resources on the relationship of perceptions and values with students' achievement in mathematics in TIMSS 2019 (U.S., Grade 8).

Results of Confirmatory Factor Analysis (CFA)

A confirmatory factor analysis (CFA) was performed by importing the SPSS data into IBM AMOS version 29 to assess data fit for the 43 items and student achievement, using five plausible values. The first CFA model was produced to examine the covariances of the seven factors (including achievement) and the fit indices (Figure 1). Initial results of model fit indices showed that the ratio of Chi-square Minimum to Degrees of Freedom (CMIN/DF) was 21.534, Normed Fit Index (NFI) was 0.927, Incremental Fit Index (IFI) was 0.919, Tucker-Lewis Index (TLI) was 0.923, Comparative Fit Index (CFI) was 0.930, Comparative Parsimony Fit Index (CPFI) was 0.838, and the Root Mean Square Error of Approximation (RMSEA) was 0.049. All these fit indices were good except CMIN/DF (expected to be less than 5) (see Table 2). Figure 1 shows the initial CFA model with covariances of seven factors with 43 items.

Table 2. Model Fit Indices

Model	CMIN	DF	CMIN/DF	NFI	IFI	TLI	CFI	RMSEA	Action
Model 1	22804.312	1059	21.534	0.927	0.919	0.923	0.930	0.049	Initial CFA Model Fit (7 Factors)
Model 2	16579.830	798	20.777	0.942	0.945	0.938	0.945	0.048	Deleted items 13D, 16B, 17A, 19E 20B, and 20H from Model 1 with low critical ratio (<0.6).
Model 3	27615.252	813	33.967	0.904	0.906	0.896	0.906	0.062	Path1 to relate predictors with student achievement in math with direct effect.

The critical ratio (regression estimate divided by the standard error) was used to evaluate the effects of each factor item on CFA model 1. Some items with a critical ratio (C.R.) less than 0.6 were deleted from the model to improve the fit indices. Altogether, six items (13D, 16B, 17A, 19E, 20B, and 20H) were deleted from Model 1 because their critical ratios were low (<0.6), improving all fit indices slightly. There was no further improvement by deleting items with lower C.R. Hence, 37 items were accepted for further path analysis for the impact of independent variables (perceptions, self-confidence, value) on the dependent variable (student achievement). Figure 2 shows the final CFA model with covariances of seven factors with 37 items.

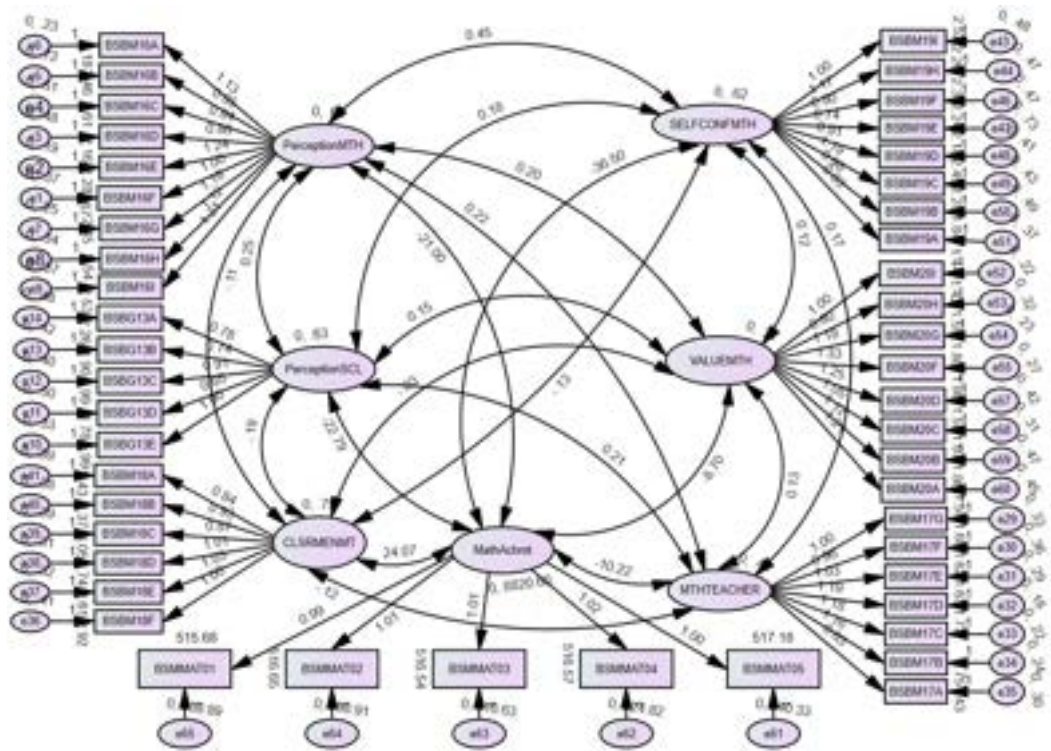


Figure 1. Initial CFA Model 1

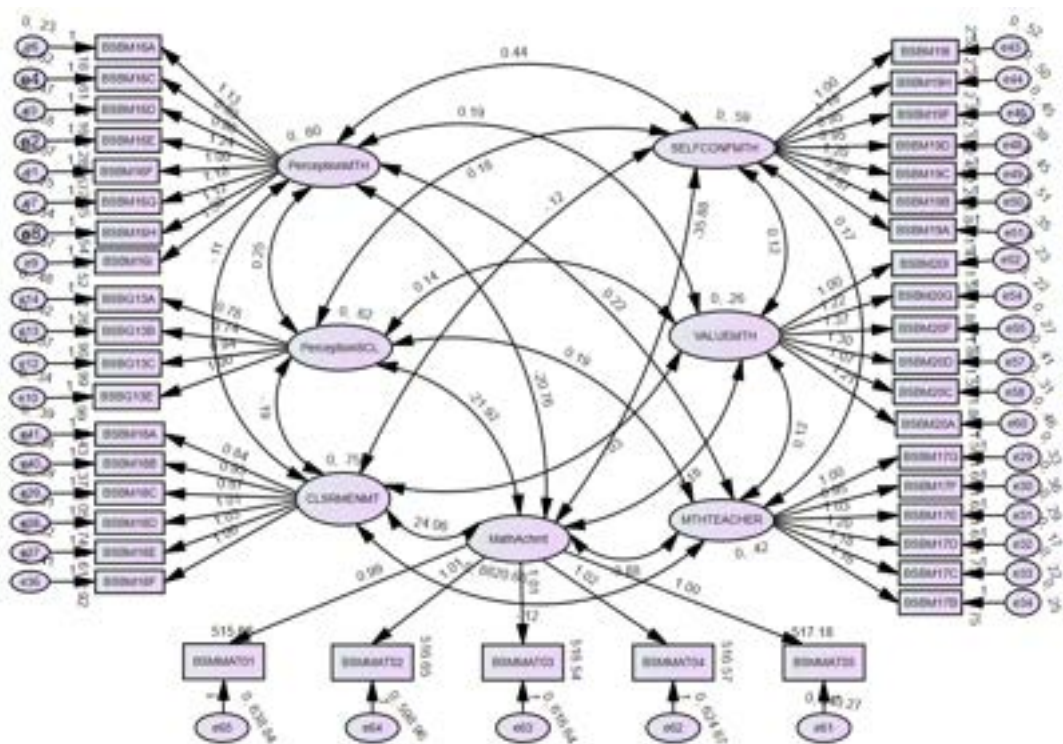


Figure 2. CFA Final Model 2

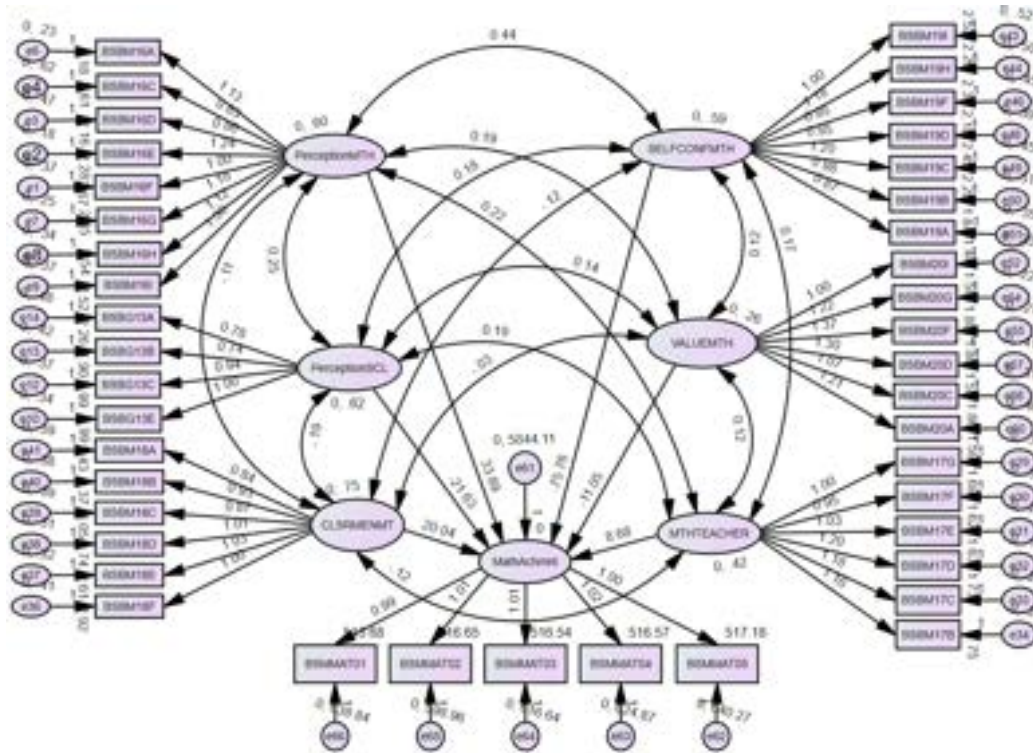


Figure 3. Path Analysis for the Relationship of Predictors and Outcome Variables Considering Covariances between the Predictors

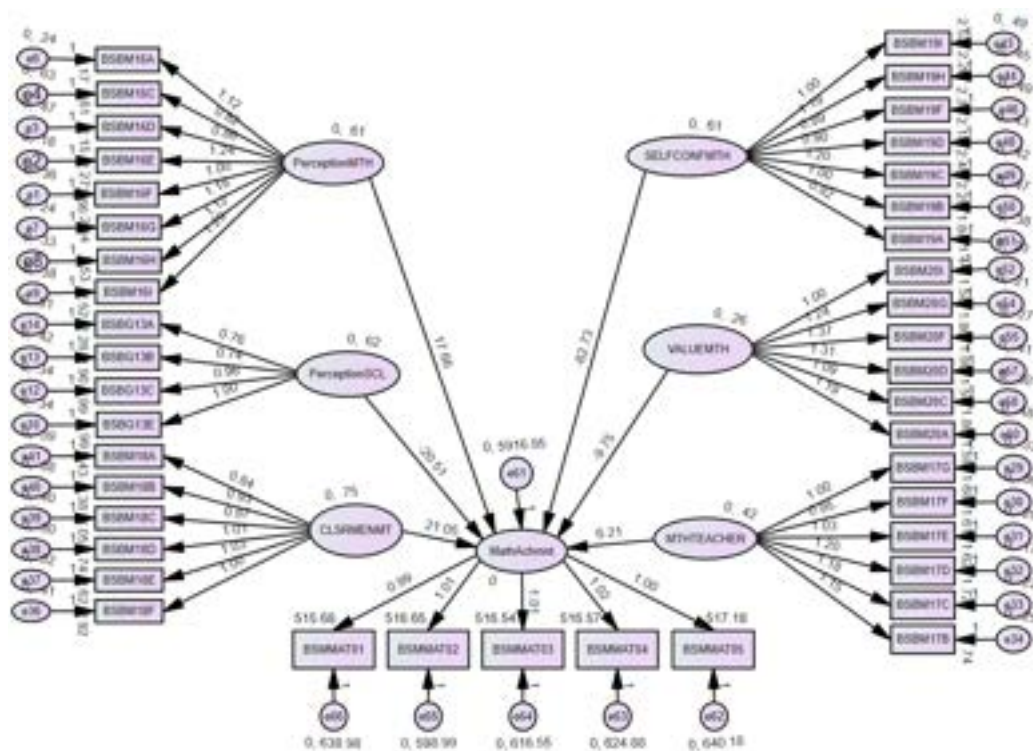


Figure 4. Path Analysis for the Relationship of Predictors and Outcome Variables without Considering Covariances between the Predictors

Results of Path Analysis

Initial path analysis was performed by considering all six factors of perceptions, self-confidence, and value as independent variables and student achievement in mathematics as the dependent variable (Figure 3). Covariances were considered for all independent variables when predicting the dependent variable, while keeping the fit indices intact, as in Model 2. The results of the path analysis for the direct effect are presented in Tables 3 and 4 and Figures 3 and 4.

Students' perception of the classroom environment was a significant positive predictor of their achievement in mathematics ($b = 20.044$, S.E. = 1.157, $p < 0.001$) (Table 3). Similarly, students' perception of mathematics was a significant positive predictor of their achievement in mathematics, $b = 33.887$, S.E. = 2.202, and $p < 0.001$. Student perceptions of mathematics teachers were also significant positive predictors of their achievement in mathematics, $b = 8.678$, S.E. = 1.721, C.R. = 5.041, and $p < 0.001$. However, students' self-confidence in mathematics was a negative predictor of their achievement, $b = -75.762$, S.E. = 2.151, and $p < 0.001$. Similarly, their perception of school was a negative predictor of achievement, $b = -21.633$, S.E. = 1.513, and $p < 0.001$. Their perception of the value of mathematics was also a negative predictor of achievement in mathematics, $b = -11.052$, S.E. = 2.283, and $p < 0.001$ (Table 3). These results showed that students' perception of their teacher was the weakest predictor of their achievement, whereas their self-confidence in mathematics was the strongest predictor, though it was negative. For all predictors, when their covariances were assumed, the mean achievement (intercept) ranged from 515.680 to 517.178 across the first to the fifth plausible values (Table 3).

Table 3. Regression Weights: (Group number 1 - Default model) with Covariances among Independent Variables

Parameters			Estimate	S.E.	C.R.	P
MathAchmnt	<—	CLSRMENMT	20.044	1.157	17.326	<.001
MathAchmnt	<—	SELFCONFMTH	-75.762	2.151	-35.224	<.001
MathAchmnt	<—	PerceptionMTH	33.887	2.202	15.391	<.001
MathAchmnt	<—	MTHTEACHER	8.678	1.721	5.041	<.001
MathAchmnt	<—	PerceptionSCL	-21.633	1.513	-14.303	<.001
MathAchmnt	<—	VALUETH	-11.052	2.283	-4.842	<.001
Five Plausible Values			Estimate	S.E.	C.R.	P
BSMMAT05			517.178	1.043	495.858	<.001
BSMMAT04			516.574	1.058	488.307	<.001
BSMMAT03			516.537	1.050	491.826	<.001
BSMMAT02			516.648	1.047	493.667	<.001
BSMMAT01			515.680	1.033	498.982	<.001

Path analysis for the predictors and dependent variables (achievements) was also performed without covariances (see Table 4 and Figure 4). The results of path analysis showed fit indices of CMIN/DF = 33.967, NFI = 0.904, IFI = 0.906, TLI = 0.896, CFI = 0.906, and RMSEA = 0.062 (see Table 2). The fit indices were lower than those obtained from the path analysis that considered covariances among the predictors.

The results of the path analysis showed that students' perception of the classroom environment was a positive predictor of their achievement in mathematics ($b = 21.050$, S.E. = 1.076, $p < 0.001$). Likewise, their perception of mathematics was a positive predictor of achievement in mathematics, $b = 17.662$, S.E. = 1.164, and $p < 0.001$. Students' perception of their mathematics teacher was also a positive predictor of their achievement, though it was weaker than other predictors, $b = 6.212$, S.E. = 1.421, and $p < 0.001$. However, students' self-confidence in mathematics negatively predicted their achievement, $b = -62.725$, S.E. = 1.340, and $p < 0.001$. Likewise, students' perception of school negatively predicted

their achievement in mathematics, $b = -20.507$, $S.E. = 1.240$, and $p < 0.001$. Similarly, their perception of the value of mathematics also negatively predicted their achievement, $b = -9.755$, $S.E. = 1.851$, and $p < 0.001$. The mean achievements (intercepts) remained the same as before (path analysis accounting for covariances among predictors) across the five plausible values (see Table 4).

Table 4. Regression Weights: (Group number 1 - Default model) Without Covariances between Independent Variables

Parameters			Estimate	S.E.	C.R.	P
MathAchmnt	<—	CLSRMENMT	21.050	1.076	19.557	<.001
MathAchmnt	<—	MTHTEACHER	6.212	1.421	4.372	<.001
MathAchmnt	<—	VALUEMTH	-9.755	1.851	-5.270	<.001
MathAchmnt	<—	PerceptionSCL	-20.507	1.240	-16.539	<.001
MathAchmnt	<—	PerceptionMTH	17.662	1.164	15.178	<.001
MathAchmnt	<—	SELFCONFMTH	-62.725	1.340	-46.797	<.001
Five Plausible Values			Estimate	S.E.	C.R.	P
BSMMAT05			517.178	1.061	487.335	<.001
BSMMAT04			516.574	1.076	479.883	<.001
BSMMAT03			516.537	1.069	483.342	<.001
BSMMAT02			516.648	1.065	485.138	<.001
BSMMAT01			515.680	1.052	490.415	<.001

Results of Linear Moderation Analysis

Access to resources was used as an indicator of socioeconomic status (SES) in the linear moderation analysis of the interaction of access to school resources with students' perceptions and values in predicting achievement in mathematics in TIMSS 2019. The items BSBG12A–BSBG12F (6 items) were related to textbook access, assignments, collaboration with other students, communication with teachers, information to aid in math and science learning, and learning games. These items indirectly reflect students' SES through their access to resources. The average values were computed, and the averages were dichotomized by recoding: 1–1.5 as yes (coded 1) and 1.6–2 as no (coded 2).

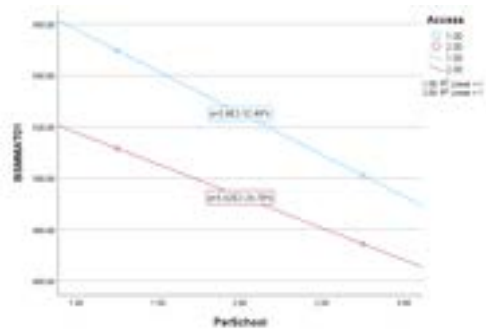
Moderation analysis was conducted to explore the impact of access to resources as part of students' SES on the relationship between student perceptions of school, classroom, mathematics teacher, mathematics, self-confidence, and the value of mathematics and their performance. Students' achievement in mathematics was used from all five plausible values from the TIMSS 2019 data for grade eight in the United States. Then pooled values of estimates (coefficients), SE, t-value, p-value, lower and upper limits of the confidence intervals were computed from the analyses with five plausible values as dependent variables. The findings of the moderation analysis are shown in Table 5 and Figures 5–10 and are reported under separate subheadings.

Table 5. Moderation of Access to School Resources on the Relationship Between Student Perception of School, Classroom Environment, Mathematics, Mathematics Teacher, Self-Confidence, and Value of Mathematics with Achievement (pooled values from five PVs as the dependent variable)

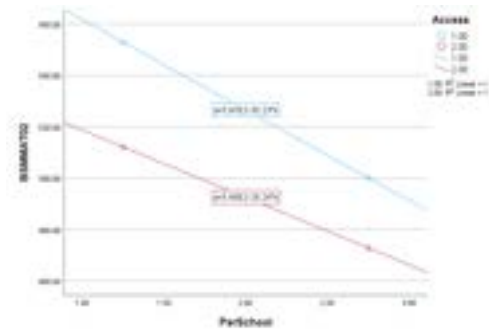
Parameters	Coeff	SE	t	p	LLCI	ULCI
Model 1. Perception of school						
Constant	643.1149	10.7596	59.7712	.0000	621.8293	664.4005
Per-School	-41.8081	4.6835	-8.9268	.0000	-51.0424	-32.5739
Access	-49.9092	8.1615	-6.1152	.0000	-65.9236	-33.8949
Int_1	8.3017	3.4408	2.4127	.0159	1.5548	15.0487
Model 2. Perception of classroom environment						
Constant	449.1917	10.9237	41.1208	.0000	427.7731	470.6102
Per_Class Env	43.1102	3.9815	10.8276	.0000	35.2931	50.9272
Access	-7.6560	8.5714	-.8932	.3718	-24.4587	9.1467
Int_1	-11.0952	3.1018	-3.5770	.0004	-17.1768	-5.0136
Model 3. Perception of mathematics						
Constant	647.2138	11.5256	56.1544	.0000	624.3415	670.0860
PerMath	-35.0680	4.1309	-8.4892	.0000	-43.2037	-26.9323
Access	-49.1752	9.2648	-5.3078	.0000	-67.5122	-30.8382
Int_1	5.8600	3.2675	1.7934	.0741	-.5747	12.2947
Model 4. Perception of mathematics teacher						
Constant	581.6380	9.2002	63.2199	.0000	563.4611	599.8149
PerMathTchr	-10.9236	4.7415	-2.3038	.0217	-20.2449	-1.6024
Access	-26.9943	7.3398	-3.6778	.0003	-41.4867	-12.5020
Int_1	-5.4525	3.6728	-1.4845	.1385	-12.6748	1.7698
Model 5. Self-confidence in mathematics						
Constant	692.3918	11.7521	58.9166	.0000	668.2212	716.5625
Self-Conf	-59.2882	4.5506	-13.0287	.0000	-68.5090	-50.0674
Access	-44.6342	9.3169	-4.7907	.0000	-63.6433	-25.6251
Int_1	5.8957	3.5976	1.6388	.1090	-1.3733	13.1647
Model 6. Value of mathematics						
Constant	601.6040	10.0516	59.8515	.0000	581.7903	621.4177
PerVMth	-22.6846	5.2563	-4.3157	.0000	-33.0065	-12.3626
Access	-41.7692	8.0254	-5.2046	.0000	-57.6101	-25.9283
Int_1	3.5065	4.0596	.8638	.3883	-4.4784	11.4915

Note. Estimates are pooled across the five TIMSS 2019 plausible values (BSMMAT01–BSMMAT05) using Rubin's rules. Each model was estimated separately for every plausible value with the PROCESS macro (Model 1), giving 30 model runs. The pooled coefficient is the mean of the five estimates; the pooled standard error is the square root of the total variance $T = \bar{U} + (1 + 1/M)B$, where $\bar{U}$ is the mean within-imputation variance and B is the between-imputation variance. Degrees of freedom follow the Barnard–Rubin adjustment, and confidence limits use the corresponding t distribution. Int_1 is the product of the perception scale and Access. Sample sizes range from 7,666 to 8,102 across models.

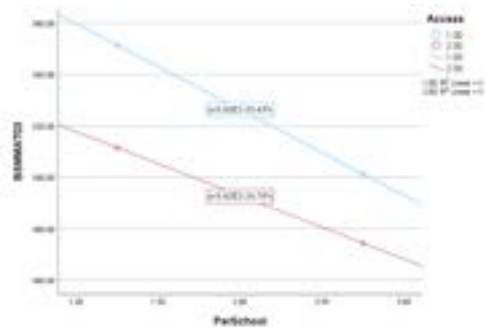
Moderation of Access to School Resources on Relationship of Student Perception of School and Their Achievement: Students' access to resources significantly moderated the relationship between their perceptions of school and mathematics achievement, $b = 8.30$, 95% CI [1.55, 15.05], S.E. = 3.44, $t = 2.41$, $p = 0.016$ (< 0.05) (Table 5). Because access to resources was coded 1 = yes and 2 = no, the conditional effects of the focal predictor at each level of the moderator, rather than the sign of the interaction coefficient alone, indicate the direction of the moderation. The conditional effect of perception of school on achievement was -33.51 among students who had access to school resources and -25.20 among those who did not. The negative association between students' perception of school and their mathematics achievement was therefore steeper among students with access to school resources than among students without access (Figures 5(a)–5(e)).



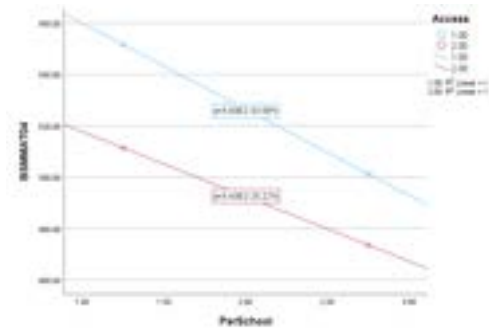
(a) Plausible Value 1 – BSMMAT01



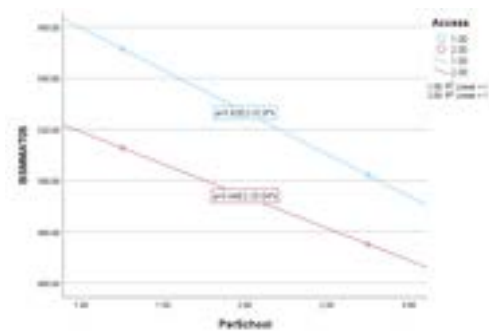
(b) Plausible Value 2 – BSMMAT02



(c) Plausible Value 3 – BSMMAT03



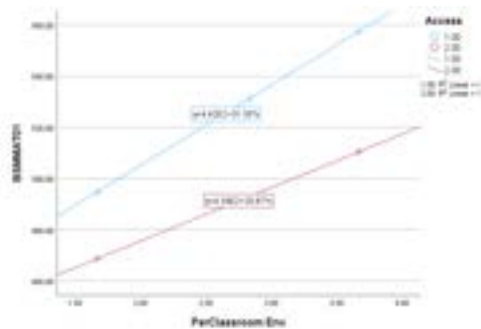
(d) Plausible Value 4 – BSMMAT04



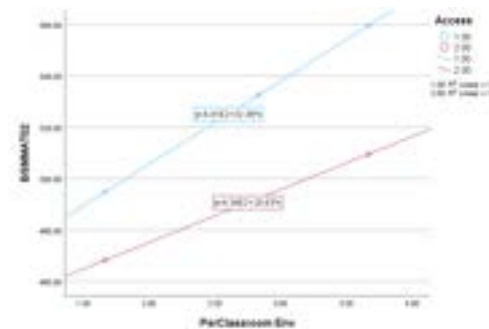
(e) Plausible Value 5 – BSMMAT05

Figure 5. Moderation of Access to School Resources on Relationship of Student Perception of School and Their Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

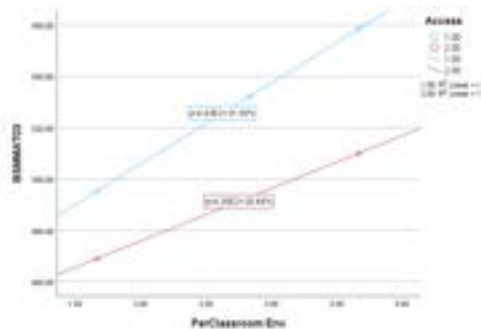
Moderation of Access to School Resources on Relationship of Student Perception of Classroom Environment and Student Achievement: Students' access to school resources significantly moderated the relationship between their perception of classroom environment and mathematics achievement, $b = -11.10$, 95% CI $[-17.18, -5.01]$, S.E. = 3.10, $t = -3.577$, $p = 0.0004$ (< 0.05) (Table 5). The conditional effects of the focal predictor at values of the moderator (1 = Yes, 2 = No) were 32.02 among students who had access to school resources and 20.92 among those who did not. The positive association between perception of classroom environment and mathematics achievement was thus stronger among students with access to resources than among those without such access, which indicates that a favorable classroom environment was translated into achievement more fully where the resources to act on it were available (Figures 6(a)–6(e)).



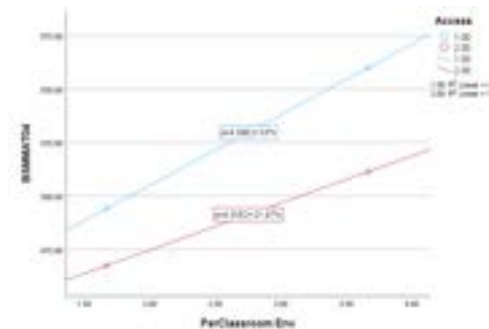
(a) Plausible Value 1 – BSMMAT01



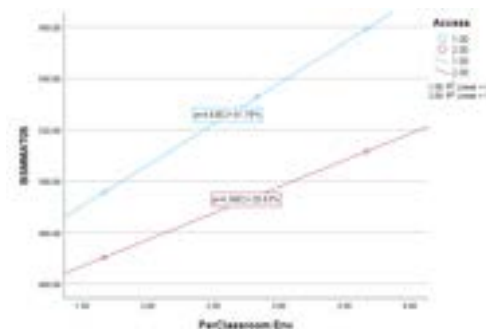
(b) Plausible Value 2 – BSMMAT02



(c) Plausible Value 3 – BSMMAT03



(d) Plausible Value 4 – BSMMAT04



(e) Plausible Value 5 – BSMMAT05

Figure 6. Moderation of Access to School Resources on Relationship of Student Perception of Classroom Environment and Student Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

Moderation of Access to School Resources on Relationship of Student Perception of Mathematics and Achievement: Students' access to resources did not significantly moderate the relationship between their perception of mathematics and student achievement, $b = 5.86$, 95% CI $[-0.57, 12.29]$, S.E. = 3.27, $t = 1.79$, $p = 0.074$ (> 0.05) (Table 5). The results show that the moderation was not significant in the relationship between perception of math and student achievement at the 0.05 level of significance. Because the interaction term was not significant at the 0.05 level of significance, these two conditional effects cannot be regarded as differing from each other, and the relationship between student perception of mathematics and their achievement is best described as comparable across the two access groups. Still, one can see that the association was stronger for the students who had access to the resources compared to those who did not, though the interaction was not significant (Figures 7(a)–7(e)).

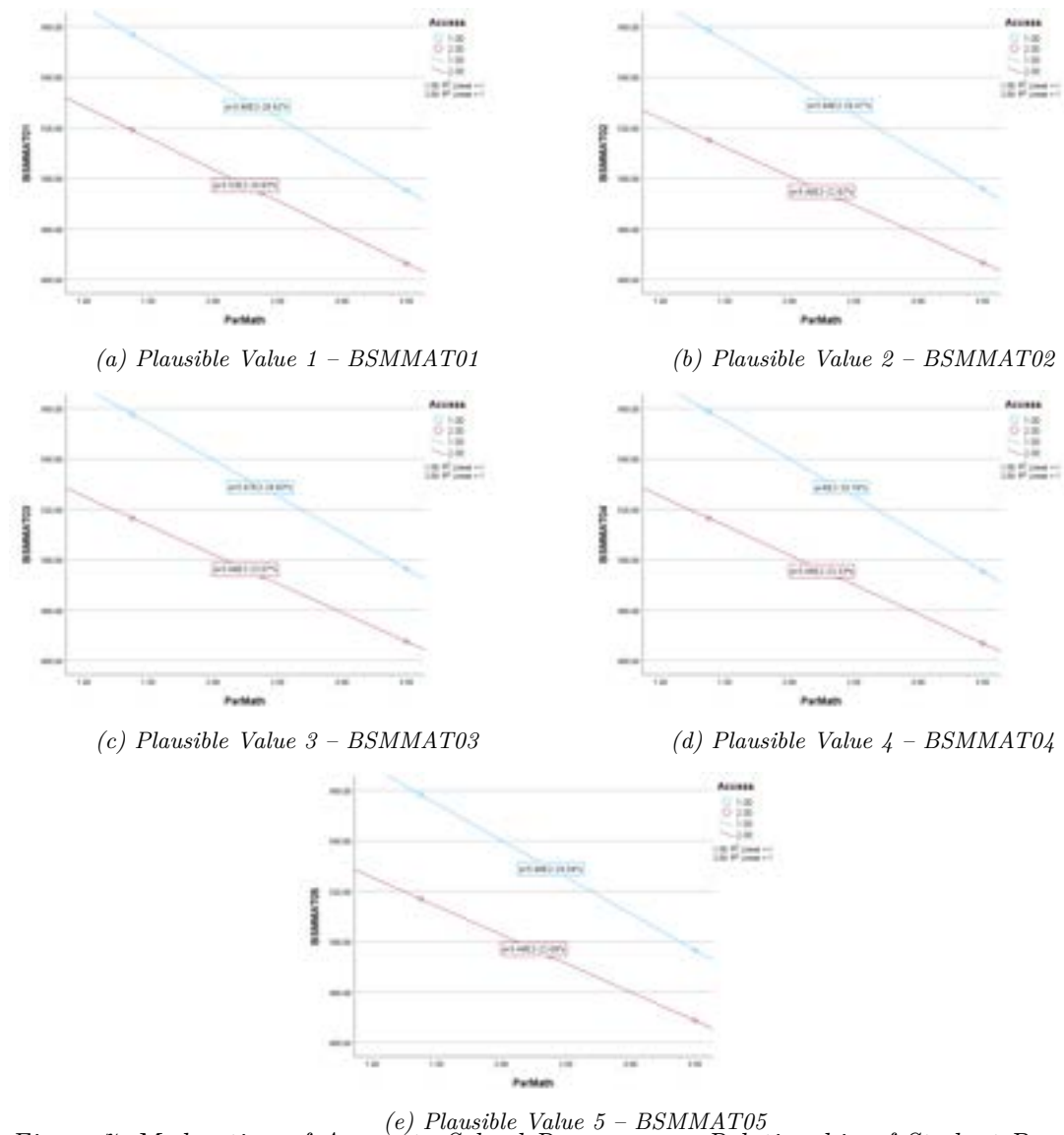
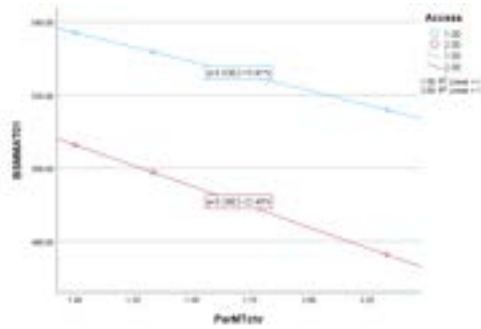
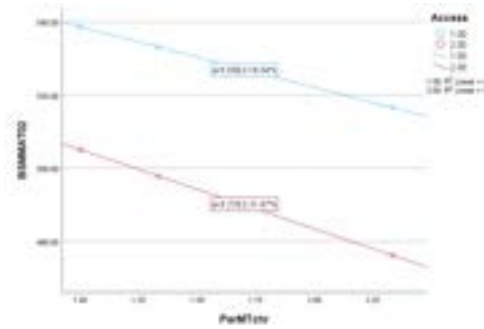


Figure 7. Moderation of Access to School Resources on Relationship of Student Perception of Mathematics and Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

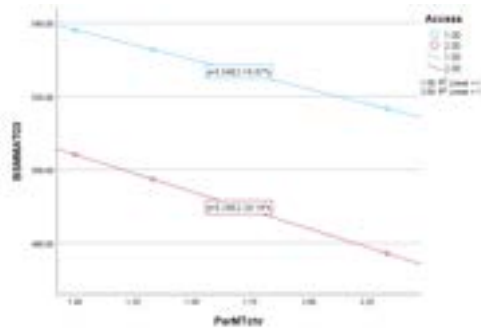
Moderation of Access to School Resources on Relationship of Student Perception of Mathematics Teacher and Student Achievement: Students' access to school resources did not significantly moderate the relationship between their perception of mathematics teacher and achievement, $b = -5.45$, 95% CI $[-12.67, 1.77]$, S.E. = 3.67, $t = -1.48$, $p = 0.139$ (> 0.05) (Table 5). There was a steeper negative association among students without access to resources; because the interaction did not reach significance at the 0.05 level, however, the difference should be treated as suggestive rather than established. This model contributes a little to the overall argument about interaction effect (Figures 8(a)–8(e)).



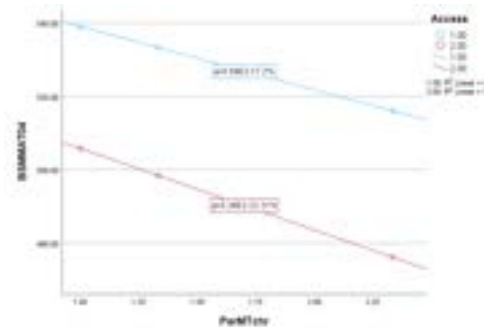
(a) Plausible Value 1 – BSMMAT01



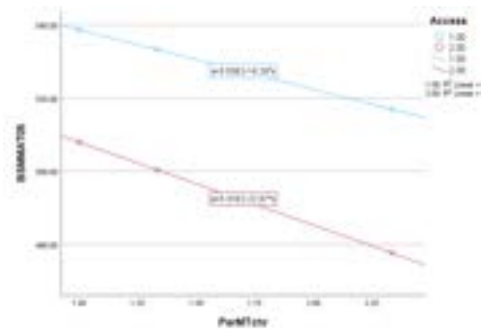
(b) Plausible Value 2 – BSMMAT02



(c) Plausible Value 3 – BSMMAT03



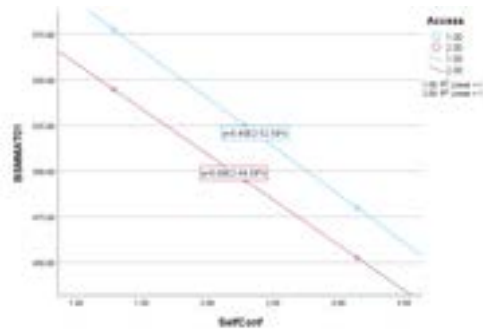
(d) Plausible Value 4 – BSMMAT04



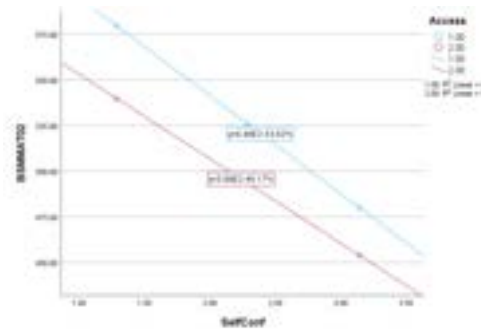
(e) Plausible Value 5 – BSMMAT05

Figure 8. Moderation of Access to School Resources on Relationship of Student Perception of Mathematics Teacher and Student Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

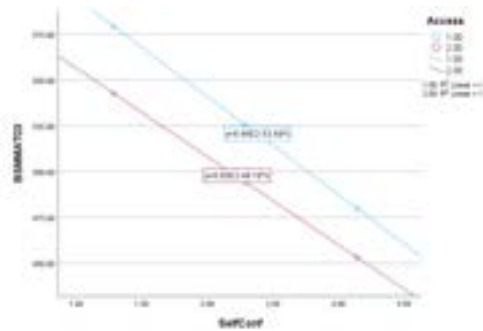
Moderation of Access to School Resources on Relationship of Self-confidence and Student Achievement: Students' access to resources did not significantly moderate the relationship between their self-confidence in mathematics and achievement, $b = 5.90$, 95% CI $[-1.37, 13.16]$, S.E. = 3.60, $t = 1.64$, $p = 0.109$ (> 0.05) (Table 5). Self-confidence remained the largest single predictor of achievement in both groups (those who have access and those who do not). Because the interaction was not significant at the 0.05 level, its relationship with achievement should be regarded as comparable for students with and without access to school resources (Figures 9(a)–9(e)).



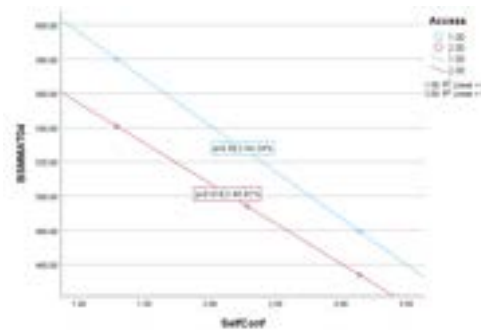
(a) Plausible Value 1 – BSMMAT01



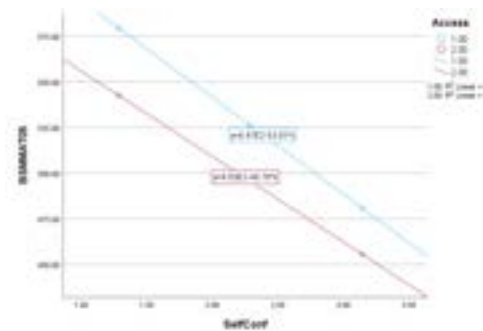
(b) Plausible Value 2 – BSMMAT02



(c) Plausible Value 3 – BSMMAT03



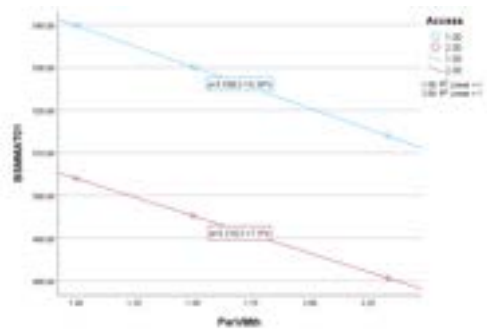
(d) Plausible Value 4 – BSMMAT04



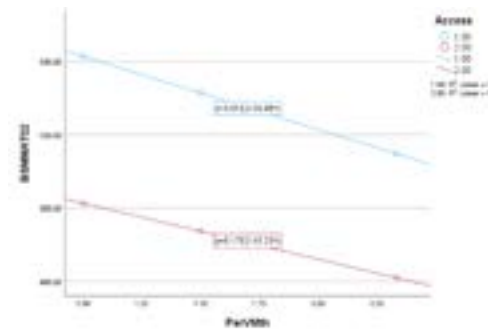
(e) Plausible Value 5 – BSMMAT05

Figure 9. Moderation of Access to School Resources on Relationship of Self-confidence and Student Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

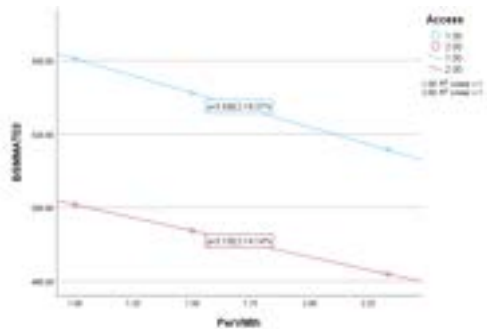
Moderation of Access to School Resources on Relationship of Student Perception about Value of Mathematics and Their Achievement: Students' access to school resources did not significantly moderate the relationship between their perception of the value of mathematics and their achievement, $b = 3.51$, 95% CI $[-4.48, 11.49]$, S.E. = 4.06, $t = 0.86$, $p = 0.388$ (> 0.05) (Table 5). This was the weakest of the six interactions, and the two conditional effects cannot be regarded as differing from each other (Figures 10(a)–10(e)).



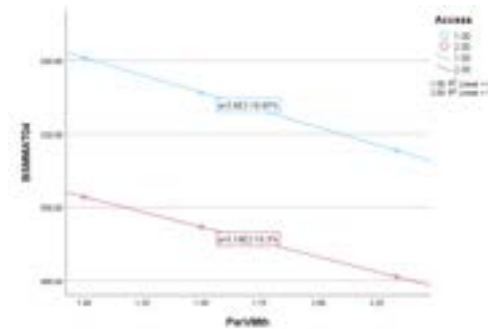
(a) Plausible Value 1 – BSMMAT01



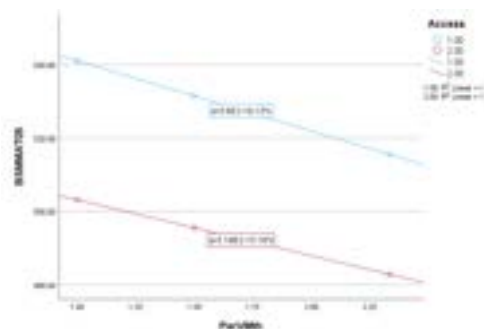
(b) Plausible Value 2 – BSMMAT02



(c) Plausible Value 3 – BSMMAT03



(d) Plausible Value 4 – BSMMAT04



(e) Plausible Value 5 – BSMMAT05

Figure 10. Moderation of Access to School Resources on Relationship of Student Perception about Value of Mathematics and Their Achievement (Plausible Values 1–5: BSMMAT01–BSMMAT05)

Taken together, the six moderation models show that the interaction of access to school resources with students' perceptions was statistically significant for only two of the six perceptual factors. Access moderated the relationship between students' perception of school and their achievement ($b = 8.30$, $SE = 3.44$, $p = .016$) and the relationship between their perception of the classroom environment and their achievement ($b = -11.10$, $SE = 3.10$, $p < .001$), both at the 0.05 level. In contrast, the interaction terms involving the perception of mathematics ($b = 5.86$, $SE = 3.27$, $p = .074$), the perception of the mathematics teacher

($b = -5.45$, $SE = 3.67$, $p = .139$), self-confidence in mathematics ($b = 5.90$, $SE = 3.60$, $p = .109$), and the value of mathematics ($b = 3.51$, $SE = 4.06$, $p = .388$) were not statistically significant at the 0.05 level, and the corresponding changes in R-squared were likewise nonsignificant. The moderating role of access to school resources in this sample is therefore specific to students' perceptions of their school and of their classroom environment—the two contextual factors most directly connected to the resources themselves—rather than a general feature of the relationship between perceptions and achievement.

5. Discussion

The results of exploratory factor analysis (EFA) followed by confirmatory factor analysis (CFA) confirmed the existence of six underlying latent variables related to student perceptions. These latent variables encompassed students' views on school, classroom environment, mathematics, mathematics teachers, self-confidence, and the value they place on mathematics. Additionally, the study incorporated five plausible values for achievement scores. These six perceptual factors have been consistently reported across studies in different educational contexts.

Despite the TIMSS study team's standardization of the background questionnaire for students, it was essential to re-evaluate the alignment of items within each category of student perceptions, beliefs, and values. CFA, a powerful statistical technique, allowed researchers to establish connections between observed variables (such as questionnaire items) and latent variables (unobserved categories). By assessing the alignment of observed variables, researchers could determine or confirm the quality of the latent variables. Notably, Roos and Bauldry (2022) emphasized the importance of this alignment.

Removing six items from the questionnaire further reinforced the model's fit indices, indicating that the data aligned well with the underlying six latent variables. These variables captured students' perceptions, beliefs, and values regarding school, the classroom environment, mathematics, mathematics teachers, self-confidence, and the value of mathematics. The confirmation of these items and their alignment with the latent variables demonstrated their validity and reliability, consistent with findings from other studies.

For instance, Uyar (2021) investigated the alignment of a mathematics attitude questionnaire using TIMSS 2015 data from Turkish eighth-grade students. In their study, CFA revealed five factors and thirty-five items related to student attitudes. Similarly, Zhang et al. (2023) explored the multiple-factor structure of student motivation in science learning using TIMSS 2015 U.S. data. Their CFA results favored a four-factor model over a three-factor model. In the current study, we reaffirmed the six-factor model for further analysis and interpretation.

Students' perceptions play a crucial role in shaping their academic achievement, particularly in mathematics. Among these perceptions, how students view their classroom environment, mathematics content, and mathematics teachers significantly impacts their overall performance (Mariamah et al., 2021). Notably, the perception of mathematics itself emerged as the most influential factor affecting achievement outcomes in the current study. The impact of student perceptions extends beyond the classroom walls. For instance, their perception of the school environment and the overall classroom setting can also influence their mathematics achievement. These findings align with the research by Wardat et al. (2022), who explored the relationship between school factors and student achievement using TIMSS 2015 data from the Abu Dhabi Emirate. Their study revealed that various school-related factors directly affected students' mathematics performance.

Furthermore, classroom characteristics have been identified as key determinants of mathematics achievement. Akyuz and Berberoglu (2010) investigated the impact of teaching practices, class size, and classroom environment on students' mathematics achievement using TIMSS-R data from Turkey and European Union countries. Their findings underscored

the importance of optimizing classroom conditions to enhance student learning outcomes.

Previous research consistently highlights the significant impact of students' perception of mathematics on their achievement in the subject. Notably, studies by Appiah et al. (2022), Bonne and Lawes (2016), Ma and Kishor (1997), and Pajares and Graham (1999) underscore the positive influence of students' perception of mathematics. This perception is closely intertwined with students' beliefs and attitudes, which, in turn, shape their learning experiences and performance in mathematics. The association between students' attitudes and mathematics achievement has been a focal point of investigation. Ma and Kishor (1997), Mutodi and Ngirande (2014), and Salifu and Bakari (2022) consistently demonstrate a strong connection between students' attitude and their mathematics performance. Specifically, students' positive attitudes towards mathematics correlate with better achievement outcomes (Mutodi & Ngirande, 2014).

However, the relationship between perception of mathematics and achievement is not universally straightforward. While Shone et al. (2023) reported that mathematics perception significantly predicts students' mathematics achievement, other studies, such as that by Hagan et al. (2020), have found a weaker or even negative association. These divergent findings highlight the complexity of the interplay between perception, attitude, and achievement in mathematics.

Students' self-confidence, perception of school, and the value they place on mathematics play pivotal roles in shaping their mathematics achievement. Surprisingly, these factors negatively influence student performance. Among them, self-confidence emerges as the most potent negative predictor of mathematics achievement. The consistency of this finding is evident in the work of Mukhopadhyay (2015), who reported similar results. Marsh (1992) also examined the relation between students' verbal self-concept and their mathematics achievement. However, the current finding diverges from that of Çiftçi and Yıldız (2019), who found a statistically significant positive effect of self-confidence on mathematics achievement. According to their study, higher self-confidence is associated with better mathematics performance.

Yalcin et al. (2017) further emphasized the impact of self-confidence on mathematics achievement using TIMSS 2011 data from Turkey. Their results revealed substantial effect sizes (0.48 for grade four and 0.99 for grade eight), indicating that self-confidence significantly influences achievement, particularly at higher grade levels. Interestingly, past research consistently supports the positive correlation between students' self-confidence and mathematics achievement. Studies by Ballane (2019), Jafri (2011), Kumaraswamy (2014), Lone (2021), and Mweni et al. (2023) all underscore the importance of self-confidence in promoting successful mathematics learning outcomes. While the negative influence of self-confidence, school perception, and the value of mathematics on achievement is surprising, the nuanced relationship between self-confidence and mathematics performance warrants further exploration. Researchers and educators should consider these factors when designing interventions to enhance students' mathematics self-concept and achievement.

The negative coefficient obtained for self-confidence in the final structural model needs a closer discussion, since most previous studies have reported a positive association between self-confidence and mathematics achievement. Several explanations are plausible in this regard. First, the coefficient is a partial estimate, adjusted for the other predictors. Student self-confidence was entered simultaneously with five other correlated perceptual factors, and the exploratory and confirmatory analyses showed substantial covariances among these factors. When correlated predictor variables share variance with the outcome, the sign of an individual coefficient may differ from the sign of its zero-order correlation, which is a common pattern known as a suppression effect. The negative estimate therefore describes the residual contribution of self-confidence once perceptions of mathematics, the classroom environment, the mathematics teacher, the school, and the value of mathematics are held constant, and it should not be read as evidence that more confident students learn less

mathematics.

Second, the direction of the coefficient may reflect the frame of reference within which students judge their own competence subjectively rather than expressing absolute confidence in the subject matter, since students appraise themselves in comparison with their immediate classmates; equally able students in demanding classrooms may express lower confidence than their less able counterparts in less demanding ones, which eventually may attenuate or reverse the confidence–achievement association in pooled data. Shen and Tam (2008) reported a comparable paradox in cross-national TIMSS comparisons, and Shen and Talavera (2002) showed that the sign of such self-perception effects can change once school- and home-level controls are introduced in the models.

Third, differences in measurement may contribute to the direction of the association. The TIMSS self-confidence items are self-reported Likert-type judgments about the ease or difficulty of mathematics rather than performance-based measures of competence, and response tendencies such as modesty or reluctance to endorse extreme categories may weaken their alignment with tested achievement. The response bias to the items related to personal experiences and perceptions tends to be highly skewed, and even mathematically good students may choose to be at the lower end of the perceptual variables, and access may have no direct impact on the relationship with these perceptual constructs and their association with achievement. These explanations are not mutually exclusive, and the cross-sectional design of the present study cannot adjudicate among them. Hence, the findings should be read as a within-model partial association that invites replication using alternative model specifications, for example by estimating the effect of self-confidence on its own and then adding the remaining factors stepwise, rather than as evidence against the value of building students' confidence in mathematics.

There is an intricate interplay between student perceptions, access to school resources, and mathematics achievement. The moderation effect of school resources on this relationship is particularly noteworthy. Firstly, the significant moderation effect emerges when considering students' perception of school. This finding aligns with prior research conducted by Gustafsson et al. (2018), Lamb and Fullarton (2002), Malik and Rizvi (2018), and Wardat et al. (2022). Gustafsson et al. (2018) emphasized that school-related socioeconomic status (SES) is the most robust predictor of mathematics achievement. However, it is essential to recognize that this relationship can swing either way, contingent on the educational context.

Secondly, students' access to school resources plays a pivotal role in moderating the relationship between the perception of the classroom environment and achievement. A well-equipped classroom environment, rich with resources, significantly impacts student achievement. This observation resonates with the findings of Liu et al. (2022) and Shi et al. (2023), who underscore the importance of resource-rich contexts for enhancing mathematics learning outcomes.

Thirdly, while the moderation effect of access to school resources on the relationship between perception of mathematics, self-confidence, and the value of mathematics is positive, it does not attain statistical significance. Similarly, the moderation effect on the relationship between the perception of mathematics teachers and achievement is negative, albeit non-significant. Taken together, the moderating role of student access to school resources was confined to the two contextual factors of perceptions—of the school and of the classroom environment—and did not extend to students' perceptions of mathematics, of the mathematics teacher, of their own self-confidence, or of the value of mathematics, a distinction that should be kept in view when interpreting the moderation results.

These findings carry some practical implications for schools, policymakers, and mathematics classrooms. Because the significant moderating effects were concentrated in students' perceptions of the school and of the classroom environment, investment in the learning context appears to be where resources make the greatest difference to the way students'

perceptions are translated into learning and achievement. In practical terms, this means ensuring that every student, and not only those in better-resourced schools, can obtain textbooks and instructional materials when they are needed, can reach digital resources for assignments and for collaboration with classmates outside lesson time, and can communicate with teachers about mathematics beyond the class period, since these are the specific forms of access captured by the items used in this study. It also means attending to the conditions that shape how the classroom is experienced: class routines for different learning activities, adequate instructional time for conceptual learning, manageable class sizes, and the ready availability of help when students are stuck. Schools that combine such material provision with a supportive classroom climate may give students both the means and the reason to engage with mathematics, whereas supplying resources without attending to the classroom environment, or improving the classroom climate while material access remains uneven, is likely to yield smaller gains. For school leaders and policymakers, the results suggest that decisions about resource allocation are not merely administrative matters, since they shape the extent to which students' perceptions of school and classroom are converted into measurable mathematics learning.

In summary, these results, along with evidence from previous studies, reinforce the notion that school resources and SES play a pivotal role in moderating the relationship between the classroom environment and student achievement in mathematics. The intricate dance between perception, resources, and achievement continues to shape our understanding of effective educational contexts.

6. Conclusion and Recommendation

This study confirms the existence of six underlying latent variables related to student perceptions, encompassing views of school, classroom environment, mathematics, mathematics teachers, self-confidence, and the value of mathematics. The alignment of observed variables with these latent factors demonstrates their validity and reliability. Moreover, the impact of student perceptions extends beyond the classroom, influencing overall academic achievement. Researchers should consider these factors when designing effective strategies to enhance mathematics learning outcomes.

Students' perceptions significantly shape their academic achievement, particularly in mathematics. Their views on the classroom environment, mathematics content, and teachers directly impact overall performance. Notably, the perception of mathematics itself emerges as the most influential factor affecting achievement outcomes. Beyond the classroom, students' perception of the school environment also influences their mathematics achievement. Additionally, classroom characteristics play a crucial role in enhancing student learning outcomes. Previous studies consistently highlight the positive influence of students' perceptions of mathematics, which are closely intertwined with their beliefs and attitudes, shaping their learning experiences and performance in this subject.

Self-confidence significantly influences mathematics achievement, particularly at higher grade levels. A positive correlation exists between students' self-confidence and successful mathematics learning outcomes. However, the nuanced relationship between self-confidence, school perception, and the value of mathematics warrants further exploration. Additionally, an intricate interplay exists between student perceptions, access to school resources, and mathematics achievement. School-related socioeconomic status (SES) emerges as a robust predictor, but its impact can vary across educational contexts. Access to well-resourced classrooms also plays a pivotal role in enhancing mathematics learning outcomes.

The following are the recommendations drawn from this study:

1. *Holistic Approach to Student Perceptions:* Researchers and educators should consider a holistic approach to student perceptions, recognizing that views on school, classroom

environment, mathematics, teachers, self-confidence, and the value of mathematics all contribute to academic achievement. Addressing these factors collectively can lead to more effective strategies.

2. *Emphasize Mathematics Perceptions*: Given its significant influence, educators should prioritize fostering positive perceptions of mathematics among students. Encouraging a favorable attitude towards the subject can enhance overall achievement outcomes.
3. *Beyond the Classroom Walls*: Educators should acknowledge that student perceptions extend beyond the classroom. Factors such as the school environment shape achievement. Creating a supportive and conducive overall environment can positively impact mathematics learning.
4. *Consider Classroom Characteristics*: Classroom conditions matter. Educators should optimize teaching practices, class size, and the classroom environment to enhance student learning outcomes. A well-equipped classroom can contribute to better mathematics achievement.
5. *Account for Self-Confidence and SES*: Educators and institutions should recognize the nuanced relationships among self-confidence, school perception, and mathematics achievement. While self-confidence matters, socioeconomic status (SES) also plays a role. Therefore, interventions must be tailored to the specific educational context and available resources.
6. *Target Resources at the School and Classroom Level*: The findings showed that access to school resources moderated the relationship between students' perceptions of school and of the classroom environment and their achievement; therefore, school leaders, administrators, and policymakers should give priority to the equitable distribution of resources, so that all students have access to instructional materials, digital resources, technological tools, and teacher support.

Declaration

On behalf of all authors, the corresponding author declares no conflict of interest in publishing this work.

Acknowledgement

The study data were obtained from the TIMSS 2019 International Database. We would like to acknowledge the data source as IEA's Trends in International Mathematics and Science Study – TIMSS 2019, Copyright © 2021 International Association for the Evaluation of Educational Achievement (IEA). The publisher is the TIMSS & PIRLS International Study Center at the Lynch School of Education and Human Development, Boston College.

Funding Source

There was no funding from any institution to support this study.

Use of Artificial Intelligence

Gemini and Claude were used for grammar correction and structural organization of the manuscript.

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